Migration pressure, tenure security and agricultural intensification. Evidence from Indonesia[1]

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September 2014

Forthcoming in *Land Economics*.

Abstract — We explore the role played by migration induced population pressure for the endogenous adoption of formal land titles and subsequent investments in land in Central Sulawesi (Indonesia). Using original village and household-level data we provide evidence that migration pressure increased the incentives to formalize landownership. The adoption of formal land rights was in turn associated with increased expenditures for agricultural inputs and investment in trees, terraces, ditches and irrigation systems. We show that the availability of a demand-driven land titling system has been critical for increased agricultural intensification in our Indonesian setting.

***JEL* Codes:** K11, O12, Q12.

Key words: Migration, formal land rights, investment, agricultural development, Indonesia.

A previous version with the title "Endogenous institutional change and economic development: A micro-level analysis of transmission channels" has been published as Courant Research Center Working Paper #14 (2009), University of Göttingen.

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Acknowledgements: This paper draws on data from the German-Indonesian collaborative research centre referred to as *Collaborative Research Center* 552: STORMA ("Stability of Rainforest Margins"). The project was carried out by the Universities of Göttingen and Kassel in Germany, the Agricultural University of Bogor and the Tadulako University of Palu in Indonesia. Funding by the German Research Foundation (DFG) is greatly acknowledged. We also thank sub-project A3 for kindly granting access to the village survey and Stefan Erasmi for providing detailed maps. The paper benefited from comments by Chairil Anwar, Denis Cogneau, Stefan von Cramon Taubadel, Heiko Faust, Cecilia Garcia-Penalosa, Melanie Grosse, Michael Lipton, Jean-Philippe Platteau, Mark Rosenzweig, Paul Schultz, Stefan Schwarze, Chris Udry, and Walter Zucchini. Earlier versions of that paper have been presented at conferences and seminars in Maastricht (UNU-MERIT), Göttingen (VfS Development Economics), IDS Sussex, Berlin (PEGNet), Yale University, ZEF Bonn, ISS The Hague, Paris (EUDN), Amsterdam (EALE), Cornell University, University of Frankfurt, Paris School of Economics, University of Passau and at the OECD Development Centre in Paris.

1. Introduction

Indonesia has experienced rapid agricultural growth from 1960 onwards (Hill, 2000; Mundlak et al., 2002; Timmer, 2007). Between 1961 and 1998 the compound average annual growth rate stood at 3.4% in the aggregate and 1.4% in per capita terms (Mundlak et al., 2002). This growth was marked by a significant expansion of land used, the adoption of new technologies such as irrigation, fertilizer, pesticides and improved seeds and changes in land use patterns including an increasing cultivation of various cash crops including coffee and cocoa (Mundlak et al., 2002). We explore some of the drivers underlying this growth in one part of Indonesia, Central Sulawesi. We focus in particular on land tenure institutions and the adoption of formal land titles which we partly explain by internal migration induced population pressure. We also analyze the role of land titles in facilitating a more efficient resource allocation and hence higher agricultural productivity.

A particular strength of our study is that it is based on a very detailed data set consisting of village survey covering more than 20 years of socio-economic change and a household data set, albeit cross-sectional, but with plot level information. Since the data is observational in nature we cannot derive causal relationships but, based on village fixed effects and household fixed effects regressions, provide evidence for a set of hypotheses linking migration, the adoption of land tiles and agricultural growth. Despite the spatially confined empirical setting, which of course has the advantage of allowing us to operate with very homogenous initial conditions, there is a large heterogeneity in migration flows, the emergence of land titles in villages, investments in land, and the adoption of new technologies. Studying the determinants of this heterogeneity is the central contribution of our article.

By demonstrating the empirical relevance of our proposed transmission mechanisms, we believe that we are not only able to contribute to the literature on the emergence and effects of land rights, but are also able to provide critical details on the emergence and relevance of local institutions more generally which complements the more macroeconomic and historical studies explaining long run differences in economic development across countries (Engerman and Sokoloff, 1997; Hall and Jones, 1999; Acemoglu et al., 2001; Easterly and Levine, 2003; Rodrik et al., 2004; Galor et al., 2009). We believe there is value-added to examine the transmission mechanisms implied by the institutions hypothesis at the micro level in the more homogenous setting of a single country, where concerns about parameter heterogeneity and unobserved heterogeneity are arguably less serious than with cross-country regressions. Moreover, the macroeconomic literature is typically relatively silent about the precise nature of the relevant institutions, how exactly these institutions emerged and how they shaped the pattern of economic development.[2]

Our analysis suggests that increased population pressure enhanced the demand for formal land titles that were accessible through a land titling scheme supplied by the Government. These patterns are also consistent with the idea that in villages were such titles were in use, agricultural inputs were used more intensively and investment, such as tree planting, terracing and building ditches and irrigation systems were enhanced. This is in contrast to some studies that have analyzed the role of land titles in particular in the African context (e.g. Braselle, 2002; Jacoby and Minten, 2007) but also confirms what has been found in other regions such as China (e.g. Deininger and Jin, 2003), India (e.g. Deininger et al. 2007) or Vietnam (e.g. Do and Iyer, 2008). The intention of our study is neither to downplay the negative findings nor to overemphasize the positive findings but rather to elaborate on a few factors that can explain why in our context overall land titles seem to have

[2] Typically used proxies for institutions such as "social infrastructure" (used in Hall and Jones, 1999), "the risk of expropriation of private foreign investment by government" (used in Acemoglu *et al.*, 2001) or Kaufmann's institutions index[2] (used in Easterly and Levine, 2003) are rather broad measures and say little about the precise transmission mechanisms that led to these particular institutions as well as the transmission mechanisms from these institutions to economic outcomes. Also, most of these studies (Galor et al, 2009 being a notable exception) lump together growth that emanated largely from agricultural productivity improvements and growth that was result of industrialization where different sets of institutions might be relevant.

played a rather positive role. Moreover, given the narrow regional focus, we do not pretend to generate findings that are valid without further testing beyond that particular context.

The remainder of this article is organized as follows. In Section 2 we discuss the related literature and derive some hypotheses that guide our empirical analysis. In Section 3 we describe the context and the different data sets used for the empirical analysis. In Section 4 we present and discuss the results of our empirical analysis. In Section 5 we conclude.

2. Land tenure, property rights and agricultural development: a brief review

We focus in this review on two aspects. First, the role of property rights for land for agricultural investment, both theoretically and empirically, and, second, on the emergence and the evolution of formal land rights.

In the theoretical literature, the use of formal land rights is typically associated with three types of effects (see e.g. Feder and Feeny, 1991; Besley, 1995; Sjaastad and Bromley, 1997; Feder and Nishio, 1999; Platteau, 2000; Place 2009). First, formal land rights are assumed to increases the return on long-term land improvements and conservation measures and therefore farmers are expected to have a higher incentive to undertake investments (the 'assurance effect'). If perennial crops such as coffee and cocoa are gaining prominence as the most lucrative cash crops, as has been the case in the area we investigate (Klasen, Rudolf, and Priebe, 2013), this effect is potentially particularly important. Second, with formal land rights it is easier to sell or rent the land and thus to realize improvements made through investments enhancing such investments (the 'realizability effect'). Third, formal land titles enable its holders to use land as collateral, which in turn facilitates access to credit and enables the farmer to finance investments in fertilizer and pesticides in the short term (which often have to be financed up-front) and tree planting, the construction of terraces or an irrigation system in the long-term (the 'collateralisation effect').

Analyzing the relationship between land rights and productive agricultural investments empirically is a major challenge as one needs to control for the possible endogeneity of land rights with respect to investment in land and the adoption of new technologies. Studies that have addressed in one way or another endogeneity problems show mixed results ranging from positive (see e.g. Bandiera, 2007; Deininger and Jin, 2003; Deininger et al., 2007; Feder, 2007; Do and Yyer, 2008; Goldstein and Udry, 2008; Holden et al., 2009; Deininger et al., 2011; Ali et al., 2011) to heterogeneous, partly insignificant if not negative effects (see e.g. Besley, 1995; Otsuka et al., 2003; Braselle, 2002; Jacoby and Minten, 2007; Van den Broeck et al., 2007).[3]

In those cases were formalized land titles did not have positive or even had negative effects, the failure is typically related to the lack of conditions that would enable one or several of the effects discussed above to work. Moreover the potential of traditional institutions to allocate land, to deal with land disputes, and to provide security to farmers are often underestimated. And finally not enough attention is given to implementation flaws and the costs of land titling programs and the equity issues that are associated with such programs.

In fact the literature suggests that formalization is particularly attractive where traditional tenure systems are weak and unable to generate sufficient tenure security, where land is getting increasingly scarce, when the return on investment in land is high, opportunities for productive agricultural investments exist, and where collaterized lending exist (e.g. Platteau. 1996; Bromley, 2008). These conditions are likely to apply in many regions in Latin America and Asia, including our study region, and some regions of Sub-Saharan Africa where land is increasingly scarce, but less so in many other parts of relatively land-abundant Sub-Saharan Africa. In many of those African settings, poorly implemented top-down land titling reforms in conjunction with weak administrative capacity, the lack of investment opportunities and appropriate technical innovations

[3] A much more exhaustive and detailed review of the evidence for Sub-Saharan Africa is provided by Place (2009).

for land-intensive agriculture and relatively well-functioning informal institutions governing land access can explain the mixed evidence of the effects of land titling there. In such contexts land tenure policies ignoring the complex rules of locally evolved property institutions can even lead to more conflict and a loss of social cohesion, particularly if marginalized groups are excluded from the process of land regulation or in an extreme small elites even dominate the process (see e.g. Bruce, 1986; Migot-Adholla, 1991; Platteau, 1996, 2000; Sjaastad and Bromley, 2000; Bromley, 2008; Place, 2009).

Another closely related strand of the literature deals with the question whether formal land titles are an inevitable outcome of rising pressure on land resources. This is proposed by the so called 'Evolutionary Theory of Land Rights' (ETLR, hereafter).[4] The proponents of the ETLR compare institutional change to technological change and hence base their argument on the induced innovation hypothesis, according to which disequilibria on the factor markets caused for instance by rapid population growth or increased commercialization of agriculture lead to an enhanced innovation and adoption of existing innovation of agricultural technology (Boserup, 1965; Hayami and Ruttan, 1985; North 1981). Since formal land titles cannot directly evolve out of customary land rights the ETLR assumes that governments realize in time 'the need' for formal land titles and provide land titles once land is scarce (Platteau, 1996).

The ETLR is criticized for many of its underlying assumptions. Platteau (1996) for instance points out that it is unlikely that there is a massive and homogenous demand for formal land titles as some people will always realize that they lose through land reform. Feder and Feeny (1991) emphasize the role of cultural factors, which may prevent the demand for land titles to develop. A transfer of land to a person from another clan or ethnic group may represent a violation of cultural norms which is not accepted. Another often mentioned problem is that even if there has been agreement on laws to provide formal land titles, the required subsequent registration and enforcement mechanisms are often absent and difficult to establish (Feder and Feeny, 1991). Finally, even if there is a broad-based agreement that some sort of land titling is needed, people may see the greater potential in the evolution of indigenous land tenure systems towards individualization (Bruce, 1988, 1993; Migot-Adholla, 1991).

The case we describe is interesting in the sense that the supply of land titles was indeed exogenously provided throughout the entire observation period including the institutional structures needed to manage formal land rights over time, although obviously not without smaller failures. Hence, our study does not deal with the critical element of supply. We focus entirely on the conditions that enhanced demand. While the commercialization of agriculture certainly played a role, we think a major force was migration-induced population pressure and conflict about land. We also provide suggestive evidence that once land rights were there they enhanced agricultural intensification and investment (rather the other way around). These, at least on average, positive effects may have materialized because of a favorable context: land was increasingly scarce, conflicts emerged, traditional allocation mechanisms were no longer functioning well, there were enough agricultural investment opportunities and sufficient access to credit and input markets so that land titles could generate the three positive effects described above. However, the qualitative field research that we conducted, revealed that, not surprisingly, some lost from the titling in the village, in particular those who hastily sold their land because of (temporarily) economic hardship.

In sum, we look at two links in our empirical analysis. First, the effect of migration-induced population pressure on formal land titles and, second, the effect of formal land titles on agricultural expenses, in particular the purchase of inputs and on agricultural investment. Again, our data does not allow making any strong causal claims, but we think the data is good and original enough to tease out those factors which in our case ensured that the adoption of formal land titles promoted agricultural development.

[4] The term 'ELTR' is used by Platteau (1996). Further references to the theory can be found there.

A close antecedent to our work, also studying Indonesia is Quisumbing and Otsuka (2001), but they analyze the effects of changes in *customary* land tenure institutions on agricultural productivity, cropland management and investment in Sumatra. As we do they also explored the factors affecting the changes in these land tenure institutions; instead, we focus in our study on the adoption of *formal* institutions and their effects.

3 Data and study context

3.1 Data

The longitudinal village level data set we use was collected during March to July in 2001 in the Lore Lindu region. This region includes the Lore Lindu National Park and the five surrounding sub-districts. It is situated south of Palu, the provincial capital of Central Sulawesi/Indonesia. For the survey 80 of the 119 villages in the region were selected using a stratified random sampling method (Zeller, Schwarze and van Rheenen, 2002). The survey collected data on current and past demographics, land use practices and technology adoption, conflicts and the implementation of land rights, conservation issues, infrastructure and qualitative information on income and well-being. Additional information on geographic features was taken from secondary data sources and added to the data set by Maertens, Zeller and Birner (2006). It is important to note that the retrospective information on population size, migration, land rights and so on was taken from administrative records available in each village. Therefore this information is very reliable and not affected by recall bias. Interviews were held not only with the village leader but also with other persons who had good knowledge about the surveyed village.

Yet, to further substantiate our findings, we make also use of household survey data which was collected within the same research program mentioned above. In 13 out of the 80 villages covered by the village survey, a representative sample of 318 households were interviewed in 2001 regarding their activities, the acquisition and possession of land, land rights and land use practices. The information on agriculture is recorded on the level of plots allowing for a very detailed analysis of the relationship between household characteristics, land rights, investment and output. In particular, different plots of the same household can have different land rights so that we are able to explore differences in the link between land rights and differences in agricultural expenses and planting decisions across different plots for the same household.

3.2 Economic activity

The Lore Lindu region is rural. 87% of the 33,000 households living in the region depend economically on agriculture. 15% of the total area—excluding the National Park—is used for agricultural production. The rest of the area is mainly grasslands and forests. The principal food crop is paddy or sawah rice (‘sawah’ means wet rice field). Important cash crops are cocoa and coffee. Households mainly operate as smallholders (see Maertens *et al.*, 2006). Logging is either done informally, mainly for land conversion and not for selling the wood, or is done formally but then by companies from outside the Lore Lindu Region and has then only a marginal or even no impact on local incomes; compared to the rest of Indonesia (and other tropical forests), deforestation rates are, in any case, relatively low (see e.g. Erasmi and Priess, 2007).

Table 1 shows that the average population size per village was 730 in 1980 and increased to 1,100 in 2001. The average size of land used for agricultural production per village was 340 ha in 1980 and increased to 510 ha in 2001. The development of the land use pattern over time shows that a relatively stable share of 40 percent is used for paddy rice. The average share allocated to cash crops — cocoa, coffee and coconuts — increased from 25 percent to 46 percent over time reducing the share of land allocated to corn and other crops. The last column of Table 1 shows also the means

for the sub-sample of the 13 villages covered by the household survey. While these villages are on average a bit larger than the total sample of villages, there are quite similar in terms of their land use patterns.

[please insert Table 1]

The statistics on infrastructure availability and housing conditions suggest that on average the villages in the study region experienced substantial improvements in their living standards over the period 1980 to 2001 which went along with population growth and an increased cultivation of perennial crops, though with important differences across villages. As the statistics in Tables 1 and 2 show, there is also great deal of heterogeneity in terms of access and use of technologies and investments in land between and within these villages, and across time. In particular, the use of modern seeds, fertilizer, and pesticides rose across all villages, but at different speeds and with great heterogeneity. It is this heterogeneity that we will exploit in our empirical analysis.

3.3 Migration, population growth and population density

During the past decades a significant part of the immigration into the study region has taken place from the south and middle-west of Sulawesi to the north-east of the Lore Lindu region, in particular to the districts of Palolo, Sigi Biromaru and Lore Utara.[5] Some immigration has also taken place within so called 'transmigration programs', organized by the government mainly during the 1960s and 1970s. These programs resettled people in particular from the islands Java, Bali and Lombok in Central-Sulawesi. The places were chosen according to factors such as soil fertility and land availability (Faust, Maertens, Weber *et al*., 2003). Most of these migrants have today returned and the programs are seen as having failed and were stopped with the demise of the 'New Order' regime of former president Suharto. In our sample none of the villages was affected by these programs during the 1980s, but three villages were affected during the period 1990-2001 and we decided to remove these three villages from our sample. That means we work throughout the article with a sample of 77 villages. None of the removed villages was part of the household survey.

Table 1 shows that annual net population growth across the villages, i.e. natural population growth plus the balance of in and out-migration, averaged around 2.1 to 2.3 percent over the period 1980 to 2001. Yet, the variance is large with a number of villages showing negative population growth and many villages having annual population growth rates as high as 10 percent. The annual net migration rate defined here as the difference of immigrating and emigrating households over a given period divided by the number of households in the village at the beginning of that period was on average 2.2 percent during the period 1980 to 1990, 1.2 percent during the period 1990 to 1995 and 1.4 percent during the period 1995 to 2001. Finally, the share of migrant households averaged between 14 and 18 percent over the period of study, but again with a large variance across villages. Given these demographic forces, population density, measured by population size per hectare of used and unused agricultural land (i.e. land that has been cleared for agricultural production), increased on average from 1.2 to 1.8. Here as well the variance is large across villages. 10 out of the 13 villages covered by the household survey are situated in the three above-mentioned districts that were preferred destinations by migrants. This is reflected by a higher average net immigration rate, a slightly higher share of migrants and a higher population density in these villages.

3.4 Land tenure and land rights

Land tenure systems are quite heterogeneous in Indonesia and some historical background is required to understand their evolution over time. The land tenure system has experienced a

[5] The study region covers five districts in total. The two remaining districts are Kulawi and Lore Selatan.

substantial change in 1953 when land ownership went from the 'swaprajas' (local 'kingdoms') to the state. A few years later, in 1960, the 'Basic Agrarian Law' was passed that allowed for the individual titling of land. The National Land Agency was created and in charge of organizing the titling process. This agency has a decentralized structure so that actual records are kept at local offices throughout Indonesia. The law allowed for the titling of land and promised, in principle, a titling of all land in Indonesia. However, this was implemented at a very slow pace, so that by the mid-90s only about 7-10 percent of land was titled (see Safitri, 2009; Slaats *et al.*, 2009; Reering and van Gender, 2010). The outer islands of Indonesia, such as Sulawesi, were hardly covered. To circumvent this problem of the failure of government to follow through on titling, individuals were allowed to register individually parcels of land with the National Land Agency. This process is, however, very expensive and cumbersome as the applicant has to bear the full costs of the titling and has to ensure to get agreement from potential other claimants as well as the village leader that this claim is valid. As a result, the process has become de facto demand-driven with individuals or groups of individuals applying for land to be titled. In order to speed up the titling process, the PRONA and PRODA programs were instituted in 1981; PRONA at the national level, and PRODA at the district level. PRONA/PRODA subsidize the cost of titling, particularly for poorer households. Thus the process essentially remained the same, but was now much cheaper for claimants but for Indonesian standards still substantial (about 250,000 rupees per plot, roughly 80 intl. $ at PPP). These PRONA/PRODA certificates are held by the local offices of the National Land Agency. The titles provide ownership rights to land holders, including the right to transfer the land through sell, rent, bequeath, pledge, mortgage and gift. In principle the program also offers the option to title the entire village land together. However, given the difficulties and costs of the process, the limited budget of the program, this happens only occasionally and did not happen in the villages we focus on. Next to these formal titles, which we refer to as government titles, there exist also informal titles as still many people find the costs of titling too high and procedures too cumbersome. As a result, villagers resort to using letters from the village head, sale contracts, and similar evidence as informal titles which tend to be enforced and adjudicated by the village leaders.

Regarding the government land titles, it is the responsibility of the title holder to report to the National Land Agency any change in the title status (e.g. sale of land, etc.). When titled land is sold this change is usually made. This involves again a fee to be paid to the National Land Agency. However, if a certificate stays within a family (e.g. is inherited) then the change is usually not registered. But it is important to note that the village leaders usually have good sense of up-to-date titles as they issue letters substituting for titles and provide information in case of conflicts over land. And they clearly recognize the government titles as firm proof of titling.

In our study region formal land titles became more and more widespread in the 1980s and 1990s (see also Nuryartono, 2005). Table 1 shows that the share of villages in which legal government land titles exist increased from 9 percent in 1980 to 63 percent in 2001. 85 percent of the villages covered by the household survey data have land titles. In 90 percent of all cases land titling was done under the PRONA/PRODA scheme. Our data set comprises the *share* of households with such formal ownership rights only for the year 2001. It is on average 26 percent, but in some villages as high as 75 percent. Table 2 shows that out of the 1,326 plots cultivated by the 318 sampled households, 445 plots are titled (33.6 percent). 43 percent of these titles correspond to legal government titles — including those obtained under PRONA/PRODA. In 11 percent of the plots the title consists of a purchasing contract and in 23 percent the title is a letter from the village leader. The remaining 23 percent of plots have other types of titles which are not further specified in the data set. According to villagers these are basically written agreements by the concerned persons that land has changed the owner.

[please insert Table 2]

Most plots were acquired through inheritance (29 percent), purchase (23 percent) and clearing forest (17 percent). The rest was obtained as a gift, through marriage or alike. Acquiring land by

clearing forest became more and more difficult over time due to the implementation of laws and regulations aimed at protecting the rainforest, including a prohibition of logging activities inside the National Park (see Schwarze *et al.*, 2009). Hence, land expansion through the clearance of forest has clear limits. But where it happens, it usually implies the absence of any land title or land certificate. It is important to note that purchasing land does not mean automatically getting a formal land title or even a contract. In the villages we study, about 50 percent of all purchased plots are without such titles.

Migrants usually buy land from local villagers or the village leader or, in some cases, simply get land or a piece of forest to clear from the village leader by making a small gift. This is again often (in more than 80 percent of the cases) done without any legal land transfer and land certificate (Nuryartono, 2005). Indeed in our data set, the share of plots lacking titles does not significantly differ between migrants and locals. If the more narrow definition of 'government titles' is used, locals have even slightly more often land rights than migrants.

If no legal land title is issued, land tenure security for migrants is in our study region usually very low and it often means that land can only be used for a limited period of time. Even a letter of temporary land-use rights issued by the village leader is not powerful enough to avoid land conflicts in the future (Nuryartono, 2005). This again suggests that there is a hierarchy of tenure security which is highest for legal government titles, and lower for most other forms of titles; given the heterogeneity of non-government titles and the circumstances under which they were issued, it will be largely an empirical question to what extent they serve as a close substitute to these formal government titles. We hypothesize, however, that any form of title will enhance tenure security in this dynamic environment, compared to existing informal customary land access.

The village survey asked village leaders also regarding the occurrence of conflicts about land rights in the village. As Table 1 shows such conflicts seem to occur quite frequently. Out of the 77 villages, 55 villages reported conflicts among native households in the village, 18 reported conflicts between native households and migrants, 35 reported conflicts with households residing in other villages and 21 reported conflicts with governmental or other institutions.

4. Migration and changes in land tenure arrangements

In this section we analyze whether migration and the associated pressure on land enhance land titling. For this purpose, we rely first on the village level data, but use in a second step also the household survey data to further substantiate our findings.

4.1 Evidence from the village level data

As explained above in the data section, the village level data consists of information about the year 2001 and retrospective information back to 1980. Some of our variables of interest are available quasi continuously. For instance, we know in which year formal land titles emerged and hence can code for each year and each village whether formal land titles existed or not in any year during this period. For other variables we only have information for the years 1980, 1990, 1995 and 2001. This is for example the case for the demographic information. A few variables are only available for the year 2001, such as *the share* of households having formal land titles in a village. Hence, wherever possible we rely on a panel estimator covering the years 1980, 1990, 1995 and 2001. If panel estimation is not possible, we rely on an analysis of the 2001 cross-section.

In order to analyze whether migration enhances land titling at the village level, we specify the following econometric equation:

$$R_{it} = \alpha_R M_{it-1} + X_{it}^{'}\gamma_R + T_t^{'}\tau_R + \lambda_{Ri} + \upsilon_{Rit}, \quad (1)$$

where R_{it} is a dichotomous variable which takes the value one if legal government titles (formal ownership rights) for land exist in village *i* at time *t*. The household survey data does not allow distinguishing other types of land titles, such as informal or traditional land titles. This issue will be addressed in the next sub-section below using the household survey data. M_{it-1} stands for the average annual net migration rate.[6] The time-lagged index indicates that we link past migration to present land rights, i.e. for instance whether migration between 1980 and 1990 has had an effect on the existence of land rights in 1990.

The vector X_{it} stands for a set of time-varying village control variables. In X_{it} we include for instance population density, since we think migration bears a higher potential for land conflicts than natural population growth alone, thus it should be significant even when controlling for population density. We also control for village infrastructure as this may have an impact on the marginal productivity of land, and thus determine migration and land titling simultaneously. However, there is a risk that infrastructure is correlated with the same unobservables as land titling thus raising a potential endogeneity problem. To show that this does not affect our estimates, we estimate Equation (1) with and without infrastructure as controls.

The panel structure also allows including village-fixed effects (λ_{Ri}) and year dummies (T_t). That means we can control for all unobserved factors which are constant within villages across time, such as land form, soil quality and historical background characteristics, which might be correlated with migration flows and institutional change.[7] The period-specific effects allow us to control for temporal shocks which are constant across villages, such as country-wide or province-specific policy reforms and macro-economic shocks. The error term in Equation (1) is denoted υ_{Rit}. To avoid an incidental parameters problem, we use a simple linear probability fixed-effects model using the within regression estimator. However, the results below also hold if a probit model with random effects is used.

Column (1) in Table 3 shows that increased immigration is strongly associated with the existence of land rights. The estimated coefficient suggests that an increase in the net migration rate to a village by 10 percentage points (which is within the range of observed differentials in migration rates) is associated with an increased probability of the existence of formal land titles in the village by about 4.3 percent. In Columns 2 to 5 we include various control variables which do not substantially change the association between migration and land rights. Moreover, column (4) shows that *natural* population growth does not appear to have any impact on the existence of land rights, this suggests that it is migration-induced population pressure and not population pressure *per se* that leads to land titling. Again, we think, as we explained in Section 2, migration usually means new agricultural households (and not just the extension of existing households) and bears a higher conflict potential than just natural population growth.[8]

[please insert Table 3]

We also tested whether being at the border of the rainforest in interaction with time had any effect on land titling (not reported in Table 3). Given that, as mentioned above, during the period of

[6] It should be noted that we take here the household as the observation unit and not the individual, since rural-rural migration is in this context usually household migration.

[7] We believe that for our purposes, the fixed effect specification is best as discussed above. We also perform the usual statistical tests (esp. the Hausman test) to test whether random effects might be preferred as it is the more efficient estimator. The choice of fixed versus random effects has no significant effects on the results.

[8] Regarding the specification in column (5) note that, as we argue below, land use patterns, including the decision to cultivate cash crops may respond to formal land titles, in the sense that land titles provide an incentive to invest in coffee and cocoa trees and thus have to be considered as endogenous. Thus the coefficients in column (5) of the effect of cash crop production should be treated with caution; our preferred specification is thus in column (3). We include the regression with crop choices merely to show that a possibly bi-directional correlation is not affecting our central results.

study more and more rainforest protection rules and laws emerged, it could be that land conversion became particularly difficult in villages at the rainforest margin and that therefore in these villages land scarcity became a more important problem and land titling more likely. However, border-time interactions were not significant and thus were dropped from the list of included control variables. This also seems again to indicate that population growth as such is not the driver of change in land rights.

As we have explained above the data set includes some other variables which are potentially interesting for our analysis, but which are not available for different years and can thus only be analyzed using the cross-sectional dimension of the data. This set includes the prevalence of conflicts about land, the availability of unused agricultural land for paddy rice and inequality in the distribution of land. They can all be seen as proxy variables for the pressure on land. In particular a high inequality in the distribution of land may imply that many households have very little or no land and this may - especially in the presence of demographic growth - increase the pressure on land. More generally, high inequality in land may lead to political and social instability and enhance conflicts over land. We analyzed these factors and also considered estimations where we use the *share* of households in a village having formal land titles as the dependent variable (instead of the binary land title variable, results not shown here). They are fully consistent with the findings in Table 3. They show that an increase in the share of migrants, conflicts about land and land inequality are all associated with a higher probability of formal land titles adoption. Conversely, in villages where lots of unused land is still available formal land titles are less often adopted (see Table A1).

Although we have relied above on an appropriate lag-structure and used a fixed-effects estimator and thus controlled for unobserved heterogeneity that is constant over time, we cannot, based on the above estimations, fully rule out that reverse causality is not an issue, i.e. prospective migrants chose destinations according to the possibility to register newly acquired land. To investigate this possibility, we also estimated a regression where land rights in *t* is on the left hand side and migration in *t+1* on the right hand side. The result is shown in Column (6). It turns out that future migration is negatively related to the existence of land titles in a village. This also suggests that past migration rather discourages future migration. This is of course a very rudimentary test, but it makes it very unlikely that the found correlations are dominated by migration flows that positively respond to the existence of land titles. Moreover, the found correlations do not depend on whether we take the gross or the net immigration rate, whether we look at the eighties or the nineties or whether we add further controls.

Another issue which may bias our results is that migrants frequently acquire land by purchasing it and this may make it more likely that land is formally registered. We now use the household survey data to investigate this issue further. It allows us in particular to focus on the land title status of plots held by non-migrant households conditional on the level of past migration into the village.

4.1.2 Evidence from the household survey data

Using the household survey data we now test whether the share of migrants in a village increases the probability that a plot is titled controlling for migrant status of the household head. We also estimate this relationship on a sub-sample of non-migrants. If the share of migrants in the village is positive and significant, we can take this at least as suggestive evidence that migration-induced population pressure makes land titling more likely. We specify the following probit model:

$$\Pr(R_{ijp}=1)=\phi(\beta_R M_i + MS_{ij}^{'}\chi_R + X_{ij}^{'}\delta_R + P_{ijp}^{'}\eta_R + \varepsilon_{Rijp}), \qquad (2)$$

where R_{ijp} is a binary variable taking the value 1 if plot *p* of household *j* in village *i* is titled. With the household level data we now distinguish two types of land titles: formal government land titles ('government land titles' hereafter), these correspond to those we consider on the village level and a broader set of land titles which includes also purchasing contracts, letters by the village chief and other certificates ('land titles' hereafter). As discussed above, these titles are rather heterogeneous; some may grant similar security and functions as government title, while others might be less valuable.

M_i stands for the share of migrants in village *i*, which should measure the migration-induced pressure on land. MS_{ij} stands for the migration status of the household head. We distinguish four categories: household head is a migrant, the household head's parents were migrants, the household head's grandparents were migrants and none of these, i.e. neither the household head, nor his or her parents or grandparents were migrants. X_{ij} is a vector of household and household head characteristics, e.g. gender of the household head. P_{ijp} is a vector of plot characteristics including a self-assessment of the soil quality by the household head, and the log size of the plot. The error term is denoted ε_{Rijp}. We do not include household or village fixed-effects as this would then not allow analyzing the impact of the household head's migration status and the isolated impact of the share of migrants in the village on the probability of plot titling. Descriptive statistics for the variables we use here are presented in Table 2.

[please insert Table 4]

The results in Table 4 (columns (1) and (2)) suggest, in line with our hypothesis, that the share of migrants in the village is indeed associated with a higher probability that a plot is titled. The marginal effect evaluated at the sample means indicates that an increase of the share of migrants in a village by 10 percentage points (again, well within the range of actual observations) increases the probability that a plot has some form of a land title by 4.3 percent and the probability that a plot has an official government title by 2.6 percent. These effects are significant at the 5 percent level and they also hold and show a similar order of magnitude if we restrict the estimation to the sub-sample of non-migrant households (columns (3) and (4)), showing that the effect between the share of migrants in the village and the probability of finding titled plots is not driven by the fact that migrants may have more often than non-migrants formal land titles as they often have to buy their land. In line with our argument it rather suggests that more migrants mean more pressure on land, more conflicts over land and hence a higher propensity to adopt formal land titles. The share-of-migrants-effect also remains significant if further plot characteristics are introduced as control variables such as soil quality and the log of plot size (columns (5) and (6)). It should also be noted that although first generation migrants are more likely to have some type of land rights, often a purchase contract, but they are *not* more likely than locals to have a formal government title. Households in which the parents of the household head came as migrants to the village, have even a clearly lower probability of having land titles.[9]

5. Changes in land tenure arrangements and investments in land and agricultural technologies

We now turn to estimating the effects of land titles on agricultural investments. We first rely on our household survey data. Expenditure for inputs, investment decisions and to some extent also the adoption of new technologies are rather individual decisions, hence, the problem is better treated by

[9] Surprisingly, third generation migrants, i.e. households, in which the grand-parents came as migrants to the village have again a higher probability of having land titles. However, only 1.8 percent of all plots (24 cases) fall into this category and hence one should be cautious in interpreting this effect, but it might suggest that on the one hand these households still face a higher potential risk of expropriation and on the other hand thanks to their long stay in the village have more possibilities than more recent migrants to obtain formal land titles.

analyzing the behavior of households at the plot level and not at the village level. This also allows to deal with the fact that in a village in which land rights exist not necessarily all households have such land titles, and even within households there are often titled and non-titled plots. After having established the link between land titles and expenditures for and investment in agricultural technologies, we will go back to our village level data to link this part of the analysis with the previous part. More precisely, we will show that heterogeneity in investment in terraces and irrigation systems and in the adoption of fertilizer across villages can be explained by differences in migration patterns that, in turn, seem to explain an important part of the variance in land titling.

When examining the plot-level, we look at two types of expenditures and investments. First expenditures in land quality and land fertility which we measure by expenditures made for land preparation, seeds and planting, fertilizer, pesticides and irrigation. These are generally more short-term investments which pay out within a year or two, or sometimes even within a single planting season. Second, the planting of cocoa and coffee trees, which entail a significant amount of investment costs in form of labor, expenses for land preparation and forgone earnings in the short term. The latter is due to the fact that these trees start producing beans only after three to five years. For both types of investment land rights may matter through all three channels discussed in Section 2. In all 13 villages covered by the household survey data, credit programs are available now and were available during the past 20 years. And indeed, Nuryartono, Schwarze and Zeller (2004) report that titled land is frequently used as collateral in this region. Credits are in principle not only important for longer term investments but also for expenditures for seeds, fertilizer and pesticides, as these typically have to be paid up-front, i.e. before the harvest. We would expect, however, that these effects of titling on investment are larger and more important for the choice of planting perennial crops than for land preparation expenditures, as particularly the assurance and realizability effect also depend on whether investments yield a return in the long term or not.

As before, we distinguish between formal government land titles and a broader set of land titles including purchase contracts and letters by village leaders and other 'official titles'. We speculate that there is unlikely to be much difference between them when it comes to short-term expenditures (such as land preparation expenditures) but the government titles might have a larger effect on longer-term investments such as planting of perennial crops.[10]

To analyze expenditures for land quality and land fertility (in millions of Rupiah), *EXP*, by household *j* on plot *p*, we specify a tobit model since for part of the plots no expenditures at all have been undertaken (in what follows we omit the village index *i*). The model is as follows:

$$EXP_{jp}^{*} = \beta_E R_{jp} + C_{jp}^{'}\zeta_E + P_{jp}^{'}\eta_E + \omega_{Ej} + \varepsilon_{Ejp}, \qquad (3)$$

$$\text{with } EXP_{jp} = 0 \text{ if } EXP_{jp}^{*} \le 0, \; EXP_{jp} = EXP_{jp}^{*} \text{ if } EXP_{jp}^{*} > 0,$$

and where, as before, R_{jp}, is a binary variable taking the value one if plot *p* of household *j* is titled. The vector C_{jp} stands for different types of crops and plants, such as maize, coffee, cocoa, and others or whether a plot is left fallow. P_{jp} is again a vector of plot characteristics such as self-assessed soil quality, slope of the plot, log distance of the plot from the house of its owner and of course log plot size. Given that households own usually several plots, we can also control for household random effects, ω_{Ej}.[11] The error term is denoted ε_{Ejp}. We exclude from this analysis paddy rice fields since these fields require very different land investments, compared to fields with other crops.

[10] We exclude from the analysis plots which are leased, because depending on the contractual arrangements, the costs for inputs may be shared and the incentive structure is probably different from own plots.

[11] A parametric model with fixed instead of random effects cannot be estimated as there does not exist a sufficient statistic allowing the fixed effects to be conditioned out of the likelihood.

To analyze coffee and cocoa tree planting, we estimate the following linear probability fixed-effects model:

$$CO_{jp} = \beta_{CO} R_{jp} + P_{jp}^{'} \eta_{CO} + \nu_{COj} + \varepsilon_{COjp}, \quad (4)$$

where the variable CO_{jp} is a binary variable which takes the value one if a plot has coffee and cocoa trees as a primary or secondary crop. Often plots are used to cultivate different crops and households were asked which crop the main or primary crop on each plot is. All plots, including paddy rice plots, are used for estimation. The other variables are defined as before, except that in Equation (4) we include household specific fixed-effects, ν_{COj}, not random effects as here the estimated model is linear. Identification is thus over households which have at least two plots that have a different land title status. In our sample 95 percent of all plots belong to households which have more than one plot. 42.0 percent of these plots (554 plots) have a counterpart with a different land title status if the broader set of land titles is used. If we stick to official government titles only, this percentage declines to 33.4 percent (440 plots). To test the robustness of our results, we also estimate a probit model with random effects.

There are at least three potential reasons why the identification of the effect of land rights on investment might pose a problem, but we think that our estimation strategy deals with these problems quite satisfactorily. First, a bias may arise because farmers may register more often plots that have a higher productivity and these get also higher investments. Given that we control for a large number of plot characteristics, we think that this source of bias is not a serious problem in our case. We cannot think of a plausible reason why two plots of the same quality within the same household get different investments for another reason other than a difference in the land tenure status. Second, a bias may arise because more profitable farms, and thus farms with higher investments, make it easier to bear the costs of land registration. Again, we think we can deal with this problem, since our estimations include household fixed effects, so we control for the overall-profitability of the farm. Third, a bias may arise because investments such as tree planting are undertaken to enhance tenure security. Here again, we think that the inclusion of household fixed-effects and controls for plot characteristics can solve this problem to a large extent. It is not obvious why a farmer would invest in only one out of two plots of the same quality to enhance tenure security. But more importantly, investment to enforce property rights may be more relevant for customary land rights as shown in the discussion on this relationship in African settings (e.g. Besley, 1995; Braselle et al. 2002), but less for formal land titles that we analyze.

Lastly, one might still be worried about the possibility that commercial tree planting and getting land rights are simultaneous decisions. We think even if that was the case, it would not contradict our main hypothesis which is that land rights enhance tree planting. If household chose tree planting and land rights together then this happens because they think the land rights increase the expected return from the tree. If land rights were not accessible, households may not want to plant commercial trees.

If indeed our household-fixed-effects estimator can deal with the above-mentioned endogeneity problems, which would all lead, if not addressed, to an overestimation of the effect of land rights, then the only remaining source of bias is measurement error in land titling. Measurement error may occur if our two binary land title variables do not capture the full heterogeneity in rights which may exist. Measurement error would downwardly bias our estimate; hence in this sense our results would constitute a lower benchmark.

As a further approach to address endogeneity, we also present in addition an instrumental variable approach in the crop choice estimation. Partly following Besley (1995), we use the following two instruments: (1) the number of years since the plot was taken into cultivation the first time and (2) whether the owner is the first owner of this plot. For both variables one can argue that

they have an influence on whether a plot is titled but that they have not a direct impact on investment decisions, or influence investment decisions only through their impact on land rights.[12]

Table 5 shows the results for the regressions looking at land preparation expenditures. In line with our hypothesis, we find that in all three specifications and for both types of land titles, tenure security is associated with higher land preparation expenditures on plots (see cols. (1) to (6)). This result does also hold if we run the regression only on the sub-sample of non-migrants (results not shown in Table). Thus we can exclude the possibility that our result is only driven by migrants' land titles and investments. We do not find a significant difference between the effects of the broader definition of land titles and government titles. This is as we might expect since it is likely that in the short term, the value of these titles for the three effects is quite similar. The order of magnitude of the estimated effects suggests that on titled plots expenditures are higher by 70 percent to 100 percent. The effects are somewhat larger if we do not control for the types of crops planted. This suggests that if the type of crops is not controlled the effect of land titles is a bit overestimated. Including crop choices leads, however, to a potential simultaneity problem. Hence, both estimates – with and without the crop choice controls – can be seen as a lower and upper bound of the effect of interest.

In cols. (7) to (12) we try to circumvent this simultaneity problem by estimating the model for cocoa and coffee trees together but without all other crops (cols. (7) to (8)) and for both crops separately (cols. (9) to (12)). For coffee trees the estimated effect is insignificant, but for the two other specifications the association between land rights and land expenditures is clearly positive and significant. The variance of the estimated coefficient across different specifications varies a bit but overall is consistent with the estimates discussed above.

[please insert Table 5]

Table 6 shows the results for the analysis of cocoa and coffee tree planting. Again, we find a substantial positive and significant effect of both types of land titles. As expected, the point estimate is always larger for government titles (rather than all land titles). It could suggest that for longer-term investments, government titles are more important, but the difference between both coefficients is not statistically different.[13] Our results also hold if we use a probit model instead of a linear probability model (columns (3) and (4)). It also holds if we use only the sub-sample of non-migrants for estimation (not shown). The specification with the full set of explanatory variables suggests that land titles increase the probability of tree planting by 15 to 19 percent (columns (5) and (6)). The effects are very similar if we exclude paddy rice plots from the sample. This may matter because planting trees on such plots means land conversion (results again not presented in Table). If we instrument land titles, as described above, we still find a significant effect, but the estimation coefficients become relatively large (columns (7) and (8)).[14] Overall we conclude from this analysis that formal land titles have a (substantial) positive impact on land preparation expenditures and on tree planting.

[12] However, these instruments are not totally beyond reproach. If, for example farmers decided to first accumulate experience with a particular plot to get precise knowledge about the soil quality and soil characteristics before they make specific investments, then (1) would not necessarily satisfy the exclusion restriction. A similar argument may apply to (2). If a farmer is not the first owner, he or she may copy investment decisions by previous owners which may make such investments more likely, since there is less uncertainty involved. However, with the data set at hand we found it difficult to come up with any better instrument.

[13] Moreover, if we define a variable 'non-governmental titles' and exclude from the regression all plots with government titles, although the coefficient has the right sign, we do not obtain a significant effect for the 'non-government titles variable', which would also be consistent with the idea that for longer-term investments government titles are more important.

[14] This can either be a sign of strong measurement error in the land rights variable or indicate a weak instrument problem. Indeed the *F*-statistics are just above the critical value of about 10 when land titles are instrumented and slightly below when government titles are instrumented. However, when we perform an over-identification test exogeneity of the instruments is not rejected.

[please insert Table 6]

Now, we go back to our village level data to link this part of the analysis with the previous part by showing that heterogeneity in investment across villages is associated with differences in migration patterns that, in turn explain an important part of the variance in land titling. We estimate the following equation:

$$A_{it} = \alpha_A R_{it} + \lambda_{Ai} + \upsilon_{Ait}\,, \qquad (5)$$

where A_{it} stands for investment in village i at time t, R_{it}, for the existence of land titles and λ_i stands for village fixed effects. We consider three types of investments: first, the building of terraces for paddy rice in villages which have steep slopes; second, the investment in a technical or semi-technical irrigation system; and, third, the use of improved seeds, fertilizer and pesticides. Both the construction of terraces and irrigation systems require substantial resources, hence land titles should be potentially relevant because of all three effects discussed above; the assurance effect, the realizability effect and the collateralization effect. For the adoption of improved seeds, fertilizer and pesticides at least the collateralization effect is relevant, because as explained above such inputs have to be financed before harvest. Moreover, although such technologies often lead to a higher average return, they also involve more risk. Hence, households that have access to credit may be more likely to use such inputs, since they have better possibilities to smooth out income shocks. To deal with the potential endogeneity of land titles in such an investment equation, and to show that migration-driven land rights might be a relevant channel, we instrument land titles with migration using the specification of column 1 in Table 3 as the first stage (controlling additionally for population size).[15] According to our theoretical considerations in Section 2 and the empirical findings presented in Section 4, migration should be relevant. This is also confirmed by the corresponding first-stage *F*-statistics presented in Table 7. Moreover, we assume here that migration does not directly affect investment, but this is obviously a very strong assumption.[16] The results show that in each case the existence of land titles is associated with a higher probability in the village exists an irrigation system, fertilizer is used and terraces are built. The instrumented effects are slightly higher than the non-instrumented ones (not shown), which suggests that reverse causality is not the dominating bias here, but that rather unobservables and measurement error introduce a downward bias if IV is not used. These results do also hold if we restrict the sample to those villages that have land titles established under the PRONA/PRODA framework (which was described in Section 3).[17]

[please insert Table 7]

15 We additionally include population size to ensure that it is immigration rather than population per se which drives the titling which was also investigated in more detail in Table 3 (e.g. columns 3-5). As shown in the column (2) of Table 7, the first stage is nearly identical to column (1) in Table 3.

[16] One may argue that migration has a direct impact on technology adoption (and not an indirect impact through its effect on institutions). Such a link could exist if migrants brought new technologies to the villages. For example, there is evidence that Bugis (or Buginese, an ethnically Malay, nomadic tribe from the south-western 'leg' of Sulawesi) are well experienced in growing coffee. While we do not deny this link — in fact it is complementary to our approach — we claim that this is not the dominating force. We tested this link also empirically by estimating a regression of technology use on past migration. It turned out that the migration was never significant in these regressions.

[17] In a more extensive working paper version, we also investigate to what extent access to extension services might affect adoption of new technologies and find that this does not affect the results when included as a regressor which is also supported by circumstantial evidence on the role of extension services in the project area (Reference omitted).

6. Conclusion

In this paper we focus on land tenure institutions and the adoption of formal land titles in Central Sulawesi/Indonesia. We explain the adoption of formal land titles at least partly by internal migration induced population pressure. Our data is consistent with the idea that increased population pressure following migration enhanced the demand for formal land titles that were accessible through a land titling scheme supplied by the Government. The demand for formal land titles was not limited to migrants; rather to the contrary, the resident population developed a significant demand for formal titles. Moreover we find evidence that in villages where such titles were in use agricultural inputs were used more intensively and investment, such as tree planting, terracing and building ditches and irrigation systems were enhanced. We are unable to quantify by how much land titling spurred agricultural development, but the least we can say that land titles played a supportive role. These, at least on average, positive effects may have materialized because of a favorable context: there were enough agricultural investment opportunities, land titles could be used as collateral to take a credit and the formal land tenure system was relatively well managed.

This does not mean that everyone benefited from this institutional change, some households clearly lost once land could be traded. In particular, because poorer households sometimes tended hastily to sell their land to cope with shocks but by doing this they lower their long term income generation capacity and increase their vulnerability.

An interesting open question for further research concerns the causes of migration to these villages which set into motion this chain of events studied here. In a working paper version of this paper, we show some descriptive evidence that migration decisions are associated with favorable geographic conditions (such as access to infrastructure, land quality, and favorable climatic conditions) in the destination villages (Grimm and Klasen, 2009). As this evidence provides an interesting link to the macro-level debates on the role of geographic conditions affecting institutional change, this is an issue that deserves further research and analysis.

Of course, given the narrow regional focus, we do not pretend to generate findings that are valid without further testing beyond this particular context. We believe, however, that the interesting aspect in our case is that the supply of land titles was exogenously provided throughout the entire observation period including the institutional structures needed to manage formal land rights over time. The availability of a demand-driven land titling system seems to have been critical for the emergence of land rights and the associated investment and technological change. In fact, such a demand-driven approach might be better suited to promote agricultural development than the often heavy-handed supply-driven approaches that have tended to fail in the past. Another interesting aspect is that Indonesian policy has been to accommodate and sometimes encourage migration which then may have helped, as our data suggests, along the process of endogenous titling and technological change. Allowing such migration can thus be critical to set a virtuous chain of events in motion. Finally, policy might help along the process in other ways.

Apart from the more obvious policies of supporting technological change and investments by lowering their costs (through subsidies or extension services), placing further restrictions on rainforest conversion (and enforcing them) might actually help the process of establishing land rights and then promoting land use intensification outside the rainforest.

Appendix

[please insert Table A1]

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Tables

Table 1 Summary statistics of village-level variables of interest (village survey)

Variable	1980	1990	1995	2001	2001 (sub-sample)
Basic characteristics					
Population size	733	912	987	1102	1549
	(693)	(826)	(857)	(876)	(996)
Size agricultural land (ha)	338	374	436	514	572
	(270)	(310)	(358)	(398)	(424)
Share of land allocated to	0.417	0.443	0.431	0.410	0.362
paddy rice	(0.317)	(0.311)	(0.312)	(0.302)	(0.290)
Share of land allocated to coconuts,	0.252	0.305	0.389	0.459	0.472
cocoa and coffee	(0.199)	(0.204)	(0.229)	(0.248)	(0.234)
Share of land allocated to	0.176	0.129	0.082	0.052	0.050
other crops	(0.242)	(0.202)	(0.155)	(0.110)	(0.103)
Primary school in village	0.857	0.961	n.a.	0.987	0.923
Drinking water system in village	0.416	0.455	n.a.	0.896	1.000
Health facility in village	0.169	0.338	n.a.	0.442	0.385
Percentage of stone	0.054	0.125	0.214	0.317	0.371
houses in village	(0.107)	(0.180)	(0.235)	(0.303)	(0.320)
Demographic dynamics					
Annual population growth (relative to		0.023	0.021	0.021	0.030
previous period)		(0.024)	(0.018)	(0.037)	(0.049)
Annual net immigration rate (relative		0.022	0.012	0.014	0.072
to previous period)		(0.130)	(0.071)	(0.100)	(0.190)
Share of migrants	0.151	0.150	0.176	0.146	0.161
	(0.283)	(0.254)	(0.271)	(0.215)	(0.120)
Population density (population	1.237	1.488	1.652	1.829	2.067
per used and unused agric. land))	(0.909)	(1.047)	(1.173)	(1.187)	(1.291)
Land distribution and land titles					
Formal land titles in village	0.091	0.351	0.403	0.636	0.846
Percentage of households				0.260	0.270
with formal land titles				(0.220)	(0.168)
Conflicts about land among native				0.714	0.769
households				(0.455)	(0.439)
Conflicts about land between native				0.234	0.462
people and migrants				(0.426)	(0.519)
Further expansion of				0.416	0.462
paddy rice fields possible				(0.496)	(0.519)
Technology use					
Irrigation system[a)]	0.200	0.329	0.371	0.514	0.667
Use of fertilizer	0.403	0.584	0.649	0.727	0.846
Use of pesticides	0.455	0.636	0.753	0.948	1.000
Use of improved seeds	0.286	0.416	0.545	0.870	0.923
Building of terraces [b)]	0.065	0.217	0.283	0.522	0.571
Number of villages	77	77	77	77	13

Standard deviations in parentheses. The sub-sample (last column) refers to the sample of 13 villages, which were covered by the household survey. [a)] Villages with paddy rice fields only. [b)] Villages with fields on slopes only.

Table 2 Summary statistics of household-level variables of interest (household survey)

Variable	Mean	Standard Dev.
Household level information (n=318)		
Age household (HH) head	44.155	(12.531)
HH head male (=1)	0.761	
HH head primary educ. completed	0.635	
HH head migrant	0.390	
HH head's parents migrants	0.063	
HH head's grandparents migrants	0.016	
Plot level information (n=1326)		
Average number of plots per household	4.170	(2.243)
Crop choices		
Paddy rice	0.134	
Maize	0.090	
Coffee (as primary or secondary crop)	0.162	
Cocoa (as primary or secondary crop)	0.352	
Fallow	0.075	
Land acquisition		
Heritage	0.289	
Purchase	0.233	
Clearing forest	0.170	
Gift	0.053	
Other (e.g. marriage)	0.063	
Plots with land titles	0.336	
Of which		
Government titles	0.434	
Purchasing contract	0.112	
Letter from the village chief	0.227	
Other letter	0.121	
Other type of title	0.106	
First plot owner	0.750	
Years since plot is in cultivation	20.741	(17.215)
Soil quality (self-assessed)		
Less fertile soils	0.025	
Medium fertile soils	0.321	
Fertile soils	0.494	
Missing	0.160	
Plot size in ares	65.8	(222.3)
Distance plot–house walk. min.	25.2	(52.7)
Slope of plots		
Plot not on slope	0.688	
Plot on slope of 0-15°	0.115	
Plot on slope of 15-25°	0.064	
Plot on slope of 25-35°	0.063	
Plot on slope of 35-45°	0.070	
Land preparation expend. (in 1000 Rupees)	963	(3667)

Table 3 The effect of immigration on the existence of formal land titles (village level)
linear probability fixed-effects model, dependant variable: in village exist formal land titles (= 1)

	(1)		(2)		(3)		(4)		(5)		(6)†	
Net immigration rate	0.435	(1.84*)	0.636	(1.95*)	0.437	(1.84*)			0.411	(1.70*)		
Future net immigration rate											-0.615	(–2.53**)
Population growth rate							-0.180	(–0.17)				
Population density					0.027	(0.29)	0.033	(0.29)	0.027	(0.28)	-0.007	(–0.08)
Health facility in village			–0.164	(–0.91)								
Primary school in village			0.285	(0.88)								
Drinking water system in village			0.040	(0.38)								
Share cash crop fields									0.201	(0.68)		
Share paddy rice fields									0.154	(0.40)		
Year 1990	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
Year 1995	0.053	(1.20)			0.048	(1.03)	0.042	(0.86)	0.033	(0.63)	0.262	(5.19***)
Year 2001	0.289	(6.57***)	0.275	(3.86***)	0.279	(5.08***)	0.273	(4.53***)	0.253	(3.73***)	0.318	(5.39***)
Constant	0.350	(11.09***)	0.113	(0.35)	0.309	(2.14**)	0.314	(1.95*)	0.182	(0.66)	0.112	(0.95)
Fixed effects	yes		yes		yes		yes		yes		yes	
Observations	231		154		231		231		231		231	
Number of villages	77		77		77		77		77		77	
R^2 (within)	0.260		0.329		0.260		0.243		0.262		0.306	

The net immigration rate and population growth rate refer to the periods 1980-1990, 1990-1995 and 1995-2001. The regressions including infrastructure variables as regressors cover only the periods 1980-1990 and 1995-2001, therefore column (2) does only include 154 village-year observations. Cash crops include coconuts, coffee and cocoa (this definition refers to the primary crop on a field). † In column (6) we regress the existence of formal land titles in *t* on migration between t and *t+1*.
Robust *t*-statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 4 The effect of migration and migrant status on the prevalence of formal land titles (household-plot level)
probit model, dependent variable: plot is titled (= 1)

	All households				Non-migrant households				All households			
	Land Titles (1)		Government land Titles (2)		Land Titles (3)		Government land titles (4)		Land Titles (5)		Government land titles (6)	
Age household (HH) head	0.088	(2.65***)	0.058	(2.14**)	0.071	(1.61)	0.053	(1.14)	0.089	(2.77***)	0.056	(2.03**)
Age HH head squared/ / 100	-0.075	(-2.21**)	-0.055	(-2.12**)	-0.063	(-1.35)	-0.042	(-0.89)	-0.077	(-2.33**)	-0.053	(-2.00**)
HH head male (=1)	-0.502	(-1.40)	-0.039	(-0.12)	-0.284	(-0.68)	0.427	(1.19)	-0.476	(-1.26)	0.014	(0.04)
HH head primary educ. Completed	0.591	(3.18***)	0.717	(4.10***)	0.626	(2.62***)	0.697	(2.97***)	0.617	(3.21***)	0.777	(4.40***)
HH head migrant	0.451	(3.10***)	0.135	(0.89)					0.517	(3.53***)	0.192	(1.21)
HH head's parents migrants	-0.334	(-1.31)	-0.163	(-0.68)					-0.291	(-1.16)	-0.138	(-0.56)
HH head's grandparents migrants	0.645	(1.72*)	1.179	(2.88***)					0.815	(2.02***)	1.452	(3.18***)
Share of migrants in village	1.210	(2.14**)	1.266	(2.21**)	1.180	(1.74*)	1.132	(1.71*)	0.983	(1.70*)	1.205	(2.02**)
Less fertile soils									Ref.		Ref	
Medium fertile soils									-0.298	(-1.17)	0.088	(0.28)
Fertile soils									0.050	(0.21)	0.304	(1.02)
Log plot size in ares									-0.035	(-1.20)	-0.105	(-2.74***)
Constant	-3.164	(-3.63***)	-3.446	(-4.20***)	-2.918	(-2.54**)	-3.870	(-3.09***)	-2.977	(-3.34***)	-3.311	(-3.66***)
Number of plots	1326		1326		808		808		1326		1326	
Number of households	318		318		194		194		318		318	
Pseudo R^2	0.073		0.077		0.057		0.072		0.098		0.108	

Robust *t*-statistics in parentheses, standard errors adjusted for clustering of households within villages; * significant at 10%; ** significant at 5%; *** significant at 1%. We included a dummy variable taking the value 1 if the self-assessed soil quality variable was missing.

Table 5 The effect of land titling on investment in plots, (household-plot level)
tobit household random-effects model, dependent variable: land preparation expenditures (in millions of Rupees)

	(1)		(2)		(3)		(4)		(5)		(6)	
	All crops		All crops		All crops		All crops		All crops		All crops	
Land titles	1.706	(2.94***)			2.136	(3.37***)			1.823	(2.99***)		
Government land titles			1.400	(1.83*)			2.277	(2.77***)			1.582	(1.97**)
Log plot size in ares	2.393	(9.22***)	2.416	(9.31***)	2.218	(7.43***)	2.222	(7.46***)	2.062	(6.93***)	2.080	(7.00***)
Other crops	Ref.		Ref.						Ref.		Ref.	
Maize	4.852	(5.96***)	4.852	(5.97***)					4.370	(5.35***)	4.372	(5.36***)
Coffee	-0.023	(-0.03)	0.111	(0.17)					-0.127	(-0.19)	0.046	(0.07)
Cocoa	4.690	(7.61***)	4.690	(7.57***)					4.727	(7.55***)	4.716	(7.50***)
Plot is fallow	-2.497	(-2.02**)	-2.470	(-2.00**)	-5.883	(-4.77***)	-5.832	(-4.74***)	-2.603	(-2.08**)	-2.550	(-2.04**)
Less fertile soils									Ref.		Ref.	
Medium fertile soils					3.306	(1.47)	3.212	(1.42)	3.096	(1.35)	3.055	(1.32)
Fertile soils					3.369	(1.52)	3.345	(1.50)	2.958	(1.30)	2.994	(1.31)
Log dist. plot–house min.					0.619	(2.47**)	0.684	(2.68***)	0.575	(2.35**)	0.612	(2.48**)
Plot not on slope									Ref.		Ref.	
Plot on slope of 0-15°					2.208	(2.77***)	1.963	(2.48**)	1.888	(2.42**)	1.637	(2.12**)
Plot on slope of 15-25°					-0.870	(-0.84)	-1.012	(-0.98)	-0.766	(-0.76)	-0.964	(-0.96)
Plot on slope of 25-35°					-2.105	(-1.66*)	-2.482	(-1.97**)	-2.213	(-1.79*)	-2.612	(-2.13**)
Plot on slope of 35-45°					-1.622	(-1.44)	-1.819	(-1.63*)	-1.494	(-1.35)	-1.750	(-1.60)
Constant	-16.954	(-13.57***)	-16.664	(-13.47)	-18.488	(-7.45***)	-18.069	(-7.30***)	-20.229	(-7.90***)	-19.866	(-7.75***)
Random effects	yes		yes		yes		yes		yes		yes	
Number of plots	1148		1148		1148		1148		1148		1148	
Number of households	317		317		317		317		317		317	

(Table continues next page)

Table 5 *(… continued)*

	(7) Coffee and cocoa		(8) Coffee and cocoa		(9) Coffee		(10) Coffee		(11) Cocoa		(12) Cocoa	
Land titles	1.916	(1.77*)			1.221	(0.58)			2.377	(2.08**)		
Government land titles			2.618	(2.03**)			2.305	(0.96)			2.600	(1.96**)
Log plot size in ares	3.437	(5.86***)	3.431	(5.91***)	3.881	(3.41***)	3.776	(3.36***)	3.641	(5.85***)	3.629	(5.87***)
Coffee	7.464	(3.98***)	7.072	(3.81***)								
Cocoa	0.190	(2.01**)	0.173	(1.84*)								
Age of trees (years)					-0.267	(-2.42**)	-0.262	(-2.43**)	0.520	(4.04***)	0.495	(3.86***)
Less fertile soils												
Medium fertile soils	1.692	(0.42)	1.766	(0.44)	32.444	(0.04)	31.777	(0.04)	0.807	(0.20)	0.926	(0.23)
Fertile soils	1.614	(0.41)	1.668	(0.43)	34.639	(0.04)	34.013	(0.05)	0.406	(0.10)	0.548	(0.14)
Log dist. plot–house min.	0.752	(1.75)	0.868	(2.01**)	-0.216	(-0.30)	-0.108	(-0.15)	0.941	(2.04**)	1.048	(2.26**)
Plot not on slope					Ref.		Ref.		Ref.		Ref.	
Plot on slope of 0-15°	2.366	(1.90*)	2.155	(1.77*)	7.109	(2.93***)	6.959	(2.94***)	1.888	(1.44)	1.622	(1.27)
Plot on slope of 15-25°	-2.400	(-1.43)	-2.381	(-1.43)	-2.038	(-0.54)	-1.801	(-0.49)	-1.565	(-0.90)	-1.650	(-0.96)
Plot on slope of 25-35°	-1.688	(-0.82)	-1.990	(-0.99)	3.554	(0.99)	3.362	(0.98)	-1.909	(-0.87)	-2.396	(-1.12)
Plot on slope of 35-45°	-2.251	(-1.19)	-2.195	(-1.17)	1.023	(0.31)	1.179	(0.37)	-1.839	(-0.94)	-1.859	(-0.96)
Constant	-29.284	(-6.03***)	-28.813	(-6.01***)	-55.623	(-0.07)	-54.706	(-0.08)	-23.602	(-5.31***)	-23.268	(-5.27***)
Random effects	yes		yes		yes		yes		yes		yes	
Number of plots	462		462		183		183		394		394	
Number of households	236		236		124		124		222		222	

Robust *t*-statistics in parentheses, standard errors adjusted for clustering of plots within households; * significant at 10%; ** significant at 5%; *** significant at 1%. We included a dummy variable taking the value 1 if the self-assessed soil quality variable was missing. On some plots both coffee and cocoa trees are cultivated.

Table 6 The effect of land titling on investment in plots (household-plot level)
linear probability household fixed-effects model and probit random-effects model, dependent variable: planted cocoa or coffee trees

	LP model (1)		LP model (2)		Probit model (3)		Probit model (4)	
Land titles	0.222	(4.49***)			0.244	(2.53***)		
Government land titles			0.274	(5.12***)			0.597	(4.84***)
Fixed effects	yes		yes					
Random effects					yes		yes	
Constant	0.404	(18.28***)	0.439	(27.48***)	-0.130	(2.16**)	-0.135	(2.55**)
Number of plots	1135		1135		1135		1135	
Number of households	310		310		310		310	

	LP model (5)		LP model (6)		IV-LP model (7)		IV-LP model (8)	
Land titles	0.156	(3.16**)						
Government land titles			0.187	(3.39***)				
Land titles IV					1.174	(3.55***)		
Government land titles IV							1.759	(3.28***)
Log plot size in ares	-0.088	(4.76***)	-0.090	(4.89***)	-0.059	(2.35)	-0.070	(2.45**)
Less fertile soils	Ref.		Ref.		Ref.		Ref.	
Medium fertile soils	-0.007	(0.07)	-0.007	(0.06)	0.023	(0.18)	0.034	(0.21)
Fertile soils	0.078	(0.70)	0.081	(0.73)	0.046	(0.38)	0.060	(0.39)
Log dist. plot–house (min)	-0.011	(0.70)	-0.003	(0.17)	0.015	(0.70)	0.100	(2.42**)
Plot not on slope	Ref.		Ref.		Ref.		Ref.	
Plot on slope of 0-15°	0.294	(5.07***)	0.281	(4.87***)	0.366	(5.18***)	0.267	(3.49***)
Plot on slope of 15-25°	0.325	(4.41**)	0.320	(4.35***)	0.364	(3.42***)	0.332	(2.90***)
Plot on slope of 25-35°	0.178	(2.16**)	0.168	(2.03**)	0.189	(1.92*)	0.089	(0.74)
Plot on slope of 35-45°	0.185	(2.39**)	0.178	(2.30**)	0.196	(2.17**)	0.133	(1.22)
Fixed effects	yes		yes		yes		yes	
Constant	0.653	(5.39***)	0.670	(5.59***)				
Number of plots	1135		1135		1135		1135	
Number of households	310		310		310		310	
First-Stage *F*-statistic					12.56		8.97	
Sargan statistic					0.006		0.008	
p-value					0.939		0.927	

Robust *t*-statistics in parentheses, standard errors adjusted for clustering of plots within households; * significant at 10%; ** significant at 5%; *** significant at 1%. We included a dummy variable taking the value 1 if the self-assessed soil quality variable was missing.

Table 7 The effect of land titling on agricultural investment (village level)
linear probability fixed-effects IV model, dependent variable: in village exists irrigation system (= 1), are improved seeds, pesticides and fertilizer used (=1), are terraces built (=1) respectively

	Irrigation [a)]	Fertilizer	Terraces [b)]
	(1)	(2)	(3)
Land titles (instrumented)	0.543	1.017	3.688
	(3.53***)	(5.49***)	(5.31***)
Fixed-effects	yes	yes	yes
N	202	227	138
First-stage regressions			
Net immigration rate	0.503	0.435	0.434
	(2.05**)	(1.84*)	(1.57)
Ln pop.	-0.021	0.084	0.444
	(-0.12)	(0.50)	(1.71*)
Year 1990	Ref.	Ref.	Ref.
Year 1995	0.066	0.044	0.015
	(1.3)	(0.92)	(0.23)
Year2001	0.303	0.269	0.210
	(4.9***)	(4.59***)	(2.7***)
First-Stage *F*-statistic	11.9	12.9	9.4
Sargan statistic	3.78	10.10	6.41
p-value	0.286	0.018	0.093

Robust *t*-statistics in parentheses. *** significant at 1%, ** significant at 5%, * significant at 10%. [a)] Information about irrigation is only available in villages cultivating sawah rice. [b)] Terraces are only relevant for villages with steep slopes. Therefore the sample sizes are slightly smaller and the first-stage regressions in columns (1) and (3) show slightly different results from Table 3.

Table A1 The effect of immigration on the existence of formal land titles (village level)
probit model, dependent variable: in village exist formal land titles in 2001 (= 1)
tobit model, dependent variable: share of household in village having formal land titles in 2001

	Probit model (1)		Probit model (2)		Probit model (3)		Probit model (4)		Probit model (5)		Tobit model (6)	
Share of migrants in 2001	2.426	(1.91*)									0.326	(1.97*)
Conflicts about land in the past (=1)			0.725	(1.79*)								
Further expansion of paddy rice fields possible in 2001					–0.700	(–2.18**)						
Gini coefficient of land distribution in 2001							1.766	(1.93*)	1.305	(1.35)		
Population density in 2001	0.060	(0.39)	0.174	(1.20)	0.042	(0.29)			0.071	(0.49)	0.004	(0.11)
Share other fields in 2001	Ref.		Ref.		Ref.				Ref.		Ref.	
Share cash crop fields in 2001	1.459	(1.20)	1.412	(1.18)	1.830	(1.62)			1.590	(1.38)	0.248	(0.89)
Share paddy rice fields in 2001	1.891	(1.79*)	1.541	(1.49)	2.234	(2.29**)			1.755	(1.76*)	0.369	(1.59)
Constant	–1.467	(–1.50)	–1.801	(–1.71*)	–1.150	(–1.22)	–0.250	(–0.74)	–1.661	(–1.69*)	–0.241	(–1.03)
Number of villages	77		77		77		77		77		77	
Pseudo-R^2	0.107		0.095		0.107		0.039		0.078		0.121	

Robust *t*-statistics in parentheses. *** significant at 1%, ** significant at 5%, * significant at 10%. Cash crops include coconuts, coffee and cocoa (this definition refers to the primary crop on a field).