Do emerging land markets promote forestland appropriation? Evidence from Indonesia

Vijesh V. Krishna, Unai Pascual & Matin Qaim

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Abstract

This paper empirically examines the emergence and functioning of land markets and their impacts on deforestation in Sumatra, Indonesia. While the evolution of land markets is expected to promote deforestation activities by rural households, we find no sizeable impact, due to two major reasons. First, land transactions occur in cultural and spatial isolation from forest encroachment. Second, the emergence of speculative land markets, which could accelerate deforestation, is evaded through institutional constraints, primarily weak property rights on land. However, while land markets do not promote deforestation, they also do not deter forestland appropriation, because of ambiguous legal frameworks.

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JEL codes: O13, Q12, Q15, Q23, R14.

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1. Introduction

Population growth, in combination with innovative labour-saving technologies and growing market integration, tends to result in increased demand for land resources (Platteau, 1996). In the absence of strong socio-political institutions and policies, the resulting land scarcity instigates conversion of natural forestland, especially in the global South (Bhattarai & Hammig, 2001). About 83 percent of all agricultural land added in the tropics during the 1980s and 1990s is shown to be derived from either intact or disturbed forests (Gibbs et al., 2010). Since forests embody key ecological and environmental functions, ranging from carbon sequestration to biodiversity conservation, deforestation has become a cornerstone of major global policy initiatives and discussions, particularly since the United Nations Conference on Environment and Development (UNCED) at Rio in 1992 (Pülzl & Rametsteiner, 2002).

While land use transformations and deforestation in developing countries are postulated as driven by institutional constraints and opportunities (Southgate, 1990; World Bank, 2007), there exists only little empirical evidence in this regard. An active land market, as an evolving rural institution that facilitates farmer access to cultivable land, is hypothesized in this paper to have significant implications on the rate of deforestation. Farmers generally access land through different routes, including inheritance and inter-vivo transfers, community membership, direct appropriation through forest encroachment, market transactions, and occasionally coercive and non-coercive state interventions (de Janvry & Sadoulet, 2001). Following Demsetz (1967), scholars of evolutionary theory of property rights suggest that increasing resource scarcity could lead to land market transactions becoming more prominent for acquiring cultivable land, following a shift from the common property to individualized property rights regimes (Fitzpatrick, 2006; Platteau, 1996; Atwood, 1990). Such evolution is viewed by some as an efficient institutional mechanism to allocate land to its most productive use, due to the prevailing heterogeneity across farm households, by way of creating opportunities for efficiency gains (Zimmerman & Carter, 1999). On the other hand, some studies highlight that potentials of land markets in developing countries are limited by weak forest governance and inefficiencies in other factor markets – especially credit and insurance (Deininger et al., 2009; Holden et al., 2009; Deininger & Jin, 2008). Furthermore, speculative land trading is also pointed out at as a key driver of deforestation (Angelsen, 2007).

A large conceptual body of literature exists on determinants of land markets and their impacts on deforestation and forest degradation at the global level, principally concerning the role of agricultural expansion (e.g., Geist & Lambin, 2002; Barbier, 2001; Bhattarai & Hammig, 2001; Southgate, 1990). There also exists some country specific literature on farmer participation in land markets, e.g., Deininger et al. (2009) in India; Deininger & Jin (2008) in Vietnam, and Deininger et al. (2003) in Nicaragua. However, there is little empirical evidence on the role of land market development on deforestation at the micro level, possibly due to data limitations.

In this paper, we examine determinants of smallholder decisions concerning pathways of land acquisition and impacts on deforestation by addressing two broad questions: First, how do land markets evolve over time as a land acquisition pathway for smallholders under an increasing land scarcity scenario? Second, what are the impacts of land market participation on deforestation? We address these questions by analysing empirical data collected from smallholder farmers in Sumatra, Indonesia. Individual household's history of plantation establishment – from primary forests and bush lands to extensive and intensive rubber plantations and to oil palm plantations – was obtained alongside information on the cost of land acquisition across different acquisition pathways.

Indonesia is an interesting study location, primarily due to the acute depletion of forest resources instigated by the expanding agrarian sector. Despite experiencing one of the highest rates of deforestation in the past decade, the country still has 2.3 percent of global and 39 percent of Southeast Asian forest coverage (Margono et al., 2012; FAO, 2010; MoF, 2009; Achard et al., 2002). A significant share of deforestation can be attributed to private sector corporations and the state, like mining and plantation establishments (Wheeler et al., 2013; Benhin, 2006), which is often associated with collusive and non-collusive corruption in the forestry sector (Smith et al., 2003). In terms of magnitude, smallholder farming activities may be responsible for a relatively small share of forest cover loss. Nonetheless, these decentralized activities are more difficult to monitor and regulate. This is a critical challenge for governmental initiatives on forest conservation (Indrarto et al. 2012).

In addition, the evolution of property rights and land markets chronologically corresponds to deforestation in many parts of Indonesia, such as Sumatra. While there are a number of studies on ecological and environmental impacts of deforestation in Indonesia (e.g., Maas et al., 2009; Priess et al., 2007), the role of land market institutions remains largely unexplored. The development of land markets is one of the major goals of the government and of international agencies' programmes on land governance in Indonesia, as rural land market transactions are believed to facilitate optimal resource allocation and enhance factor productivity in agriculture, following the dominant economic thinking (e.g., Deinigner et al., 2009; Holden et al., 2009; Wallace & Williamson, 2006). While the effects of improved property rights protection over land resources, which is a necessary pre-condition for functioning land markets, are examined in a few studies (e.g., Liscow, 2013; Godoy et al., 2001; Alston et al., 1996), no consensus exists about the direction of impacts on deforestation (Angelsen, 1999).[i]

This paper contributes to the literature on institutional and socio-political causes of tropical deforestation. We examine whether the pluralistic legal framework over land resources in Indonesia affects the emergence of land markets and their potential for deterring deforestation. The evolving land governance system of Indonesia is described in detail in section 2. The main hypotheses, methods and a description of the data used in the empirical models – including regression analysis on farmer participation in the land markets vis-à-vis direct encroachment, and hedonic pricing of land prices over time – are provided in section 3. The main results are presented and discussed in section 4 and the final section concludes, highlighting the key findings and the main policy implications.

2. Land governance in Indonesia

2.1. Evolution of land policies in Indonesia

In Indonesia, the indigenous legal systems based on *adat* (customary law) were prevalent both during the Dutch colonial rule (before 1945) and the early independence era (Szczepanski, 2002; Hauser-Schaeublin & Steinebach, 2014). *Adat* is largely unwritten and forms part of the oral history of the ethnic groups.[ii] One of the most important legislations on land governance during the era of independence was enacted in 1960, known as the Basic Agrarian Law (BAL) or Law number 5, under the "Guided Democracy Regime" (1957-1966) with Indonesia's first president, Sukarno. The BAL was primarily aimed at unifying all the land laws of Indonesia into a single system (Szczepanski, 2002; Hauser-Schaeublin & Steinebach, 2014). Indigenous legal systems based on *adat* co-existed with the BAL in many places. The BAL itself recognizes *adat* rights, but conditionally – as far as these rights do not collide with the wider national interests. Different forms of registrable interest over private land were also possible under the BAL, alongside community property rights (Lindsey, 1998). Nevertheless, the

abundance of land resources limited the financial incentives for the development of land markets in the past (Slaats et al., 2009).

A significant shift in land governance occurred under the "New Order Regime" (1967-1998) with Indonesia's second president, Md. Suharto. Specifically, legislations enabling forestry and mining leases were enacted, including the Forestry Law of 1967, which set the framework for forest management for the following 30 years, and which is seen as disenfranchising the rural population from forest resources (Haverfield, 1999). The administration of over 70 percent of the country's territory, designated as forestland and previously governed by the National Land Agency, was assumed by the Ministry of Forestry (Indrarto et al., 2012). All unregistered plots, albeit under cultivation, were regarded as a form of state forest (*kawasan hutan*). Unsurprisingly, the unilateral occupation of *kawasan hutan* by dispossessed peasants and their conflict with the bureaucracy started at the same time. However, the Indonesian government never recognized the land rights of these farmers over the converted forestland.[iii] As in the case of most tropical forests, even in the absence of any government recognition, small farm households were found claiming *de facto* use and ownership rights over land resources by clearing the forests for crop production (Peluso, 2005). In Indonesia, there exists rather a strong conviction by peasant households that such *de facto* tenure is secure at least within the community (Resosudarmo et al., 2013).

Decentralization policies in the post-New Order (1998-present) have brought about some favourable changes on land governance. The traditional *adat* right, which was considered largely irrelevant during the New Order regime (Slaats et al., 2009), obtained increased recognition (von Benda-Beckmann & von Benda-Beckmann, 2011). Another major change was the decentralization of the land governance. Primary responsibility for routine land administration was handed over to the district administration from the Central Land Agency (Burgess et al., 2012; Thorburn, 2004).

Provision of land titles is the key institutional factor, on which the evolution of land markets critically, although not exclusively, depends. While the necessity of land titling is embedded in the BAL, only a very limited share of agrarian land with titles had ever been bought or sold. In 1981, the Indonesian government introduced a programme called the National Agrarian Operation Project (PRONA) to increase the area with titles and reduce transaction costs in the land titling process. The project did not achieve much of its original goal (Slaats et al., 2009); less than 20 percent of all registrable plots (about 10 percent in rural areas) had been titled until the end of the 20th century (Fitzpatrick, 1997). In the early 1990s, the Government of Indonesia intensified its efforts to develop a reliable land titling system over non-forestland. Land Administration Project (LAP) funded by the World Bank and the Australian Government were initiated in 1994. About 2 million plots of land were registered, mostly on West Java, during the first phase of that project (Reerink & van Gelder, 2010). The series of LAP phases aims to title all agrarian land in Indonesia by 2020 (Thorburn, 2004). The underlying assumption of these policy interventions is that community tilting is inherently ineffective in ensuring economic development and reducing deforestation rates (USAID, 2010; Lindsey, 1998).

Under the modern land governance and regulatory system in Indonesia, two kinds of land titling are possible for agrarian land: (i) *systematic* titling, in which a large number of contiguous plots, across different users, is registered at a subsidized rate in a public process involving neighbouring units, and (ii) *sporadic* titling, in which the single landholder applies for titling. Being unsubsidized by the government, the cost of sporadic titling is significantly higher, and the titling process is also time-consuming (USAID, 2010). While PRONA in-

volved provision of sporadic titling, the different LAP phases aimed for systematic titling of land at significantly lower costs (Slaats et al., 2009). However, there exits significant uncertainty on how these policy initiatives would affect the development of land markets, due to two main reasons. First, *adat* land rights, which are not easily amenable to individualization and titling, still apply in large parts of Indonesia (Slaats et al., 2009), and could be excluded from the institutional purview of land markets. Second, the state law allows landowners to transfer their ownership rights through civil agreements, without necessitating any titling during the transaction (Lindsey, 1998).

2.2. Current state of land governance and deforestation in Indonesia

At present, a diverse set of property rights regimes, such as state *kawasan hutan*, communal *adat* land and private land, co-exist in Indonesia. The pluralistic legal regime, a complex and highly expensive land titling process, gender imbalances in accessing land, and a high level of insecurity over unregistered land remain key characteristics of the national land regulatory system (Lindsey, 1998), which critically determine the farmers' choice of acquisition pathways to land. There are four major pathways: inheritance and inter-vivo transfers, non-coercive state-led *transmigrasi* programs, direct forestland appropriation, and land market transactions. The last two are the most prevalent means nowadays. Individual land rights are recognized by the state only under the following conditions: (i) the land was obtained from the government as part of a *transmigrasi* or developmental programme, (ii) formal access to *production forest* was granted for economic purposes by the Ministry of Forest through a concession system,[iv] or (iii) the land occupied was classified as non-forest private land that was excluded from state control in the 1967 Basic Forestry Provisions, and has a title deed.

Even in the absence of any state recognition of individual ownership right, a large share of rural households in Sumatra appropriate forestland, which is later developed into plantation crops. High opportunity costs of forestland as compared to plantation crops may be one reason from a private short-term perspective. Sumatra is declared as a "Center for Production and Processing of Natural Resources as the Nation's Energy Reserves" in the *Masterplan for Acceleration and Expansion of the Indonesian Economic Development* (MP3EI) 2011-2025, and the region's strategic location is likely to become the forefront of national forest-based commodity exports (Manning & Purnagunawan, 2011). For the Sumatran economic corridor, the main economic activities are palm oil, rubber, coal and steel.

In our study we focus on Jambi Province in Sumatra, a region with particularly interesting dynamics. Land use in Jambi has undergone significant changes during the last three decades, including the conversion of primary forests to rubber agro-forests and intensive rubber plantation, and later to oil palm plantations (Wilcove et al., 2013). Even before the initiation of MP3EI, trade in palm oil and rubber resulted in the expansion of the large-scale commercial plantation sector and associated extensive forest clearing in Jambi. Selective logging, mining and industrial and smallholder oil palm and rubber plantations are also responsible for the land use changes. About 43 percent of the 2.65 million hectares of primary forest in 1990 was lost in Jambi by 2010 (Margono et al., 2012). Another recent study in Jambi, using data from a village survey, has shown a similar decline in forest cover between 1992 and 2012, due to the spread of smallholder agriculture (Gatto et al., 2014).

3. Data and methods

3.1. Data sources

Primary data collection was carried out during the second-half of 2012 through a farm household survey among 701 smallholder farmers in Jambi province. Aim of the survey was to understand the micro-level determinants of recent land use changes, particularly those involving primary and secondary forests. We further aim to quantify the impacts of smallholder land conversions on forest cover changes in the sample villages and to understand the socio-economic and resource-use status of smallholder farming systems.

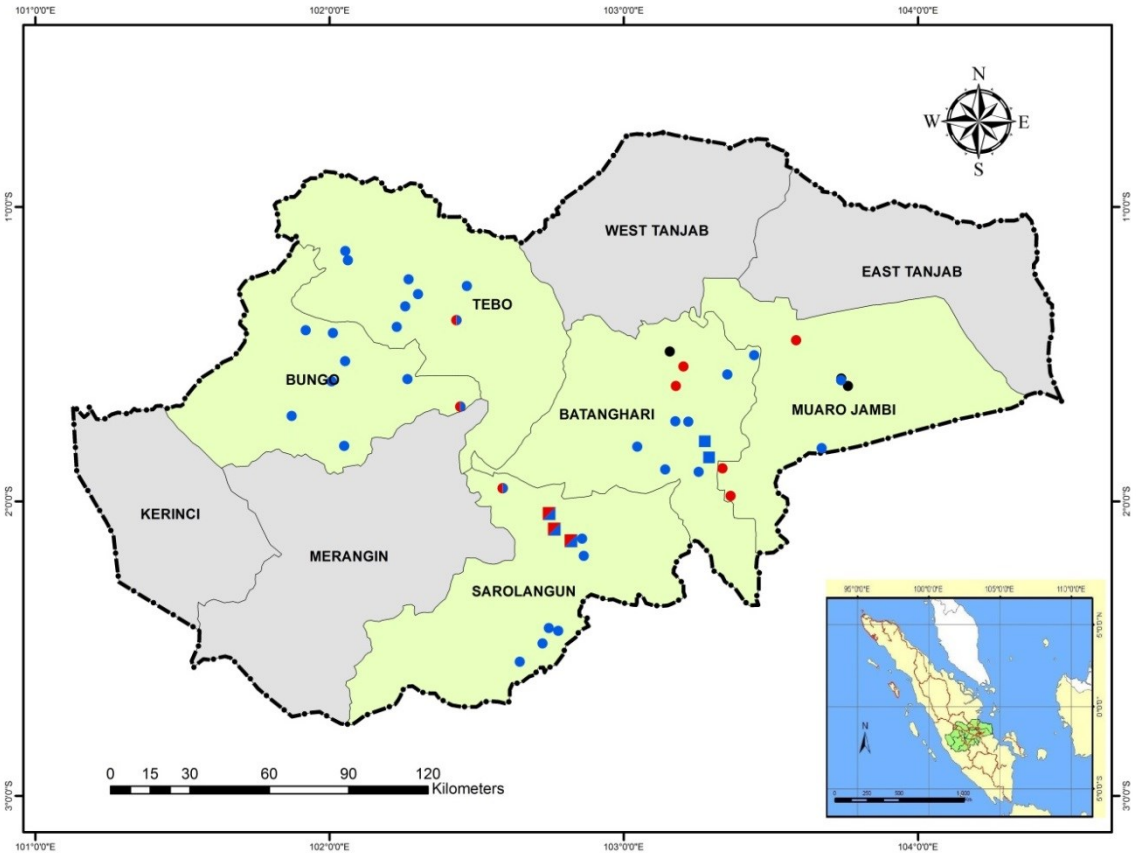
As a first step of sampling, five regencies, which comprise most of the lowland transformation systems of Jambi province, were selected purposively. These regencies are Sarolangun, Bungo, Tebo, Batanghari and Muaro Jambi. A total of 45 villages were included in the study (Figure 1). In order to capture the geographical diversity, the numbers of districts per regency and villages per district were fixed. Further, four districts per regency and two rural villages from each of the districts were selected randomly. In addition, five villages were purposively selected from around the Bukit Duableas National Park and the area bordering the Harapan Rainforest project, where rapid land use transformation is taking place.

A complete list of households was compiled for every sampled village. A significant diversity exists with respect to village population size – ranging from about 100 to more than 2.000 households per sampled village. For the household survey, sampling a constant number of households per village was expected to under-represented households residing in larger and over-represented households residing in smaller villages. To reduce this bias, we divided the randomly selected villages into four quarters based on population size. Only six households were selected from each of the 10 villages in the lowest size quartile, 12 per village from the second quartile, 18 per village from the third, and 24 per village from the largest village size quartile, resulting in a total sample of 600 households. From each of the five purposively selected villages, about 20 households were selected for the survey. Details of sampling, alongside a list of sample villages and number of sample households per village are available in Faust et al. (2013, pp. 16-19).

The survey gathered information on the type of land acquisition (market purchase, direct appropriation mostly through forest encroachment etc.), land use, and land use changes for all plots of the sampled farm households. In case of land use change following ownership change, the original land use was also documented. Details of cropping activities, input use, output and marketing etc. were collected associated with all the crops and livestock units, managed by the households during 2011-12. Here we focus on the plots with plantation crops. Of the 1259 plots in the sample, 44 percent were obtained through market transactions and 19 percent through direct appropriation. At the time of the survey, rubber (oil palm) was cultivated on 72 (28) percent of these plots. We recorded the history of land acquisition and use dating back to 1958, although about 86 percent of the plots were acquired only after 1990.

Besides the farm household survey, a semi-structured village-level survey with village heads and other key informants was carried out. Data on village-level characteristics were recalled for the years 1992, 2002 and 2012. Further details of this village survey are provided by Gatto et al. (2014). Significant diversity is found across the selected villages with respect to a number of characteristics, especially ethnicity and population density. This observation is supported by available secondary data (*Potensi Desa 2008*).

Figure 1. Map of Jambi Province showing the sample villages



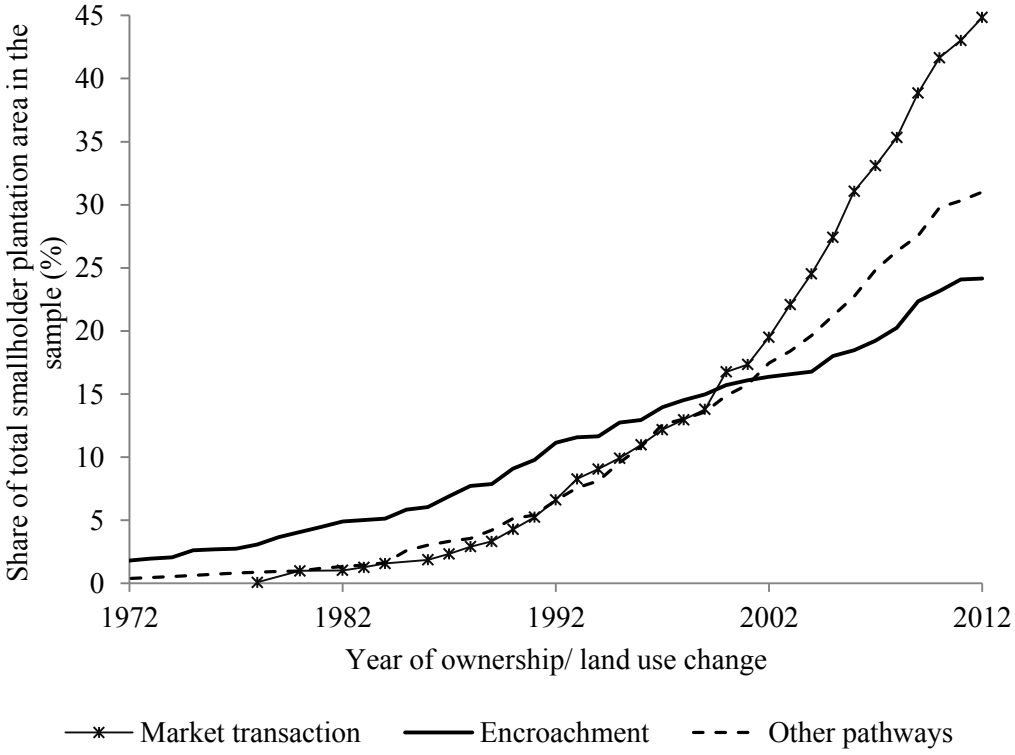
Note: Dot and squares indicate the purposively- and randomly-selected villages, respectively.

3.2. Hypotheses and analytical framework

As a pathway of acquiring cultivable land for smallholders, land markets are gaining in importance over direct land appropriation in Jambi (Figure 2). Of all plantation plots acquired by the sampled farmers in or before 1992, only 27 percent were obtained through markets transactions, while 46 percent were acquired through direct encroachment. The relevance of these pathways switched during the following two decades. Of all plots acquired during 1993-2012, about 50 percent were acquired through the market, and only 17 percent through direct appropriation. This reversal may indicate the deterring impact of the land market on forest encroachment. On the other hand, it could also imply that there is an increased scarcity of land leading to reduced rates of deforestation and increased land market activity. The increased prominence of land markets as a pathway to acquire cultivable land, with only a small and diminishing share of forestland being traded, might imply that land markets are not directly responsible for deforestation. Additionally, if direct appropriation of state or community land by smallholders is associated with high transaction costs and/or social ostracisation, a well-developed land market might cause a decline in the rate of deforestation. The existing linkage between land markets and direct appropriation, hence, needs to be examined in detail.

Even if evidence exists for land markets being an alternative to direct forestland appropriation, it is necessary to know what type of land is commonly traded. Of course, the effectiveness of land market development to deter deforestation inversely depends on the share of forestland being transacted through markets. We find that, while some primary forestland was traded through the market (13 percent of total plots transacted), farmland dominated market channels (45 percent), followed by land under bush and grass land (42 percent) (Table 1). On the other hand, direct land appropriation fully corresponds to clearing of primary forests. Not only was deforestation a rare occurrence on land transacted through the markets, but also the trade of forestland was observed to be diminishing over time (Figure 3). In fact, the composition of land traded through land markets over the studied period altered significantly. Only 9 percent of the plots that entered the market during 2003-2012 were with primary forest cover, as compared to 29 percent in the preceding decades. Correspondingly, the share of agricultural plots being transacted in land markets increased over the same period. These observed patterns constitute the basis for the first set of hypotheses.

Figure 2. Importance of different pathways of land acquisition over time



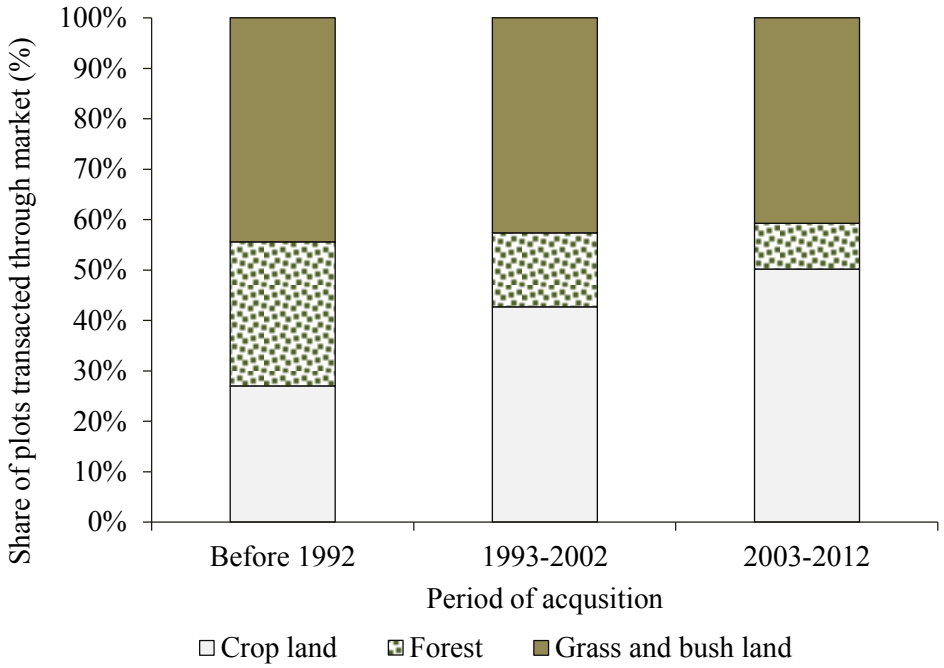
Note: Other pathways include plots obtained through government programmes, inheritance and inter-vivo, or through crop conversion.
N = 1259 plots.

Table 1. Pathways of land acquisition and land use at the time of acquisition

Acquisition pathway	Land use indicated as percentage to row total				
	Crop land	Grass and bush land	Forest	No information	Overall (number of observations)
Land market transaction	45	42	13	0	100 (555)
Direct appropriation	0	0	100	0	100 (240)
Government programmes	0	0	0	100	100 (109)
Inheritance or inter-vivo	45	45	10	0	100 (333)

[#] The χ^2 statistic (calculated excluding plots acquired through government programmes) to test for a possible association between row and column variables is statistically significant at the 0.01 level.

Figure 3. Composition of land traded through markets



N = 555 market transactions.

Land use transformation decisions are made in a decentralized manner by smallholders, in concurrence with financial and labour constraints. Direct appropriation and land market transactions occur in parallel in geographically separated sites. In a process that can be explained as 'rural gentrification', farmlands that are nearer to residential areas and with better access to roads and markets are demanded more, valued higher, and hence bought mostly by households with greater access to capital.[v] The available empirical evidence suggests that buyers in the land market are especially large land owners (Deininger et al., 2003). Also the ethnicity, migration status, and other socio-economic factors of households could determine the options for land acquisition. If the operation of land markets systematically disenfranchises a section of society, then the benefits of market evolution on natural resource management cannot be assumed as universal. In this regard, the following hypotheses are formulated.

Hypothesis 1a: Households involved in direct forest encroachment are different from households participating in the land market with respect to socio-economic characteristics.

Hypothesis 1b: There are distinct spatial patterns for plots traded through markets and those developed through direct appropriation.

Details on 795 plantation plots – excluding those obtained through government programmes and inherited or transferred inter-vivo – were used for testing hypothesis 1. These plots were cultivated with either oil palm or rubber, and owned by 427 smallholder households. About 70 percent of the landholdings were acquired through market transactions, while the rest were established through direct appropriation of the state or community forestlands.

Our analysis focuses on the factors determining land market purchases *versus* direct appropriation. Probit models are used to test these hypotheses. A number of socio-economic attributes, viz. ethnicity, education, and migration status of household heads as well as possession of land at the time of acquisition were included in the set of explanatory variables. Distance from the plot to the place of residence is also included, alongside regency dummies to capture locational effects. Certain village-level attributes on forest cover and deforestation – available only for 1992, 2002 and 2012 – were also controlled for in model estimation. If the model indicates that households involved in direct appropriation of forestland are different from land market participants, and that there are distinct spatial patterns for landholdings traded through markets against those developed through direct appropriation, this would imply that land markets may not be functioning as an alternative pathway of land acquisition and that the deforestation impact of land market development would be limited.

Another factor that could undermine the potential of land markets to restrict deforestation is the temporal price movement of land. As Angelsen (2007) and Clark et al. (1993) noted, land prices may reflect not only the production potential of the resource but also an element of speculation, that is, farmers would purchase land to sell it at a higher price at some future date. This happens when the price of the land increases faster than the land rent. A significant share of households in the study area have *de facto* land rights over land through direct appropriation, and the absence of formal land titles might lead to an undervaluation of the land resource in the market.[vi] To check for the potential of speculative land markets, we develop the following hypothesis:

Hypothesis 2a: The market value of land corresponds to the potential rent in the prevailing market scenario.

Hypothesis 2b: The rate of increase of the land rent over time is comparable to the rate of increase of the land market value.

To test *Hypotheses 2a*, we compute the net present value (NPV) of the cash-flow from rubber and oil palm plantations and compare it to the land market price for the respective plantation type, adjusted for inflation.[vii] To test *Hypothesis 2b*, the rate of change in the market price of land is estimated through a hedonic price model, and then compared with the average annual change in the land rent once adjusted for inflation. Due to lack of data on farm profitability over various years and across different land use systems, we use the average export prices of oil palm and rubber for the three years prior to the land acquisition as proxy to capture expected land rents.

Hedonic price modelling is a revealed preference method for non-market valuation of environmental and natural resources (Ma & Swinton, 2011). Hedonic price models are regression models of market price of land over various characteristics of the resource that potentially

determine the price. However, theoretical assumptions relating to its distribution cannot be made *a priori*. Hence, we design a new model that has important aspects of the original model and satisfies the assumptions on its functional form, by applying a power transformation to the data following Box & Cox (1964).[viii] The general form of the implicit price function can be represented as,

$$y_i^{(\theta)} = f(X_i) \qquad \ldots. (1)$$

where y_i is market price of land in thousand Indonesian Rupiah (IDR) per hectare, θ is the transformation parameter, and X_i is the matrix of explanatory variables. The Box-Cox transformation of the dependent variable, $y_i^{(\theta)}$, takes on the following form:

$$y_i^{(\theta)} = \begin{cases} \frac{y_i^{\theta}-1}{\theta}\,; & \theta \neq 0 \\ \ln(y_i)\,; & \theta = 0 \end{cases} \qquad .... (2)$$

The marginal implicit price of a given explanatory variable, such as proximity to road, residential area etc., is obtained by multiplying the respective coefficient with $\bar{y}^{(1-\theta)}$. The necessary, but not sufficient, condition for existence of speculative markets is a positive growth of inflation-adjusted market price over time. Only if its increase is greater in magnitude than the increase in the expected rent – thereby denoting over-valuation of the resource in the market – development of speculative trading of land would take place.

Two hedonic price functions are estimated – one with the year of land market transaction as one of the explanatory variables, and the second with the average export prices of palm oil and rubber three years before the time of transaction. Since there is significant correlation between year and export price, both cannot be included in the same model.

If households involved in direct land appropriation are not different from land market participants with respect to socio-economic attributes, and if there are no clear spatial patterns regarding the location of plots with respect to acquisition pathways (rejection of *Hypotheses 1a* and *1b*), then land markets could play a significant role in curbing deforestation. But, if the temporal change of land market prices is positive and greater than that of the land rent (rejection of *Hypotheses 2a and 2b*), then a rational individual would find clearing the forest and selling the land in the market financially more lucrative than cultivating the land. This would lead to speculative trading of land, where increased forest encroachment might be observed alongside the evolution of rural land markets. Due to the possibility that mutually opposing effects of land markets may counterbalance, we phrase the following additional hypothesis:

> *Hypothesis 3*: The development of land markets has neither affected nor is affected by the rate of deforestation in the village.

To test whether the development of land markets is affected by the rate of deforestation, two sets of models are employed – one using the household level data and a second using the village level observations. In the first approach, probit models (similar to the ones used to test *Hypothesis 1*), with additional village characteristics are estimated. Village characteristics, viz. ratio of communal land to agricultural land and presence of primary forest in the village in 1992, were obtained from the village survey. A positive coefficient for these characteristics would denote that the land market was more active in villages with greater coverage of communal land and primary forest. Further, to address the possibility that deforested land in the past ends up in the land market as fallow land and boosts the number of transactions in the

decade following, another model is estimated. Here, only the plots established between 2003 and 2012 are included, but with an additional explanatory variable, namely deforestation during the previous decade (1993-2002) in the village.

Combining the village- and household-level data, a regression model is estimated with the share of land market transactions in all land acquisitions in a village during 2003-2012 as dependent variable. The net change in forest and communal land during the previous decade (1993-2002) forms the principal explanatory variable. A positive coefficient would denote the possibility of deforested land ending up in the land markets at a later point in time.

To test whether the rate of deforestation is affected by the development of land markets in the village, village-level models are estimated, with the area of primary forest and the area of other communal land that was lost during 2003-2012 as dependent variables. In both cases, the principal explanatory variable is the prominence of market transactions as a type of land acquisition in the previous decade (1993-2002). Villages without any forestland in 1992 were excluded from the estimation of the first model. A positive and significant coefficient of land market development might indicate market-induced deforestation activities in these villages. Similar village-level models of land use transformation were estimated by Gatto et al. (2014).

4. Results and discussion

4.1. Land market participation *versus* direct appropriation

Most of the sampled households acquired land for cultivation through direct appropriation or by participating in land markets, depending on resource and financial constraints, locational factors, the importance placed on *de jure* recognition against *de facto* ownership, risk aversion against possible government or community action and availability of communal land in the village. The role of these individual factors is estimated through probit models. The dependent variable is a dummy describing the type of land acquisition; this dummy takes a value of one if the farmer had acquired the plot through the land market and zero if the plot was appropriated through forest encroachment. The estimates are presented in Table 2.

As anticipated and shown in figure 2, the time variable has a positive impact on land market participation. The estimated likelihood of participation in the land market by a given household over direct appropriation increased drastically during the 1980s and 1990s [*Model 1* & *2*], but the rate of growth plateaued after 2002 [*Model 3*]. The asset status, represented by a dummy variable for households with no plantation land at the time of acquisition the new plot, is insignificant. Household heads with higher education are more likely to participate in land markets; this education effect is fairly consistent across the three models. Migrants do not acquire land in a systematically different way than the local autochthonous population, although those households that migrated to transmigrant villages have a higher probability to participate in the land market.

Market participation was significantly higher among Javanese and Sundanese ethnicities.[ix] The local Melayu population (autochthonous) is found more likely to get involved in direct appropriation of forestland for plantation establishment. This is not necessarily evidence of anti-conservationist attitudes of the autochthonous population, but rather an indication of "strategic squeezing" for agricultural land. Autochthonous villages were usually targeted for land appropriation by the state or plantation companies (Gatto et al., 2014). This is especially relevant as property rights are weakly defined in a legal sense (Miyamoto, 2006). Here, public or private companies and local communities are competing over land resources, and deforestation by one is costly to the other. Converting land from forest to agriculture and claiming this as *adat* or private land may reduce the chances to be the target of land expropriation. A

similar pattern of deforestation was mentioned in previous studies by Angelsen (2001) and Araujo et al. (2009).

Table 2. Determinants of land market participation *versus* direct encroachment

	Probit model coefficients (std. error)		
	Model 1 [all years]	Model 2 [1993-2012]	Model 3 [2003-2012]
Time of land acquisition [1950 = 0, …, 2012 = 62]	0.059***	0.045***	-0.002
	(0.007)	(0.013)	(0.035)
Household with no land under plantation at time of acquisition [dummy]	0.134	0.096	0.204
	(0.122)	(0.145)	(0.197)
Distance from place of residence to plot [km]	-0.019**	-0.020**	-0.021**
	(0.008)	(0.009)	(0.010)
Square of distance from place of residence to plot	1.E-04*	1.E-04	1.E-04*
	(5.E-05)	(6.E-05)	(6.E-05)
Education of household head [year]	0.056***	0.059***	0.046*
	(0.016)	(0.019)	(0.024)
Household migrated to autochthonous village [dummy]	0.031	0.173	0.108
	(0.146)	(0.171)	(0.220)
Household migrated to transmigrant village [dummy]	0.784***	0.950***	0.616**
	(0.181)	(0.222)	(0.289)
Javanese or Sundanese ethnicity [dummy]	0.840***	0.971***	0.945***
	(0.148)	(0.172)	(0.218)
Farmer from purposively selected villages [dummy]	0.219	0.589***	0.478*
	(0.170)	(0.223)	(0.289)
Regency [dummies; reference: Sarolangun]			
Batanghari	0.409***	0.605***	0.319
	(0.161)	(0.198)	(0.260)
Muaro Jambi	0.247	0.595	0.384
	(0.212)	(0.274)	(0.350)
Tebo	-0.350*	-0.185**	-0.183
	(0.188)	(0.234)	(0.320)
Bungo	0.653***	0.962***	0.730**
	(0.227)	(0.284)	(0.366)
Presence of primary forest in the village in 1992 [dummy]		-0.531***	-0.564**
		(0.192)	(0.280)
Ratio of primary forest and bush/grass land to agricultural land area in the village in 1992		0.009	0.008
		(0.012)	(0.014)
Extent of deforestation in the village during 1993-2002 [percent forest area in 2002 relative to 1992]			-0.002
			(0.003)
Model intercept	-3.626***	-2.848***	0.299
	(0.412)	(0.771)	(2.039)
Number of observations	795	610	380
Log-likelihood ratio (LR)	-335.98	-236.80	-140.83
LR χ^2 statistic	301.84***	186.01***	84.37***

Dependent variable: 1 if the household acquired the plot through the land market, 0 if acquired through encroachment. ***,**,* statistically significant at the 0.01, 0.05 and 0.10 levels, respectively.

Plot location, i.e., distance from the farmer's place of residence to the plot, is found statistically significant and negative. Deforestation is more likely in the village fringes, whereas the plots near to the villages were transacted more frequently in the market. Land markets are found to be most active in Bungo, and least active in Tebo regency.

These results indicate that *Hypotheses 1a* and *1b* cannot be rejected. The effect is consistent after including the village-level factors in the set of regressors. This implies that there are statistically significant differences with respect to key socio-economic attributes between those households involved in direct forest encroachment and those involved in land market transactions. The existence of distinct spatial patterns in plots obtained through different acquisition pathways implies that there might be significant geographical constraints for land markets to evolve in Jambi, thus limiting the scope of markets to deter forest encroachment by farmers.

4.2. Land price analysis

The second question is whether land market development creates an environment congenial for speculative trading of land, thus leading to increased deforestation. This could occur when the land price in the prevailing market scenario is greater than the potential rent (rejection of *Hypothesis 2a*), and when the increase in land prices over time is higher than the increase in land rents (rejection of *Hypothesis 2b*). Here we report results regarding the possibility of a speculative land market in the study area by examining the changes in farmland prices. The recall data from farmers, who were involved in land market transactions during the period 1993-2012, and a detailed input-output dataset collected as part of the household survey is used in this regard. The inflation-adjusted land values are compared with the land rent (NPV of cash flows obtained from smallholder oil palm and rubber plots).

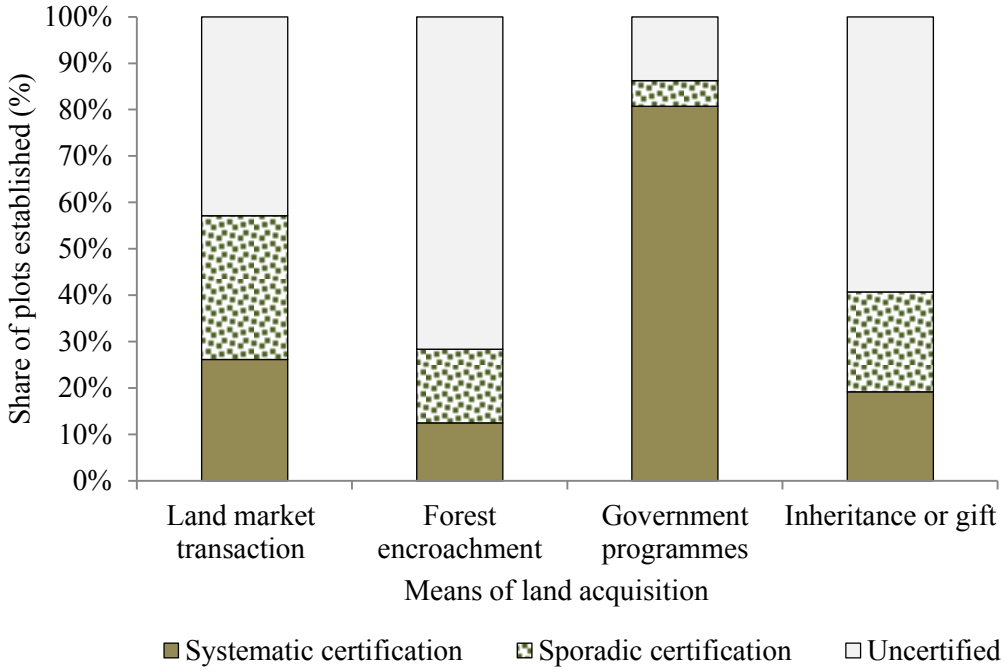
Table 3 shows a comparison of land prices of established plantations with the land rent (NPV of cash flows from plantation crops at different discount rates). The mean land price was around IDR 28 million per hectare for rubber and around IDR 39 million for oil palm (1 USD = IDR 9387, on average in 2012).[x] Land rents (NPVs) are significantly higher: 81 million per hectare for rubber and IDR 61 million per hectare for oil palm in 2012, when a discount rate of 10 percent is employed. Since Indonesia underwent a phase of significant inflation during the second half of the 1990s, the use of a fixed rate for discounting might be criticized. However, the mean price of land with rubber becomes equal to the land rent only when the latter is computed at a discount rate greater than 18 percent, which is high even by Indonesian standards. Keeping the land for own cultivation instead of selling it in the market hence seems to be financially rational for the average farmer.

Table 3. Comparison of land market price and land rent

	Land market price in million IDR/ha (1992-2012 average)[#]		NPV in million IDR/ha of plantation investment at the discount rate of		
	Mean	Median	5 percent	10 percent	15 percent
Rubber plantation	27.36[***] (2.10)	18.49	175.40	81.10	42.04
Oil palm plantation	38.59[***] (4.33)	27.34	122.38	60.54	31.98

[#] Inflation-adjusted values. Figures in parentheses are standard errors.
[***] The difference with the NPV calculated at a 10 percent discount rate is significantly different at the 0.01 level.

Figure 4. Pathways of land acquisition and possession of land titles



N = 1259.

One possible explanation for the undervaluation of land is the weak property rights protection. At the time of the survey, about 50 percent of all plots owned by the sample households had land titles. Strikingly, across all pathways of land acquisition, a high share of the plots (57 percent) transacted through land markets had formal titles. This was not the case for appropriated forestland (Figure 4).[xi] Due to lack of data on the exact time of title procurement, we do not know whether titles were obtained before or after land market transactions. Either way, most of the plots traded in the market were private land and not forest. Nevertheless, surprisingly, about 28 percent of the directly appropriated forestland also got *de jure* title recognition, mainly through the sporadic titling process. This may happen in case of encroachment to non-state village lands. However, in some cases also previous state forest land was titled, given existing legal ambiguities and rent-seeking in the Indonesian bureaucracy.[xii]

Lack of a formal title does not indicate lack of internal security among landholders. Especially for the autochthonous population, the *de facto* ownership over encroached forestland is secure enough to engage in cultivation of perennial crops, but evidently not to participate in land markets and obtain high prices. The *de facto* property right protection is strong only internally (within the village community); this trust might not transpose to outsiders, who form the majority of the buyers. Thus, asymmetry of information on the security of ownership between buyers and sellers might contribute to lower land market prices (Feder & Nishio, 1999). Although data limitations prevent us to analyse this in more detail, plots with land titles were priced 53 percent higher in market transactions than plots without titles. Similar observations were made by Deininger & Chamorrow (2004) in Nicaragua. Hence, while the *de jure* government regulations do not prevent forestland encroachment in Sumatra, they contribute to undervaluation of the resource in the market, thus discouraging rural households to convert forestland for speculative trading.

On average, land prices dropped during the financial crisis in Indonesia (1997-98) and revived after 2005, possibly following the positive trend in the export price of rubber and palm oil. There was a significant decline in the rubber and palm oil prices during 1995-2001. Although rubber prices revived shortly afterwards, international palm oil prices only started increasing by 2006. A detailed examination is necessary to understand the relationship between land prices and land rents for different plantation crops.

The factors affecting land market prices are analysed with the help of hedonic price models (Table 4). The associated marginal effects or marginal implicit prices (MIP) are estimated and shown in Table 5. Model [1] estimates show that land prices declined during 1993-2002, and increased afterwards. The land price of rubber plantations exhibited an increasing trend prior to that of oil palm plantations, probably reflecting international price developments (*cf.* Appendix 1). From the MIP estimates, the market value of bush and grass lands (keeping all the land use dummies at zero and keeping time at 2012) is found increasing at about 7.0 million IDK per hectare per year, and the rate was only marginally different from forest, jungle rubber or other crop land. Although the overall land market price was higher for oil palm during the study period, the land value was significantly lower in 2012, compared to 1992 (*cf.* Table 5). On the other hand, the market price of rubber plantations is found to grow at a higher rate (Appendix 1). The differences between oil palm and rubber plantations are getting narrower over the years, possibly because of the widening gap between rapidly increasing rubber prices and rather stationary palm oil prices in international markets.

One of the other factors that critically influences land prices is the size of the traded plot, which has a negative impact. Prices are expressed per hectare, and larger plots are often traded at lower prices per hectare. The land price is substantially higher in transmigrant villages, due to a number of factors, including better infrastructure facilities in the village, a greater share of titled land, proximity to output markets and an assurance that better quality seedlings were used for planting, as the plantation was established by or with the help of private companies.

For estimating Model [2], the export price of palm oil and the palm oil to rubber export price ratio are used in quadratic form. Averages of export prices during the previous three years of the land market transaction are used. The coefficients are statistically significant. During a period of general economic boom, with both palm oil and natural rubber prices increasing in the international market, the land prices are also observed to be increasing.

An examination of the marginal rate of changes of deflated land prices under oil palm and rubber from Model [1] vis-à-vis export prices is carried out to examine the potential of speculative trading (Table 4). The growth in land prices became positive and increasing after 2002 for rubber and after 2005 for oil palm plantations. The land rent is also found to be increasing, but at a relatively lower rate. Clark et al. (1993) suggested that when both land rents and land market prices are increasing, the latter would increase at a higher rate, paving the way for speculative trading. For example, the inflation-adjusted land prices were increasing by about 7 million IDR per year as of 2012. Since the rubber price is also increasing, deforesting the land for rubber plantation and selling it at a future point in time could yield a significant profit.

Table 4. Hedonic functions of land price

	Coefficients (std. error) of Box-Cox model	
	Model 1	Model 2
Year of transaction [1992 = 42, .. , 2012 = 62]	-1.564***	
	(0.203)	
Square of year of transaction	0.015***	
	(0.002)	
Export price of palm oil [thousand IDR/kg; average of previous 3 years of land market transaction]		0.565***
		(0.110)
Square of export price of palm oil		-0.022***
		(0.005
Rubber to palm oil price ratio [export prices in thousand IDR/kg; ratio of average prices of previous 3 years of land market transaction]		1.791**
		(0.902
Square of natural rubber to palm oil price ratio		-0.256
		(0.174)
Plot size [ha]	-0.163***	-0.170***
	(0.050)	(0.050)
Square of plot size	0.011***	0.011***
	(0.003)	(0.003)
Previous land use at time of transaction [reference: bush and grass lands]		
Oil palm [dummy]	5.541***	1.436***
	(2.233)	(0.200)
Oil palm * Year of transaction	-0.074*	
	(0.041)	
Plantation rubber [dummy]	-0.677#	0.980***
	(1.409)	(0.141)
Plantation rubber * Year of transaction	0.031#	
	(0.026)	
Jungle rubber [dummy]	0.062	-0.052
	(2.257)	(0.210)
Jungle rubber * Year of transaction	-0.003	
	(0.041)	
Other crops [dummy]	-2.036	-0.228
	(4.584)	(0.391)
Other crops * Year of transaction	0.033	
	(0.084)	
Forest [dummy]	3.098*	-0.393**
	(1.853)	(0.192)
Forest * Year of transaction	-0.067*	
	(0.035)	
Plot from transmigrant village [dummy]	0.644***	0.594***
	(0.149)	(0.148)
Plot from purposively selected village [dummy]	-0.003	-0.058
	(0.173)	(0.171)
Regency [reference: Sarolangun]		
Batanghari	-0.038	-0.034
	(0.146)	(0.145)
Muaro Jambi	0.005	-0.052
	(0.217)	(0.215)
Tebo	0.167	0.230
	(0.213)	(0.213)
Bungo	0.559**	0.523**
	(0.237)	(0.237)
Model intercept	42.836***	-3.763***
	(5.277)	(1.373)

		Coefficients (std. error) of Box-Cox model	
		Model 1	Model 2
Transformation parameter, θ		0.086***	0.076***
		(0.026)	(0.026)
LR χ^2 statistic	H_0: θ = -1	2297.04***	2269.17***
	H_0: θ = 0	11.04***	8.55***
	H_0: θ = +1	931.21***	933.14***
Adj. R^2		0.33	0.30
Number of observations		563	563

Observations include both plots sold and purchased. ***,**,* statistically significant at the 0.01, 0.05 and 0.10 level, respectively. # Joint significance at the 0.01 level.

Table 5. Marginal implicit prices: factors affecting land market value

		Marginal effect in million IDR/ha	
		Model 1	Model 2
Time [year of transaction] for all land categories together	in 1992	-8.00	
	in 2002	-0.50	
	in 2012	6.99	
Export price of palm oil [when palm oil and rubber prices are taken as of year 2012]			2.71
Plot size		-2.78	-3.02
Land price according to use at time of transaction [increment price with reference to: grass and bush lands]			
(i) Oil palm	in 1992	61.49	37.55
	in 2002	42.82	
	in 2012	24.14	
(ii) Plantation rubber	in 1992	15.35	25.63
	in 2002	23.08	
	in 2012	30.80	
(iii) Forest	in 1992	6.74	-10.28
	in 2002	-10.28	
	in 2012	-27.31	

Estimated from the Box-Cox regression models presented in Table 4. Due to statistical insignificance, marginal effects were not calculated for land use under jungle rubber and other crops.

In sum, *Hypothesis 2b* can be rejected, as there is a significant potential for the development of speculative markets for land in the study area. However, this had not been realized as the NPV of plantation crops was significantly higher than the land market price, which led to rejection of *Hypothesis 2a*. A farmer would rather go on cultivating on the plot appropriated from the forest rather than trading it in the land market, provided that there are no major constraints in input markets. Hence, due to weak property rights protection of the encroached land, the evolution of land markets might not have led to increased deforestation in the study area.

4.3. Aggregate impacts of land market development on deforestation

The aggregate impacts of land market development on deforestation are estimated in two steps. First, the probit models on smallholder participation in land markets are extended with village-level variables on forest resources (*cf.* Table 2). The ratio of community land, including primary forest and bush lands, to agricultural land in the study villages in year 1992 is not found to have any significant impact on land market development during the following decades (Model [2]). However, the presence of primary forest in the village reduces the chances of households' market participation. Further, the rate of deforestation in a village during 1993-2002 is not found to affect the rate of market development in the succeeding decade, as shown in Model [3]. If the majority of deforested land ultimately ends up in the land market, the rate of deforestation in the village would have a positive impact on farmer participation in land markets. From these estimates, any causal role of deforestation on land market development cannot be established. However, these models are not suitable for showing whether the reverse is true, namely that land market developments in a village induces deforestation activities (e.g. through spill-overs). For this purpose, we use data derived from the village survey. Village-level forest cover change and state of land market development form the dependent variables in these models.

Despite a small number of observations, the village-level data show a significant saturation effect for deforestation (Table 6). A saturation effect means that the rate of deforestation declines when forests become scarcer in a region (Wheeler et al., 2013; Araujo et al., 2009). The share of land market transactions over all pathways of land acquisition is found insignificant in Models [1] and [2], indicating that land market activity does not induce deforestation. Furthermore, Model [3] also shows that village-level deforested area has no pronounced impact on land market development in the succeeding decade. Farmers might find keeping the deforested plots under own cultivation more profitable than selling them in the speculative land market.

In sum, despite the vibrant nature of markets and increasing land prices, land markets in Jambi are not found to have a significant impact on deforestation. The culturally and spatially segregated activities of market transactions and forest encroachment, alongside the severe undervaluation of land in the market due to incomplete property right protection, are two important reasons for this non-existent effect. The land market price is critically influenced by palm oil and rubber prices, and hence a stagnant price of palm oil during the last few years in the international market is likely an additional reason for the relatively slow pace of deforestation by smallholders in Jambi.

The analysis thus suggests that the major threat for the forest cover in Jambi lies well outside the purview of land markets; it is rather the appropriation of state land instigated by a booming export sector, unregulated due to legal ambiguity, and high internal security of the plots developed through direct land appropriation. Using secondary data, Wheeler et al. (2013) demonstrate similar impacts of economic factors in the dynamics of forest clearing. Many of our findings also coincide with Resosudarmo et al. (2013). Against this backdrop, different national and international initiatives aiming at providing land titles to rural households may not generate any significant impact on curtailing forestland appropriation by smallholders in Sumatra.

Table 6. Village-level deforestation and land market participation models

	Coefficients (std. error)		
	Model 1: Reduction in primary forest [ha; 2003-2012]	Model 2: Reduction in bush and grass land [ha; 2003-2012]	Model 3: Share of market transaction over all pathways of land acquisition [percent; 2003-2012]
Area under primary forest in 2002 [ha]	0.485*** (0.067)	0.198*** (0.076)	
Area under bush and grass land in 2002 [ha]		0.358*** (0.079)	
Share of market transaction over all pathways of land acquisition during 1993-2002 [percent]	3.871 (6.958)	3.784 (6.983)	0.596*** (0.105)
Area reduction in primary forest during 1993-2002 [ha]			-0.001 (0.001)
Area reduction in bush and grass land during 1993-2002 [ha]			-0.002 (0.002)
Model intercept	15.603 (305.600)	316.571 (317.124)	32.960*** (4.949)
Model statistics			
Number of observations	20	34	40
Adjusted R^2	0.72	0.41	0.46

***,**,* statistically significant at the 0.01, 0.05 and 0.10 level, respectively.

5. Conclusion

This study was carried out to analyse the relationship between evolving land markets and deforestation. Using farm survey data from Jambi Province in Sumatra, Indonesia, determinants and impacts of land market transactions over a timespan of two decades were modelled. The focus was on explaining the decision of smallholders concerning the acquisition of land either through the market or through direct appropriation (forest encroachment). The results suggest that most deforestation activities are not driven by land market developments. The autochthonous population, which is more often involved in forest encroachments than migrants, hardly participates in land markets. Moreover, land is undervalued in the market, largely because of weak property protection. Although it has been observed in some cases that titles were obtained for encroached forestland, this is rather rare and associated with high transaction costs.

An examination of land prices over the 1992-2012 period suggests that the sense of external security over communal property rights is low in the absence of formal land titles, leading to an undervaluation of directly appropriated land from the forest. Further analysis has shown that it is financially more lucrative for households to cultivate rubber or oil palm on the plots than selling the land in the market. Because of the imperfect (insecure) property rights protection, land markets coexist with forest encroachment, without significantly affecting each other. It can be expected that a reduction in transaction costs associated with obtaining land titles for appropriated forestland could trigger speculative market conditions with adverse impacts on forest conservation.

However, while weak property rights protection may curb speculative land market transactions, it does not deter deforestation activities by smallholders, because at the community lev-

el *de facto* property rights are respected. Weak *de jure* property protection may also provide favourable conditions for plantation and logging corporations to appropriate forestland in autochthonous communities (*land grabbing*) (Miyamoto, 2006). Possibly as a response and a protective strategy, local communities are actively involved in the conversion of forestland themselves. Here, however, we have not analysed the role of corporations and other external agents. Further analysis along these lines may be an interesting topic for future research.

Providing basic property right protection for agricultural landholdings, defining boundaries for private, community and state lands, and conserving forest resources are no easy tasks for land-governing agencies in Indonesia. While almost 70 percent of Indonesia is legally state land, it is mostly inhabited by the local and indigenous population who are claiming customary rights over it. The lack of a strong property right framework may be conducive for promoting opportunistic behaviour and a race-to-the-bottom between public/private plantation corporations and local smallholders aiming at securing *de facto* property rights. Also, multiple interpretations of legal frameworks by vested interest groups promote deforestation, while presenting opportunities for rent-seeking behaviour. This becomes evident from the fact that smallholders could obtain formal titles for some of the plots that were appropriated through forest encroachment. Hence it is essential that, alongside providing land titles for private land, existing forestland be gazetted and put under constant government monitoring, possibly involving community institutions. Further, sustainable forest management should be regarded as a productive use of land in Indonesian law. Spreading this message across the rural population could possibly contribute to reducing deforestation at relatively low administrative costs. This is especially relevant, since the opportunity cost of forestland has been increasing during the last decade due to rising land rents under oil palm or rubber.

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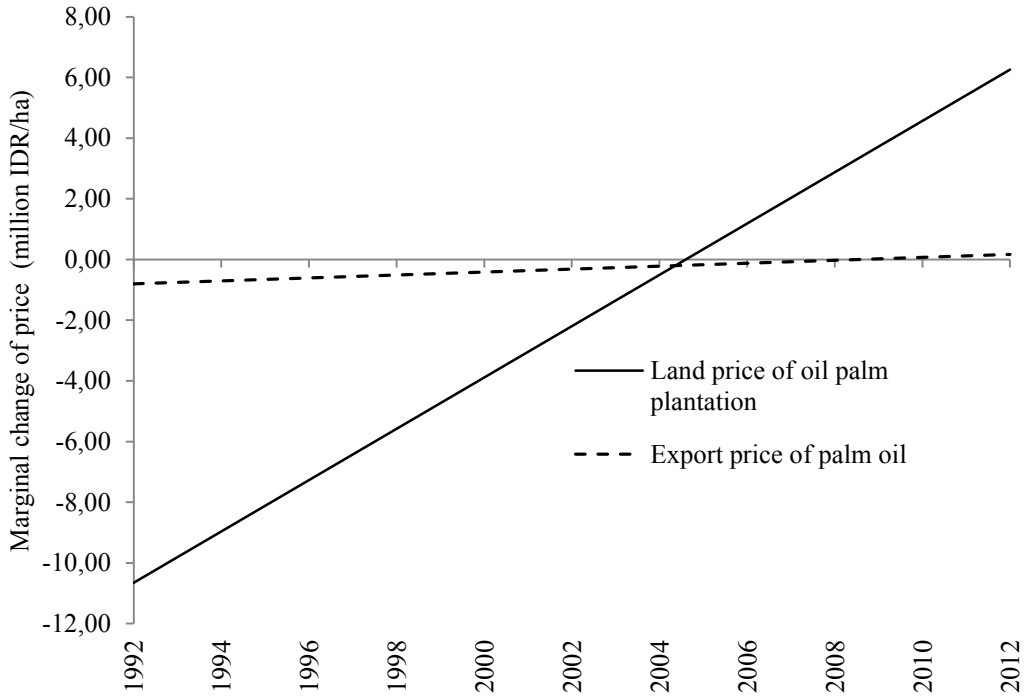
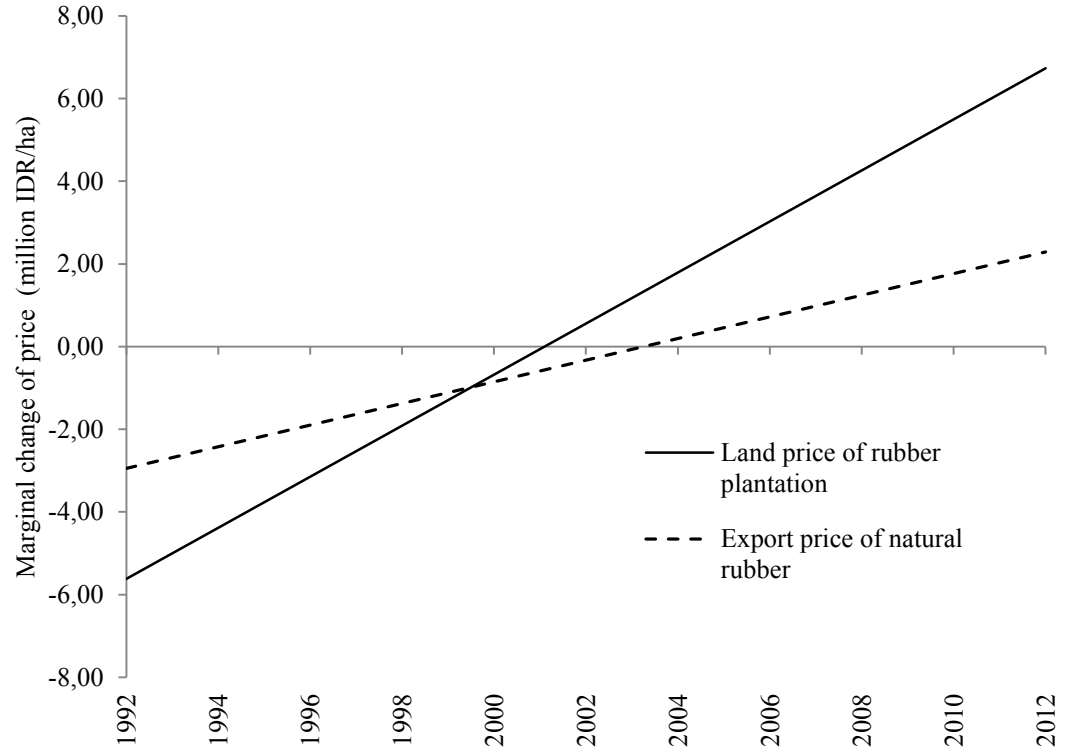
Appendix I. Marginal change of land price and land rent over time

a. Oil palm



b. Natural rubber



Sources: Estimated from Table 4 [Model 1] and FAOSTAT (2013).

[i] Liscow (2013) indicates that such lack of consensus could be due to two conflicting effects of private property rights – a "conservation effect" and an "investment effect". According to the conservation effect, stronger property rights could prompt landholders to discount the future less and realize the long-term benefits of forestry instead of the short-term benefits of agriculture. This conflicts with the "investment effect", which indicates that more secure property rights increase investment on land, thereby increasing the value of agriculture relative to that of forest. The conservation effect theory predicts an increase in forest cover with stronger property rights, while the investment effect theory predicts a decline.

[ii] While significant regional diversity exists with respect to *adat* in its details, like degree of predictability, application and adherence etc., there are certain common underlying principles for maintaining the societal equilibrium and collective unity (von Benda-Beckmann & von Benda-Beckmann, 2011; Fitzpatrick, 1997).

[iii] Hence, in the government documents, the term *kawasan hutan* is understood as the land under jurisdiction of the Ministry of Forestry, rather than actual forest land (McCarthy, 2000; Thorburn, 2004). This is also why there is a significant divergence between data from the national sources and data derived with the help of satellites on forest cover.

[iv] Within the boundaries of the generic term "forest area" covering about 143.8 million hectares in Indonesia, six different types of areas were classified for land use, viz. protection forests, nature reserves or conservation areas, production forest, limited production forest, conversion forest and unclassified forests (McCarthy, 2000).

[v] Cloke & Little (1990) indicated rural gentrification as class-dictated population movement into accessible rural areas, through immigration of middle-class residents at the expense of the lower classes. In this paper, we hypothesize that land markets would allow the capital-rich residents to purchase parcels near the village centre with better access to roads and infrastructure, while the poor develop plantations in the village periphery.

[vi] The Indonesian regulatory system prescribes but does not make land titles mandatory for inter-household transfer of properties (Lindsey, 1998). Weak land administration, a cumbersome formal land-development process, and corruption encourage sellers and buyers to evade the formal titling process (USAID, 2010).

[vii] The NPV of oil palm and rubber were computed based on input-output data obtained from 363 oil palm and 882 rubber plots. These plantations have different ages, as they were established at different points in time. Hence only in its totality, the cross-sectional dataset provides the critical information on profitability of plantations for different age levels throughout the lifecycle of these crops. Family labour was not included in calculating the cost of cultivation. Since NPVs do not stand for a single plot or farm-household, distribution of these values could not be captured. A limitation of our approach is that we implicitly assume the input-output relations at a particular plantation age to be the same for plantations established at different points in time.

[viii] *cf*. Standiford & Scott (2008) and Snyder et al. (2007) for applications of the Box-Cox model for land valuation.

[ix] Sundanese is an ethnic group native to the western part of Java Island. Due to similarities in place of origin and migration pattern to the study area, they are clubbed with Javanese migrants for analytical purposes.

[x] http://data.worldbank.org/indicator/PA.NUS.FCRF/countries?page=4&display=default

[xi] Plots obtained through government-assisted *transmigrasi* programmes, unsurprisingly, have the highest rate of land titles. Unless in the event of failure of loan repayment scheme with plantation companies, the transmigrant households could easily obtain the land titles at the end of prescribed period of time.

[xii] Although the Forestry Law of 1967 clearly designates around 3/4th of the national land area as *kawasan hutan* (Article 1.3), there exists another stipulation (Article 14) that this land needs to be gazetted to technically become state land. Hence, designation of forest land can be regarded only as a preparatory activity, which should be followed by boundary demarcation, particularly for areas bordering privately owned land. With roughly less than 10 percent of state land being gazetted so far (Indrarto et al., 2012), multiple legal interpretations are possible over state-ownership, leading to ambiguity allowing the intent of the 1967 Law to be evaded by peasant households to avail land titles. Legal ambiguity, hence, could be attributed as a major source of deforestation in the study area.