LAND TITLES, INVESTMENT, AND AGRICULTURAL PRODUCTIVITY IN MADAGASCAR:

A POVERTY AND SOCIAL IMPACT ANALYSIS

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Executive Summary

Land rights formalization has been promoted as a way to encourage agricultural investment and stimulate land markets, yet little is known about the potential benefits of such policies in sub-Saharan Africa. Strong indigenous tenure systems, low returns on investment in land, and thin rural credit markets all militate against a high payoff to land registration and titling in this region. This paper examines the question of land titling in Madagascar, a country where modern and informal tenure systems coexist and overlap to a significant extent. The empirical analysis is based on a large sample of rice plots from an intensively titled area, the Lac Alaotra basin. The data allow a comparison of land-specific investments, land productivity, and land values between titled and untitled plots cultivated by the same household.

The study reviews the three main arguments for land titling and their relevance for Madagascar. Potentially the most important benefit is protection against expropriation, yet simulation evidence suggests that the effect of reduced expropriation risk on land-specific investment and land values would not be large. Titles may also facilitate land transactions. However, in the context of rural Madagascar the effect in the land sales market is ambiguous *a priori*, while the effect in the leasing market is found to be empirically unimportant. As for the third argument, collateral, there is no evidence that owning titled land improves access to formal credit or increases the volume of formal credit conditional on access.

The main empirical analysis finds no significant effect of having a title on investments in rice plots, which are principally of the recurrent type (maintenance of canals, bunds, and land equalization). Titling also has correspondingly small impacts on land productivity and land values. Our point estimate of the premium for titled land is 6% of plot value, well below comparable figures for Asia and Latin America. A cost-benefit analysis based on these findings suggests that it would not be economical to expand the current system of formal titling in rural Madagascar. The estimates also provide a threshold for the costs of any new land rights system in Madagascar above which it would not make economic sense to implement.

1. Introduction

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 much larger set of studies exists on the effects of customary land rights in Africa (see, e.g., Besley, 1995; Gavian and Fafchamps, 1996; Braselle et al., 2002), but this literature is concerned with a different question; namely, the economic response to greater tenure security. The present study focuses instead on the potential benefits of a land titling program, a crucial distinction. 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, and could even have the opposite effect.

[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.

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, 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 the magnitude of the private benefits of land titles, with an emphasis on the role of expropriation risk. Madagascar is particularly interesting in this respect because 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, to compare economic performance on titled and untitled land. Our estimates should tell us not only how much farmers stand to gain by extending the coverage of the modern land rights regime at the margin, but also should give us an upper bound on the social cost of introducing such a system de novo.

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

[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." (pp. 259).

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* 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 2 describes the setting and data used in the study, focusing on the relationship between formal and informal property rights in land. The empirical work is organized into two parts. The first part, in section 3, goes through the different arguments for why land titling might be beneficial and assesses the relevance of each for Madagascar, and for Lac Alaotra in particular. The second part of the empirical work, in section 4, presents estimates of the impacts of land titles on land-specific investment, land productivity, and land values. Section 5 concludes with implications of the findings for land policy in Madagascar and sub-Saharan Africa more broadly.

2. Setting and Background

2.1. 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

[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. To the extent that these areas are otherwise identical, this IV strategy corrects for selection bias due to unobserved attributes of property owners. See also Lanjouw and Levy (2002) for a different approach to dealing with the endogeneity of land rights in hedonic price regressions.

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 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.

In 1961, the Malagasy administration took over management of the *mailles* with the establishment of the parastatal SOMALAC. Although SOMALAC was charged with maintaining the irrigation infrastructure, by the end of the 1970s it began falling into varying states of disrepair, depending on the perimeter. Also during this period of state management, land within the *mailles* was redistributed among the 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

[5] Another advantage was that SOMALAC undertook the cartography for all *maille* parcels, work which would otherwise have to have been done by the understaffed land administration. With the dissolution of SOMALAC in 1991, its role in facilitating land titling abruptly ended. More details of the titling system in Lac Alaotra and elsewhere in Madagascar can be found in Rakotosihananka (1995).

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 of this brief history is that the irrigated perimeters of Lac Alaotra not only contain some of the country's most productive riceland but are also perhaps the most intensively titled areas 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*.

2.2. Data and Sampling

The data used in this study are based on a specially designed survey conducted in the Lac Alaotra region in April-May 2005. Over 1,700 households were surveyed in 38 communes surrounding the lake. In the first phase, about 900 landowning households were randomly selected from 29 communes lying wholly outside of the *mailles* boundaries. Taking advantage of the more densely titled areas, the second phase of the survey focused on the 9 communes encompassing the *mailles*. Within these communes about 800 households were randomly sampled from among those owning land in 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.[6] 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*.[7] 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*,[8] 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.[9]

The extent to which this greater productivity is due to the higher rate of titling in the *mailles* is a question that will be examined in detail in Section 4. 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 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, at best, subtle. The figure also shows that the *dispersion* of plot values is much greater outside the *mailles* than within, and this is true of the other productivity indicators as well. The coefficient of variation of yield, revenue, and plot value inside the *mailles* are

[6] During the slack (dry) season, however, some lowland plots with ample irrigation are used to grow vegetables. Also, about 2% of lowland plots in Lac Alaotra are reportedly not cultivated, although practically all *maille* plots are.

[7] Yield and revenue figures are based only on the approximately 2,800 owner-cultivated plots. The sample underlying the titling and plot value calculations includes rented out and uncultivated plots but, in the case of value, excludes the 8% of plots with missing data, leaving a total of 2,961 plots.

[8] Given problems of past surveys in eliciting accurate information about land documentation in Madagascar, enumerators were trained to ensure that respondents understood exactly what was meant by a formal title, referring explicitly in the question to the single regional land administration office.

[9] 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*.

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.

2.3. Informal tenure and land markets 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").[10] 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, 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. The main purpose of such a procedure seems to be to assure the buyer that, in

[10] We should perhaps also distinguish between a title in the name of a current household member and one in the name of a living relative who is not a household member (27% of up-to-date titles are of the latter sort). The fact that the title is lodged in another household, albeit a related one, may arguably be a source of tenure insecurity.

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.[11]

A second type of local-level land documentation is the *acte de donation*. This paper, issued by the commune, indicates that a specific person has transferred a well-demarcated parcel of land to another person and may be given in cases of either purchase or inheritance. The *acte de donation* is much more common on land with an up-to-date title, probably because it is viewed as an important step toward formalizing ownership within the community. Owners of a given plot who were determined to follow this procedure were also more likely to pursue a title on that plot.

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 common is the *acte de patrimoine*, a document issued by the local tax administration office which itemizes the estate of a deceased person, followed closely by the *acte de notorité* (issued by the land administration office) indicating that the person holding the land is indeed an heir of the deceased.

There are also a minority of lowland plots (virtually all outside the *mailles*) that were originally cleared by the current owner. In some cases, advance written authorization was obtained for the exploitation of the land, which could later help to establish ownership. Under the law, occupants who have developed new lands can apply for title based on the principle of improvement (*mise en valeur*) if they can prove that they have been working the land 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

[11] 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.

occupation. After so many years, however, the titling process is for all intents and purposes moribund. Some owners of purchased and inherited plots in the *mailles* also claim to have an *acte d'attribution*, but mostly for land acquired after the demise of SOMALAC. Since these certificates are most probably in the name of the previous owners, they are of no value in obtaining a title.

There are still other local institutions that serve to recognize land ownership, with survey respondents mentioning receipts for the payment of communal land taxes and tax roles kept on file in commune headquarters. To be sure, none of the informal documents enumerated in this subsection have juridical standing, as would a formal title, but they may nonetheless impart a considerable sense of tenure security.

Also salient in Table 2 is the extent of land market activity in Lac Alaotra. In this regard, the region stands out from the rest of Madagascar, and perhaps from much of sub-Saharan Africa as well. Nationally, only about 13% of lowland plots in rural areas are purchased,[12] compared to 41% in our data. Leasing markets are also more active in Lac Alaotra than elsewhere in the country. One-quarter of cultivated plots, comprising one-fifth of cultivated area, are leased in, compared to the national figures of 10% for both. Tenancy is limited in Madagascar as a whole largely because land ownership is not very concentrated. Later we examine the extent to which lack of formal title might also discourage land leasing.

2.4. 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 amount of suitable lowlands that remains unexploited. 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

[12] This nationwide statistics on rural land markets are obtained from the nationally representative income-expenditure survey (EPM) of 2001.

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 much 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.[13] There are other indications that this is so. Farmers were asked whether each investment had existed on the plot five years before, and thus whether the investment was made for the first time only in the last five years. For 92% of the cases of canal work, 91% of bund work, and 87% of land leveling, the investment already existed on the plot five years before. Thus, the vast bulk of investment in riceland appears to be recurrent.[14]

3. Benefits of Formal Title and their Relevance to Madagascar

There are three avenues for land titling to increase investment in land, agricultural productivity, and land values. Braselle et al. (2002) usefully term these the *assurance*,

[13] Land leveling on existing rice plots is almost by definition a maintenance activity, whereas it would be very rare for an entirely new field channel to be dug in an already configured irrigated parcel. At any rate, it would have probably been difficult for survey respondents to distinguish construction from maintenance activities very precisely, so they were only asked to provide the combined costs of both.

[14] The breakdown between cash costs and family labor costs is fairly similar across the three major investments; about 40-50 percent of expenditures are in cash.

realizability, and *collateralizability* effects. In this section, we establish the relevance of each effect in turn for rural Madagascar and for Lac Alaotra in particular.

3.1. Titles and expropriation risk

An 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. However, the extent to which registering land or issuing titles would reduce expropriation risk depends on how well existing institutions guarantee tenure security as well as on how the modern and traditional systems of land rights interact.

3.1.1. Private versus 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 (Table 4) see protection against competing claimants as the chief benefit of a title under the current system. Another 6 percent said a title mainly facilitates bequests of land to children, which, arguably, amounts to the same thing.[15] Thus, what some commentators view as a dysfunctional system of land administration, nonetheless appears to deliver a measure of tenure security to those fortunate enough to fall under its umbrella. 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 5). 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.

[15] 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.

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.

If farmers' opinions are any indication, then the main channel for titling to have an economic impact in the Lac Alaotra region is through the assurance effect.[16] 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

[16] 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.

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.

3.1.2. 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 of recurrent investment costs) and *r* is the annual discount rate.[17] 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 $\alpha \in (0,1)$.[18] Let us further suppose that granting a formal title reduces expropriation risk from θ to 0. Under these

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[17] 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, but is discussed below.

[18] 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.

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.[19] Both of these ratios are easily calculated for different configurations of the parameters $\{r, \delta, \theta, \alpha\}$.

For purposes of exposition, assume a discount rate of 0.1 and a depreciation rate of 0.28.[20] 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 6 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 6 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 6 tells more or less the same story for land

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[19] The expression is $\dfrac{(r+\theta)(r+\theta+\delta)^{1/\alpha}(r+\alpha\delta)}{r(r+\delta)^{1/\alpha}(r+\theta+\alpha\delta)}$. 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.

[20] 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 value 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.

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

It is worth concluding this analysis with a caveat. Our investment model assumes that farmers have no preferences over the risk of land expropriation itself; i.e., they are risk neutral. Since Malagasy farmers are poor and land makes up a large component of their asset portfolio, risk neutrality is probably not an innocuous assumption. Risk aversion, while difficult to incorporate formally into the investment model, would raise the value of titled land relative to untitled land over and above the figures presented in Table 6 (see Feder et al., 1988, for an illustrative calculation in a different model); the extent of this discrepancy, as a theoretical matter, must be left for future research. As an empirical matter, however, any risk premium is impounded in the price or value differential between titled and untitled land and so will be captured in our estimates.

3.2. Titles and land transactions

The second channel by which titling can potentially benefit landowners is by lowering the cost of land transactions. Besley (1995) shows how, in the context of customary tenure, facilitating land transfers increases the gains from trade and thus raises the expected return on land-specific investment. This is the so-called realizability effect. In this subsection, we consider the precise mechanisms by which titling affects transactions costs in both the land sales and leasing markets.

3.2.1. Land sales

Return to 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 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. For the sake of the discussion, 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, further, that it is prohibitively costly to update or transfer a title. Whereas the current plot owner still takes $\theta = 0$, the potential buyer has $\theta = \theta' > 0$. A sale will now occur only if $\pi' > \frac{r+\theta'}{r}\pi > \pi$. In this scenario, then, land titling leads to a transactions cost. More generally, while updating a title may not be prohibitively costly, it is still very expensive for a typical peasant household and requires a long wait, which effectively delivers the same conclusion; the market for titled land is more limited than that for untitled land. Titling, under these circumstances, creates a *negative* realizability effect.

Evidence of this sort of phenomenon can be found in the Lac Alaotra data. When titled land is transferred from one household to another in Madagascar, the transaction must be formally registered in order to maintain the legal validity of the title. Besides the burdensome procedures that this entails, subdividing the land for purposes of either sale or inheritance raises additional bureaucratic hurdles, among which is the necessity to resurvey each sub-parcel. In the case of inheritance, however, 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%).[21] Moreover, titled plots that have been purchased from close relatives, with whom the buyer might share a family name, are less likely to be up-to-date than those purchased from distant relatives, friends, or strangers (56 versus 66%). One can infer, therefore, that titled land will be *less* likely to be sold outside of the immediate family than untitled land, which is to say that the extent of the market for titled land is more limited.

Another aspect of land titling, however, may lower transactions costs in the land sales market. A title is the ultimate proof to the buyer that the land is actually the property of the seller and that no outsider will come later to challenge the original owner's right to sell.[22] Furthermore, by relinquishing the actual title deed to a buyer, even without a formal transfer, the seller can provide 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. On the other hand, buying titled land 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.

It should be noted that 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, although this was reported as a *secondary* benefit for around 6% of respondents (Table 4). The survey also asked farmers 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 5 do suggest that they are somewhat more common than land expropriation.

Overall, then, the impact of land titles on transactions costs in the land sales market is ambiguous. Under the conditions found in Madagascar, in which updating titles is costly, it may be harder to find a buyer for titled land than for untitled land. On

[21] This difference is highly significant in a regression that also controls for year of plot acquisition.

[22] 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.

the other hand, to the extent that titles attenuate transactions uncertainty, titled land may be easier to sell.

3.2.2. Land Leasing

Holding a title may also enhance the realizability of land-specific investment through the leasing market. For this to occur, there must be a significant danger that renters or sharecroppers will lay claim to the plot that they have been leasing and successfully appropriate it. Absent other effective means of property rights protection, a title provides the landowner with the security necessary to be willing to lease. Risk of tenant expropriation has two types of effects: First, it lowers the supply of land made available for lease, thus raising equilibrium land rents and reducing the total amount of leased land. As fewer landowners find it attractive to lease, the realizability of investment returns is diminished. Second, conditional on a plot being leased, the risk of having it appropriated by a tenant reduces the incentive for the owner to invest on it, exactly like the assurance effect arising from generic expropriation risk.

The question, of course, is whether a significant risk of expropriation by tenants actually exists. The methodology we use to address this question is also employed extensively in section 4 where it is justified and explained more fully. Essentially, we compare outcomes between titled and untitled plots owned by the same household, controlling for other plot characteristics. In the present case, the outcomes of interest are the propensity to lease out the plot and the duration of the lease conditional on the plot being leased out. Both should be higher on titled plots if titles protect landlords from tenant squatters.

The first set of regressions in Table 7 considers the propensity to lease. Only 11% of lowland plots in our sample are leased out by their owners. The discrepancy between this figure and the 25% of cultivated plots that are leased in lies in the fact that, in a random sample of households, large landowners are underrepresented relative to their importance in the leasing market.[23] Column 1 of Table 7 reports household fixed effects

[23] Since our sample is based on resident households, it also does not include absentee landlords, of which there are a fair number, especially in the *mailles*. It is possible that absentee landlords are more susceptible

estimates of a linear probability model for the leasing out decision. According to these estimates, titled plots are no more likely to be leased out than untitled plots owned by the same landlord.[24]

To obtain more precision, we next turn, beginning in column 2, to the efficient household random effects estimates. These specifications add household-level controls for the value of agricultural landholdings, agricultural equipment, and zebus. The coefficients on these asset variables all have the expected sign; households with greater land assets have a higher propensity to lease out, but, conditional on land, households with greater stocks of complementary capital are less likely to do so. More importantly, the standard error on the titling coefficient falls by almost 40% in the random effects specification even while a Hausman test cannot reject it against fixed effects. Despite the greater precision, the titling coefficient remains negative and insignificant. The second random effects specification in column 3 asks whether landowners are any more likely to lease out plots with up-to-date titles (as defined above) than they are those with out-of-date titles. We find no significant difference in the propensity to lease out by title status.

A very significant determinant of leasing decisions, by contrast, is the travel time between the plot and the household domicile. Not surprisingly, distant plots are far more likely to be leased out. It is also worth introducing at this stage the other plot-level characteristics, whose coefficients appear in Table 7, and which are used as controls throughout our empirical analyses. Position of the plot in the *mailles* and (log of) plot area are always included. Travel time between plot and nearest route passable by zebu cart is an indicator of the cost of transport. The irrigation variables are self-explanatory (omitted category: traditional irrigation), with the exception of the quality index which is constructed 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. We also control for soil type (omitted category: brown/white), but not for

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to being expropriated by their tenants, in which case we will underestimate the effect of titling on leasing decisions. If this were true, however, and there were no other benefits of titling, then only a limited subset of the population, namely absentee landlords, would stand to gain from tenure reform.

[24] Using a similar methodology, Giné (2005) finds that lack of title significantly constrains leasing in a setting (Thai forest reserves) where the risk of *government* expropriation is nontrivial.

topography, which for rice plots is level by necessity. Descriptive statistics for these variables are reported in Table A.1 of the Appendix.

Returning to Table 7, in the last three specifications we examine the determinants of lease duration based on the sample of 349 leased plots. The mean lease duration is 5.4 years (median 4 years), and the question is whether (log) duration is greater on the 91 titled plots than on the 258 untitled plots, holding other plot characteristics constant. Because there are 72 households that lease out more than one plot, a household fixed effect estimator is also feasible in this case. Once again, though, we find no evidence that having land with a title, up-to-date or otherwise, influences leasing decisions.[25] [26]

In sum, then, we find no evidence that expanding land titling at the margin will render leasing out more attractive to landowners. This suggests that, despite the informality of tenure on the majority of plots, there is little perceived danger of expropriation by squatting tenants. The most plausible explanation for limited tenancy in rural Madagascar is the relatively egalitarian distribution of land rather than the limited reach of the modern titling system.

3.3. Titles and access to credit

The collateralizability effect of land titles is emphasized by Feder et al. (1988) in their study of rural Thailand. They 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 the accessibility of formal credit and also allow existing borrowers to obtain

[25] One might question the power of this test, given the limited sample of leased plots. An inverse power function calculation (Andrews, 1989) based on the standard error of the household random effects estimator (which is, as before, on the order 40% smaller than its fixed effects counterpart) yields the following: We can be 95% certain that the true effect of having a title on tenancy duration is no greater than 35%, which amounts to less than two years of tenancy duration. Thus, it seems that we are able to detect modest-sized tenancy duration effects in our data set.

[26] Using the same approach, we also find no evidence that untitled plots are more likely to be leased out to tenants who are related to the landowner and who may thereby be less likely to lay claim to the land.

larger loans, resulting in higher investment. As pointed out by Feder and Feeny (1991), the market value of a titled plot will thus 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. How far has the Lac Alaotra region progressed in this direction? This is the topic to which we now turn.

While institutional lenders play a miniscule role in rural Madagascar as a whole,[27] the relatively commercialized Lac Alaotra region is exceptional in this regard. About 14% of surveyed households report that they took out a formal sector loan in the past three years. Most of this credit came from OTIV and CECAM, two institutions, which, although run by NGOs, generally demand collateral. Bank of Africa (BOA) appears to be the only commercial bank with significant operations in rural Madagascar and accounts for 24% of loans in our sample. More than half of these BOA loans are secured with land, as compared to 24% for OTIV and 17% for CECAM. Agricultural machines and zebu are much more likely to be used to secure loans from these latter institutions.

Can the unusually high rate of formal credit use in Lac Alaotra be explained by the high proportion of titled land in the region? Before attempting to answer this question, consider that only 3% of respondents who actually receive formal credit view the main advantage of titled land as being its collateral value for loans (see Table 4). Collateral is cited as a *secondary* advantage of a title among 14% of households overall, and, interestingly, among 20% of formal borrowers. Even this, however, could largely reflect wishful thinking to the extent that respondents view mortgaging land as only a remote possibility.

Table 8 presents probit estimates for whether a household borrowed from institutional sources in the last three years. The only covariates are measures of household landownership, in terms of either number of plots (columns 1 and 2) or land area (columns 3 and 4). Our main interest lies in the differential impact of titled land over untitled land. Columns 1 and 3 show a significant differential; owning titled land

[27] Less than 1% of cultivating households in the nationally representative EPM-2001 survey report borrowing from formal sources.

enhances access to formal credit by more than owning untitled land. However, this result evaporates when we disaggregate land according to whether or not it lies within the *mailles* (columns 2 and 4). In particular, both within and outside the *mailles* there is no significant advantage to having titled land. The only land characteristic that seems to matter is position in the *mailles*, irrespective of titling status. To be sure, ownership of titled land (as well as ownership of land in the *mailles*, for that matter) may be endogenous with respect to formal credit access. More entrepreneurial farmers, for example, may have both a higher demand for credit and for titled land. But this cannot explain our results, since we are not finding that having titled land makes any difference.

The next set of regressions concerns whether putting up titled land as collateral allows formal sector borrowers to obtain larger loans than putting up untitled land. For this purpose we use data on the 347 institutional loans over the last three years reported by 234 borrowing households. In each case, the household was asked the amount of the loan and the type of collateral required. In case land was pledged, respondents had to identify the particular plot, allowing us to determine the titling status of the plot as well as its area and position in the *mailles*. Of the one-third of formal loans secured with land almost two-thirds (63%) are backed by titled plots, much higher than the overall percentage (27%) of titled plots in our sample.[28] On the other hand, *mailles* plots are much more likely to be titled and, as we have just seen, owners of *mailles* land are more likely to borrow from the formal sector. Again, there is no evidence yet that titles are valuable.

Our analysis of (log) loan amount in Table 9 follows a pattern similar to that in Table 8. We include a set of dummy variables for titling status interacted with the log(area) of the collateralized plot. Without distinguishing plots according to their position in the *mailles*, titled plots appear to make significantly better collateral than untitled plots of equivalent size (column 1). The second specification in Table 9 indicates that institutional lenders prefer plots with up-to-date titles over those with either out-of-date or no title at all. However, when we control for plot location in columns 3 and 4 we find that only having land in the *mailles* matters, mirroring the results for credit access in Table 8. There is no longer a significant advantage to having a titled plot *vis a*

[28] Upland plots were used as land collateral in only 5% of the cases and none were titled.

vis an untitled plot, but plots with up-to-date titles still make significantly better collateral than plots with out-of-date titles (column 4). Since the source of this latter ambiguity appears to be the high colinearity between titling status and plot location, only a larger sample of loans (which is not available at present) can help to resolve it.

Given these findings, it would be hard to argue that intensive land titling has opened up institutional credit opportunities for farmers in Lac Alaotra. There can be some debate about the impact of titles on loan size, but this issue is salient only for the small minority of households that already have access to formal credit. Expansion of land titling at the margin, moreover, would not increase such access, at least according to our evidence. Finally, the market value of titled land in Lac Alaotra should not incorporate a significant collateral premium, not only because of this negligible collateralization effect but also because titles cannot be easily transferred. Having to wait many years and incur large costs to transfer the deed undermines any additional value of titled land as collateral.

3.4. Summary

Before moving on to the main estimates, it is worth recapitulating the points made in this section. Farmers in Lac Alaotra assert that the key benefit of a title is protection against expropriation by influential individuals, yet simulation evidence suggests that this risk is likely to have such minimal effects on investment and land values in our context that it may not even be detectable. Titled land may also carry a premium in the land sales market (which can encourage greater investment) because titles reduce transactions uncertainty. But a countervailing effect, arising from the high cost of updating titles in Madagascar, makes titled land more difficult to sell, thus tending to vitiate any such price premium. Lastly, as just discussed, we would not expect to see a significant effect of land titles on investment or land values resulting from the greater collateralizability of titled land. The next step in our analysis is to see whether or not the data support these conjectures by directly examining the impact of titles on investment, productivity, and land values.

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

4.1. Empirical strategy

The basic regression model used in this section is given by

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

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 observables characteristics, x_{ih}.

For ease of interpretation, and especially to clarify the inverse power function calculations, each dependent variable is normalized by the mean of y_{ih} taken over all untitled plots. In this way, for continuous variables, α estimates the percentage difference in the mean between titled and untitled plots, whereas for binary variables 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.[29] 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 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, far thornier, endogeneity issue involves the plot-specific unobservable, ε_{ih}. The return to titling may simply be higher on more fertile plots. These plots may also receive greater investment and will certainly be more productive. In this case, even household fixed effects estimates would tend to yield upward biased estimates of α. Table 10 provides evidence that plots at least are selected for titling on the basis of *observable* characteristics, even after accounting for the strong effect of *maille* position. The household fixed effects linear probability model estimates in column (1) show larger, less remote, and more reliably irrigated plots significantly more likely to be titled.[30]

We do not have an obvious instrument for T_{ih}, particularly one that varies across plots within the same household. To be sure, position in the *mailles* strongly determines whether a plot is titled, but plots within the *mailles* are likely to be more productive than those outside for reasons that have nothing to do with titling status. In short, plot location is not excludable from equation (1).

Lacking an instrument, we take the approach suggested by Altonji et al. (2005) of estimating an upper bound on the bias due to endogeneity (selection),[31] or, equivalently,

[29] 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).

[30] Observed plot characteristics explain about 8% of the variance in titling status; the household fixed effects alone explain 76%. The estimates in Table 10 use the plot characteristics included in the land value regresssions.

[31] The terms endogeneity and selection bias are used interchangeably here because in the context of a binary endogenous variable model they are conceptually identical.

a lower bound on α. We do this in certain cases where titling is found to have a positive and statistically significant effect on outcomes. Essentially, the strategy assumes that the degree of selection on *unobservable* plot characteristics should not exceed the selection on *observable* plot characteristics. We adapt this methodology to the present problem by allowing for a continuous dependent variable as well as for a large number of fixed effects. Details of the procedure are relegated to a technical appendix.

4.2. Titles and investment

The final 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 condition on the nature and quality of the plot's irrigation infrastructure. This might seem problematic, as plot infrastructure 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 11 reports the results for binary indicators of investment, overall and by type, in the past five years, 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.[32]

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 11. For example, we can be 95% confident that, had land titling raised the proportion of 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 be nothing more than a statistical anomaly.

4.3. Titles and land productivity

Within the framework developed in section 3, 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

[32] 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.

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.[33]

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, 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 12 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. The *ceteris paribus* productivity effect of having a plot in the *mailles*, by comparison, is on the order of 30%.

The question is whether this small productivity effect of titling is real – i.e., a consequence of greater investment on titled plots –or simply an artifact of unobserved heterogeneity; that titled plots tend to be more naturally fertile, for example. Unfortunately, this question is impossible to answer if investment is indeed measured with significant error. We can certainly ask how much of the productivity effect can be explained by *observed* investment. Assuming that (1) investment is perfectly observed

[33] According to the model of subsection 3.1.2, 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.

and (2) that the plot-specific error term in the productivity regression is uncorrelated with the titling status of the plot, the titling effect on productivity should go away once we control for observed investment. The results of this exercise are reported in Table 13 and show only a very minor attenuation of the titling coefficients when investment variables (the three binary indicators and total expenditures per hectare) are included. The random effects estimates of the impact of titling remain statistically significant. Thus, evidently, one or both of the two hypotheses maintained above is false. This outcome is not surprising given the lack of relationship between investments and titling already noted in the previous section.

It is also possible to ask whether selection on the unobservables (endogeneity bias), whatever the interpretation of these unobservables might be, can plausibly account for the *entire* estimated titling effect on productivity. The answer to this question is given by the lower bound estimates in Table 14, which, as explained earlier, assume as a worst-case scenario that selection on the unobservables has the same effect as selection on the observables. All of the lower bound estimates for the titling effect are essentially zero. From this we conclude that the entire effect of titling on productivity estimated in Table 12, small as it is, *could* in fact be due to the presence of unobservables correlated with titling status. Once again, though, it is impossible to say whether these unobservables are unmeasured investments, fixed attributes of the plot (i.e., natural fertility), or some combination of the two.

Lastly, in Table 15, 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 investment differentials.

To summarize, while evidence for an impact of land titles on land productivity, either gross or net, is mixed, even in the most optimistic scenario these effects are

modest. Moreover, the analysis of the next subsection will suggest that the 6-7% figure is, if anything, probably an overestimate.

4.4. 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 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. If this is the case, then controlling for household fixed effects would yield unbiased estimates of the titling effect.

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 12, are considerably smaller than those for the corresponding coefficients in the land productivity regressions.[34] There is also much less of a difference between the precision of the fixed

[34] 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

and random effect estimates. The latter specification, at any rate, is rejected in favor of fixed effects in the present case.

Titled plots are on average 5.6% more valuable than untitled plots, a difference which is statistically significant. How robust is this estimate of the titling effect likely to be against endogeneity bias due to plot-level unobservables? Following our previous strategy, we estimate the lower bound on the titling effect in Table 14. If selection on unobservables were just as strong as selection on observables, then the market premium on titled plots would be 3.6%, which is within only one standard error of the actual estimate. The truth probably lies somewhere in between this remarkably tight interval. Given this, it is unlikely that the productivity effect found in Table 12 of 6-7% is entirely real, since the impact of titles on productivity is bounded from above by the impact of titles on the market value of land. In any case, the important point to keep in mind here is that our estimate of the market premium for titled land is small despite the possibility of *positive* bias due to endogeneity of land titles.

It is also worth trying to distinguish the different channels by which titles influence land values.[35] 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 5). Columns (1) and (2) of Table 16 reports a 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

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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.

[35] Even if the collateral channel were important in Lac Alaotra, contrary to what we argued in section 3.3, there should be no effect on the land value premium estimated by household fixed effects. As pointed out by Besley (1995), the collateralizability of land titles affects investment on all household land, not only on the plots that have the title. The fact that the fixed and random effects estimates of the titling effect on land values are essentially identical is thus further confirmation that titles have no substantial collateral value.

according to whether or not they are up-to-date.[36] In other words, 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 16, 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.

Based on our review in section 3 of the different channels by which titling may influence land values in rural Madagascar, we did not expect to uncover a dramatic impact. Our findings bear out this expectation. The point estimate of the market premium for titled plots is at most 6%, a figure even higher than our simulations in Table 6 might have indicated. The upper end of the 95% confidence interval for this estimate is 10%. To put this into context, World Bank (2003) reports comparable land differentials in Asia and Latin America ranging from 40% to 80%. We can definitively say that the corresponding number for rural Madagascar lies well below this range.

[36] Similar results are obtained when we define the likely to be expropriated category to include those who say they have "rarely" heard of cases of expropriation.

5. Conclusions and Policy Implications

The consistent message emerging from this study is that the private economic benefits from extending land titling in Madagascar would be minor, especially relative to its cost. 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. [37] 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 and still maintain the semblance of a centralized, formal titling system.[38] 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.[39] 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 that tenure security is the dominant issue, our estimates approximate the benefits of such

[37] 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.

[38] World Bank (2003) and Bruce, Migot-Adholla, and Atherton (1997) report various estimates of titling and registration costs. There is a lot of variation in these costs, partly based on what constitutes a 'title'.

[39] Enabling legislation passed by Madagascar's parliament in 2005 now allows for the piloting of these new systems.

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 routine issuing of titles for agricultural land, at least outside of peri-urban areas, should be discontinued, while still legally 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.[40] 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$.[41] This calculation ignores the costs already incurred by current title-holders to obtain their titles. However, since this cost is sunk, it should not enter the decision of whether to suspend the current system. Even if it turns out that the true social cost is half this amount, it is still a big number in the context of rural Madagascar; by way of comparison, the value of yearly rice production for the entire Lac Alaotra basin is around 28 million US$.

[40] One could also argue 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.

[41] 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.

Last but not least, it is worth considering the potential distributional consequences of land tenure reform, putting aside any cost-benefit imbalance. *Prima facie*, it is not obvious that expanded land titling, or community-based land registration for that matter, constitutes the best route to attaining distributional objectives, since wealth is increasing in landholdings. Policies that raise the value of existing assets, without accomplishing any redistribution, do not generally target the poor very effectively. Still, in countries like Madagascar, where most rural residents are poor and agricultural landholdings are not highly concentrated, a distributional case could be made for land tenure reform on the grounds that it raises average rural wealth by more than it raises urban wealth, particularly if urban taxpayers must foot the bill. The question that remains, however, is whether alternative policies cannot achieve similar objectives at lower cost.

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Technical Appendix

A Lower Bound for the Titling Effect when Titling is Endogenous

Consider an index model for the titling decision of the form

$$T_{ih} = 1(\gamma' x_{ih} + \delta\eta_h + \nu_{ih} > 0) \tag{2}$$

where $1(\cdot)$ is the indicator function and ν_{ih} is a plot-specific error correlated with ε_{ih}. In particular, we assume that ν_{ih} and ε_{ih} are jointly normally distributed with correlation coefficient ρ. The system formed by equations (1) and (2) is sometimes called a treatment effects regression. As indicated, we have no exclusion restrictions; i.e., all the observables in equation (2) coincide with those in equation (1). In this case, the parameter of interest, α, is nonparametrically unidentified.

The presence of the household-level unobservable η_h in equation (2) complicates matters considerably because of the nonlinearity of the probability model. The main problem arises when η_h is correlated with x_{ih}. To assess the relevance of this issue in the present case, Table 10 presents a Hausman test of the fixed effects versus random effects linear probability models for the indicator of plot titling status. Recall that this tests precisely the null that η_h is uncorrelated with x_{ih}, albeit in a linear specification. Our failure to reject this null suggests that we can proceed as though η_h is orthogonal to the regressors in equation (2).

Next, we make the additional assumption that η_h has an independent normal distribution, which implies that the compound error term in equation (2), $u_{ih} \equiv \delta\eta_h + \nu_{ih}$, is itself normally distributed, and that, consequently, the model can be estimated as a probit. Moreover, it is clear that $corr(u_{ih}, \varepsilon_{ih}) = corr(\nu_{ih}, \varepsilon_{ih}) = \rho$. The regression model for equation (1) thus becomes

$$y_{ih} = \alpha T_{ih} + \beta' x_{ih} + \lambda d_{ih} + \eta_h + e_{ih} \tag{3}$$

where $d_{ih} = T_{ih}\dfrac{\phi(\gamma' x_{ih})}{\Phi(\gamma' x_{ih})} - (1 - T_{ih})\dfrac{\phi(\gamma' x_{ih})}{\Phi(\gamma' x_{ih})}$, ϕ and Φ are, respectively, the pdf and cdf of the normal distribution, $\lambda = \sigma_\varepsilon \rho$, and σ_ε is the standard error of ε in equation (1). Using the residuals from equation (3), σ_ε can be computed according to the formula

$$\sigma_\varepsilon^2 = \frac{\sum e_{ih}^2}{N - K} + \lambda^2 \frac{1}{N}\sum d_{ih}(d_{ih} + \gamma' x_{ih}) \tag{4}$$

where *N* is the sample size and *K* is the appropriate number of degrees of freedom. Equation (3) collapses to equation (1) in case $\rho = 0$.

The calculation of the lower bound on α works as follows: Suppose that the index of unobservables explaining our outcome, ε_{ih}, has the same relationship with the

latent titling status indicator $T_{ih}^{*} = \gamma' x_{ih} + u_{ih}$ as does the index of observables, $\beta' x_{ih}$. In other words,

$$\frac{\text{cov}(T_{ih}^{*}, \varepsilon_{ih})}{\text{var}(\varepsilon_{ih})} = \frac{\text{cov}(T_{ih}^{*}, \beta' x_{ih})}{\text{var}(\beta' x_{ih})} \tag{5}$$

Substituting and rearranging this equation, using the normalization $\text{var}(u_{ih}) = 1$ gives

$$\lambda = \sigma_{\varepsilon}\rho = \sigma_{\varepsilon}^{2} \frac{\text{cov}(\gamma' x_{ih}, \beta' x_{ih})}{\text{var}(\beta' x_{ih})} \tag{6}$$

Altonji et al. (2005) argue that the degree of selection bias, as reflected by λ, can be no higher than the number on the right-hand side of equation (6). Consequently, the true value of α can be no *lower* than the estimate of α produced by equation (3) with λ fixed at this value.

Technically, the problem is that both the estimates of γ and of σ_{ε} (cf., equation (4)) needed to compute the upper bound on λ, given by equation (6), themselves depend on the value of λ used to estimate equation (3).[42] To handle this, we proceed by iterating over values of λ, estimating equation (3), until we find one such value that satisfies equation (6) to an arbitrarily close approximation. The estimation of equation (3) conditional on the chosen λ is straightforward; we simply regress $y_{ih} - \lambda d_{ih}$ on T_{ih} and x_{ih} using household fixed effects. The household random effects case works the same way, except that the first term on the right-hand side of equation (4) is replaced by the appropriate residual variance from the random effects regression.

[42] This issue does not arise in the bivariate probit setup of Altonji et al.

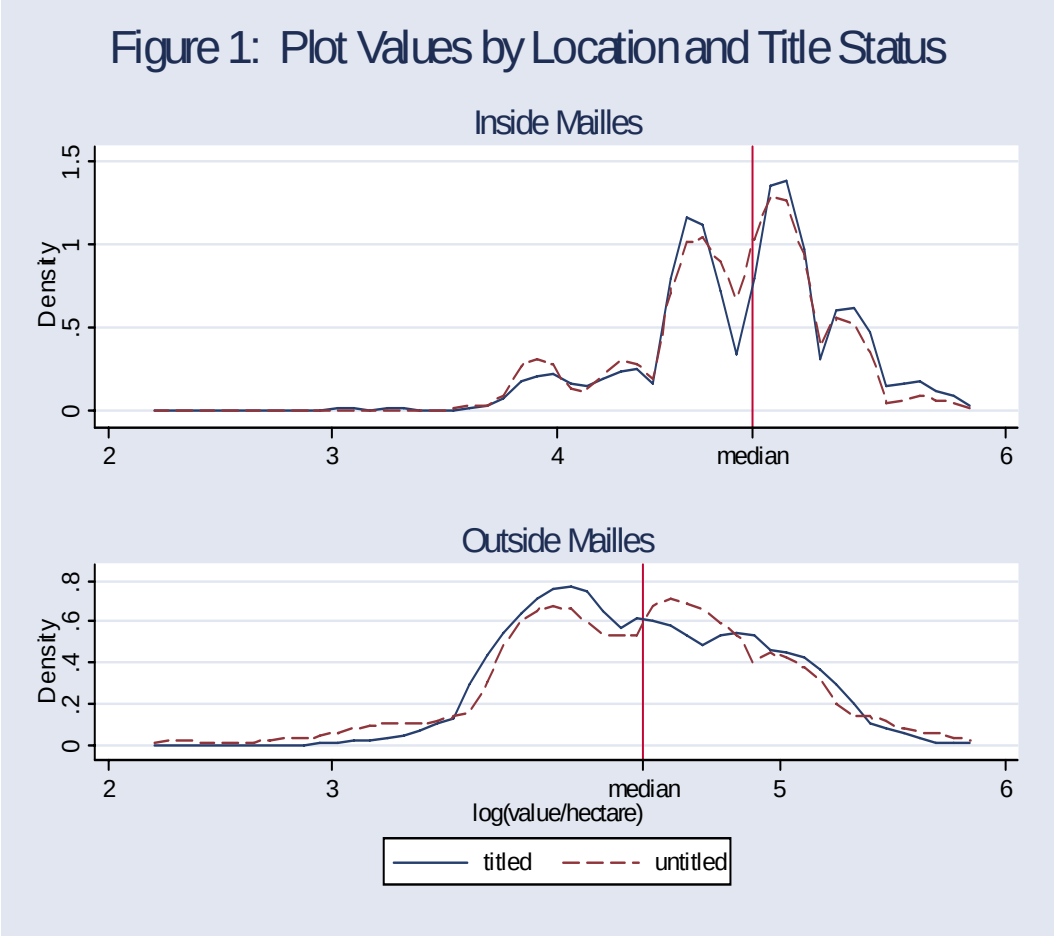
Figure 1: Plot Values by Location and Title Status
Inside Mailles
Density
0
.5
1
1.5
2
3
4
median
6
Outside Mailles
Density
0
.2
.4
.6
.8
2
3
median
5
6
log(value/hectare)
titled
untitled

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 revenues are for main season rice crop.

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 Benefits of Land Titles by Formal Credit Status

	First most important			***Second most important***		
Most important benefits of having a land title	**Received formal credit in past 3 yrs.**			**Received formal credit in past 3 yrs.**		
	yes	**no**	**total**	**yes**	**no**	**total**
Protects against competing claimants	91.9	90.1	90.3	6.0	9.2	8.8
Facilitates inheritance	4.7	6.7	6.4	66.7	72.1	71.4
Facilitates sale	0.4	0.6	0.6	7.1	6.0	6.1
Serves as collateral	3.0	2.3	2.4	20.2	12.5	13.5
Other	0.0	0.3	0.3	0.0	0.2	0.2
Total	100.0	100.0	100.0	100.0	100.0	100.0

Notes: A total of 13.6% of households received formal credit in past 3 yrs.

Table 5: 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 6: 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 7: Effects of Titles on Land Leasing Decisions

	Lease out (yes/no)			Log lease duration (yrs.)		
Independent Variable	***(1)***	***(2)***	***(3)***	***(4)***	***(5)***	***(6)***
titled plot	-0.012	-0.014		0.159	0.082	
	(0.023)	(0.014)		(0.178)	(0.101)	
up-to-date title			-0.017			0.116
			(0.016)			(0.122)
out-of-date title			-0.009			0.033
			(0.019)			(0.138)
log value of owned land		0.038*	0.038*		0.040	0.043
		(0.007)	(0.007)		(0.050)	(0.050)
log value of equipment		-0.033*	-0.033*		-0.064*	-0.065*
		(0.004)	(0.004)		(0.030)	(0.030)
log value of zebus		-0.006*	-0.006*		-0.002	-0.002
		(0.002)	(0.002)		(0.013)	(0.013)
plot in *mailles*	0.009	-0.008	-0.008	-0.069	-0.028	-0.026
	(0.022)	(0.014)	(0.014)	(0.139)	(0.094)	(0.094)
log plot area	0.008	0.015*	0.015*	0.146	0.137*	0.133*
	(0.009)	(0.007)	(0.007)	(0.089)	(0.053)	(0.054)
log travel time to nearest zebu cart route	-0.002	-0.002	-0.001	-0.032	0.029	0.029
	(0.004)	(0.003)	(0.003)	(0.036)	(0.019)	(0.019)
log travel time to home	0.038*	0.026*	0.026*	0.011	0.001	0.000
	(0.007)	(0.005)	(0.005)	(0.047)	(0.032)	(0.032)
no irrigation (rainfed)	0.028	0.005	0.006	-0.813*	-0.423	-0.420
	(0.045)	(0.03)	(0.03)	(0.383)	(0.227)	(0.228)
irrigated by river	-0.05	0.021	0.022	-0.720	-0.388	-0.381
	(0.053)	(0.034)	(0.034)	(0.385)	(0.233)	(0.233)
quality of irrigation index	0.002	0.007	0.007	-0.149*	-0.068	-0.067
	(0.008)	(0.005)	(0.005)	(0.064)	(0.037)	(0.037)
black soil	0.015	0.017	0.017	0.008	-0.018	-0.018
	(0.027)	(0.019)	(0.019)	(0.205)	(0.15)	(0.15)
red soil	0.028	0.017	0.017	-0.122	-0.107	-0.105
	(0.036)	(0.025)	(0.026)	(0.244)	(0.191)	(0.192)
Household effects	fixed	random	random	fixed	random	random
Hausman test p-value (fixed vs. random effects)	---	0.185	---	---	0.223	---
Sample size	3,232	3,232	3,232	349	349	349

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

Table 8: Land Ownership and Access to Formal Credit

	Number of plots		Land area	
Independent Variable	***(1)***	***(2)***	***(3)***	***(4)***
titled lowlands	0.241*		0.067*	
	(0.047)		(0.014)	
titled & within *mailles*		0.332*		0.091*
		(0.051)		(0.016)
titled & outside *mailles*		-0.075		-0.012
		(0.120)		(0.036)
untitled lowlands	0.069*		0.028*	
	(0.033)		(0.011)	
untitled & within *mailles*		0.254*		0.084*
		(0.05)		(0.017)
untitiled & outside *mailles*		-0.004		-0.017
		(0.038)		(0.017)
upland or forest	-0.064	-0.01	-0.014	-0.008
	(0.035)	(0.037)	(0.013)	(0.011)
Tests (p-values):				
titled = untitled	< 0.001	---	< 0.001	---
titled = untitled *mailles*	---	0.154	---	0.730
titled = untitled non-*mailles*	---	0.565	---	0.896

Notes: Probit coefficients (standard errors) for binary indicator of household receipt of institutional credit over past three years. Asterisk denotes significance at 5% level. Constant term not reported. Sample size is 1726 for all regressions.

Table 9: Collateral Type and the Size of Formal Loans

Form of collateral	*(1)*	*(2)*	*(3)*	*(4)*
titled plot × log(area)	0.138*		-0.035	
	(0.039)		(0.070)	
up-to-date title × log(area)		0.199*		0.025
		(0.043)		(0.072)
out-of-date title × log(area)		0.056		-0.118
		(0.056)		(0.081)
untitled plot × log(area)	0.040	0.039	-0.042	-0.044
	(0.040)	(0.040)	(0.055)	(0.056)
plot within *mailles* × log(area)			0.170*	0.171*
			(0.057)	(0.057)
agricultural equipment	0.193	0.184	0.178	0.168
	(0.271)	(0.271)	(0.271)	(0.272)
zebus	0.358*	0.349*	0.343	0.333
	(0.176)	(0.176)	(0.177)	(0.177)
Adjusted R^2	0.054	0.078	0.067	0.092
Tests (p-values):				
titled = untitled	0.039	---	0.883	---
up-to-date titled = untitled	---	0.002	---	0.137
out-of-date titled = untitled	---	0.779	---	0.208
up-to-date titled = out-of-date titled	---	0.026	---	0.027

Notes: Standard errors in parentheses adjusted for clustering at the level of the household. Dependent variable is the log of loan size (347 observations). Omitted collateral form is "other" (consisting mainly of unspecified or perhaps no guarantee as well as residential houses). Asterisk denotes significance at 5% level or higher. Constant term not reported.

Table 10: Plot-Level Determinants of Title Status

Independent Variable	***(1)***	***(2)***
plot in *mailles*	0.449*	0.437*
	(0.024)	(0.017)
log plot area	0.048*	0.039*
	(0.010)	(0.008)
log travel time to nearest zebu cart route	-0.018*	-0.023*
	(0.005)	(0.003)
no irrigation (rainfed)	0.241*	0.181*
	(0.054)	(0.04)
irrigated by river	0.160*	0.124*
	(0.064)	(0.046)
quality of irrigation index	0.040*	0.028*
	(0.010)	(0.007)
black soil	-0.051	-0.044
	(0.030)	(0.024)
red soil	-0.059	-0.056
	(0.041)	(0.032)
Household effects	Fixed	Random
Hausman test p-value (fixed vs. random effects)	---	0.220

Notes: Standard errors in parentheses. Asterisk denotes significance at 5% level. Constant term not reported. Dependant variable is indicator for whether plot has title. Sample size is 2,769 rice plots.

Table 11: 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 12: 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 13: Titles and Land Productivity Controlling for Investment

	Yield		Net revenue/ha	
Independent Variable	***(1)***	***(2)***	***(3)***	***(4)***
titled plot	0.051	0.064*	0.054	0.062*
	(0.042)	(0.025)	(0.046)	(0.027)
total investment expenditure per hectare	0.002	0.004*	0.002	0.002
	(0.002)	(0.001)	(0.002)	(0.001)
any canals	0.104*	0.080*	0.096*	0.093*
	(0.042)	(0.027)	(0.046)	(0.030)
any bunds	0.064	0.0470*	0.060	0.044
	(0.050)	(0.022)	(0.055)	(0.024)
any land leveling	-0.067	-0.042	-0.089*	-0.048
	(0.040)	(0.024)	(0.044)	(0.026)
Household effects	fixed	random	fixed	random
Sample size	2642	2642	2633	2633

Notes: Standard errors in parentheses. Asterisk denotes significance at 5% level. Regressions also include the same plot characteristics used in Table 12.

Table 14: Lower Bounds for Impact of Titles

	Yield		Net revenue/ha		Log(value/ha)	
Independent Variable	***(1)***	***(2)***	***(3)***	***(4)***	***(5)***	***(6)***
Lower bound on $\hat{\alpha}$	0.006	-0.012	-0.005	-0.033	0.036	-0.073
	(0.042)	(0.025)	(0.046)	(0.027)	(0.024)	(0.020)
Implied $\hat{\rho}$	0.081	0.104	0.093	0.114	0.053	0.137
Household effects	fixed	random	fixed	random	fixed	random

Notes: Standard errors in parentheses. Asterisk denotes significance at 5% level. See technical appendix for procedure to estimate the lower bound. Regressions also include the same plot characteristics used in Table 12.

Table 15: 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 12.

Table 16: Land Value Regressions withTitling 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 12.

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.