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Cropland rental market and farm technical efficiency in rural Vietnam

Hoang Trieu Huy[a], Trung Thanh Nguyen[b,*]

[a] College of Economics, Hue University, 99 Ho Dac Di Street, Hue City, Viet Nam
[b] Institute for Environmental Economics and World Trade, Leibniz University Hannover, Königsworther Platz 1, 30167 Hannover, Germany

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ABSTRACT

Increasing farm technical efficiency in developing countries is essential to raise farm productivity, and cropland rental market is theoretically expected to contribute to farm production efficiency growth. However, empirical evidence on the relationship between cropland rental market and farm technical efficiency in developing countries is scarce. In this paper, we apply the one-step stochastic frontier approach to evaluate farm technical efficiency and to determine the effect of cropland rental market on farm technical efficiency. We use a nationally representative sample dataset collected in 2004 and 2008 in Vietnam for our analysis. We find that cropland rental transactions promote farm technical efficiency and that the rental market transfers cropland from less to more efficient producers. We suggest that the constraints for cropland rental market operation be removed. In addition, promoting cropland registration for land use certificate, encouraging land defragmentation, and facilitating rural education should be undertaken to increase farm technical efficiency.

1. Introduction

Cropland is one of the most important productive assets of rural households in the developing world (Lowder et al., 2016), where poverty and food insecurity remain development challenges. This is even more critical in the next coming decades due to several reasons. First, food production is expected to double to meet the food demand of an increasing human population, and nearly all of the population growth will be in developing countries (Nguyen et al., 2017). Second, the scope of extending arable cropland for food production is negligible or even impossible due to land degradation and land conversion to other uses in many parts of the developing world (Khanal et al., 2018; Herzig et al., 2018). Third, the adoption of new technologies by farmers in developing countries is slow (D'Souza and Mishra, 2018). In this regard, an improved understanding of how to increase technical efficiency of cropland use and of the factors driving the efficiency growth deserves further attention.

According to Deininger (2003), well-functioning land markets can contribute to enhancing land use efficiency by transferring land from less to more efficient producers. While land transactions can be done through both land sales and rental markets, there are reasons that land rental market is more attractive, particularly for poor households. An efficient land rental market imposes an opportunity cost on the landholder of underutilised or idle cropland (Huy et al., 2016). If the landholder is unable to match this cost, he or she will have an incentive to rent the land to other farmers who can farm it more efficiently. In this way, land rental market not only improves allocative efficiency (Lyne and Nieuwoudt, 1991) but also allows rural households to exchange and consolidate fragmented land parcels and hence improve their cost efficiency (Norton, 2004; Vranken and Swinnen, 2006). However, in situations where risk is high, credit markets are imperfect and non-agricultural uses drive land purchase demand, land markets may not bring the ownership distribution of land closer to the optimum and may lower overall productivity. The pre-mature of land market operation might lead to land consolidation by better-off households. This limits the opportunities for the poor to access the land. Fear of such efficiency and equity reducing outcomes lead a number of countries either to forbid or to impose restrictions on the operation of land markets (Deininger, 2003; Ma et al., 2015).

Vietnam is a typical case for an examination on the relationship between cropland rental market and farm technical efficiency. The country transformed from a centrally-planned to a market-oriented economy with a series of structural reforms known as "*Doi Moi*". One of the most important reforms was to distribute cropland to farmers and to allow for land transfers. However, a ceiling on cropland ownership of three hectares (ha) is still regulated by the Land Law 2003. This legal restriction means that land sale market is unlikely to bring about an optimal distribution of operational land sizes, and the opportunities for consolidation and expansion of farm sizes through land sale market are thus limited. In this context, cropland rental market has been

* Corresponding author.
E-mail address: thanh.nguyen@iuw.uni-hannover.de (T.T. Nguyen).

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developed, although there are still various institutional constraints which make land transaction costs very high (Huy et al., 2016).

Against this background, our research aims to address the following questions: (i) what are the patterns and trends in the cropland rental market in rural Vietnam? And (ii) how does cropland rental market improve cropland use efficiency? To answer these questions, we first formulate a theoretical model for the relationship between land tenure security, land rental market and farm technical efficiency. We then empirically test the relationship with a nationally representative dataset of rural households (the Vietnam Household Living Standards Survey, VHLSS) collected in 2004 and 2008 in Vietnam (hereafter VHLSS04 and VHLSS08, respectively). Our study is the first effort to estimate this relationship in Vietnam using the VHLSS data. Given stringent limits on the area of cropland that individuals may own and restrictions in the rental market that prevent farmers from consolidating land parcels, this study provides useful information for Vietnam's policy makers to remove such restrictions.

2. Agricultural reforms and challenges in Vietnam

2.1. Agricultural reforms

Vietnam was one of the five poorest countries in the world in 1985, and there was little indication that Vietnamese households had any hope of raising their level of welfare (Glewwe et al., 2004). In 1986, beginning with a set of policy changes collectively known as "*Doi Moi*" (Nguyen, 2012), Vietnam transformed itself into one of the most successful countries in the developing world in terms of economic growth and poverty reduction (Amare and Hohfeld, 2016; Do et al., 2019). The real annual rate of agricultural growth averaged 4.2% during 1990–2003 (Food and Agriculture Organization (FAO, 2006). In 1993, 58% of the population lived in poverty and this figure declined to 14% in 2008 (WB, 2016).

In the agricultural sector, cropland reforms were one of the main contributors to these achievements. Cropland in state-run agricultural cooperatives was allocated to rural households for a duration of 10–15 years (Nguyen et al., 2016). The allocation was managed in a decentralised way with equity as a primary consideration. Although the land allocation process varied between regions, the distribution of cropland to rural households was both efficient and egalitarian (Deininger and Jin, 2008). Since land remained the property of the State, rural households were initially assigned only the right to use land (the Land Law 1988). Without rights to transfer land, however, cropland markets did not develop apart from some informal transactions (Do and Iyer, 2008; Nguyen et al., 2010). To make up for this deficiency, the Land Law 1993 introduced official land titles and permitted land transactions. Although land remained the property of the State, land use rights could be legally transferred, exchanged, mortgaged, leased and inherited. In addition, the Land Law 1993 extended the duration of rights to 20 years for annual cropland and to 50 years for perennial cropland. While these newly assigned land rights unleashed farmers' incentives to invest and put more effort into farming, more remained to be done in order to achieve higher levels of land use efficiency (Do and Iyer, 2008). The Land Law 2003 was an additional step towards this end. This law streamlined land administration and expanded the bundle of land rights to include sub-letting.

In the early stage of transition, the egalitarian distribution of land use rights resulted in pro-poor growth (Ravallion and van de Walle, 2008). Improved land tenure security encouraged small farming households to increase their farm output by applying more labour, their most abundant input. Evidence of the labour intensification included gains in agricultural production achieved with only modest growth in the use of market inputs and with little or no technological change (Che et al., 2006). Labour intensification in the farming sector also supported (demand-led) growth in the rural non-farm economy (Hazell et al., 2007). These farm and non-farm growths combined to reduce poverty (van de Walle and Cratty, 2004).

2.2. Current challenges in cropland use

Although economic growth and poverty reduction in response to "*Doi Moi*" have been impressive, there are concerns that the reforms have not produced enough incentives, and that economic growth has slowed. There was a sustained increase in agricultural growth from 1988 to 2000. Since then, the annual growth has declined (Gaiha and Thapa, 2007). Furthermore, agriculture's share of the country's labour force remained relatively high, at 47% in 2012, although there was a sharp decline in its share of total GDP, from 30% in the early 1990s to 19% in the early 2010s (WB, 2016).

The egalitarian distribution of cropland left Vietnam with very small farms. In most cases, local authorities allocated cropland to rural households based primarily on their number of adult equivalents (AE). Recent data show that nearly 8.9 million ha were cultivated by about 8.9 million farming households in 2011 (WB, 2016). Despite the overall increase in average farm size, the mean is still far below the global average of 3.7 ha per person (Fan and Chan-Kang, 2005). In addition, farms are not only small but also highly fragmented. There were about 75 million parcels or plots of cropland throughout Vietnam (Hung et al., 2007), 10% of which had an area of only 100 m^2 or less in 2004 (Kerkvliet, 2006).

Moreover, although Vietnam has undertaken cropland reforms to liberalise agriculture, there is ample evidence that cropland use efficiency is still constrained by various administrative measures. One of these constraints is the zoning policy for paddy rice. This is a government policy that restricts the conversion of paddy fields from rice to other crop production. Markussen et al. (2011) show that, at the plot level, about 36% of the plots sampled in their study must grow rice in all seasons despite the users' preference for other crops. Regarding land rental markets, procedures for transferring cropland use rights are cumbersome and costly, wasting time and raising transaction costs (Huy et al., 2016). For example, a formal land transaction documented in An Giang province passed through 23 administrative steps (Smith et al., 2007).

Finally, despite cropland was allocated to rural households, full property rights for cropland are still far to achieve. This includes the incomplete allocation of land use rights and the limited duration of these rights (Do and Iyer, 2008). Recent statistics show that 18% of the country's agricultural land remains uncertified, leaving 1.6 million ha without security of land tenure in 2007 (Huy et al., 2016). In addition, the powers of local government officials reduce the user's rights of management and exclusion. According to the Land Law 2003, the rights to annual use expires after 20 years, and to perennial use is 50 years. Renewal is conditional on an assessment of local authorities that the farmer has complied with the law and will continue to use the land for its certified purpose. When making its assessment, local government can (and may have a political incentive to) adjust rights, for instance to maintain farm size equality (Kerkvliet, 2006). Such uncertainty undermines land tenure security and reduces the incentive to improve land use.

3. Theoretical background and literature review

3.1. Theoretical background

Theoretically, if there are perfect markets for all non-land factors of farm production, then achieving efficiency may not require the cropland rental market to function (Bardhan and Udry, 1999). These non-land factors can be hired in or out by landowners until the marginal products are equal for all factors of production (Pender and Fafchamps, 2006). In reality, smallholders in developing economies tend to confront missing or highly imperfect markets for non-land factors (Sadoulet et al., 1997; Ho et al., 2017). Furthermore, participating in a cropland

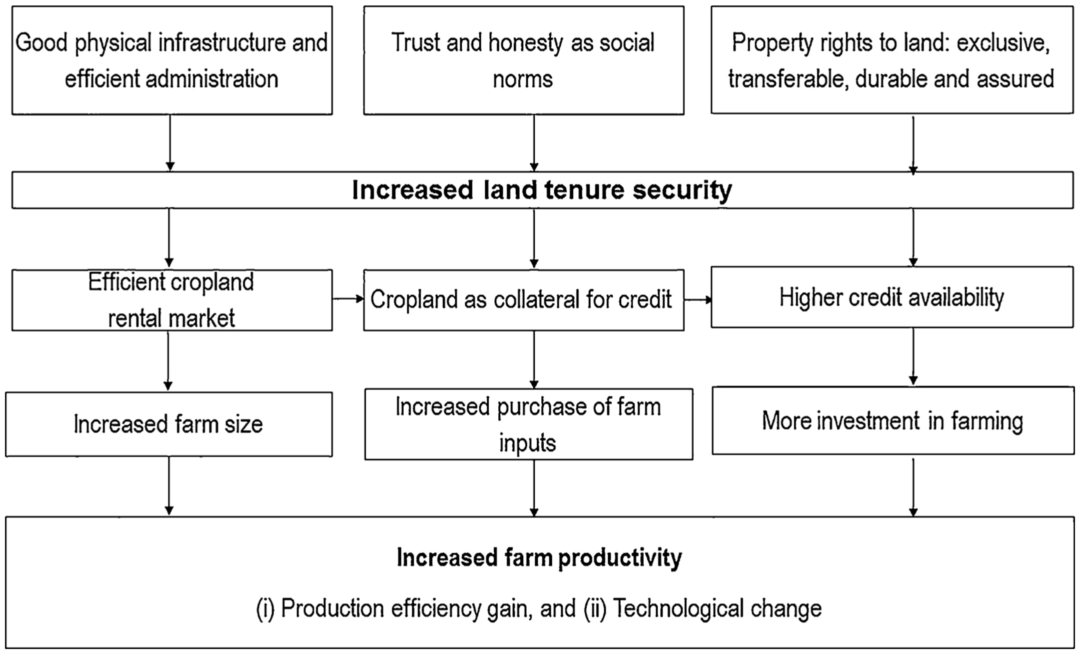

Fig. 1. Conceptual model linking land tenure security, land rental markets and farm productivity.

rental market requires some levels of farmers' heterogeneity (Teklu and Lemi, 2004). This includes, for example, different land endowments or farm management ability. For land markets to function properly, one requirement is that land tenure must be secure. Fig. 1 summarises the theoretical links among land tenure security, land rental market and farm productivity.

An efficient land rental market can boost agricultural productivity and hence farm incomes via several channels. First, an active land rental market will impose an opportunity cost on idle and underutilised land, and thus, promote efficient land use and reduce imbalances in land at household level. Second, an active land rental market could lead to comparative-advantage gains by transferring land to more effective farmers and permitting them to specialise in agricultural production. Third, an active land rental market provides investors a safe exit option of selling or leasing the land and recouping the present value of the expected future income. In addition, an efficient land rental market allows consolidation and growth of farms and these strengthen the incentive to invest in new agricultural technologies (Kille and Lyne, 1993) and to reduce cost inefficiency due land fragmentation (Swinnen et al., 2006).

The concept of technical efficiency refers to the ability to avoid waste, either by producing as much output as possible, given fixed input use, or by minimizing input use, for a given output level (Fried and Lovell, 2008; Ebers et al., 2017). Assume that farm household *h* has a household-specific farming ability, θ, which is unobserved. The literature often suggests that household-specific technical efficiency can be used as a proxy for the unobserved household farming ability (Carter and Yao, 2002; Holden and Otsuka, 2014). Fig. 2 illustrates the concept of technical efficiency and productivity and the distinction between them in an output dimension for a simple case of one output and one input (i.e. cropland). In this figure, the production frontier defines the maximum output attainable from each input level given the available technology. Farm households operate either on or beneath the production frontier. The technical efficiency of a farm household operating at point E° is defined as the ratio AE°/AE^{1}, where E^{1} is the maximum output attainable from *A* units of land. It follows from this definition that technical efficiency lies in the [0, 1] interval and that the higher the farming ability is, the closer the technical efficiency to unity is.

The slope of a ray through the origin is used to measure productivity at a particular data point. The productivity of the farm household operating at point E° is the slope of the ray OE°, which is Q°/A. If the household operating at point E° were to move to the technically efficient point E^{1}, the slope of the ray would be greater, implying higher productivity at point E^{1}, given the level of *A* units of land (i.e. $Q^{1}/A > Q^{\circ}/A$). Therefore, an increase in the technical efficiency implies higher farm productivity for any given level of inputs. An increase in farm productivity cannot only be attributed to technical efficiency improvements, but also may be due to the exploitation of economies of scale or technical changes or changes in the environment in which farms operate or some combination of these factors. In Fig. 2, the greatest slope is at the point E^{*} where the ray from the origin is tangent to the production frontier and therefore defines the point of maximum possible productivity. By moving from E^{1} to E^{*}, the household would achieve its highest productivity while maintaining technical efficiency. This movement is an example of exploiting economies of scale. E^{*} is the point of technically optimal scale. Given that the scale of a farming operation can seldom be changed quickly, technical efficiency and productivity can in some cases be given short-run and long-run interpretations. In this study, the estimate of household-specific technical efficiency rather than productivity is taken as a proxy for unobserved household farming ability, and is used to test whether rental transactions transfer cropland from less to more effective farming households. If a comparison of the mean farming ability of lessees ($\bar{\theta}^{i}$) and lessors ($\bar{\theta}^{o}$) shows that $\bar{\theta}^{i} > \bar{\theta}^{o}$ then, on average, the land rental markets lead to efficiency-enhancing land transfers.

3.2. Literature review

Literature on the relationship between land tenure security and access to credit, agricultural investment and productivity is extensive (Feder et al., 1988; Place and Migot-Adholla, 1998; Michler and Shively, 2014. Koirala et al., 2016). A widely accepted notion is that increased land tenure security enhances access to credit, agricultural investment and productivity. There is also evidence suggesting that investment may be undertaken to enhance tenure security (Besley, 1995; Sjaastad and Bromley, 1997; Brasselle et al., 2002). Regarding farm land sales and rental markets, there have been a number of studies on other factors, in addition to land tenure security, that affect land market development (Thomson and Lyne, 1991; Chamberlin and Ricker-Gilbert, 2016; Wang et al., 2018; Su et al., 2018). Deininger

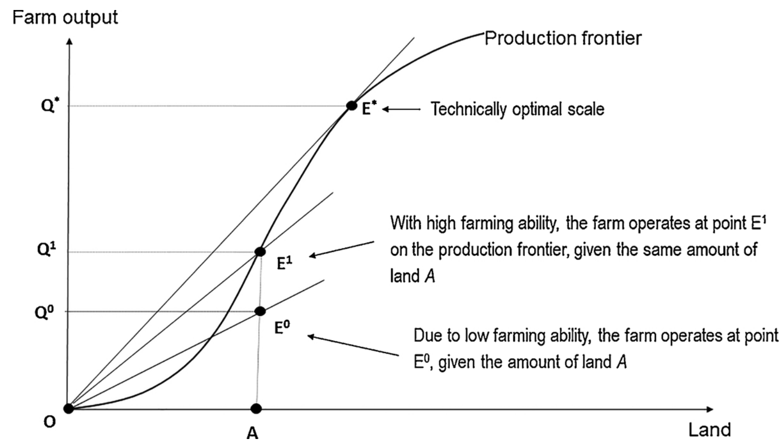

Fig. 2. Production frontier, technical efficiency and productivity.

et al. (2003) examine the determinants and impacts of rural land markets in Nicaragua. They find that land markets do not contribute to an equalization of returns, but land sales contribute to land concentration. They suggest that measures to reduce land transaction costs such as land titling be needed. Deininger et al. (2008) investigate the efficiency and equity impacts of rural land rental restrictions and find that the restrictions negatively affect productivity and equity. They thus suggest to liberalise land rental market. Jin and Deininger (2009) examine the productivity and equity impacts of land rental markets in China and find that land markets are critical for productivity gains and non-agricultural growth. This is in line with the findings of Rahman (2010) and Holden and Ghebru (2016). The impacts of land fragmentation on technical efficiency have also been investigated by Niroula and Thapa (2005); Tan et al. (2010); Deininger et al. (2017), and Ciaian et al. (2018). However, literature on the relationship between land rental market and technical efficiency of cropland use is limited (Deininger et al., 2008), with the exception of Feng (2008). This study examines the effects of land rental market participation on the technical efficiency of rice production in rural China and show that rice production on rented land is as efficient as on contracted land.

In Vietnam, some authors have examined the development of cropland markets, for example, Deininger and Jin (2008); Do and Iyer (2008), and Ravallion and van de Walle (2008). However, these studies were conducted in the context of the Land Law 1993 and use the data from the Vietnam Living Standards Survey waves 1993 and 1998. While these studies are step-forward, they are still restrictive. Do and Iyer (2008) have to rely on the province-level proportion of households with land use certificates as a measure of the probability that a given household would have a land use certificate. Deininger and Jin (2008) use the share of cultivated land in the village to which households had land certificates as a measure of land tenure security. These proxies suffer from aggregation bias. Huy et al. (2016) use the VLHSS04 and VLHSS08 to identify the factors affecting land rental market development. They find that land rental market in Vietnam is characterized with high transaction costs. Nevertheless, there have been no attempts to examine the effect of land rental on farm technical efficiency using recent nationally representative rural household data.

4. Data and variable description

4.1. Data source

The data used in this study are from the Vietnam Household Living Standards Survey (VHLSS) collected by the General Statistics Office of Vietnam in 2004 and 2008 (VHLSS04 and VHLSS08)[1]. This is a comprehensive nationwide survey of household and commune data with the technical support from the World Bank. The sample of each round is approximately 9000 households (see Tung and Phong, 2006 and Trung and Hung, 2009 for more information on the sampling procedure).

This study focuses on the agricultural land module which collects plot-level information about the agricultural land, its use, users, water access and retrospective data that can be used to better understand the history of household landholdings and which provides a view of the development of cropland markets in recent years. One section asks households how they initially acquired their land, whether through commune allocation, purchase, inheritance, reclamation, or other means. Another section asks when they started using the plots of land to which they currently have land-use certificates and how they initially obtained their land-use rights. It is worth noting that the VHLSS04 and VHLSS08 are respectively the first and second of Vietnam's nationally representative household surveys to ask about land-use right certificates (LUCs) at the plot-level. The data on agricultural land, however, were available only for households that used or managed cropland during the 12 months preceding the survey time. Since the information on household land rental market participation comes from this section, neither the VHLSS04 nor the VHLSS08 provide information on land rented out by rural households that did not undertake any farming during that 12 month period. This is an issue that affects all studies, whether in Vietnam or elsewhere, that follows the standard format of the World Bank Living Standards Measurement to examine cropland transactions (Grosh and Glewwe, 2000). The magnitude and severity of a possible bias introduced by such non-inclusion and the loss of information are, however, negligible (see Appendices A1 and A2 for an overview of the dataset classified according to the timeline of rental market participation).

Since only a small portion (approximately 20%) of the sample households in 2004 was re-interviewed in 2008, and also due to discarding observations, particularly those on renting in or renting out land, creating panel data would imply the loss of a large amount of valuable information. Other problems of forming panel data include the high attrition rate of respondents and difficulties identifying panels in the absence of clear guidelines from the data provider and some

[1] There have been more recent VHLSS rounds, for example VHLSS 2010 and VHLSS 2012. However, changes in the survey design over time have resulted in many incomparabilities between these rounds and the earlier rounds (2004 and 2008) in terms of content and sampling design. The changes include shortening of the questionnaire, a change in the recall period used in the consumption, and the drawing of the sample from the 2009 instead of the 1999 Population Census (WB, 2017, p. 57). We thus decided to use VHLSS04 and VHLSS08 to ensure the comparability and consistency of the data.

inconsistencies (Trung and Hung, 2009). In contrast, the independently pooled cross section preserves information on land rental market and increases the sample size. This gives rise to more precise estimators and test statistics with more power (Wooldridge, 2003). Thus, we pool these two year data for the analysis. A rural household is defined as a landless lessee if it has no cropland other than cropland it rents in. In contrast, a landed household is defined as a rural household that possesses some positive amount of cropland. The sub-sample comprising of only farming households, which accounts for more than 92% of households with cropland, are used to investigate the technical efficiency of farming households in relation to cropland rental market. This includes 5782 households in 2004 and 5648 households in 2008 (see Appendix A3 for the descriptive statistics of household characteristics).

4.2. Description of variables in the production function

For the production function, we define the crop output (CROPOUTPUT) as the real value of the aggregated crop production (including own food consumed) evaluated at the farm gate price. Inputs for crop production include land, labour, capital and materials, and other inputs. Land variable (SOWNAREA) is measured as the gross area (in ha) sown once and more than once during the 12 months preceding the survey. Since different crops were cultivated and data on inputs were aggregated to the farm level, we use data on expense of farm inputs. Labour (LABOUR) is the real cost of labour used in crop production, including hired and family labour. The opportunity cost of household labour was imputed by applying commune average daily earnings to the daily household labour in agriculture. With this imputation method, household members are assumed to be fully employed. Because rural households engage in other agricultural activities, the estimate of household labour for crop production was further adjusted by the percentage of crop production in total agricultural production[2]. Farm assets (FARMASSET) are measured as the real market value of aggregate farm assets excluding the value of land. Purchased materials include seed (SEED), chemical fertilisers, herbicides and pesticides (FERTILISER), and other purchased inputs (OTHERINPUT).

As we use the Cobb-Douglas production functional form, estimates of coefficients on these conventional inputs are production elasticities and the signs are expected to be positive. In addition, draft animals and tractors play important roles in Vietnamese crop production for timely land preparation and transportation. Hence, it is expected that crop output is lower for households that do not possess traction power, i.e. HIRETRACTION, a dummy variable if the household does not possess traction power, is expected to have a negative effect on crop output. Another feature of the agricultural production problem is that output depends on inputs of labour effort, not just labour time. The hypothesis that hired labour and family labour are equally productive can be tested with the coefficient on the dummy variable HIRELABOUR. Farm productivity is also influenced by factors related to land quality. A higher share of irrigated cropland in total area operated (IRRIGATION) is expected to impact positively on crop output.

At the commune level, three dummy variables, DELTA, MIDLAND and MOUNTAIN, were included to capture general land quality that systematically differs between the four topologies in which a commune is located (the coastal topology is the default category). At the regional level, seven regional dummy variables were included to capture regional differences associated with climatic variability, rural infrastructure system and other factors that systematically differ between the regions (the Red River Delta is the default region). Finally, the inclusion of a time dummy, YEAR, captures the possibility of Hicks-neutral technical change. It may also reflect variation in weather over the study period, among other unknown time-variant factors. The descriptive statistics of these variables are summarized in Appendix A4

4.3. Description of variables in the technical efficiency model

Literature shows that technical efficiency is likely to be affected by the factors associated with farm management practices (Forsund et al., 1980). Apart from variables under farmer control, however, technical efficiency may also be affected by different exogenous variables characterising the environment in which farmers operate (Gathon and Pestieau, 1995). In our study, the following variables are selected to include in the technical efficiency model.

The rice zoning index, RICEZONING, measured as the ratio of rice area designated by local government to total sown area, intends to capture the effect of the government policy that restricts the conversion of paddy fields from rice to other crop production (Markussen et al., 2011). Restrictions are administered by commune authorities. This variable is expected to have a negative effect on farm technical efficiency. LANDTITLED, measured as the percentage of the area registered with land use certificates in the total operated area, is expected to have a positive effect on technical efficiency. LANDRENTED is defined as the percentage of rented-in area in the total operated area. This variable could have a positive or negative effect on technical efficiency. On the one hand, it is alleged that owned land is often farmed more efficiently than rented land (Awasthi, 2009). On the other hand, the higher the value of LANDRENTED, the larger the farm size. A larger farm size allows the farmer to benefit from size economies and could therefore exert a positive effect on technical efficiency.

Variable PLOT100 is a measure of land fragmentation and is defined as the number of operated plots less than 100 m^2 in size. This variable is expected to impact negatively on technical efficiency. Households with more farm assets (FARMASSET) are expected to improve technical efficiency. Household size measured in adult equivalents, HHLDSIZE, is expected to affect technical efficiency through its effect on the household time endowment. Higher levels of formal education (HEADEDU) and greater specialisation in farming (SELFFARM) of the household head are expected to improve technical efficiency. Women are more likely to struggle with farming operations that require physical strength than are men (Coelli and Battese, 1996). It is therefore expected that female headed households, FEMALE, will have lower technical efficiency. The expected signs of the parameters in the technical efficiency model are not clear in some cases. Variable HEADAGE, the age of the head, might have a positive or a negative effect on technical efficiency. Older farmers are likely to have more farming experience and hence be more efficient. However, they are also likely to be more conservative and perhaps less willing to adopt new practices. The square of this variable, HEADAGE2, is added to the model to capture non-linearity in the impact of age on technical efficiency. Liquidity constraints may prevent farmers from operating in the rational stage of their production function. In this study, liquidity is measured by wage employment income, WAGEINCOME, and the value of loans, LOANVALUE. Increases in the levels of these variables are expected to impact positively on technical efficiency. Variable EXTENSION, which measures the number of visits by agricultural extension agents to the commune, is used in the model. Poor households (POORHHLD), which hold the Poor Household Certificate issued by the Commune People's Committee[3], are expected to have less social capital and hence a negative effect on their farm efficiency.

[2] Household labour units are assumed to be equally productive across crop and livestock enterprises.

[3] In a commune, a household is classified as poor in a given year by the Commune People's Committee if the household's self-reported income in the previous year was below the income poverty line constructed by the Ministry of Labor, Invalid and Social Affairs (MOLISA). Some additional criteria set up by each commune, such as lacking food or living in a very poor condition house, may also be added to the income criterion and they can be different from one commune to another.

Some commune variables are included to capture the environment in which farmers operate and which are assumed to affect technical efficiency. RELIGION and REMOTE are dummy variables representing religious diversity and distance from home to agricultural markets, respectively. Distance and differences in religions tend to impede the flow of information, raising transaction costs and reducing technical efficiency. Variable FARMWAGE, representing commune average farm wage, is also expected to impact negatively on technical efficiency. The descriptive statistics of these variables are summarized in Appendix A5. All variables measured in nominal monetary values at different point in time are converted into real values in constant January 2004 prices throughout this study. They are also deflated by a monthly price index to allow for variations in the time of the household interviews and by a spatial price index to take into account of regional price variation.

5. Empirical strategies

We use the stochastic frontier approach (SFA) to estimate farm technical efficiency (Aigner et al., 1977; Meeusen and van den Broeck, 1977). This is a parametric approach that accounts for noise and data measurement errors (Fried and Lovell, 2008)[4]. Following Kumbhakar and Lovell (2000) and Ebers et al. (2017), a single-output stochastic production frontier model can be expressed as follows:

$$Q_h = f(X_h;\beta).\ \exp\{v_h\}.\ TE_h \tag{1}$$

where Q_h is the scalar crop output of farming household *h; X_h* is a vector of inputs used by farming household *h;* $f(X_h;\beta).\ \exp\{v_h\}$ is the stochastic production frontier, also called 'best practice' frontier, with β being a vector of $J+1$ technology parameters to be estimated; and TE_h is the output-oriented farm technical efficiency of farming household *h*. The stochastic production frontier includes two parts: a deterministic part, $f(X_h;\beta)$, that is common to all farms, and a farm-specific part, $\exp\{v_h\}$, that captures random variation in crop output due to factors beyond the control of households and accounts for measurement error. From Eq. (1), output-oriented technical efficiency becomes:

$$TE_h = \frac{Q_h}{f(X_h;\beta)\exp\{v_h\}} \tag{2}$$

which defines technical efficiency as the ratio of observed output to the maximum feasible output under the condition of random shocks, $\exp\{v_h\}$, that vary across households. Accordingly, farming household *h* that produces crop output of Q_h achieves its maximum feasible output of $f(X_h;\beta).\ \exp\{v_h\}$ if, and only if, $TE_h = 1$; otherwise $TE_h < 1$ provides a measure of the deviation of observed output from the maximum feasible output. Assume that the deterministic part, $f(X_h;\beta)$, takes the log-linear Cobb-Douglas form, then the stochastic production frontier model given in Eq. (1) can be rewritten as

$$\ln Q_h = \beta_0 + \sum_{j}^{J}\beta_j \ln X_{jh} + v_h - u_h \tag{3}$$

where β is a vector of $J+1$ technology parameters; the symmetric error term, v_h, is associated with random shock of household *h* and is assumed to be independently and identically distributed as $N(0,\sigma_v^2)$. The u_h term represents the random component associated with technical inefficiency, where

$$TE_h = \exp\{-u_h\} \tag{4}$$

$TE_h \le 1$ implies that $u_h \ge 0$. A value of u_h equal to zero represents perfect technical efficiency (i.e. $TE_h = 1$) while higher values of u_h imply lower levels of farm technical efficiency. The term u_h is often assumed to be independently (but not identically) distributed as non-negative truncations of a general normal distribution and can be linearly expressed as

$$u_h = \delta_0 + \sum_{l}^{L}\delta_l Z_{lh} + \varepsilon_h \tag{5}$$

where Z_h is a vector of explanatory variables expected to influence technical efficiency with associated $L+1$ parameters δ, and ε_h is a random variable that is defined such that u_h is a non-negative truncation of the $N(\delta' Z_h, \sigma_u^2)$ distribution. The condition $u_h \ge 0$ guarantees that all observations of crop output lie on or beneath the stochastic production frontier. Variance terms in the likelihood function are parameterised by replacing σ_v and σ_u with $\sigma_S^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2/\sigma_S^2$, where the gamma parameter (γ) lies in the [0,1] interval. Given that the inefficiency effects are stochastic, Battese and Coelli (1995) argue that some explanatory variables can be included in both Eqs. (3) and (5). Parameters β, δ, σ_S^2 and γ can be consistently estimated by the maximum likelihood method (Nguyen et al., 2018).

In the first step, multi-collinearity diagnostics for the stability of the production function and technical efficiency model were investigated. The means of variance inflation factor (VIF) for the stochastic frontier and technical efficiency models were 2.25 and 6.21, respectively. These suggest that the estimated modes are free of any serious multi-collinearity problems (results of these VIF tests are in Appendices A6 and A7). In the second step, the Cobb-Douglas stochastic frontier production function model for crop output with technical efficiency effects specified in Eq. (3) was statistically tested against more restricted and parsimonious models following Battese and Coelli (1995). The first hypothesis is that the farming households are fully technically efficient or, equivalently, that the mean production function is an adequate representation of the data. This hypothesis was rejected at 1% in favour of the Cobb-Douglas stochastic frontier production function model with the technical inefficiency component u_h. Further, a test for the null hypothesis which specifies that the inefficiency effects are not stochastic (i.e. $\gamma = 0$) was strongly rejected at 1%. Finally, the hypothesis that the coefficients of the explanatory variables in the model for the inefficiency effects are simultaneously zero was tested and rejected at 1% (results of these tests are in Appendix A8).

6. Results and discussion

6.1. Farm production and cropland rental markets

Table 1 summarizes the key attributes of farm production. The operated area is defined as the cropland endowment plus the area of cropland rented-in, less the area of cropland rented-out. The average area operated by household was not significantly higher in 2008 than it was in 2004. Nevertheless, the data suggest a consolidation of parcels, indicated by a reduction in the average number of plots. Farm assets consisted mainly of tractors, draught animals, threshing machines, pesticide sprayers, carts and pumps, among others. There were no statistically significant differences in the real market value of farm assets per household between 2004 and 2008. However, the share of farm assets in total household assets fell by nearly 4% from 2004 to 2008. A decrease in the share of farm assets in total household assets may indicate that, on average, farm assets are less profitable than non-farm assets and that some rural households diversify their assets into non-farm activities. This is consistent with a decrease in the shares of the households that owned draught animals, threshing machines, pesticide

[4] Another approach for efficiency analysis is the deterministic data envelopment analysis (DEA). DEA is a nonparametric approach and therefore is sensitive to outliers and data measurement errors (Nguyen et al., 2012). Studies that treat the production function as deterministic to quantify technical efficiency assume that all deviations from the frontier are associated with inefficiency. This assumption is often difficult to accept given the inherent variability of farm production due to weather, pests and diseases. The SFA is, however, without weaknesses. It requires an explicit imposition of a parametric functional form representing the underlying technology and an explicit distributional assumption for the error terms.

Table 1
Summary of farm assets and crop production, 2004 and 2008.

Item	2004 (n = 5,415)	2008 (n = 5,186)	Change
Farmland and farm assets			
Operated area (ha)	0.63	0.66	0.03
Rented-in area in operated area (%)	4.3	4.6	0.3
Irrigated area in operated area (%)	72.3	73.3	1.0
Annual cropland area in operated cropland area (%)	77.0	76.5	−0.5
Number of operated plots	4.15	3.56	−0.59***
Number of operated plots less than 100 m^2	0.28	0.18	−0.1***
Value of farm assets (1,000VND)[a]	4,809	4,430	−379
Farm assets in total household assets (%)	30.0	26.2	−3.8***
Farm assets per adult equivalent (1,000VND)	1,508	1,420	−87.5
Household has traction power (%)	29.6	27.9	−1.7
Household has pesticide sprayers (%)	3.0	2.1	−0.9***
Household has carts (%)	12.5	9.6	−2.9***
Household has threshing machines (%)	9.5	5.7	−3.8***
Household has pumps (%)	37.7	48.2	10.5***
Farm input expense			
Expense on labour input (1,000VND/ha)	15,873	20,319	4,446***
Expense on hired labour (1,000VND/ha)	653	903	249**
Expense on hired traction (1,000VND/ha)	739	945	206***
Expense on seeds and seedlings (1,000VND/ha)	1,711	2,319	608
Expense on chemical and fertilisers (1,000VND/ha)	3,168	4,205	1,037***
Expense on other purchased inputs (1,000VND/ha)	1,336	1,331	−5
Crop outputs			
Gross output of crop production (1,000VND)	12,767	14,877	2,109***
Gross output per ha (1000VND/ha)	30,046	31,872	1,826
Crop output in agricultural output (%)	69.79	72.90	3.112***

[a] Value of land is not included; *, **, ***: significantly different from zero at the 10%, 5% and 1%, respectively. Sample weights are used to compute population statistics. All values are in January 2004 prices, 1 USD = 15,730 VND.

Table 2
Cropland rental market (LRM) participation and transaction.

Participation	2004 (n = 5,782)	2008 (n = 5,648)	Change
Household participates in LRM (%)	***16.9***	***18.4***	***1.4****
Pure lessors in LRM (%)	6.3	8.8	2.5***
Absentee lessors (%)	2.3	3.7	1.4***
Pure lessees in LRM (%)	10.1	9.3	−0.8
Landless lessees (%)	0.8	1.1	0.4*
Households are both lessors and lessees (%)	0.5	0.3	−0.2*
By type of cropland			
Annual cropland			
Lessors in annual cropland LRM (%)	6.1	8.3	2.2***
Lessees in annual cropland LRM (%)	9.9	8.8	−1.1*
Perennial cropland			
Lessors in perennial cropland LRM (%)	0.6	0.7	0.1
Lessees in perennial cropland LRM (%)	0.6	0.8	0.2
Land autarkic household (%)	**83.1**	**81.6**	**−1.4***
Transaction	**Pure Lessor (n = 820)**	**Pure Lessee (n = 1096)**	**Difference**
No. of rented plots	1.8	1.5	−0.3***
Area of rented cropland (ha)	0.27	0.32	0.05*
Average rented plot size (ha/plot)	0.22	0.27	0.05*
Transaction with land use certificate (LUC)			
No. of rented plots with LUC	1.5	0.4	−1.1***
Area of rented cropland with LUC (ha)	0.23	0.12	−0.11***
Share in rented area (%)	83.7	29.9	−53.8***
Transaction by type of land			
LRM for annual cropland			
No. of rented annual plots	1.7	1.4	−0.3***
Area of rented annual cropland (ha)	0.25	0.30	0.05
Share in rented area (%)	93.3	93.6	0.3
LRM for perennial cropland			
No. of rented perennial plots	0.1	0.08	−0.02
Area of rented perennial cropland (ha)	0.02	0.02	−0.00
Share in rented area (%)	6.7	6.4	−0.3

A group (less than 0.5%) of households that are both lessors and lessees are excluded; *, **, ***: significantly different from zero at the 10%, 5% and 1%, respectively. Sample weights are used to compute population statistics.

sprayers and carts over the study period. Regarding crop production, all real value of the inputs, except for seeds, seedlings and other inputs, increased during the 2004–2008 period. The real value of crop outputs also increased and accounted for 70% to 73% of total agricultural output.

Table 2 reports the descriptive statistics on cropland rental market participation and transaction in 2004 and 2008. Overall, the data show an increasing use of the cropland rental market by rural households to adjust their farm sizes. The number of rural households participating in the supply side of the market increased by 2.5%, suggesting that lessors are gaining confidence in the cropland rental market. On the demand side, the share of lessee households remained at approximately 10% of the sample, but the share of landless households using the rental market to access cropland increased, suggesting that rental market allows the poor and landless to access land. A small group (less than 0.5%) of rural households participate in the cropland rental market as both lessors and lessees. These participants may use the rental market primarily to consolidate their farms by renting out distant parcels and renting in plots close or adjacent to their farms. Overall, this evidence suggests that the cropland rental market in rural Vietnam is improving. The majority of participants transacted annual cropland.

The average area of cropland rented out by lessors is 0.27 ha, while the average amount rented in by lessees is 0.32 ha. The difference between these two figures is statistically significant and suggests that lessees are consolidating land by renting in cropland from several different lessors, implying the emergence of a commercial farmer class. It is also interesting to note that the average area of cropland transacted with land use certificates is much higher for lessors (0.23 ha) than for lessees (0.12 ha). This suggests a perception that certification reduces the lessor's risk of losing cropland when it is rented out.

Although there is evidence suggesting an improvement in the functioning of cropland rental market in Vietnam, the extent of non-participation is still profound, accounting for more than 80% of the sample. This estimate is much higher than the corresponding estimates of 54% for India (Deininger et al., 2008) and 37% for rural Bangladesh (Rahman, 2010). Huy et al. (2016) explain that high transaction costs drive a wedge between potential lessees and lessors. This may well be the case because it is unlikely that all non-participating households have optimal levels of all factors (both land and non-land factors). The evidence that some 4–5% of sample households left cropland idle also supports the argument of high transaction costs. In addition, rented cropland accounts for a very small share (approximately 4%) of the total cropland. This is much lower compared to that of 29.9% % for rural Bangladesh (Rahman, 2010) and suggests that cropland rental market is still very modest.

Table 3 summarizes the descriptive statistics for lessees and lessors and shows that on average, lessees are younger and have higher levels of formal education and farming experience, more family labour, farming equipment and machinery than lessors. Despite cultivating larger farms, they appear to apply seasonal inputs and family labour more intensively than lessors do. It is likely that the rental market is transferring cropland from households that are less able or willing to farm to those with the means and motive to make more profitable use of

Table 3
Summary statistics of cropland rental market outcome.

Items	Lessor (n = 839)	Lessee (n = 1123)	Difference
Household characteristics			
Female headed household (%)	34.5	16.7	−17.8***
Age of the head (years)	58.2	43.9	−14.7***
Education of the head (years)	6.3	7.3	1.0***
Head mainly working on own farm (%)	34.9	58.8	23.9***
Farming experience (years)	17.6	20.5	2.9***
Household size	3.3	4.3	1.0***
No. of working-age adults	2.0	2.7	0.7***
Child dependency ratio (%)	14.3	30.3	15.9***
Aged adult dependency ratio (%)	31.7	4.70	−27.0***
Land endowment (ha)	0.47	0.38	−0.09***
Land endowment per adult equivalent (ha/AE)	0.19	0.13	−0.06***
Value of farm assets (1,000VND)	3,991	5,135	1,144
Share of farm assets in total household assets (%)	12.96	34.20	21.24***
Value of farm assets per adult equivalent (1,000VND/AE)	1,234	1,702	468*
Value of farm assets per ha endowed land (1,000VND/ha)	13,105	24,737	11,632***
Owns draft animals (%)	8.3	32.3	24.0***
Owns tractors (%)	0.5	1.9	1.4***
Owns pesticide sprayers (%)	1.4	3.2	1.8**
Owns threshing machines (%)	2.7	10.8	8.1***
Owns carts (%)	6.0	18.1	12.1***
Owns motorised vehicles (%)	51.1	54.6	3.5
Owns TVs (%)	77.9	85.1	7.2***
Owns telephones (%)	42.7	31.2	−11.5***
Uses credit (%)	37.2	55.2	18.0***
Farm production			
Total operated area (ha)	0.21	0.71	0.50***
Expense on labour input (1,000VND/ha)	16,270	17,336	1,067
Expense on hired labour (1,000VND/ha)	663	1,045	381
Expense on traction input (1,000VND/ha)	1,195	1,416	222
Total expense on material inputs (1,000VND/ha)	7,279	9,539	2,260
Gross output value of crop production (1,000VND/ha)	33,532	36,972	3,441

*, **, ***: significantly different from zero at the 10%, 5% and 1%, respectively.
Sample weights are used to compute population statistics.

the land. Land rental market also transfers cropland from land 'rich' to land 'poor' households. On average, lessees own about 0.4 ha while lessors own nearly 0.5 ha. However, in contrast to what is observed in most developing countries, the cropland rental market in Vietnam has more than equalised the areas operated by lessees and lessors and is beginning to concentrate cropland in hands of an emerging class of larger farmers. Lessees operate an average farm size of 0.71 ha whereas lessors operate only about 0.21 ha.

6.2. Technical efficiency of crop production

Table 4 reports the estimated coefficients of the stochastic frontier model. The estimated coefficients have signs that generally conform to prior expectations. All estimated coefficients are significant, except for some regional dummy variables and variable HIRETRACTION. The estimate of production elasticity for land (0.79) is the largest, being nearly 1.5 times of the estimated elasticities with respect to labour, farm assets and purchased materials. This estimate compares favourably with production elasticities of 0.76 for wheat farmers in eastern England (Wilson et al., 2001), and 0.87 for UK potato growers (Wilson et al., 1998). Regarding land quality, the estimated coefficient of IRRIGATION is positive and significant, conforming to prior expectations. Topologies (DELTA, MIDLAND and MOUNTAIN) associated with land quality play an important role in crop production. On average, the land quality in the coastal area is less productive than other areas, as suggested by the positive coefficients of DELTA, MIDLAND and MOUNTAIN.

The estimate of production elasticity for farm labour is approximately 0.19, which is close to an estimate of 0.21 for rural households in China (Zhang et al., 2011). The estimated coefficient of HIRELABOUR is positive and significant, suggesting that hired labour is more productive than family labour. The lowest production elasticity is for farm assets, FARMASSET. This is not surprising as the average value of farm assets is only 309 USD and these farm assets tend to be simple like hand hoes and buffalo carts. Crop output was found to be lower in all regions, except the Mekong River Delta, when compared to the Red River Delta. The returns to scale value of 1.4 is obtained from the summation of the coefficients of estimated production elasticities. This suggests that farms in the study area are in stage one of the production frontier, which is characterised by increasing returns to scale. This means that farms in Vietnam are constrained as profit could still be increased by adding more of all inputs in the long run. Other studies have found similar results. For example, the mean returns to scale was estimated at 1.68 for small scale yam based farmers in Nigeria (Ojo et al., 2009) and 1.2 for maize farmers in Thailand (Nonthakot and Villano, 2008). The coefficient on the year of observation is significant. This estimate may be assigned to a Hicks-neutral technical change, indicating reasonable growth in productivity over the period. However, the estimated coefficient may also capture some variation in weather over time and other unknown time-variant factors.

The estimate of the average technical efficiency for the sample is 0.85. This suggests that reasonable gains in crop production can still be achieved by improving farm management practices under existing technologies. However, the predicted efficiencies differed substantially among farmers, ranging from 0.58 to 0.98 with the median of 0.86. Fig. 3 displays the density distributions of farm technical efficiency.

Regarding the difference in technical efficiency between lessees and lessors, on the cropland supply (i.e. lessor) side, the average of estimated technical efficiency of participants is 0.80. On the cropland demand (i.e. lessee) side, the estimate is 0.86. This difference is statistically significant and suggests that, on average, lessees are technically more efficient than lessors. This finding is consistent with those of earlier research by, for instance, Thomson and Lyne (1991) and Crookes and Lyne (2001). The implication is that the land rental market in rural Vietnam is 'doing the right things' by transferring land to farmers who are 'doing things right'. Hence, promoting the cropland rental markets is important for facilitating the allocation of cropland to achieve higher levels of efficiency in land use and agricultural productivity.

The predicted efficiencies, however, differ within each market regime. Figs. 4–6, present the frequency distributions and kernel density of technical efficiency for lessees and lessors. The predicted efficiencies of lessors range from 0.59 to 0.97 and the shape is balanced and centred at the mean of 0.80. On the other hand, the predicted efficiencies of lessees range from 0.61 to 0.96 and the distribution is skewed to the left (bunched up toward the right with a 'tail' stretching toward the left). When the focus is on what happens 'on average' or perhaps 'typically', the mean is appropriate if the distribution is symmetrical, and especially when it is 'mound-shaped', such as a normal distribution (Gujarati, 2004). If a distribution is skewed, however, the mean is usually not in the middle and a better measure of the centre for this distribution would be the median (Gujarati, 2004). In the case of the predicted efficiencies of lessees, the median (0.87) is greater than the mean (0.86). However, this difference is minor.

6.3. Impact of cropland rental market on technical efficiency of crop production

Table 5 presents the estimated effects of the factors affecting the technical efficiency of crop production. In general, the estimated coefficients of all variables have signs that conform to prior expectations. The effect of LANDRENTED is positive, indicating that farmers who rent in more cropland are more efficient land users than other

Table 4
Estimates from the stochastic frontier model.

	Production function		
Variable	*Description*	*Coefficient*	*Std. Error*
SOWNAREA (ln)	Sown area of all crops	0.79***	(0.0144)
LABOUR (ln)	Labour expense	0.19***	(0.00508)
FARMASSET (ln)	Farm asset value	0.009*	(0.00490)
SEED (ln)	Expense on seeds and seedlings	0.026***	(0.00300)
FERTILISER (ln)	Expense on chemicals and fertilizers	0.18***	(0.00377)
OTHERINPUT (ln)	Expense on other purchased inputs	0.18***	(0.00430)
HIRELABOUR	If household hires labour (1 = yes)	0.091***	(0.00872)
HIRETRACTION	If household hires traction (1 = yes)	−0.016	(0.0101)
IRRIGATION	Share of irrigated area	0.0012***	(0.000139)
DELTA	If commune is in delta areas (1 = yes)	0.10***	(0.0195)
MIDLAND	If commune is in midland areas (1 = yes)	0.064***	(0.0237)
MOUNTAIN	If commune is in mountain areas (1 = yes)	0.091***	(0.0214)
REGION2	If commune is in North East (1 = yes)	−0.095***	(0.0164)
REGION3	If commune is in North West (1 = yes)	−0.029	(0.0221)
REGION4	If commune is in North Coast (1 = yes)	−0.14***	(0.0143)
REGIONS5	If commune is in South Coast (1 = yes)	−0.11***	(0.0163)
REGION6	If commune is in Central Highlands (1 = yes)	−0.0017	(0.0220)
REGION7	If commune is in South East (1 = yes)	−0.022	(0.0202)
REGION8	If commune is in Mekong (1 = yes)	0.041**	(0.0162)
YEAR	If year = 2008	0.020**	(0.00939)
CONS	Constant	4.56***	(0.0573)
	Technical efficiency estimate		
		Mean	***Median***
	Whole sample	0.85	0.86
	Lessor households	0.80	0.80
	Lessee households	0.86	0.87
N	Number of observations	10,601	
sigma^2	$\sigma_S^2 = \sigma_v^2 + \sigma_u^2$	0.153	
gamma	$\gamma = \sigma_u^2/\sigma_S^2$	0.037	
LL	Log Likelihood	−4907.5	

[ln] is the natural logarithm; standard errors are in parentheses; *, **, ***: significant at the 10%, 5% and 1%, respectively.

farmers. Furthermore, in the context of rural Vietnam where virtually all households have access to cropland and farm sizes are uniformly small, the positive effect of LANDRENTED may also reflect gains from economies of scale.

The effect of RICEZONING is negative, suggesting that zoning land only for rice production reduces technical efficiency. Kurosaki (2008) report similar results for rice farmers in Myanmar. However, the estimated coefficient for RICEZONING is not statistically significant although its t-value is greater than unity (1.07). The effect of LANDTITLED is positive, indicating that technical efficiency is higher on cropland that is registered with a land use certificate. This finding is consistent with Nguyen (2012) that land registration is positively associated with increased farm technical efficiency. The effect of PLOT100 is negative, implying that farmers with less fragmented land operate at higher levels of technical efficiency. The result is consistent with Hung et al. (2007) for Vietnam and Rahman and Rahman (2008) for Bangladesh. The effect of FARMASSET is positive but insignificant. As explained above, this is not surprising as the farm assets tend to be simple like hand hoes and buffalo carts. The effect of HHLDSIZE is positive, indicating that larger households and households with

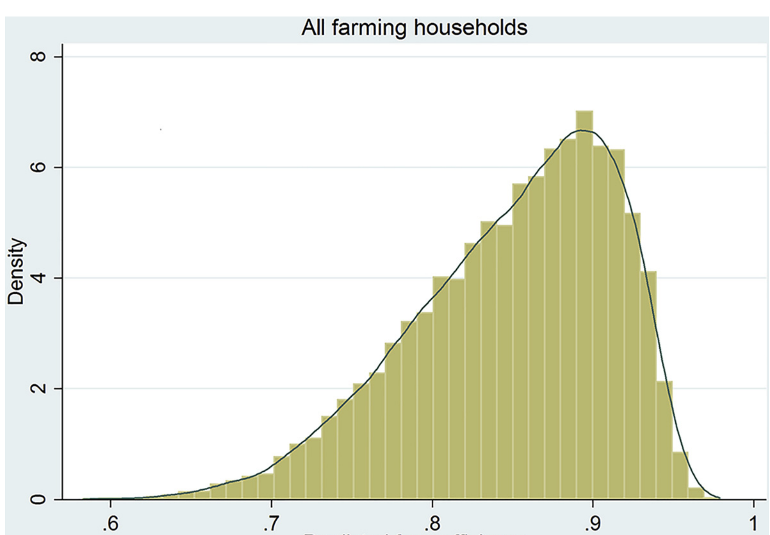

Fig. 3. Density distribution of farm technical efficiency.

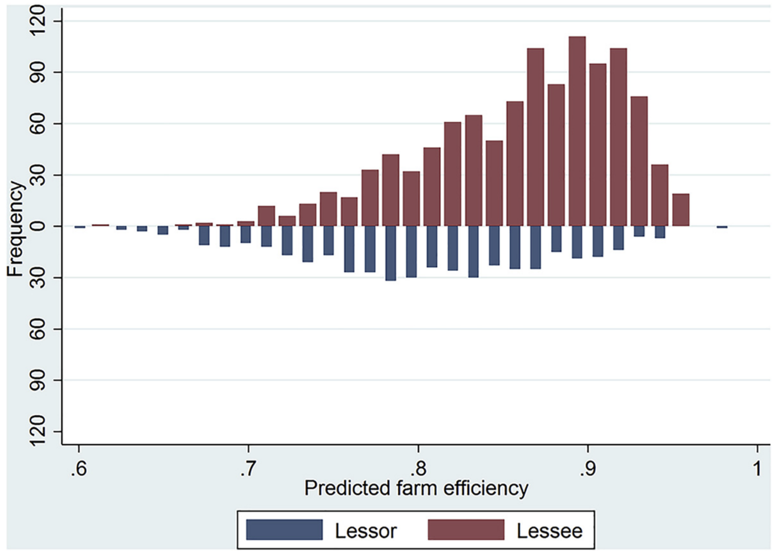

Fig. 4. Frequency distributions of farm technical efficiency for lessees and lessors.

relatively fewer dependents are more technically efficient. Formal education of household head, HEADEDU, has a positive effect on technical efficiency. This result is consistent Zhang et al. (2011) for farmers in China. The negative effect of FEMALE supports the view that female headed households are less technically efficient than their male counterparts. The effect of HEADAGE (i.e. the age of the farmer) is positive but insignificant. The effects of WAGEINCOME and LOANVALUE are both positive. As expected, farmers with higher levels of liquidity tend to be more technically efficient. Surprisingly, the number of visits by agricultural extension agents to the commune (EXTENSION) has no significant effect on farmers' technical efficiency. A possible explanation is that insufficient qualified staff and poor coordination and management are the major problems to limit the efficiency of agricultural extension in Vietnam (Huy et al., 2016). Poor households tend to be less technically efficient, as suggested by the negative and significant coefficient estimated for POORHHLD. The other commune dummy variables (RELIGION, REMOTE and FARMWAGE) also have negative effects on technical efficiency.

7. Conclusions

Increasing farm technical efficiency of smallholder farmers in developing countries is important; and land rental market development might have important effects on land use efficiency. Economic theory suggests that voluntary rental transactions provide an equitable way of improving the efficiency of land use, promoting agricultural productivity and growing rural incomes. However, empirical evidence on factors that impede or promote the operation of land rental markets, especially in transition economies like Vietnam where farms are uniformly small, remains limited. The rental market for cropland seems to be inefficient in rural Vietnam, preventing farmers from consolidating land parcels. This study investigates the technical efficiency in crop production and examines the effect of land rental market participation on technical efficiency. To address these issues, an analytical framework is constructed to better understand how land tenure security, land rental markets and technical efficiency are related. We use the nationally represented farming household data from two rounds of the Vietnam Household Living Standard Survey 2004 and 2008 for the analysis. A one-step stochastic frontier approach is applied to overcome the misspecification of efficiency levels. Our analysis results in several

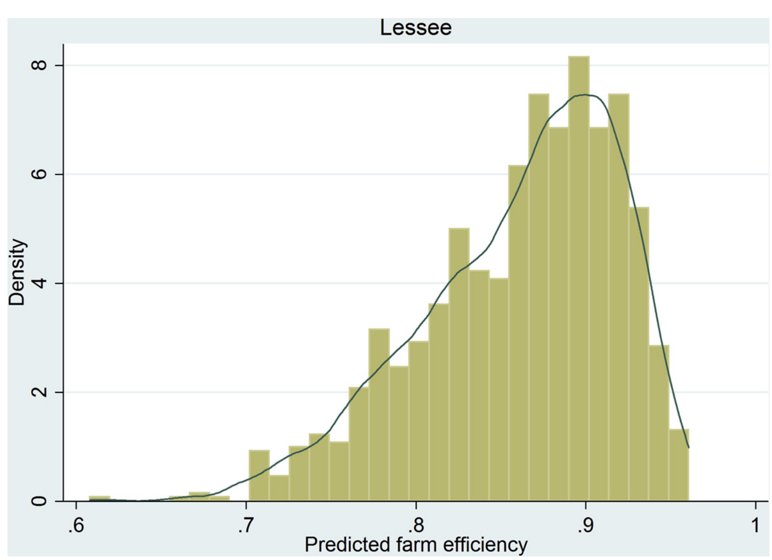

Fig. 5. Density distributions of farm technical efficiency for lessees.

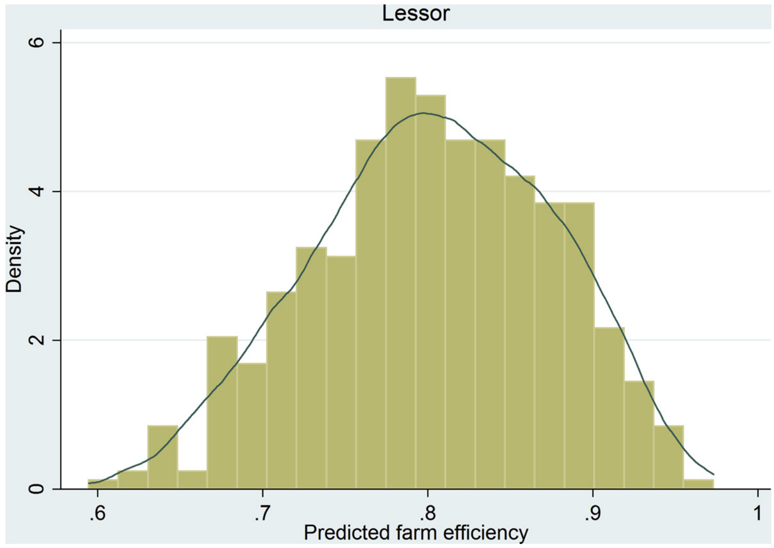

Fig. 6. Density distributions of farm technical efficiency for lessors.

Table 5
Determinants of farm technical efficiency.

Variable	Description	Coefficient	Std. Error
RICEZONING	Rice zoning index	−0.022	(0.0206)
LANDTITLED	Share of titled land area (%)	0.00030**	(0.000131)
LANDRENTED	Share of rented-in land area (%)	0.00055*	(0.000328)
PLOT100	No. of operated plots less than 100 m2	−0.024***	(0.00636)
FARMASSET (ln)	Value of farm assets (1,000VND) (ln)	0.0030	(0.00545)
HHLDSIZE	Adult equivalent household size	0.013**	(0.00585)
SELFFFARM	If household has self-employed activities (1 = yes)	0.0075	(0.0108)
HEADEDU	Education of the head (years)	0.0045***	(0.00164)
FEMALE	If household is female-headed (1 = yes)	−0.051***	(0.0122)
HEADAGE	Age of the head (years)	0.00046	(0.00237)
HEADAGE2	Square of head age	−0.000012	(0.0000218)
WAGEINCOME	Remittance income (1,000VND)	1.67e-06*	(9.87e-07)
LOANVALUE	Total loan amount (1,000VND)	1.40e-07	(4.24e-07)
EXTENSION	No. of visits by agricultural extension agents	−0.00063	(0.000409)
POORHHLD	If household is poor (1 = yes)	−0.089***	(0.0138)
RELIGION	If commune has diverse religions (1 = yes)	−0.024**	(0.0116)
REMOTE	If commune is remote (1 = yes)	−0.037***	(0.0134)
FARMWAGE	Commune average farm wage (1,000VND/hr)	−0.058***	(0.00559)
CONS	Constant	0.0022	(0.0815)
N	Number of observations	10,601	

Dependent variable is technical efficiency estimated in a single stage procedure with the frontier function; coefficients are multiplied by minus one for ease of interpretation; ln is the natural logarithm; standard errors are in parentheses; *, **, ***: significant at the 10%, 5% and 1%, respectively.

important findings.

First, we find that the cropland rental markets have been more active, although they are still at the beginning stage of the development. Participation in cropland rental markets is found at a way for rural households to adjust their farm size and this has facilitated an emerging commercial farmer class. Second, the crop production function exhibits increasing returns to scale with the elasticity for land being the largest of the estimated elasticities, suggesting that an expanding farm size leads to higher returns to land in the long run. In this sense, a promotion of access to land through the land rental market is vital. Third, the estimate of the average technical efficiency is 0.85, suggesting that reasonable gains in crop production (15%) could still be achieved under the existing technologies. Fourth, households renting in land achieve higher technical efficiency, indicating that the cropland rental market facilitates an efficient allocation of cropland by transferring cropland from less to more efficient land users. In addition, land registration and land fragmentation also have significant effects on farm technical efficiency. Therefore, we suggest that the restriction on the operation of cropland rental markets should be removed. In addition, promotion of land registration and land defragmentation should also be undertaken.

Our study can still be extended in several ways. We use only one variable (the rented land share in the total operated land) to examine the effect of land rental market on technical efficiency. In addition, neither the VHLSS04 nor the VHLSS08 provides information on land rented out by rural households that did not undertake any farming during the 12 months preceding the survey. Such non-inclusion may introduce a bias to econometric estimates. This is an issue that affects all studies of agricultural land market activity, whether in Vietnam or elsewhere, that follow the standard format of the World Bank Living Standards Measurement Study to examine cropland transactions. Data on input and output prices are also not available for this study, limiting alternative methodologies that utilise dual approaches, such as cost minimisation or profit maximisation, to analyse effects of the cropland rental market on farm technical efficiency. Further, there are some questions left unanswered in this study. For example, how other market imperfections and household level constraints affect land rental markets. These are important topics for future research.

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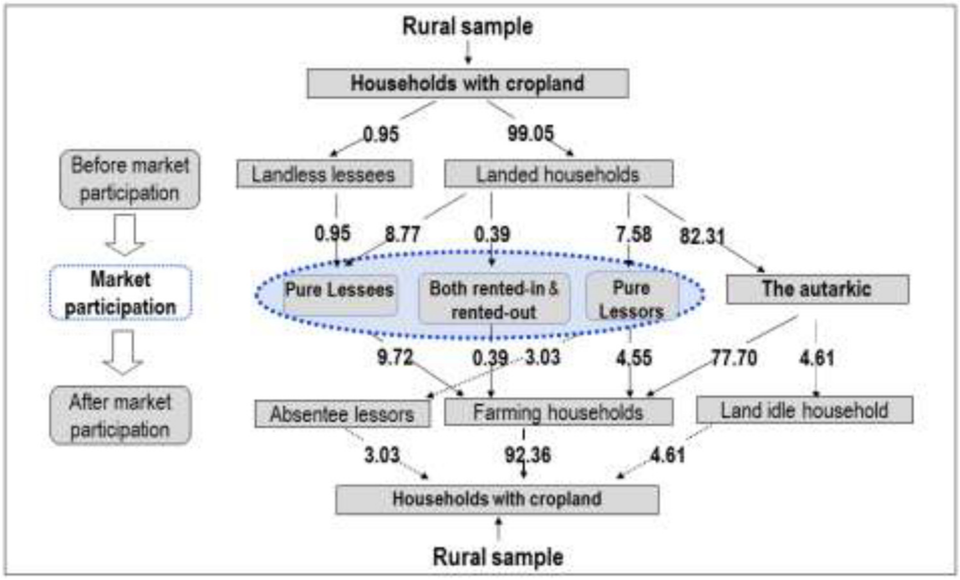
Appendix A1 Shares of rural households with cropland and its subsamples (%)



Appendix A1 shows that the share of landless lessees accounts for less than 1% of the rural sample. The sample was classified into four types of households, namely, pure lessee households (9.7%), households that are both lessees and lessors (0.4%), pure lessor households (7.6%), and autarkic households (82.3%). However, households that both rented in and rented out cropland are classified as either lessees if the net area rented in is greater than zero, and lessors otherwise. The autarkic households are further classified as either farming households or land idle households. The latter (accounting for less than 5% of households with cropland) may include those who wanted to rent out their land but failed to do so.

Appendix A2 The sample of rural households with cropland and its sub-populations

Items	Pooled sample (n = 11,430)	2004 (n = 5782)	2008 (n = 5648)	Change
Before market participation				
Landless lessee (1 if yes, 0 otherwise)	0.00952***	0.00769***	0.0112***	0.0035*
	(0.00105)	(0.00120)	(0.00161)	(0.00196)
Landed household (1 if yes, 0 otherwise)	0.990***	0.992***	0.989***	−0.0035*
	(0.00105)	(0.00120)	(0.00161)	(0.00196)
Market participation				
Pure lessee (1 if yes, 0 otherwise)	0.0972***	0.101***	0.0933***	−0.0082
	(0.00330)	(0.00447)	(0.00460)	(0.00636)
Household that both rents in and out land (1 if yes, 0 otherwise)	0.00391***	0.00509***	0.00282***	−0.0023*
	(0.000614)	(0.000938)	(0.000745)	(0.00116)
Pure lessor (1 if yes, 0 otherwise)	0.0758***	0.0629***	0.0877***	0.025***
	(0.00287)	(0.00350)	(0.00428)	(0.00547)
Autarky household (1 if yes, 0 otherwise)	0.823***	0.831***	0.816***	−0.014*
	(0.00434)	(0.00571)	(0.00610)	(0.00829)
After market participation				
Absentee lessor (1 if yes, 0 otherwise)	0.0303***	0.0232***	0.0367***	0.014***
	(0.00181)	(0.00211)	(0.00275)	(0.00341)
Farming household (1 if yes, 0 otherwise)	0.924***	0.935***	0.914***	−0.021***
	(0.00294)	(0.00352)	(0.00436)	(0.00568)
Land idle household (1 if yes, 0 otherwise)	0.0461***	0.0421***	0.0497***	0.0076
	(0.00235)	(0.00286)	(0.00349)	(0.00469)

Standard deviations are in parentheses; sample weights are used; *, **, ***: significantly different from zero at the 10%, 5% and 1%, respectively.

Appendix A3 Summary of sample household characteristics in 2004 and 2008

Item	2004 (n = 5782)	2008 (n = 5648)
Household structure and human capital		
Number of household members	4.44	4.19
Number of working-age adults	2.83	2.81
Child dependency ratio	0.25	0.21

Female headed households (%)	18.7	19.1
Age of the head (years)	49.0	49.8
Education of the head (years)	6.7	6.9
Head mainly working on own farm (%)	57.6	57.2
Hours of members working on farm in total (%)	57.8	55.8
Household farming experience (years)	21.1	21.6
Assets and durable goods		
Cropland endowment (ha)	0.586	0.595
Cropland endowment per adult equivalent (ha)[a]	0.184	0.194
Value of household assets (1,000VND)[b]	25,068	31,931
Value of household fixed assets (1,000VND)[b]	16,971	22,377
Value of loans (1,000VND)	4,214	5,343
Household has car (%)	0.3	1.0
Household has other motor vehicles (%)	45.5	66.2
Household has TV (%)	75.2	87.9
Household has radio (%)	21.2	9.5
Household has telephone (%)	9.4	55.1
Income and expenditure		
Income per adult equivalent (1,000VND)	6,290	7,454
Income from agriculture in total income (%)	43.4	43.5
Income from crops in total income (%)	33.0	32.7
Income from wage employment in total income (%)	9.8	8.7
Expenditure per adult equivalent (1,000VND)	4,740	5,866
Expenditure on food in total expenditure (%)	53.0	52.1

[a] The measure of adult equivalent (AE) assigns a value of 1 to the working-age adults, 0.7 to each aged member and 0.5 to each child; [b] value of land is not included; *, **, ***: significantly different from zero at the 10%, 5% and 1%, respectively. Sample weights are used to compute population statistics. All values are in January 2004 prices, 1 USD = 15,730 VND.

Appendix A4 Summary statistics of the variables used in the production frontier

Variables	Description	Mean (n = 10,548)	S.D
Dependent variable			
CROPOUTPUT	Gross output of crop production (1,000VND)	13,768	32,759
Explanatory variables			
SOWNAREA	Gross sown area of all crops (ha)	1.08	1.64
LABOUR	Total expense on labour input (1,000VND)	6,356	6,126
FARMASSET	Value of farm assets (1,000VND)	4854	18,019
SEED	Expense on seeds (1,000VND)	615.7	15,408
FERTILISER	Expense on chemicals and fertilisers (1,000VND)	1,846	4,039
OTHERINPUT	Expense on other purchased inputs (1,000VND)	623.6	1,785
HIRELABOUR	Household hires labour (1 if yes, 0 otherwise)	0.51	0.50
HIRETRACTION	Household hires traction (1 if yes, 0 otherwise)	0.52	0.50
IRRIGATION	Irrigated area in operated area (%)	69.98	37.22
DELTA	Delta commune (1 if yes, 0 otherwise)	0.50	0.50
MIDLAND	Midland commune (1 if yes, 0 otherwise)	0.07	0.26
MOUNTAIN	Mountainous commune (1 if yes, 0 otherwise)	0.39	0.49
REGION2	North East (1 if yes, 0 otherwise)	0.18	0.38
REGION3	North West (1 if yes, 0 otherwise)	0.07	0.25
REGION4	North Central Coast (1 if yes, 0 otherwise)	0.13	0.34
REGION5	South Central Coast (1 if yes, 0 otherwise)	0.09	0.28
REGION6	Central Highlands (1 if yes, 0 otherwise)	0.07	0.26
REGION7	South East (1 if yes, 0 otherwise)	0.07	0.25
REGION8	Mekong River Delta (1 if yes, 0 otherwise)	0.16	0.37
YEAR	Time dummy (1 if 2008, 0 otherwise)	0.49	0.50

All values are in January 2004 prices, 1 USD = 15,730 VND.

Appendix A5 Summary statistics of the variables used in the technical efficiency model

Variables	Description	Mean (n = 10,548)	S.D
RICEZONING	Rice zoning index (ratio of rice sown area to total sown area)	0.58	0.36
LANDTITLED	Area with LUC in operated area (%)	75.15	38.57
LANDRENTED	Rented-in area in operated area (%)	4.40	15.68
PLOT100	No. of operated plots less than 100 m^2	0.22	0.69
FARMASSET	Value of farm assets (1000VND)	4854	18,019
HHLDSIZE	Adult equivalent household size	3.17	1.06
SELFFARM	Self-employed farmer (= 1 yes, 0 otherwise)	0.63	0.48
HEADEDU	Education of the head (years)	6.65	3.46
FEMALE	Female headed household (1 if yes, 0 otherwise)	0.17	0.38

HEADAGE	Age of the head (years)	48.52	13.38
HEADAGE2	Square of head age	2,534	1,423
WAGEINCOM	Income from waged activities (1000VND)	1706	5,395
LOANVALUE	Total loan amount (1000VND)	4553	14,894
EXTENSION	Visits by agricultural extension agents to commune	8.79	11.08
POORHHLD	Poor household (1 if yes, 0 otherwise)	0.14	0.35
RELIGION	Commune has diverse religions (1 if yes, 0 otherwise)	0.56	0.50
REMOTE	Remote commune (1 if yes, 0 otherwise)	0.24	0.43
FARMWAGE	Commune average farm wage (1000VND/hr)	3.55	1.05

All values are in January 2004 prices, 1 USD = 15,730 VND.

Appendix A6 Multicollinearity diagnostics for the stability of the stochastic production frontier model

Variable	VIF	SQRT VIF	Tolerance
SOWNAREA	2.50	1.58	0.3993
LABOUR	1.44	1.20	0.6953
FARMASSET	1.05	1.02	0.9545
SEED	1.02	1.01	0.9779
FERTILIZER	2.68	1.64	0.3729
OTHERINPUT	2.58	1.61	0.3877
HIRELABOUR	1.22	1.11	0.8184
HIRETRACTION	1.33	1.15	0.7546
IRRIGATION	1.40	1.18	0.7144
DELTA	6.42	2.53	0.1557
MIDLAND	2.52	1.59	0.3972
MOUNTAIN	7.40	2.72	0.1352
REGION2	2.51	1.58	0.3984
REGION3	1.86	1.36	0.539
REGION4	1.52	1.23	0.6568
REGION5	1.35	1.16	0.7417
REGION6	1.96	1.40	0.5108
REGION7	1.46	1.21	0.6853
REGION8	1.65	1.28	0.6067
YEAR	1.04	1.02	0.9577
Mean	**2.25**		

Appendix A7 Multicollinearity diagnostics for the stability of the technical efficiency model

Variable	VIF	SQRT VIF	Tolerance	VIF (excludingHEADAGE2)
RICEZONING	1.07	1.03	0.9361	1.07
LANDTITLED	1.08	1.04	0.9264	1.08
LANDRENTED	1.06	1.03	0.9449	1.06
PLOT100	1.03	1.01	0.9709	1.03
FARMASSET	1.02	1.01	0.9811	1.02
HHLDSIZE	1.15	1.07	0.8723	1.11
SELFFARM	1.09	1.04	0.9182	1.06
HEADEDU	1.35	1.16	0.7412	1.28
FEMALE	1.16	1.08	0.8631	1.15
HEADAGE	46.78	6.84	0.0214	1.18
HEADAGE2	47.32	6.88	0.0211	–
WAGEINCOME	1.03	1.01	0.9743	1.03
LOANVALUE	1.02	1.01	0.9773	1.02
EXTENSION	1.02	1.01	0.9794	1.02
POORHHLD	1.08	1.04	0.9289	1.08
RELIGION	1.10	1.05	0.9088	1.10
REMOTE	1.22	1.11	0.818	1.22
FARMWAGE	1.12	1.06	0.8901	1.12
Mean	**6.21**			**1.10**

Appendix A8 Tests of hypotheses for coefficients of the explanatory variables estimated for the technical inefficiency effects in the stochastic frontier production function

Null hypothesis[a]	$\log L(\widehat{\Omega}_{H0})$[d]	λ	k	Critical value $\alpha = 1\%$	Decisions
H_0: $\gamma = \delta_0 = \delta_1 = \ldots = \delta_{18} = 0$[b]	−5050.6	286.2	20	36.935	Reject H_o
H_0: $\gamma = 0$[c]	−4900.1	14.8	3	10.501	Reject H_o
H_0: $\delta_1 = \delta_2 = \ldots = \delta_{18} = 0$	−5050.6	286.2	18	34.167	Reject H_o

[a]

- *The first hypothesis*: The inefficiency effects are not present (or, equivalently, the mean production function is an adequate representation of the data).

- *The second hypothesis*: The inefficiency effects are not stochastic (i.e. the random component of the inefficiency effects is absent)

-*The third hypothesis*: The coefficients of the explanatory variables in the model for the inefficiency effects are simultaneously zero (and hence that the technical inefficiency effects have the same truncated-normal distribution)

[b] When $\mu = 0$ and $\sigma_u = 0$, the truncated-normal model reduces to a linear regression model with normally distributed errors. However, the distribution of the test statistic under the null is not well established (it becomes impossible to evaluate the log-likelihood as $\sigma_u \to 0$). Coelli (1995) derived a *one-sided test* for the presence of the inefficiency term by identifying negative skewness in the residuals from an OLS regression with the presence of an inefficiency term.

[c] If the parameter γ is zero, then the variance of the inefficiency effects is zero and so the model reduces to a traditional mean response function in which the variables explaining technical efficiency are included in the production function. In this case, the parameters δ_0 and the coefficient for FARMASSET are not identified.

[d]

- $\log L(\widehat{\Omega}_{H0})$ is the log likelihood of constrained models under the null

- $\log L(\widehat{\Omega}_{H1})$ is the log likelihood of the alternative hypothesis (no restrictions) in Table 5. The results presented in the table were obtained after running 10,000 iterations.

- $\lambda = -2[\log L(\widehat{\Omega}_{H0}) - \log L(\widehat{\Omega}_{H1})]$;

- k = number of restrictions;

- The correct critical values are obtained from Table 1 of Kodde and Palm (1986, p. 1 246) for degrees of freedom 20, 3 and 18, respectively.

References

Aigner, D., Lovell, C.A.K., Schmidt, P., 1977. Formulation and estimation of stochastic frontier production function models. J. Econom. 6, 21–37.

Amare, M., Hohfeld, L., 2016. Poverty transition in rural Vietnam: the role of migration and remittances. J. Dev. Stud. 52, 1463–1478.

Awasthi, M.K., 2009. Dynamics and resource use efficiency of agricultural land sales and rental market in India. Land use policy 26, 736–743.

Bardhan, P., Udry, C., 1999. Development Microeconomics. Oxford University Press, New York.

Battese, G.E., Coelli, T.J., 1995. A model for technical inefficiency effects in a stochastic frontier production function for panel data. Empir. Econ. 20, 325–332.

Besley, T., 1995. Property rights and investment incentives: theory and evidence from Ghana. J. Polit. Econ. 103, 903–937.

Brasselle, A.S., Gaspart, F., Platteau, J.P., 2002. Land tenure security and investment incentives: puzzling evidence from Burkina Faso. J. Dev. Econ. 67, 373–418.

Carter, M.R., Yao, Y., 2002. Local versus global separability in agricultural household models: the factor price equalization effect of land transfer rights. Am. J. Agric. Econ. 84, 702–715.

Chamberlin, J., Ricker-Gilbert, J., 2016. Participation in rural land rental markets in Sub-Saharan Africa: who benefits and by how much? Evidence from Malawi and Zambia. Am. J. Agric. Econ. 98, 1507–1528.

Che, T.N., Kompas, T., Vousden, N., 2006. Market reform, incentives and economic development in Vietnamese rice production. Comp. Econ. Stud. 48, 277–301.

Ciaian, P., Guri, F., Rajcaniova, M., Drabik, D., Paloma, S.G., 2018. Land fragmentation and production diversification: a case study from rural Albania. Land use policy 76, 589–599.

Coelli, T.J., Battese, G., 1996. Identification of factors which influence the technical inefficiency of Indian farmers. Aust. J. Agric. Econ. 40, 103–128.

Crookes, T.J., Lyne, M.C., 2001. Improvements in the rental market for cropland in a communal region of Kwazulu-Natal. Agrekon 40, 669–677.

D'Souza, A., Mishra, A.K., 2018. Adoption and abandonment of partial conservation technologies in developing economies: the case of South Asia. Land use policy 70, 212–223.

Deininger, K., 2003. Land Policies for Growth and Poverty Reduction. World Bank and Oxford University Press, Oxford.

Deininger, K., Jin, S., 2008. Land sales and rental markets in transition: evidence from rural Vietnam. Oxf. Bull. Econ. Stat. 70, 67–101.

Deininger, K., Jin, S., Nagarajan, H.K., 2008. Efficiency and equity impacts of rural land rental restrictions: evidence from India. Eur. Econ. Rev. 52, 892–918.

Deininger, K., Monchuk, D., Nagarajan, H.K., Singh, S., 2017. Does land fragmentation increase the cost of cultivation? Evidence from India. J. Dev. Stud. 53, 82–98.

Deininger, K., Zegarra, E., Lavadenz, I., 2003. Determinants and impacts of rural land market activity: evidence from Nicaragua. World Dev. 31, 1385–1404.

Do, Q.T., Iyer, L., 2008. Land titling and rural transition in Vietnam. Econ. Dev. Cult. Change 56, 531–579.

Do, T.L., Nguyen, T.T., Grote, U., 2019. Livestock production, rural welfare, & perceived shocks: evidence from panel data for Vietnam. J. Dev. Stud. 55, 99–119.

Ebers, A., Nguyen, T.T., Grote, U., 2017. Production efficiency of rice farms in Thailand & Cambodia: a comparative analysis of Ubon Ratchathani & Stung Treng provinces. Paddy Water Environ. 15, 79–92.

Fan, S., Chan-Kang, C., 2005. Is small beautiful? Farm size, productivity, and poverty in Asian agriculture. Agric. Econ. 32 (s1), 135–146.

Feder, G., Onchan, T., Chalamwong, Y., Hongladarom, C., 1988. Land Policies and Farm Productivity in Thailand. Baltimore. The Johns Hopkins University Press.

Feng, S., 2008. Land rental, off-farm employment and technical efficiency of farm households in Jiangxi Province, China. Njas - Wageningen J. Life Sci. 55, 363–378.

Food and Agriculture Organization (FAO), 2006. Rapid Growth of Selected Asian Economies: Lessons and Implications for Agriculture and Food Security. FAO Regional Office for Asia and the Pacific., Bangkok.

Forsund, F.R., Lovell, C.A.K., Schmidt, P., 1980. A survey of frontier production functions and of their relationship to efficiency measurement. J. Econom. 13, 5–25.

Fried, H.O., Lovell, C.A.K., 2008. Efficiency and productivity. In: Fried, H.O., Lovell, C.A.K., Schmidt, S.S. (Eds.), The Measurement of Productive Efficiency and Productivity Growth. Oxford University Press, New York, pp. 3–91.

Gaiha, R., Thapa, G., 2007. Growth, equity, and poverty reduction in Vietnam: prospects and challenges. In: In: Long, G.T. (Ed.), Social Issues Under Economic Transformation and Integration in Vietnam Vol. 2. Publishing House of Social Labour, Hanoi, pp. 7–50.

Gathon, H.J., Pestieau, P., 1995. Decomposing efficiency into its managerial and its regulatory components: the case of European railways. Eur. J. Oper. Res. 80, 500–507.

Glewwe, P., Agrawal, N., Dollar, D., 2004. Economic Growth, Poverty, and Household Welfare in Vietnam. The World Bank, Washington, D.C.

Grosh, M.E., Glewwe, P., 2000. Designing Household Survey Questionnaires for Developing Countries: Lessons from 15 Years of the Living Standards Measurement Study Vol. 1 The World Bank, Washington, D.C.

Gujarati, D.N., 2004. Basic Econometrics, 4th ed. McGraw-Hill, New York.

Hazell, P.B.R., Poulton, C., Wiggins, S., Dorward, A., 2007. The future of small farms for poverty reduction and growth. Discussion Paper 42. Washington, DC. International Food Policy Research Institute.

Herzig, A., Nguyen, T.T., Ausseil, A.G., Maharjan, G.R., Dymond, J.R., Arnhold, S., Koellner, T., Rutledge, D., Tenhunen, J., 2018. Assessing resource-use efficiency of land use. Environ. Model. Softw. 107, 34–49.

Ho, Q.T., Hoang, V.N., Wilson, C., Nguyen, T.T., 2017. Which farming systems are efficient for Vietnamese coffee farmers? Econ. Anal. Pol. 56, 114–125.

Holden, S.T., Ghebru, H., 2016. Land rental market legal restrictions in Northern Ethiopia. Land use policy 55, 212–221.

Holden, S.T., Otsuka, K., 2014. The roles of land tenure reforms and land markets in the context of population growth and land use intensification in Africa. Food Policy 48, 88–97.

Hung, P.V., MacAulay, T.G., Marsh, S.P., 2007. The economics of land fragmentation in the North of Vietnam. Aust. J. Agric. Resour. Econ. 51, 195–211.

Huy, H.T., Lyne, M., Ratna, N., Nuthall, P., 2016. Drivers of transaction costs affecting participation in the rental market for cropland in Vietnam. Aust. J. Agric. Resour. Econ. 60, 476–492.

Jin, S., Deininger, K., 2009. Land rental markets in the process of rural structural transformation: productivity and equity impacts from China. J. Comp. Econ. 37, 629–646.

Kerkvliet, B.J.T., 2006. Agricultural land in Vietnam: markets tempered by family, community and socialist practices. J. Agrar. Chang. 6, 285–305.

Khanal, U., Wilson, C., Shankar, S., Hoang, V.N., Lee, B., 2018. Farm performance analysis: technical efficiencies and technology gaps of Nepalese farmers in different agro-ecological regions. Land use policy 76, 645–653.

Kille, G.S., Lyne, M.C., 1993. Investment on freehold and trust farms: theory with some evidence from Kwazulu. Agrekon 32, 101–109.

Kodde, D., Palm, F., 1986. Wald criteria for jointly testing equality and inequality restrictions. Econometrica 54, 1243–1248.

Koirala, K.H., Mishra, A., Mohanty, S., 2016. Impact of land ownership on productivity and efficiency of rice farmers: the case of the Philippines. Land use policy 50, 371–378.

Kumbhakar, S.C., Lovell, C.A.K., 2000. Stochastic Frontier Analysis. Cambridge University Press, Cambridge.

Kurosaki, T., 2008. Crop choice, farm Income, and political control in Myanmar. J. Asia

Pacific Econ. 13, 180–203.
Lowder, S.K., Skoet, J., Raney, T., 2016. The number, size, and distribution of farms, smallholder farms, and family farms worldwide. World Dev. 87, 16–29.
Lyne, M.C., Nieuwoudt, W.L., 1991. Inefficient land use in Kwazulu: causes and remedies. Dev. South. Afr. 8, 193–201.
Ma, X., Heerink, N., Feng, S., Shi, X., 2015. Farmland tenure in China: comparing legal, actual and perceived security. Land use policy 42, 293–306.
Markussen, T., Tarp, F., van den Broeck, K., 2011. The forgotten property rights: restrictions on land use in Vietnam. World Dev. 39, 839–850.
Meeusen, W., Broeck, J.D., 1977. Efficiency estimation from Cobb-Douglas production functions with composed error. Int. Econ. Rev. (Philadelphia) 18, 435–444.
Michler, J.D., Shively, G.E., 2014. Land tenure, tenure security and farm efficiency: panel evidence from the Philippines. J. Agric. Econ. 66, 155–169.
Nguyen, T.T., 2012. Land reform and farm production in the Northern Uplands of Vietnam. Asian Econ. J. 26, 43–61.
Nguyen, T.T., Bauer, S., Uibrig, H., 2010. Land privatization & afforestation incentive of rural farms in the Northern Uplands of Vietnam. For. Policy Econ. 12, 518–526.
Nguyen, T.T., Ngu, V.H., Seo, B., 2012. Cost and environmental efficiency of rice farms in South Korea. Agric. Econ. 43, 367–376.
Nguyen, T.T., Bauer, S., Grote, U., 2016. Does land tenure security promote manure use by farm households in Vietnam? Sustainability 8, 178.
Nguyen, T.T., Nguyen, D.L., Lippe, R.S., Grote, U., 2017. Determinants of farmers' land use decision-making: comparative evidence from Thailand & Vietnam. World Dev. 89, 189–213.
Nguyen, T.T., Do, T.L., Parvathi, P., Wossink, A., Grote, U., 2018. Farm production efficiency and natural forest extraction: evidence from Cambodia. Land use policy 71, 480–493.
Niroula, G.S., Thapa, G.B., 2005. Impacts and causes of land fragmentation, and lessons learned from land consolidation in South Asia. Land Use Policy 22, 358–372.
Nonthakot, P., Villano, R.A., 2008. Migration and farm efficiency: evidence from Northern Thailand. Paper Presented at the Australian Agricultural and Resource Economics Society, 2008.
Norton, R.D., 2004. Agricultural Development Policy: Concepts and Experiences. Wiley, Hoboken, NJ.
Ojo, M.A., Mohammed, U.S., Ojo, A.O., Olaleye, R.S., 2009. Return to scale and determinants of farm level technical inefficiency among small scale yam based farmers in Niger State, Nigeria: Implications for food security. International Journal of Agricultural Economics & Rural Development 2, 43–51.
Pender, J., Fafchamps, M., 2006. Land lease markets and agricultural efficiency in Ethiopia. J. Afr. Econ. 15, 251–284.
Place, F., Migot-Adholla, S.E., 1998. The economic effects of land registration on smallholder farms in Kenya: evidence from Nyeri and Kakamega districts. Land Econ. 74, 360–373.
Rahman, S., 2010. Determinants of agricultural land rental market transactions in Bangladesh. Land use policy 27, 957–964.
Rahman, S., Rahman, M., 2008. Impact of land fragmentation and resource ownership on productivity and efficiency: the case of rice producers in Bangladesh. Land use policy 26, 95–103.
Ravallion, M., van de Walle, D., 2008. Land in Transition: Reform and Poverty in Rural Vietnam. Palgrave Macmillan, Washington, DC.
Sadoulet, E., de Janvry, A., Fukui, S., 1997. The meaning of kinship in sharecropping contracts. Am. J. Agric. Econ. 79, 394–406.
Sjaastad, E., Bromley, D.W., 1997. Indigenous land rights in sub-Saharan Africa: appropriation, security and investment demand. World Dev. 25, 549–562.
Smith, W., Williamson, I., Burns, A., Chung, T.K., Ha, N.T.V., Quyen, H.X., 2007. The impact of land market processes on the poor in rural Vietnam. Surv. Rev. 39, 3–20.
Su, B., Li, Y., Li, L., Wang, Y., 2018. How does nonfarm employment stability influence farmers' farmland transfer decisions? Implications for China's land use policy. Land use policy 74, 66–72.
Swinnen, J., Vranken, L., Stanley, V., 2006. Emerging challenges of land rental market: a review of available evidence for the Europe and Central Asia region. Chief Economist's Regional Working Paper Series 1(4). The World Bank, Washington, DC.
Tan, S., Heerink, N., Kuyvenhoven, A., Qu, F., 2010. Impact of land fragmentation on rice producers' technical efficiency in South-East China. Njas - Wageningen J. Life Sci. 57, 117–123.
Thomson, D.N., Lyne, M.C., 1991. A land rental market in Kwazulu: implications for farming efficiency. Agrekon 30, 287–290.
Trung, L.D., Hung, P.T., 2009. Construction of the panel data Vietnam household living standard surveys (VHLSS) 2002–2006. Working Paper. Indochina Research and Consulting, Hanoi.
Tung, P.D., Phong, N., 2006. Vietnam household living standards survey (VHLSS), 2002 and 2004: basic information. Hanoi: General Statistics Office of Vietnam.
van de Walle, D., Cratty, D., 2004. Is the emerging nonfarm market economy the route out of poverty in Vietnam? Econ. Transit. 12, 237–274.
Vranken, L., Swinnen, J., 2006. Land rental markets in transition: theory and evidence from Hungary. World Dev. 34, 481–500.
Wang, Y., Li, X., Li, W., Tan, M., 2018. Land titling program and farmland rental market participation in China: evidence from pilot provinces. Land use policy 74, 281–290.
WB, 2016. Transforming Vietnamese Agriculture: Gaining More From Less. Washington, DC.Transforming Vietnamese Agriculture: Gaining More From Less. Washington, DC.
WB, 2017. Taking Stock: an Update on Vietnam's Recent Economic Developments - Special Focus: Improving Efficiency and Equity of Public Spending. Washington, DC.
Wilson, P., Hadley, D., Asby, C., 2001. The influence of management characteristics on the technical efficiency of wheat farmers in Eastern England. Agric. Econ. 24, 329–338.
Wilson, P., Hadley, D., Ramsden, S., Kaltsas, I., 1998. Measuring and explaining technical efficiency in UK potato production. J. Agric. Econ. 49, 294–305.
Wooldridge, J.M., 2003. Introductory Econometrics: a Modern Approach, 2 ed. South-Western College Publishing, Mason.
Zhang, Y., Wang, X., Glauben, T., Brümmer, B., 2011. The impact of land reallocation on technical efficiency: evidence from China. Agric. Econ. 42, 495–507.