INSTITUTE OF DEVELOPING ECONOMIES

IDE Discussion Papers are preliminary materials circulated
to stimulate discussions and critical comments

IDE DISCUSSION PAPER No. 519

Land and labor reallocation in pre-modern Japan: A case of a northeastern village in 1720–1870

Yutaka ARIMOTO* and Satomi KUROSU

March 2015

Abstract

In agricultural societies, adjusting land and labor according to changes of labor endowment that result from family life cycle events is premised on making full use of resources for each farming household and for the economy as a whole. This paper examines how and how well households in pre-modern Japan reallocated land and labor, using a population register covering 150 years from 1720–1870 for a village in the Tohoku region. We find that households reacted to equalize their production factors; land-scarce households tended to acquire or rent-in land and out-migrate their kin members, while land-abundant households tended to release or rent-out land, in-migrate kin members, or employ non-kin members. Estimates suggest that more than 80% of the surplus or deficit area of land was resolved if the household rented or "sold" land. We discuss a potential underlying mechanism; namely, that the village's collective responsibility for tax payment (*murauke*) motivated both individual households and the village as a whole to reallocate land and labor for the efficient use of resources.

Keywords: land reallocation, land-to-labor ratio; factor equalization; land market; pre-modern Japan

JEL classification: D13; N55; O13; Q12; R20

* Researcher, Development Studies Center, IDE (Yutaka_Arimoto@ide.go.jp)

The Institute of Developing Economies (IDE) is a semigovernmental, nonpartisan, nonprofit research institute, founded in 1958. The Institute merged with the Japan External Trade Organization (JETRO) on July 1, 1998. The Institute conducts basic and comprehensive studies on economic and related affairs in all developing countries and regions, including Asia, the Middle East, Africa, Latin America, Oceania, and Eastern Europe.

The views expressed in this publication are those of the author(s). Publication does not implied endorsement by the Institute of Developing Economies of any of the views expressed within.

INSTITUTE OF DEVELOPING ECONOMIES (IDE), JETRO
3-2-2, WAKABA, MIHAMA-KU, CHIBA-SHI
CHIBA 261-8545, JAPAN

©2015 by Institute of Developing Economies, JETRO
No part of this publication may be reproduced without the prior permission of the IDE-JETRO.

Land and labor reallocation in pre-modern Japan:
A case of a northeastern village in 1720–1870*

Yutaka Arimoto Satomi Kurosu

March 26, 2015

Abstract

In agricultural societies, adjusting land and labor according to changes of labor endowment that result from family life cycle events is premised on making full use of resources for each farming household and for the economy as a whole. This paper examines how and how well households in pre-modern Japan reallocated land and labor, using a population register covering 150 years from 1720–1870 for a village in the Tohoku region. We find that households reacted to equalize their production factors; land-scarce households tended to acquire or rent-in land and out-migrate their kin members, while land-abundant households tended to release or rent-out land, in-migrate kin members, or employ non-kin members. Estimates suggest that more than 80% of the surplus or deficit area of land was resolved if the household rented or "sold" land. We discuss a potential underlying mechanism; namely, that the village's collective responsibility for tax payment (*murauke*) motivated both individual households and the village as a whole to reallocate land and labor for the efficient use of resources.

Keywords: land reallocation, land-to-labor ratio; factor equalization; land market; pre-modern Japan

JEL classification: D13; N55; O13; Q12; R20

* Yutaka Arimoto, Institute of Developing Economies, Japan External Trade Organization. (Email: arimotoy@gmail.com). Satomi Kurosu, Reitaku University. (Email: skurosu@reitaku-u.ac.jp).

We are grateful to Chiaki Moriguchi and Osamu Saito, and participants of the seminar at University of Tokyo, Hitotsubashi University, for comments and suggestions. This paper was supported by the Grant-in-Aid for Scientific Research (S) (KAKENHI- 22223003) and Grant-in-Aid for Scientific Research (A) (KAKENHI-25245047). All errors are ours.

1. Introduction

Efficient reallocation of production factors in agriculture, such as farmland and labor, is a prerequisite for making full use of resources and maximizing agricultural output in a given region. The continuous need for this factor reallocation is obvious given that the number, sex, and age composition of household members changes over the family life cycle through life events and processes such as death, birth, aging, marriage, and migration. Allocation of land from land-abundant households to land-scarce households, or allocation of labor from the latter to the former will improve the utilization of resources and raise productivity of both households.

In general, decentralized land sales and rental markets play a key role in reallocating land. Recent evidence based on farm-level data suggests that land is reallocated from land-abundant to land-scarce households, and from less productive to more productive households, by way of sales or rentals (Pant (1983); Skoufias (1995); Kevane (1996); Deininger and Jin (2005; 2008); Deininger, Jin, and Nagarajan (2008; 2009); Deininger, Ali, and Alemu (2008); Deinigner, Zegarra, and Lavadenz (2003); Vranken and Swinnen (2006)). However, in certain context such as China or Vietnam, a centralized "visible hand" of the village or community authority also plays a role (Deininger and Jin (2005); Ravallion and van de Walle (2006)). However, such administrative reallocation is reported to be less efficient than decentralized market-based solutions due to transaction costs related to obtaining information on supply and demand, negotiation of contractual terms, and contract enforcement (Deininger and Jin (2005)).

This paper aims to study the allocation of farmland and labor over a long-period historical perspective in pre-modern Japan. In particular, we attempt to answer the following questions. How and how well was land and labor reallocated between households? How did households react to abundance or scarcity of land with changes of labor endowment over family life cycle? The case of pre-modern Japan is of particular interest because, despite the land being allocated by both non-market institutions and severely regulated market institutions, the allocation seems to be comparably efficient and egalitarian compared to rural societies in the pre-modern West (Kurosu and Lundh 2014: 48–50). These facts raise the question of how and why such reallocation was achieved under regulated markets. Our aim is to provide figures that describe the resource reallocation among households via adjustments for land deficiency and to examine the efficiency of land market in this context.

To examine land and labor reallocation in pre-modern Japan, we study the case of Niita, a village in what is now Fukushima Prefecture in northeastern Japan. We make use of a longitudinal micro-level data, the *Ninbetsu Aratame Cho* (NAC)[2], a population register spanning

[2] The original database (Xavier) was made available by the Eurasian Project on Population Family History (1996-2000) directed by Akira Hayami. The database has been extended by and now is being hosted at the Population and Family History Project, Reitaku University.

150 years between 1720 and 1870. The NAC of this area was taken annually and is known for its exceptional quality in terms of length and detail. It covers all households and individuals in the village with demographic information, migration details, and information on land (area owned, rented, and cultivated). From this information on landholdings per household, we construct an index of land deficiency for each household, which measures the gap between a "standard" area operated (i.e., cultivated), with adjustment for household characteristics, and the actual area owned. We then use non-parametric and parametric techniques to examine how households responded to cope with abundance or deficiency of land relative to their labor endowments.

We find that households reacted in several ways to equalize production factors. More land-scarce households tended to rent-in or acquire land, or out-migrate kin members, while the more land-abundant households tended to rent-out or release land, employ non-kin members, acquire additional horses, and in-migrate kin members. The estimates indicate that more than 80% of the surplus or deficit area of land was dissolved if the household participated in renting or transfer of land.

We argue that this efficient and egalitarian land reallocation was driven by the *murauke* ("village-responsible") taxation system, where the households in the village were jointly responsible to pay the land tax levied to the village as a unit, which was collected as a fixed amount of rice. Decline of village members or households and inefficient land use (i.e., land abandonment) implied low total production and therefore a more severe tax burden for each household, or ultimately a failure in fulfilling the tax duty. To avoid such a situation, the village had explicit incentives to maintain the number of households and reallocate land from land-abundant to land-scarce households.

We contribute to our understanding on the function and efficiency of market and non-market mechanisms that allocates land. We add a case for pre-modern Japan to the growing literature that explores the determinants of participation to land (rental) markets in efforts to assess its efficiency (Pant (1983); Skoufias (1995); Kevane (1996); Deinigner, Zegarra, and Lavadenz (2003); Deininger and Jin (2005; 2008); Ravallion and van de Walle (2006); Vranken and Swinnen (2006); Deininger, Ali, and Alemu (2008); Deininger, Jin, and Nagarajan (2008; 2009)). Our case is unique in that the land market was highly regulated by the village, which intervened often, but yet achieved a relatively efficient allocation of land.

We also add to the small but unique literature by Japanese economic historians that explores land reallocation in pre-modern Japan, with specific focus on its relationship with family life cycle (Numata (2001); Tomobe (2007)). Motivated by Chayanov (1966/86)'s theory of peasant economy, Numata and Tomobe indicated that farm households in pre-industrial Japan with a larger dependency ratio tended to operate larger land areas, and that such adjustment was supported by land rental rather than transfer. Labor-abundant households were also more likely to participate in subsidiary jobs. However, their analyses are mostly based on cross-sectional data with a small sample size, rather than tracking of longitudinal changes within the same household. This paper is the first systematic quantitative study that fully exploits intra-household variation of labor endowment to discuss the relationship between land reallocation and family life cycle.

The paper is structured as follows. In Section 2, we provide some accounts on the background to understand the context of the study. Section 3 describes the data, measurement, and method used for the data analyses. We provide our main results in Section 4. We interpret and discuss the findings in Section 5. Finally, Section 6 concludes.

2. Background

2.1. Institutional context

In this subsection, we give an account on some notable characteristics of households and village organizations in preindustrial agrarian Japan, such as households, village organization, and household landholding and land tax. Because Tokugawa Japan is known for its regional patterns of economic and demographic diversity, we pay special attention to the practices of the study village, Niita, in northeastern Japan.

Households and village organization

Households were important units of production and consumption, and were also vital in providing welfare for villagers. Succession or continuity of the household (*ie*), as in name, property, and business, was an overriding aim of family continuity in agrarian Japan, and in turn, served as basis for agricultural and further development in the modern economy (Sakane 2011: 19). The survivorship of households, or more specifically, maintaining the necessary number of households as productive units, was also of direct concern for the village organization, where lives were structured around farming and where the tax burden was shared (Kurosu 2013).

According to the population registry of this village, villagers occupied mainly two status categories: (a) landholding villagers (*honbyakusho*); and (b) landless villagers who were either landless peasants (*mizunomi*) or house renters (*tanagari*). In general, landholding villagers were registered in the cadastral register and possessed paddy land, upland, and homestead, enabling them to be independent farmers. Such villagers were responsible for payment of basic land taxes, allowed to attend village assemblies, and had the right to voice their opinions on village affairs, while landless villagers held only minimal strips of land and were not allowed to take part in the deciding of village affairs (Sato 1991: 46). These social statuses were by no means fixed or hereditary, and changes in the economic and social conditions of individual peasants resulted in shifts in relative class standing (Sato 1991: 47).

Village officials, in principle, were selected by the village assembly, and the Tokugawa or domain government refrained from interfering and merely ratified the choice (Sato 1991: 54). However, regional variations in how village officials were selected and functioned were large. The *nanushi* (village head) was typically selected by rotation, election, or hereditary. Sato (1991: 55) discusses that where hereditary systems for *nanushi* prevailed, the position became monopolized by a single family and village governance was conducted by a handful of people. Indeed, in the case of Niita, the position was succeeded by one family over the observed period. Other village officials (*kumigashira*, group leaders) in the study villages, however, were not hereditary and households of solid economic background seem to have served the position in turn.

Household landholding and land tax

One major characteristic of the Tokugawa economy is the *kokudaka* system (Hayami 1985: 75–107). All agricultural output was measured, taxes on farmers and peasants (not individually, but on their villages as a whole) were assessed, and the income of domain lords and their warriors (samurai) were expressed in terms of potential quantity of rice output (*koku*) rather than by area. Therefore, land quality (productivity per area), in addition to area, is adjusted. This was standard in the Tokugawa period[3].

De facto land ownership was already established at the time of the study period under the Tokugawa regime[4]. The “ownership” of land was authorized by a registration (*nauke*) on the cadaster (*kenchi cho*) by the village head. The cadaster was updated upon changes of the ownership. Once an owner was registered, he shared the duty to pay a proportion of the land tax burdened to the village. Furthermore, the owner was the residual claimant and was able to freely dispose of the remaining land output after he had paid his share of the tax burden.

The land tax and other village taxes were assessed and collected on a per-village basis, as corporate units (Brown 2011). That is, taxes on farming villages were imposed not on individual households, but on the village as a whole, and the households of titled peasants were responsible

[3] The system was facilitated by the physical and social separation of samurai from farmers and peasants (Hayami 1985: 75–78). Whereas samurai lived in the castle town of their domain lord, villages were inhabited by peasants; thus, in Tokugawa Japan, the so-called landed warriors ceased to exist, and samurai became a type of salaried official of the domain governments. Meanwhile, villages and peasants were required to pay taxes: in some domains, they were required to pay solely in rice; in others, they were to pay in money (Tsuya and Kurosu 2004a: 257).

[4] For general overview of land institutions in pre-modern Japan, see Watanabe (2007) and Otsuka (2002).

for shouldering these taxes in accordance with the expected yields of the land they held. Put differently, household landholding (in *koku*) is not the physical size of farm land owned by each household, but the expected yield of that land based, on which tax was assessed. In general, the land tax was burdened to the village as a fixed amount of rice based on the expected productivity and total area of farmland in the village. The land tax was then re-assigned to each landowner by the village head or village administrators. Households in the village were obliged a joint liability in paying the tax burdened to the village. These practices characterize the *murauke* (literally meaning "village responsible") system. "If a peasant failed to contribute his share of the tax, the village as a whole had to make up the deficit. This system of communal responsibility of the land tax is a distinguishing characteristic of Tokugawa taxation (Sato 1991: 42)."

Land allocation: Land market, customs and informal interventions

In 1643, the sale of land was prohibited by law (via the *Denpata Eitai Baibai Kinshirei*). However, while the law prohibited *permanent* sales, it did not explicitly forbid *temporary* sales. Therefore, land was frequently sold "temporarily" with a pledge for a certain period of years (usually 10 to 20 years). Lending and borrowing of money among households in the village was common, and land was often used as collateral. When the borrower was not able to repay the principal by the end of the term, the land was foreclosed and the ownership transferred to the lender. Therefore, this practice of pledge-and-foreclose functioned as a major method of land transference, avoiding the official restriction of land sales. There was no legal restriction on land rental; as we see below, however, the villages often intervened into rental arrangements.

The allocation of land was affected by customs, informal rules, and interventions by the village. For example, a strong custom that restricted the complete transfer of landownership was the practice that when ownership of land was transferred after foreclosure, the original owner customarily retained the right to regain the foreclosed land whenever he/she repaid the principal (Shirakawabe 1994).

The village also intervened into the land market. Land in the village was considered to be owned by each villager, but at the same time, the village community as a whole was also regarded as holding ownership (Watanabe 2007: 146)[5]. Because of this sense of group ownership by the village, the village community intervened significantly in land transactions. For example, pledging or selling land to residents of other villages was prohibited or restricted. The village was also engaged in the formation of landlord-tenant relationships following the transfer of land. The village often set a uniform rent ceiling, and the village head played a role

[5] This concept of multi-layered or joint ownership is called "indirect land ownership (*kansetsu-teki tochi shoji*)" in the academics of Japanese pre-modern history.

in collecting the rent with land tax on behalf of the landlord (Watanabe 2007: 147).

There was even an administrative and collective land reallocation[6] (*warichi*) executed periodically to even out the tax burden and various risks, including damage from floods, landslides, and changes in soil fertility (Watanabe 2008: 71; Brown 1997). The village prevented the concentration of the best lands in the hands of a few families and ensured a diverse portfolio of lands of all types for each shareholding family (Brown 1997). This practice of *warichi* was often reported in coastal villages and in the Shikoku area but also seen in many other parts of the country (Watanabe 2008:72; Brown 1997). In Niita, there is a record of *warichi* occurring in 1794, but the lasting effect in Niita of this event is not clear. Narimatsu (1992: 145) claims that the fact *warichi* was practiced only once in the whole 150-year observation period suggests that the 1794 *warichi* might have been more of formality than a real necessity[7].

2.2. The setting

This study draws its data from local population registers in Niita, a farming village in northeastern Japan. During the Tokugawa period (1603–1868), the village belonged to the Nihonmatsu *han* (domain) that governed the central part of what is now Fukushima Prefecture. Among the major regions of Tokugawa Japan, the northeast was in general the one with the least economic development and proto-industrialization. Niita, located on a flat plane between two major population centers of domain at the time—the capital town of Nihonmatsu and the growing market town of Koriyama—had a relatively good climate for agriculture (Narimatsu 1992: 4–6). However, as it lay on the bank of the Gohyaku River, the village was vulnerable to frequent floods.

Niita was almost totally agricultural (Narimatsu 1992: 6) and the livelihood in the village was often at the mercy of fluctuations in agricultural output. Households and their members were often vulnerable to income variations caused by frequent crop failures and famines. In particular, the northeastern region surrounding Niita experienced a series of serious famines: the Horeki famine in 1755, the most devastating and long Tenmei famine from 1783 to 1787, and the Tempo famine from 1836 to 1838 (Tsuya and Kurosu 2004b: 256).

Landholding, reflecting household wealth, had a strong bearing on the demographic behaviors of peasants in rural communities in Japan. Recent studies on the same data demonstrated a significant relationship between household landholdings and individual probabilities of death, marriage, migration, and household continuation (e.g. Tsuya and Kurosu,

[6] Brown (1997) calls this custom “repartition”.

[7] However, as we see below, data reveal several spikes of land reallocation where more than 5% of the total land in the village was transferred in a year, suggesting some kind of collective reallocation that might have not been recorded officially.

2004(a), 2004(b), 2010, 2014). For example, children and elderly in wealthier households were less likely to die (Tsuya and Kurosu 2004a); landless peasants were more likely to migrate rather than die upon major crop failures (Tsuya and Kurosu 2010); and household wealth and resources prevented households from going extinct by losing their members due to death, migration, or absconding, through increasing the likelihood of headship succession after retirement of the previous head (Tsuya and Kurosu 2004b). These observations suggest that wealth inequality could incur serious negative effects on one's livelihood, especially for the poor, and indicate the need for land reallocation. Yet another way for peasants to mitigate the adverse conditions caused by economic hardship was migration. Peasants are thought to have used various types of migration to maintain an optimum level of household economy and size (through service, marriage, and adoption) or to flee from economic burden or seek opportunities elsewhere (through absconding) (Tsuya and Kurosu 2010, 2013; Kurosu 2011).

It is important to note that service migration (and out-migration in general) suddenly declined after the 1780s, continuing to decline until the end of the Tokugawa period. This change coincided with the reversal of the domain's policies from discouragement to encouragement of proto-industrial development (Koriyama-shi 1981: 79–81; Nagata, Kurosu and Hayami 1998). This suggests that local proto-industrialization including sericulture reduced the likelihood of out-migration by making it increasingly unnecessary for peasants to engage in long-term and long-distance labor contracts that kept them away from their home villages for 6 months or longer (Nagata 2001; Tsuya and Kurosu 2013).

3. Data and method

3.1. Data

We use the population register (*Ninbetsu Aratame Cho*) of Niita Village in Nihonmatsu *han*. The data is available for 150 years (1720–1870). Although there are 5 missing years (1742, 1758, 1796, 1857, and 1858), and land data is missing for years from 1725 to 1736, the data otherwise cover a virtually undisrupted period spanning the latter half of the Tokugawa era (1603–1868).

The NAC registers enumerated individuals residing in the village in terms of household (the NAC registers were in some sense household registers) and contain a wealth of information pertaining to the demographic and socioeconomic characteristics of households and their members, including household size and composition, wealth, and relationships. The NAC for Niita is particularly suited for this study as it contains a detailed description regarding land transactions: land owned, cultivated, and leased (from/to whom and for how long).

Our sample size is 134 years and 14,490 household–years. The number of unique households observed in the data is 298. Most of the analysis below uses the household–year as the unit of observation.

3.2. Method

The key variable of interest is the index of land deficiency, which measures the imbalance of land and labor in a household. The land deficit (LD) is defined as

$$LD_i = A_i^* - A_i \tag{1}$$

where A_i^* is the "standard" (effective) area[8] *operated* and A_i is the actual area *owned* by household i.

We construct two indexes. The first index is the *unadjusted land deficit* where the standard area operated is determined by egalitarian distribution of the sum of area owned in the village (i.e., total area of land in the village), among households based on their number of kin members. That is,

$$A_i^* = \frac{\sum_i A_i}{\sum_i L_i} \times L_i \tag{2}$$

where L_i is the number of kin members for household i. The unadjusted land deficit is the most simple, crude measure of land deficiency. However, it does not take into account differences in household characteristics such as the household status, and sex/age composition.

The second measure is the *adjusted land deficit*, where the standard area operated is predicted by adjusting for differences in household characteristics. To construct the adjusted standard area operated, we fit the following linear model for each year with ordinary least squares (OLS):

$$A_i + A_i^r = \alpha + \beta X_i + \varepsilon_i, \tag{3}$$

where A_i^r is the net area rented-in (negative if rented-out, so the left-hand side is the area operated) and X_i is the vector of household characteristics. We then use the estimates $\hat{\alpha}$ and $\hat{\beta}$ to predict the adjusted standard area operated for each household:

$$\widehat{A_i^*} = \hat{\alpha} + \hat{\beta} X_i. \tag{4}$$

[8] All data of land are measured and recorded by potential quantity of output of rice (in *koku*) rather than by area. Therefore, land quality (productivity per area) as well as area are adjusted. See discussion in 2.1.

In doing so, we set the number of non-kin members to zero. Thus, $\widehat{A_i^*}$ represents the "standard" area operated, if a household operated the land with only their kin members[9].

Appendix Table A1 reports the OLS estimates of equation (3), pooling all years (note that the actual $\widehat{A_i^*}$ is estimated for each year separately). We include: the head's age and its square; dummy for female-headed household; dummies for non-landowner (non-*honbyakusho*) status; landless (*mizunomi*) and others; dummy for branch household (*bunke*); number of horses; number of kin members by sex and age groups (below 15, 15–54, above 55 years old); and number of non-kin members as independent variables. Estimates indicate that non-landowner household status is negatively correlated with area, while number of horses and number of workers (both kin and non-kin) are correlated positively[10].

The outcome of interest is the adoption of factor-ratio stabilization strategies to cope with land deficiency. Instantaneous strategies that are observed in the same year facing land deficiency include: renting-out land and hiring non-kin members for land-abundant households; and renting-in land for land-scarce households. More fundamental strategies to deal with land deficiency that can be observed during a certain time interval are: acquiring land; increasing kin members (in-migration); and increasing number of horses for land-abundant households; while releasing land or decreasing kin members (out-migration) for land-scarce households. We created dummy variables for adoption of these strategies.

We quantitatively examine two questions on land allocation. First, did households adopt strategies to stabilize their land-to-labor ratio? To answer this, we estimate a probit model that regress the adoption of various factor-ratio stabilization strategies on land deficit and other controls. Secondly, how much of the land deficit had been adjusted? Conceptually, the adjustment coefficient θ is defined by

$$R_i = \theta(A_i^* - A_i) \tag{5}$$

where R_i is the net area of rental (or transfer), and $A_i^* - A_i$ is the land deficit as defined above (Otsuka (2007)). If $\theta = 1$, the land deficit is completely adjusted. We regress the following model with OLS to estimate θ:

---

9 There were few cases where $\widehat{A_i^*} < 0$. For those observations, we set them to zero.

10 The estimates indicate that the coefficient of the number of adult female kin members tend to be almost twice as large as that of male members: in column (4) the coefficient of the number of kin members for female and men aged 15–54 is 1.612 (95% CI: 1.154–2.070) vs. 0.967 (95% CI : 0.468–1.466) and 1.371 (95% CI: 0.767–1.975) vs. 0.583 (95% CI: -0.103–1.270) for age 55 years old and above. We do not have a clear explanation for this result.

$$y_{it} = \alpha + \theta LD_{it} + \gamma X_{it} + \delta_t + \varepsilon_{it}, \tag{6}$$

where y_{it} is the net area rented-in for year t or net area acquired during year t and $t+1$ (1-year interval) or during year t and $t+10$ (10-year interval). y_{it} is negative if rented-out or released. LD_{it} is the index of land deficit, X_{it} is the vector of household characteristics, δ_t is the year dummy, and ε_{it} is the error term. We estimate Eq. (6) with and without household fixed effects.

4. Results

In this section, we examine the efficiency of land allocation between households. We first describe the data, and then report the results on adoption of factor-equalization strategies and the extent to which land rental or land transfer functioned for the adjustment of land deficit.

4.1. Description of the data

Figure 1 depicts the trend of population and the number of households with resident members. The population had been relatively stable at around 520–540 persons with some fluctuations until the early 1770s, a decade before the Great Tenmei famine. However, from about 1770 until 1820, the population dropped from 514 persons to 367 persons, representing a 29% decline. The population then began to increase again and recovered to 1770 levels in 1861, reaching the highest recorded population of 555 persons in the final year of observation (1870). The number of households followed a similar trend, except that it did not recover after the decline. The number of households had been relatively stable at around 120–130 with minor fluctuations until the early 1780s (the decade of the Great Tenmei famine), but declined gradually and steadily from 143 in 1772 to 92 in 1843, a 36% decline. The number then stabilized at around 90 until the end of the NAC records.

Accordingly, the mean household size (defined by number of kin and non-kin members) shows an impressive increase, particularly after the end of the Tempo famine (1838). The mean household size was 4.0 in 1720, but rose to 6.2 by the end of observation in 1870. Kurosu (2010) attributes this dramatic increase of the household size to at least three factors: increase number of children (Tsuya and Kurosu 2010); compositional change of households due to the decline of solitary households and the increase of the stem family household; and the decline of the proportion of landless households.

Figure 2 depicts the land "market", the trend of the total area owned, operated, rented-in, and rented-out, for all recorded households. The total area owned or operated is meant to represent the total area of arable land in the village, or the extent of the village's land "market". **Figure 3**

depicts the proportion of the total area transferred (released or acquired) relative to the total area of land owned the previous year, which captures the activeness of the land "sales". **Figure 4** depicts the proportion of the total area rented relative to the total area of land owned in the same year, which captures the activeness of the land rental market.

Figure 5 shows the trend of the share of households by landholding strata. We categorized the households by area of land owned into 5 strata: 0 *koku* (landless); 0–4 *koku*; 5–10 *koku*; 10–14 *koku*; and 15+ *koku*. Two features are apparent from the figure: first, there was a decline in the share of landless households. In 1720, there were 45 (34% of 136) landless households. The number and the proportion of the landless continued to decline, reaching 4 households in 1843, and not increasing beyond 5 households thereafter. Second, the proportion of households with 10–14 *koku* increased, accounting for a plurality of households after 1794 and exceeding 50% after 1853.

Table 1 shows the characteristics of households for all observations and observations by four adjusted land deficit groups (<-5, -5–0, 0–5, and 5+ *koku*). Land-abundant households tend to have a larger area owned (per kin member) but reduced their operated area by renting out land. Households in the most land-scarce group tend to have more kin members, while households in the most land-abundant group tend to hire a non-kin member. On average, the land-to-labor ratio, based on operated land and number of kin members, is 2.8 *koku*, which means that each worker cultivates approximately 3 *koku* of land. Thus, the most land-abundant or land-scarce group, with more than 5 *koku* of land surplus or deficit, are in excess or short of land that require roughly two (1.8) or more workers to cultivate.

Figure 6 depicts the trend of the standard deviation of land-to-labor ratio among households, defined by combination of area owned or area operated and with and without non-kin members. The standard deviation is lower when it is defined by area operated as opposed to area owned, and when including the number of non-kin members. These imply that land rental and hiring of non-kin members helps equalize the factor ratio among households.

4.2. Adoption of factor equalization strategies

Figure 7 depicts the non-parametric estimates of Cleveland (1979)'s mean-adjusted locally weighted regressions (Lowess smoother) of adoption of three factor-ratio stabilization strategies (land rental, land transfer, and social migration of kin members) on adjusted land deficit.

Table 2 reports the average marginal effects of the Probit model regressing the adoption of factor equalization on adjusted land deficit group dummies and other controls. **Figure A1** in the Appendix visualizes the average predicted probabilities of adopting each strategy by adjusted land deficit groups, based on estimates. The reference land deficit group is the group with adjusted land deficit between 0–5 *koku*. Estimates indicate that compared to the reference group, the additional percentage points for the most land-abundant group (land surplus > 5 *koku*) to rent-out is 23.5 (95% confidence interval (CI): 18.2–28.9); to employ non-kin members is 13.5 (95% CI: 8.6–18.5); and to release land is 6.1 (95% CI: 4.7–7.6). However, the additional percentage points for the most land-scarce group (land deficit > 5 *koku*) to rent-in is 15.0 (95% CI: 8.9–21.1) and to acquire land is 1.8 (95% CI: 0.4–3.2). Adjustment through migration is not statistically significant at the 5% level, but the direction is consistent with factor-ratio stabilization: additional percentage points for the most land-abundant group to in-migrate is 0.9 (95% CI: -0.99–2.75) and the additional percentage points for the most land-scarce group to out-migrate is 1.5 (95% CI: -0.39–3.41).

Taken together, this evidence indicates a consistent pattern: the more land-scarce households tend to rent-in, acquire land, and out-migrate kin members, while the more land-abundant households tend to rent-out, employ non-kin members, increase the number of horses, release land, and in-migrate kin members. Clearly, these are signs that households reacted to adjust to land deficiency and stabilize the land-to-labor ratio.

4.3. Land adjustment coefficient

Figure 8a plots the net area rented-in on adjusted land deficit. Both variables are measured in the same year t. The 45-degree line guides the case of $\theta = 1$; the land deficit is perfectly adjusted for by land rental. The figure shows a clear positive correlation between the two variables. This suggests that land-abundant households tend to rent-out while land-scarce households tend to rent-in land. However, the Lowess smoother with all observations is largely deviated above the 45-degree line for the more land-abundant observations. This is driven by many observations of autarkic households that did not rent-out even though they owned excessive land. The Lowess smoother that considers only participants in land rental, appears to trace the 45-degree line more closely, especially for land-scarce observations.

Table 3, panel A reports the OLS estimates of the adjustment coefficient. As the main explanatory variable of interest, we use crude area owned in columns (1)–(4), adjusted land deficit in columns (5)–(8), and unadjusted land deficit in columns (9)–(12). Household characteristics are also included as controls (full estimates are reported in **Table A2** in the Appendix). For each of these three main explanatory variables, we estimate equation (6) with and without household fixed effects, and using all samples or limited samples that participated in land rental. The magnitudes of the coefficients for each model and sample are very similar among the three explanatory variables. The estimate in column (5) using adjusted land deficit indicates that 30.4% (95% CI: 19.1–41.7) of the land deficit is adjusted for by rental, but in column (6), the coefficient increases to 64.1% (95% CI: 50.1–78.2) when restricting the samples to participants in land rental. The adjustment coefficients are higher when including household fixed effects: 53.1% (95% CI: 44.4–61.8) for all samples and 80.3% (95% CI: 72.3–88.4) for rental participants (columns 7 and 8).

Figure 8b and **Table 3, panel B** show similar information for land transfer. The amount of land transferred is defined by the difference between the area owned in the base year t (when the land deficit is measured) and the following year $t+1$. Given that the incidence of land transfer is small, many households were not able to adjust their land deficit via this channel. For the estimation, we also control for number of deaths and births during years t and $t+1$, because land transfer is measured as a flow. The estimates in **Table 3, panel B**, column (5) indicates that overall, only 2.4% (95% CI: 1.6–3.3) of the land deficit was resolved through transfer by the following year, but if the households participated in land transfer, the adjustment coefficient is instead 47.2% (95% CI: 33.1–61.4) (column (6)). Similar to adjustment through rental, the adjustment coefficient improves dramatically when household fixed effects are included: 5.2% (95% CI: 4.3–6.2) for all samples and 81.6% (95% CI: 66.2–96.9) for samples participating in land transfer (columns (7) and (8)). Again, the results suggest that once the households were able to participate in land transactions, on average roughly 80% of their land deficit was dissolved.

Table 3 Panel C examines adjustment through transfer for longer intervals of 10 years. The dependent variable is the difference of area owned in base year t and year $t+10$, where t is set for every 10 years after 1740 through 1860 (1720 and 1730 are dropped because land data for 1730 is missing). The adjustment coefficient is 22.1% for all samples and 54.8% for samples participating in transfer (columns (5) and (6)). When household fixed effects are included, the coefficients are 46.5% for all samples and 94.9% for participants (columns (7) and (8)).

5. Discussion

We find that households reacted to stabilize their land-to-labor ratio; namely,: the more land-scarce households tended to rent-in or acquire land or out-migrate kin members, while the more land-abundant households tended to rent-out or release land, employ a non-kin member, increase the number of horses, and in-migrate kin members. Furthermore, the estimates indicate that more than 80% of the surplus or deficit land area was resolved if the household participated in rental or transfer of land.

Although simple comparison of the adjustment coefficient requires caution given the differences in methodology, the adjustment coefficient of 80% seen in the present study is much higher than 30% for renting-out and 20% for renting-in seen in Ethiopia (for years 1999, 2000, and 2004) (Deininger, Ali and Alemu (2008)) or 33% for administrative reallocation during a 5-year interval from 1992/3 to 1997/8 in Vietnam (Ravallion and van de Walle (2006)), roughly equal to the 78% for renting-out and 68% for renting-in seen in India for 1975–1984 (Skoufias (1995)), and lower than the 93% for net rental seen in Western Sudan in 1990 (Kevane (1996)). In addition, Kurosu and Lundh (2014) reports that land distribution of the two village rural communities in the northeastern part of Japan (including the village studied here) was more egalitarian than that in western communities in Scania (southern Sweden), Sart (eastern Belgium), and Casalguidi (central Italy) in the pre-modern period. Gini coefficients for the study populations were 0.74, 0.65, 0.60, respectively, while that for the two northeastern villages in Japan was 0.41 (Kurosu and Lundh 2014: 50). These comparisons suggest that land reallocation in the current context of the study was relatively efficient and egalitarian.

What was the underlying mechanism that led to this rather efficient reallocation and egalitarian distribution of land? We argue that the village played a key role in reallocating intra-village resources to comply with the duty of paying land tax under the *murauke* system discussed in Section 2.1. Under this system, the quantity of tax burdened was, in principle, fixed. Inefficient resource allocation in the village, which manifested in extreme cases as land abandonment, implied low total production and therefore a more severe tax burden for each household, or at worst, failure to fulfil the duty (which meant punishment such as imprisonment of the village head). To avoid such situations, the village had explicit incentives to maintain the proper number of workers for producing rice and to fully utilize the village's land. The former meant securing the lives of poor or landless households, and the latter implied reallocation of land from land-abundant households to land-scarce ones.

We argue that this is the underlying mechanism that led to the evolution of the idea of multi-layered / joint ownership of land, and the customs and informal interventions performed by the village for land allocation, as explained in Section 2.1. In theory, the custom of retaining the right to regain foreclosed land had the effect of helping households regain land and avoid extinction. Setting the rent ceiling secured tenants' livelihood. Administrative collective land reallocation (*warichi*) also had the effect of rebalance exposure to environmental risks, and may have coercively reallocated land from land-abundant to land-scarce households.

These deductions suggest that the underlying mechanism for the egalitarian distribution and efficient allocation of land in the pre-modern Japan was the incentives imposed by the *murauke* system of taxation, encouraging village heads to secure lives of poor or landless households and to reallocate land and labor efficiently so as to fulfill the obligation of taxation.

6. Concluding remarks

In this paper, we studied land reallocation in a pre-modern Japanese village from 1720 to 1870 by utilizing a population register with demographic and land data. Our major finding is that households tended to equalize their land-to-labor ratio using land and labor "markets", and that more than 80% of the surplus or deficit area of land was resolved if the household participated in rental or transfer of land. Therefore, we conclude that the village was successful in utilizing its contained resources.

An important question is why and how such egalitarian and efficient allocation of land was achieved. We argued that the incentive structure and institutions configured by the *murauke* tax system to fulfill the joint responsibility of taxation motivated the village to secure the livelihoods of poor or landless households and to reallocate land and labor efficiently. Formal theoretical investigation of this mechanism is left for future work.

We are aware of limitations in our analyses. First, we were not able to take labor allocation that was not reflected in the NAC into account. For example, a land-abundant household might have hired neighbors or relatives who live in a different household and who commuted daily, in which case the laborer might not have be recorded as a member of the hiring household. Second, we failed to consider subsidiary jobs. A land-scarce household can utilize its abundant labor in secondary works such as sericulture or by commuting to nearby towns. Indeed, Tomobe (2007) indicates that secondary work was important to absorb the fluctuation of labor endowment over the family life cycle. The development of sericulture in this area must be considered in our interpretation, as this development changed migration patterns of the area.

References

Brown, Philip C. (1997) "State, cultivator, land: Determination of land tenures in early modern Japan reconsidered." *The Journal of Asian Studies* 56(2): 421-444.

Brown, Philip C. (2011) *Cultivating Commons: Joint Ownership of Arable Land in Early Modern Japan*, Honolulu: University of Hawaii Press.

Chayanov, Aleksandr Vasilevich (1966/86) *A. V. Chayanov on the Theory of Peasant Economy*. (edited by Thorner, Daniel.,. Kerblay, Baslie., and Smith, R.E.F.) Madison: University of Wisconsin Press.

Cleveland, William S. (1979) "Robust locally weighted regression and smoothing scatterplots." *Journal of the American Statistical Association* 74(368): 829-836.

Deininger, Klaus., Ali, Daniel Ayalew., and Alemu, Tekie. (2008) "Assessing the functioning of land rental markets in Ethiopia." *Economic Development and Cultural Change* 57(1): 67-100.

Deininger, Klaus., and Jin, Songqing. (2005) "The potential of land rental markets in the process of economic development: Evidence from China." *Journal of Development Economics*, 78(1): 241-270.

Deininger, Klaus., and Jin, Songqing. (2008) “Land sales and rental markets in transition: Evidence from rural Vietnam." *Oxford Bulletin of Economics and Statistics* 70(1): 67-101.

Deininger, Klaus., Jin, Songqing., and Nagarajan, Hari K. (2008a) “Efficiency and equity impacts of rural land rental restrictions: Evidence from India,” *European Economic Review*, 52(5):892-918.

Deininger, Klaus., Jin, Songqing., and Nagarajan, Hari K. (2009) “Determinants and consequences of land sales market participation: Panel evidence from India.” *World Development* 37(2): 410-421.

Deininger, Klaus., Zegarra, Eduardo., and Lavadenz, Isabel. (2003) “Determinants and impacts of rural land market activity: evidence from Nicaragua.” *World Development* 31(8): 1385-1404.

Hayami, Akira (1985) *Nihon ni okeru Keizai-Shakai no Tenkai (Socioeconomic development in Japan)*, 6th edition. Tokyo: Keio Tsushin. (in Japanese)（『日本における経済社会の展開』(1985)　第 6 版　慶應通信.）

Koriyama-shi (1981) *Koriyama-shi shi 2: Kinsei, ge* (The history of Koriyama City 2: Early modern period, volume 2), 2nd edition. Tokyo: Kokusho Kanko Kai.(Japanese)（『郡山市史 II 近世下巻』(1981)　国書刊行会.）

Kurosu, Satomi. (2010) “Distribution of land in rural communities in northeastern Japan 1716-1870,” mimeo.

Kurosu, Satomi (2011) “Divorce in early modern rural Japan: Household and individual life course in northeastern villages, 1716-1870” *Journal of Family History* 36(2): 118-141.

Kurosu, Satomi (2013) “Adoption and family reproduction in early modern Japan” *The Economic Review* 64(1): 1-12.

Kurosu, Satomi and Lundh, Christer (2014) “Nuptiality: Local populations, sources, and models," pp.47-85 in Lundh, Christer, Kurosu, Satomi, et. al *Similarity in Difference: Marriage in Europe and Asia, 1700-1900*, Cambridge: MIT Press.

Kevane, Michael. (1996) “Agrarian structure and agricultural practice: Typology and application to western Sudan.” *American Journal of Agricultural Economics*, 78(1): 236-245.

Nagata, Mary L. (2001). "Labor migration, family and community in early modern Japan," pp. 60-84 in Sharpe, P. (Ed.), *Women, gender and labor migration: Historical and global perspective*.　London: Routledge.

Nagata, Mary L., Kurosu, Satomi, and Hayami, Akira (1998) "Niita and Shimomoriya of the Nihonmatsu domain in the northeastern region of Tokugawa Japan."　*EAP Working Paper Series* No.20. Kyoto: EurAsian Project on Population and Family History, International

Research Center for Japanese Studies.

Narimatsu, Saeko (1992) *Edo-jidai no Tohoku Noson: Nihonmatsu-han Niita-mura (Agricultural Villages in Northeastern Edo Japan: The Village of Niita in Nihonmatsu Domain)*. Tokyo: Dobunkan. (in Japanese) （成松佐恵子（1992）『江戸時代の東北農村―二本松藩仁井田村』同文舘出版.）

Numata, Makoto (2001) *Ie to mura no rekishi-teki iso (Historical topology of households and villages)*, Tokyo: Nihon Keizai Hyoron Sha. (in Japanese.) （沼田誠（2001）『家と村の歴史的位相』日本経済評論社.）

Otsuka, Eiji (2002) "Hyakusho no tochi-shoyu (Land holding of the hyakusho)" in Watanabe, Takashi., and Gomi, Fumihiko eds, *Tochi-shoyu-shi (History of Land Holdings)*, Tokyo: Yamakawa Shuppansha. (in Japanese) （大塚英二（2002）「百姓の土地所有」, 渡辺尚志・五味文彦編『新体系日本史 3 土地所有史』山川出版社.）

Otsuka, Keijiro. (2007) "Efficiency and equity effects of land markets." *Handbook of Agricultural Economics*, vol. 3: 2671-2703.

Ravallion. Martin, van de Walle, Dominique. (2006) "Land Reallocation in an agrarian transition," Economic Journal, 116(514): 924-942.

Sakane, Yoshihiro (2011) *Nihon no dento shakai to keizai hatten (Japanese traditional society and economic development)*, Tokyo: Nosan Gyoson Bunka Kyokai (Rural Culture Association Japan). (in Japanese) （坂根嘉弘（2011）『日本の伝統社会と経済発展』農山漁村文化協会.）

Sato, Tsuneo (1990) "Tokugawa villagers and agriculture," pp. 37-80 in Nakane, Chie and Shinzaburo Oishi (eds.), *Tokugawa Japan: The Social and Economic Antecedents of Modern Japan*. Tokyo: University of Tokyo Press.

Shirakawabe, Tatsuo (1994) *Nihon kinsei no mura to hyakusho-teki sekai (Villages and peasant world in pre-modern Japan)*, Tokyo: Azekura Shobo. (in Japanese). （白川部達夫（1994）『日本近世の村と百姓的世界』校倉書房.）

Skoufias, Emmanuel. (1995) "Household resources, transaction costs, and adjustment through land tenancy." *Land Economics* 71(1): 42-56.

Tomobe, Kenichi (2007) Zen-kogyo-ka-ki nihon no noka-keizai: Shutai-kinko to shijo-keizai (Peasant Household Economies in Pre-industrial Japan: subjective equilibrium and market economy), Tokyo: Yuhikaku. (in Japanese). （友部謙一（2007）『前工業化期日本の農家経済：主体均衡と市場経済』有斐閣.）

Tsuya, Noriko O., and Kurosu, Satomi (2004a) "Mortality and household in two Ou villages, 1716-1870," pp.253-292 in Bengtsson, Tommy,Campbell, Cameron and Lee, James Z. et al *Life under Pressure: Mortality and Living Standard in Europe and Asia, 1700-1900*. Cambridge: MIT Press.

Tsuya, Noriko O., and Kurosu, Satomi (2004b) “Household life course in two farming villages in northeastern Tokugawa Japan: Retirement, death, and extinction.” Paper presented at the 2004 European Social Science History Conference, Berlin, 24-27 March.

Tsuya, Noriko O., and Kurosu, Satomi (2010) “To die or to leave: Demographic responses to famines in rural northeastern Japan, 1716-1870” pp.79-106 in Kurosu, Satomi, Bengtsson, Tommy and Campbell, Cameron (eds.), *Demographic Responses to Economic and Environmental Crises*. Kashiwa: Reitaku University.

Tsuya, Noriko O., and Kurosu, Satomi (2013)“Social Class and Migration in Two Northeastern Villages 1716-1870.” *The History of the Family*: 18(3): 1-22

Tsuya, Noriko O., and Kurosu, Satomi (2014) “Economic household factors of first marriage in two northeastern Japanese villages, 1716-1870,” pp. 349-391 in Lundh, Christer., and Kurosu, Satomi, et. al *Similarity in Difference: Marriage in Europe and Asia, 1700-1900*, Cambridge: MIT Press.

Pant, Chandrashekar. (1983) “Tenancy and family resources: A model and some empirical analysis.” *Journal of Development Economics* 12(1): 27-39.

Vranken, Liesbet., and Swinnen, Johan. (2006) “Land rental markets in transition: Theory and evidence from Hungary.” *World Development* 34(3): 481-500.

Watanabe, Takashi (2007) *Kinsei no sonraku to chiiki-shakai (Village and regional society in the pre-modern period)*, Tokyo: Hanawa Shobo. (in Japanese). （渡辺尚志（2007a）『近世の村落と地域社会』塙書房.）

Watanabe, Takashi (2008) *Hyakusho no chikara (The power of the hyakusho)*, Tokyo: Kashiwa Shobo. (in Japanese) （渡辺尚志（2008）『百姓の力』柏書房.）

Figures

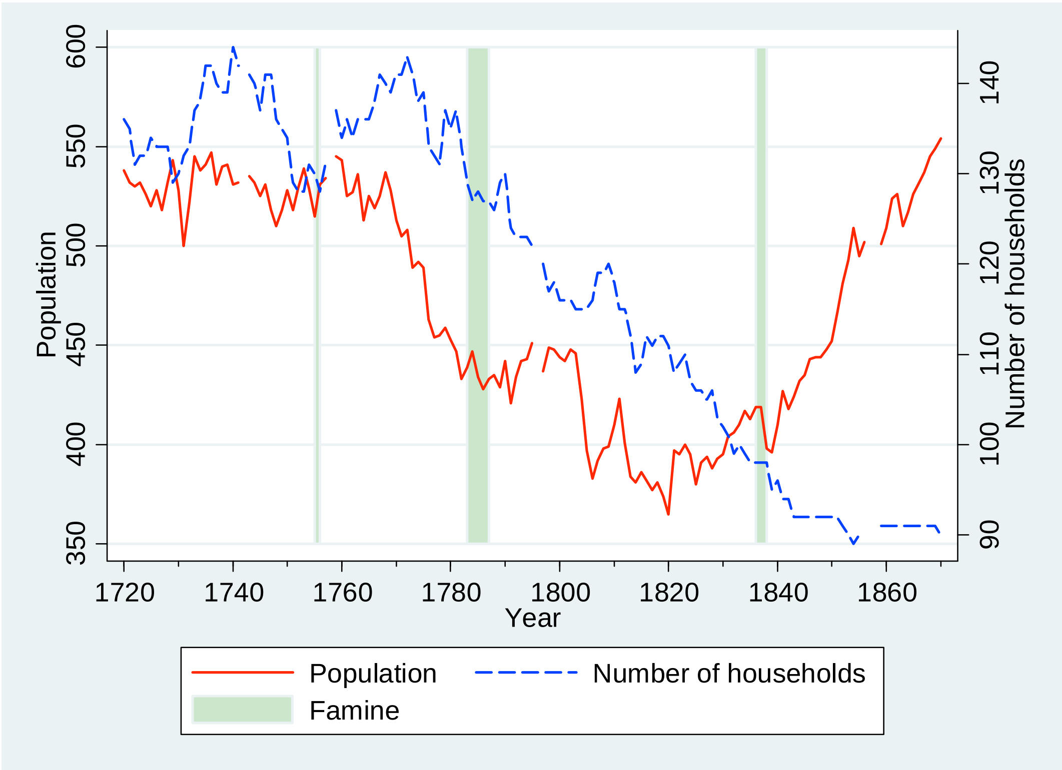


Figure 1. Population and number of households

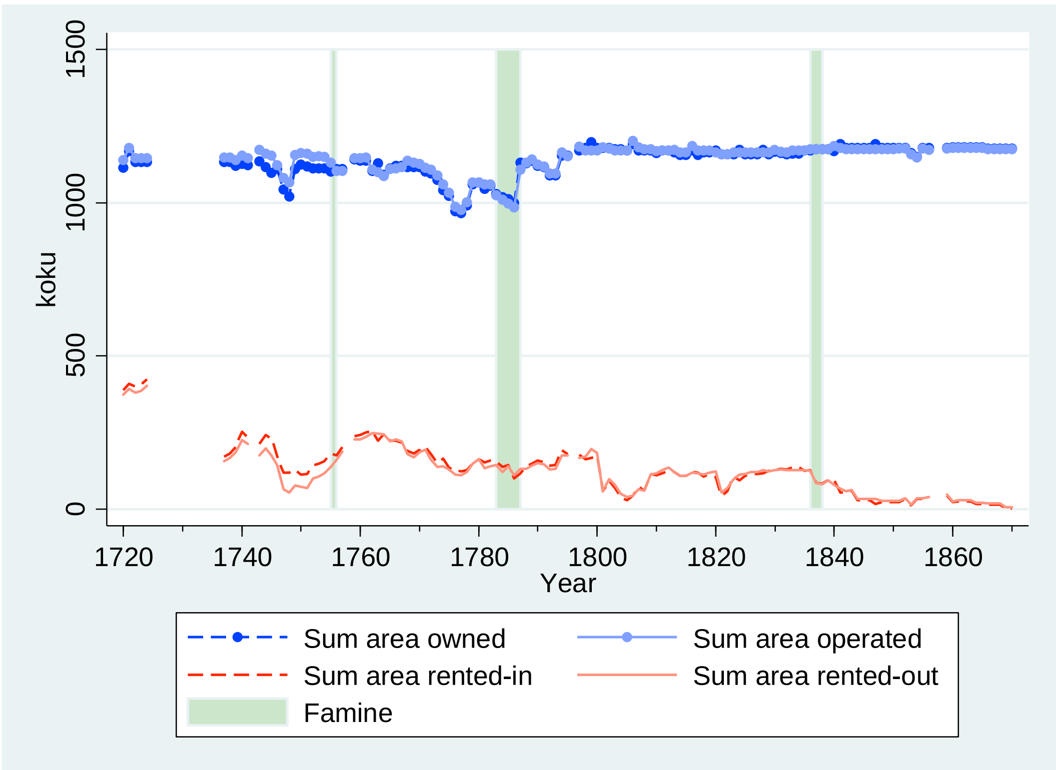


Figure 2. Land “market”

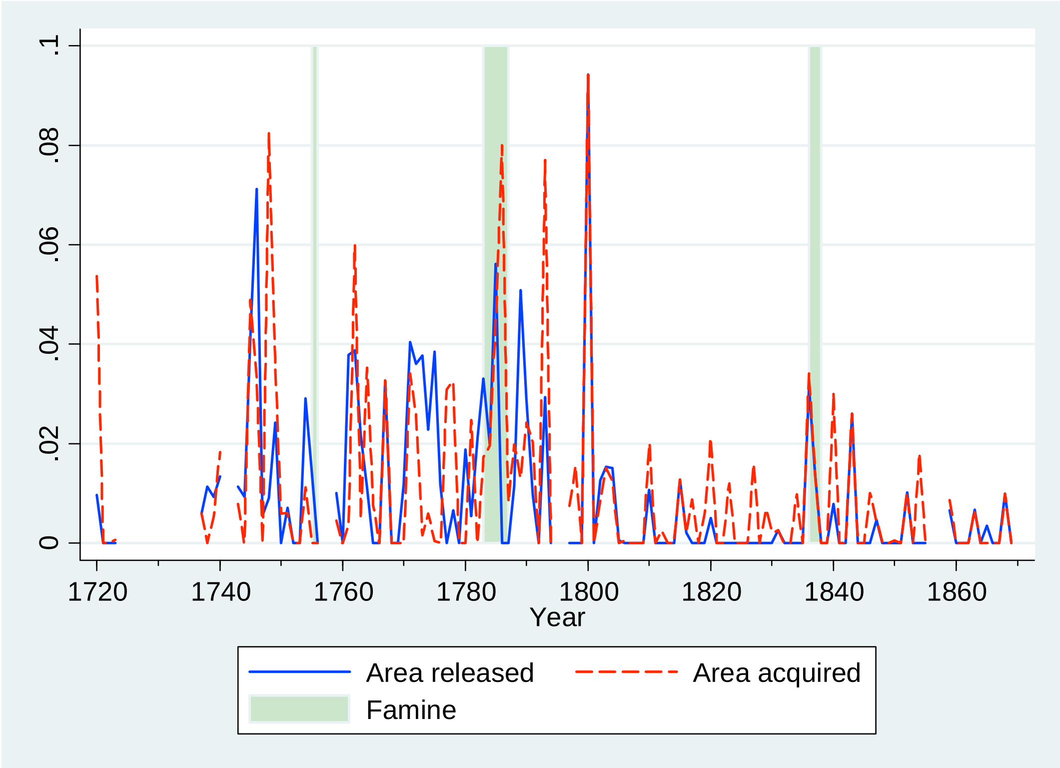


Figure 3. Proportion of land transferred on total area owned in the previous year

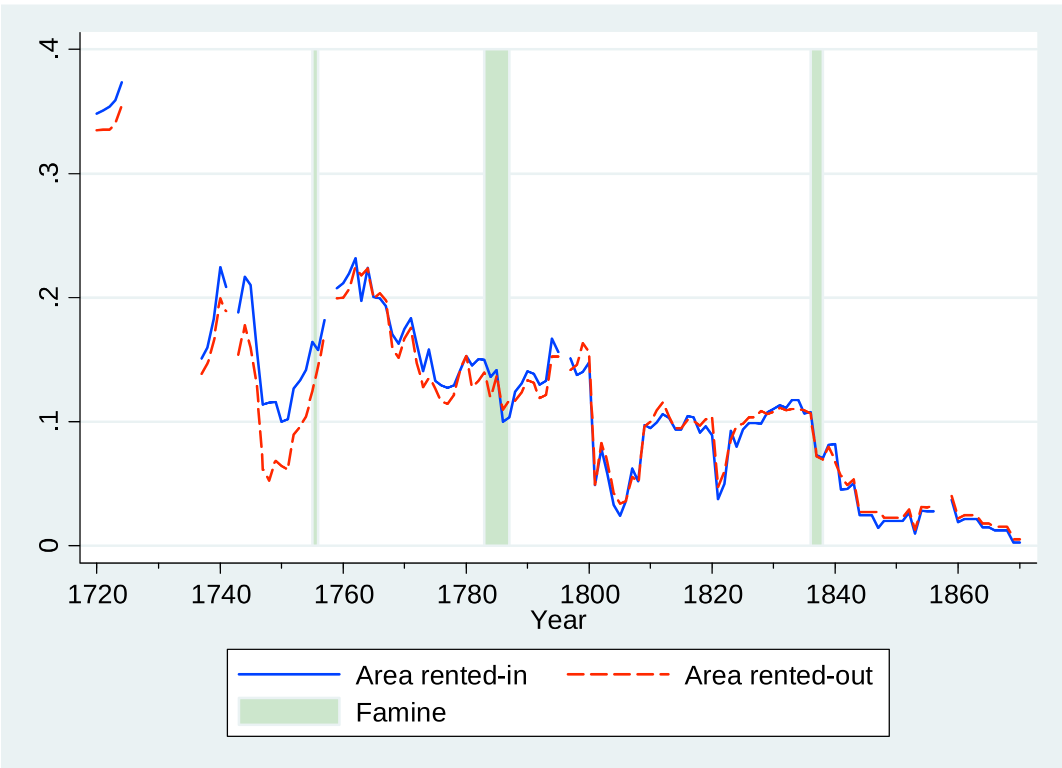


Figure 4. Proportion of land rented on sum of area owned in the same year

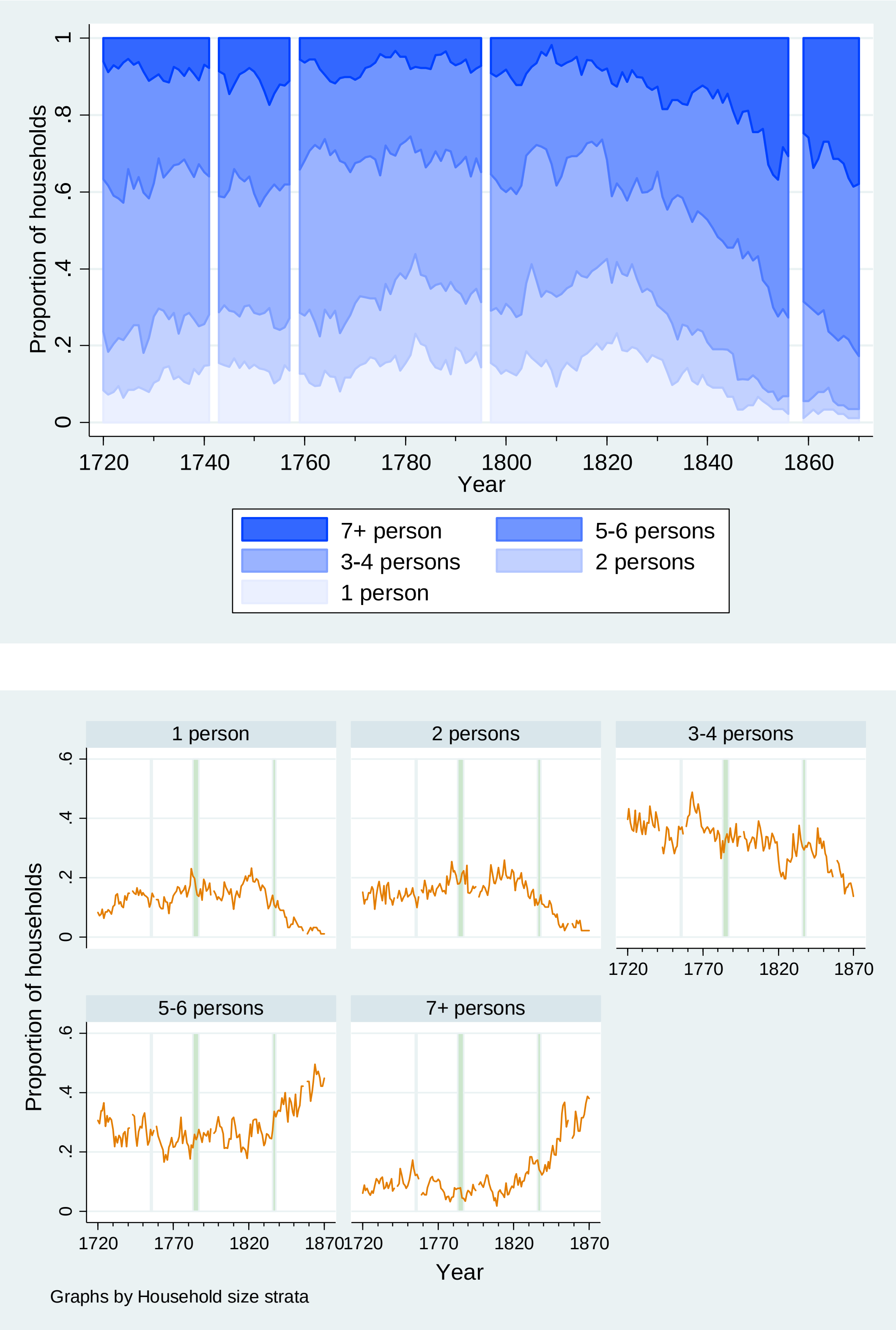


Figure 5. Proportion of households by landholding strata

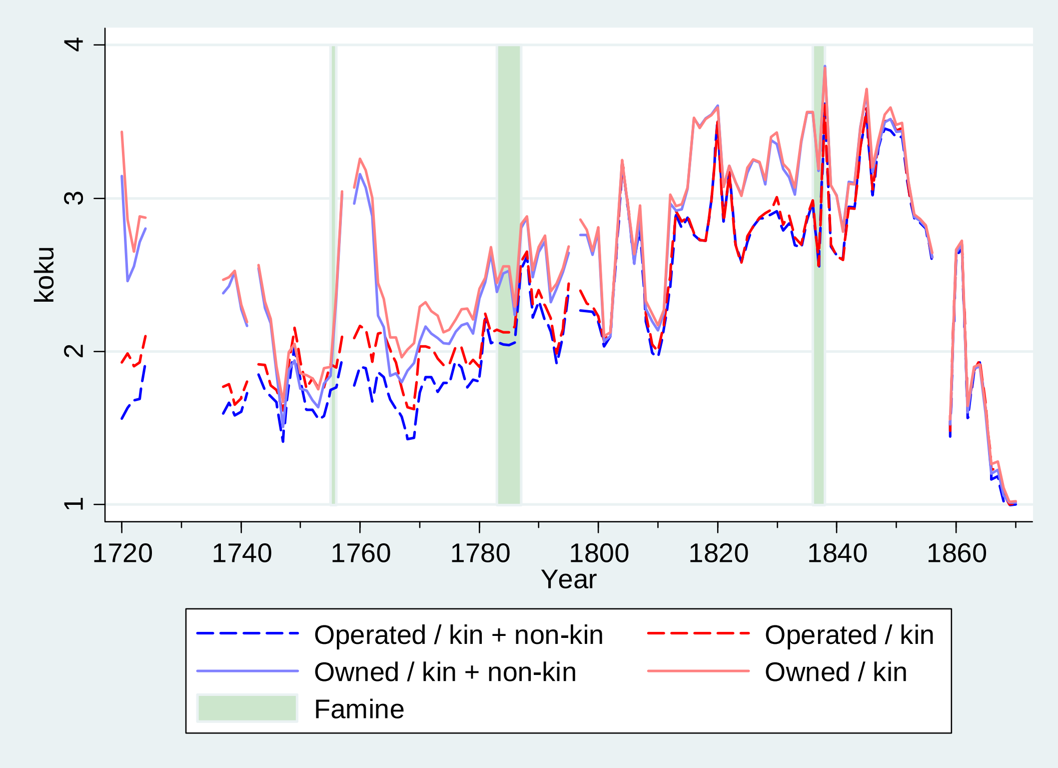
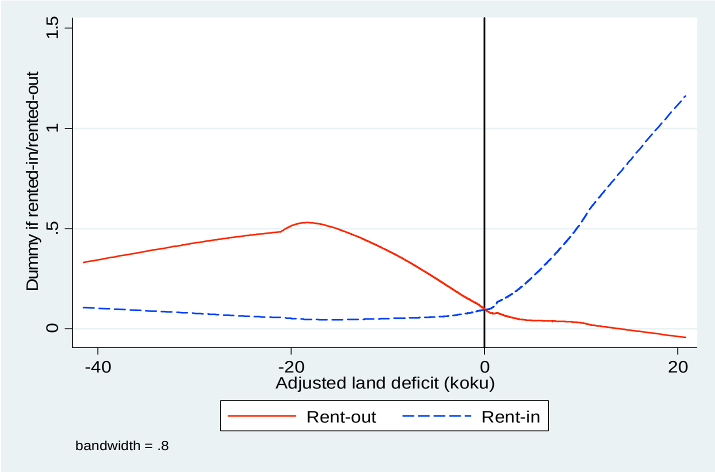
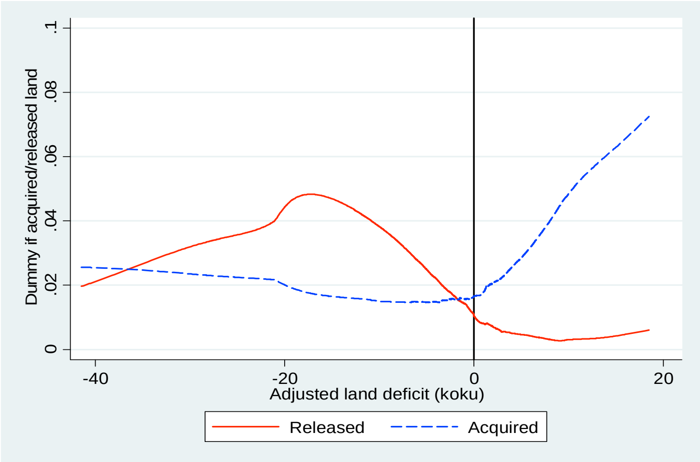


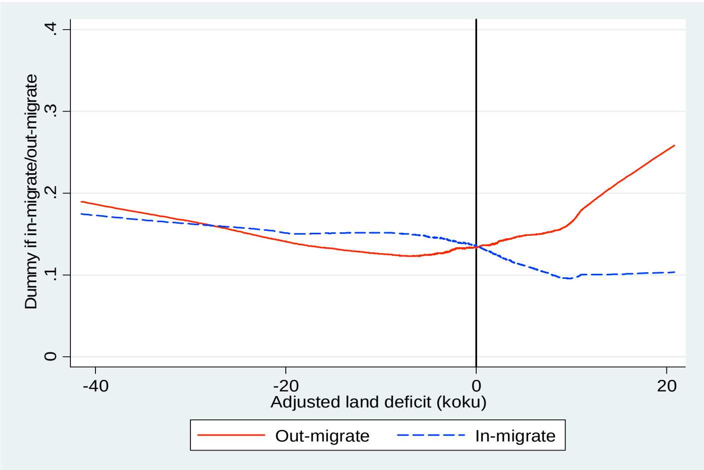
Figure 6. Trend in standard deviation of household land-to-labor ratios



a) Land rental



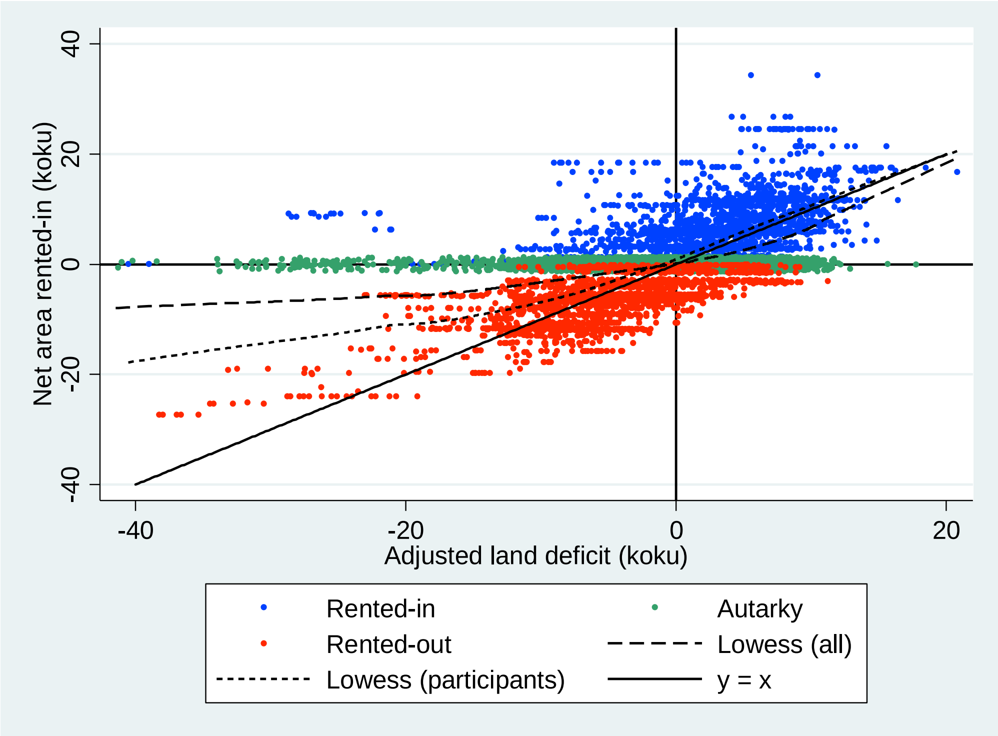
b) Land transfer



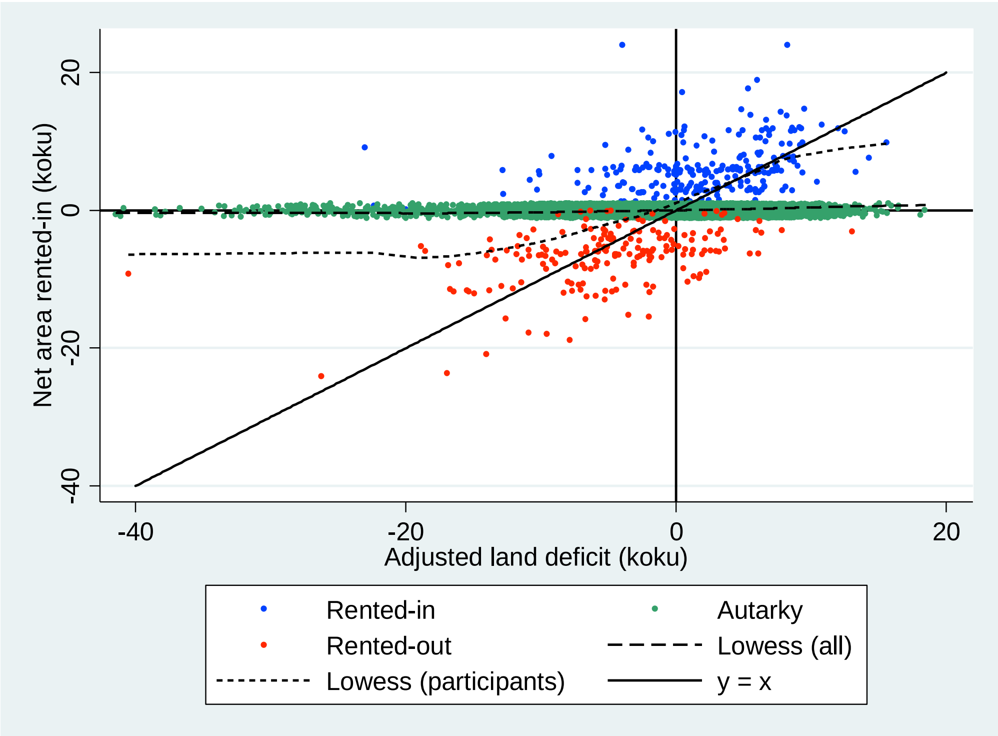
c) Social migration of kin-members

Figure 7. Adjusted land deficit and adoption of factor-equalization strategies

Note: Mean-adjusted Lowess smoother.



a) Rental



b) Transfer (1 year interval)

Figure 8. Adjusted land deficit and land rental transactions

Note: Autarky observations are jittered.

Tables

Table 1. Summary statistics (mean) by adjusted land deficit groups

	Surplus		Deficit		
	> 5 koku	0-5 koku	0-5 koku	> 5 koku	Full sample
N	2,370	4,208	5,891	2,021	14,490
Head's age	46.0	46.1	46.3	42.4	45.6
Number of kin members	4.1	4.1	3.7	4.6	4.0
Number of non-kin members	0.8	0.2	0.1	0.3	0.3
Dummy if non-kin members > 0	0.240	0.091	0.047	0.101	0.099
Number of female members age <10	0.4	0.4	0.3	0.4	0.3
Number of male members age <10	0.4	0.4	0.4	0.5	0.4
Number of female members age 10-14	0.2	0.2	0.1	0.2	0.2
Number of male members age 10-14	0.2	0.2	0.2	0.2	0.2
Number of female members age 15-54	1.1	1.1	1.0	1.3	1.1
Number of male members age 15-54	1.1	1.1	1.0	1.2	1.1
Number of female members age >55	0.4	0.4	0.4	0.4	0.4
Number of male members age >55	0.4	0.4	0.4	0.4	0.4
Area owned (*koku*)	20.7	12.4	6.7	4.2	10.3
Area operated (*koku*)	17.2	12.0	7.4	8.4	10.5
Area owned per kin member (*koku*)	6.1	3.7	1.6	0.9	2.9
Area owned per kin + non-kin member (*koku*)	5.7	3.7	1.6	0.8	2.8
Area operated per kin member (*koku*)	4.6	3.4	1.8	1.9	2.8
Area operated per kin + non-kin member (*koku*)	4.2	3.3	1.8	1.8	2.6
Land deficit (unadjusted) (*koku*)	-10.5	-2.5	2.6	7.3	-0.4
Land deficit (adjusted) (*koku*)	-10.0	-2.2	2.1	7.3	-0.4

Table 2. Probit estimates on adoption of factor-ratio stabilization strategies (average marginal effects)

	Land rental		Employ	Increase	Death and birth		Land transfer		Migration	
	Rent-out	Rent-in	member	horse	Birth	Death	Released	Acquired	Out	In
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Adjusted land surplus > 5 *koku*	0.235***	-0.0446*	0.135***	0.00244	0.00497	-0.0164*	0.0614***	-0.0120*	-0.00783	0.00882
	(0.0274)	(0.0199)	(0.0254)	(0.00787)	(0.00705)	(0.00647)	(0.00736)	(0.00500)	(0.0110)	(0.00955)
Adjusted land surplus 0-5 *koku*	0.0594***	0.00377	0.0371**	0.00386	0.00615	-0.00805	0.0124*	-0.000269	-0.0126	0.0147
	(0.0123)	(0.0153)	(0.0119)	(0.00648)	(0.00632)	(0.00590)	(0.00489)	(0.00546)	(0.00804)	(0.00760)
Adjusted land deficit > 5 *koku*	0.0101	0.150***	0.0117	0.0138	0.00941	-0.0130	-0.00460	0.0177*	0.0151	-0.00962
	(0.0190)	(0.0312)	(0.0139)	(0.00751)	(0.00743)	(0.00744)	(0.00474)	(0.00707)	(0.00969)	(0.00852)
Head's age	0.00107**	-0.000595	-0.00133**	-0.000325	-0.00124***	0.000692***	-0.000189	0.000161	-0.000378	0.0000233
	(0.000393)	(0.000445)	(0.000452)	(0.000189)	(0.000191)	(0.000179)	(0.000190)	(0.000126)	(0.000255)	(0.000225)
Female head	-0.00195	-0.0236	-0.0645***	-0.0217*	-0.00878	0.0121	0.00787	-0.000805	0.0207	0.116***
	(0.0190)	(0.0217)	(0.0136)	(0.00871)	(0.0103)	(0.0102)	(0.00860)	(0.00736)	(0.0121)	(0.0166)
Status: Mizunomi	-0.158***	0.349***	0.0371	-0.0282***	-0.0108	-0.00357		0.0193**	-0.0126	-0.0461***
	(0.0108)	(0.0365)	(0.0321)	(0.00792)	(0.00811)	(0.00776)		(0.00723)	(0.0106)	(0.00928)
Status: Others	-0.0835**	0.0429	0.125**	-0.0144	-0.0150	-0.0148	-0.0219***	-0.0131	-0.0660***	-0.0675**
	(0.0295)	(0.0842)	(0.0472)	(0.0217)	(0.0253)	(0.0170)	(0.00376)	(0.00943)	(0.0165)	(0.0217)
Bunke	-0.0547**	0.0810***	-0.0233	0.0103	-0.000885	-0.00356	-0.00144	0.0105**	-0.00864	-0.00834
	(0.0193)	(0.0176)	(0.0181)	(0.00704)	(0.00559)	(0.00525)	(0.00459)	(0.00405)	(0.00886)	(0.00782)
Number of horses	-0.0503**	0.0636***	0.134***	0.00909	0.0288***	-0.00994	-0.0129*	0.00550	-0.0789***	0.0199*
	(0.0157)	(0.0190)	(0.0171)	(0.00712)	(0.00562)	(0.00553)	(0.00523)	(0.00450)	(0.0104)	(0.00820)
Number of female members age <10	-0.00969	0.0135	0.0255**	-0.00914*	-0.00542	0.0259***	-0.0000689	0.00244	-0.000300	-0.0231***
	(0.0100)	(0.0106)	(0.00824)	(0.00447)	(0.00450)	(0.00453)	(0.00497)	(0.00354)	(0.00501)	(0.00510)
Number of male members age <10	-0.00732	0.0235*	0.00584	0.00321	-0.0161***	0.0272***	0.00376	0.00632	0.0116*	-0.0409***
	(0.00855)	(0.00927)	(0.00911)	(0.00398)	(0.00458)	(0.00424)	(0.00379)	(0.00330)	(0.00493)	(0.00457)
Number of female members age 10-14	0.00235	0.00880	0.00114	0.00426	-0.00976	0.00973	0.000692	0.00809	0.0685***	0.0150*
	(0.0119)	(0.0121)	(0.00837)	(0.00676)	(0.00552)	(0.00609)	(0.00627)	(0.00473)	(0.00668)	(0.00620)
Number of male members age 10-14	-0.00264	0.0180	0.00988	-0.00146	-0.0181***	0.00863	0.0122*	0.0103*	0.0197**	-0.0171*
	(0.0100)	(0.0131)	(0.00959)	(0.00587)	(0.00501)	(0.00596)	(0.00594)	(0.00483)	(0.00723)	(0.00677)
Number of female members age 15-54	-0.00997	0.0417***	0.0233**	0.00926*	0.0556***	0.0151***	0.00273	-0.0000281	0.0591***	-0.0245***
	(0.00993)	(0.00965)	(0.00762)	(0.00399)	(0.00478)	(0.00408)	(0.00415)	(0.00343)	(0.00537)	(0.00551)
Number of male members age 15-54	-0.0234**	0.0277**	0.00549	-0.00600	0.0181***	0.0148***	0.00194	0.00517	0.0623***	0.0123*
	(0.00893)	(0.0103)	(0.00973)	(0.00487)	(0.00418)	(0.00421)	(0.00386)	(0.00371)	(0.00579)	(0.00543)
Number of female members age >55	-0.0206	0.0452***	0.00397	0.00167	0.0171**	0.0472***	-0.00173	0.00336	0.0222***	-0.00499
	(0.0133)	(0.0133)	(0.0111)	(0.00596)	(0.00522)	(0.00441)	(0.00543)	(0.00444)	(0.00593)	(0.00628)
Number of male members age >55	-0.0570***	0.00215	0.0137	-0.00119	0.00393	0.0492***	-0.000309	-0.00455	0.0185**	-0.00537
	(0.0164)	(0.0151)	(0.0124)	(0.00587)	(0.00607)	(0.00519)	(0.00484)	(0.00422)	(0.00697)	(0.00743)
Number of female members born				0.00299			-0.000568	0.0123	-0.0589***	0.00112
				(0.00883)			(0.00984)	(0.00742)	(0.0146)	(0.0128)
Number of male members born				0.0163			-0.0108	0.0173*	-0.0382**	-0.0390**
				(0.00920)			(0.0121)	(0.00808)	(0.0133)	(0.0149)
Number of female members age <10 died				-0.0115			-0.00199	-0.0166	0.00362	0.00425
				(0.0171)			(0.0203)	(0.0183)	(0.0181)	(0.0261)
Number of male members age <10 died				-0.00652			-0.0222	-0.00652	-0.0251	0.0198
				(0.0159)			(0.0179)	(0.0138)	(0.0235)	(0.0220)
Number of female members age 10-14 died				0.0458					0.0165	
				(0.0645)					(0.0875)	
Number of male members age 10-14 died				-0.0295				0.0661*	0.0445	0.0955
				(0.0532)				(0.0275)	(0.0549)	(0.0593)
Number of female members age 15-54 died				0.0597***			0.0295	-0.0129	0.0306	0.0977***
				(0.0143)			(0.0159)	(0.0223)	(0.0221)	(0.0184)
Number of male members age 15-54 died				0.0559***			0.0286	0.00864	0.0440	0.0709**
				(0.0169)			(0.0148)	(0.0166)	(0.0230)	(0.0268)
Number of female members age >55 died				0.0152			-0.00900	-0.0329	-0.00341	0.0246
				(0.0145)			(0.0207)	(0.0199)	(0.0204)	(0.0190)
Number of male members age >55 died				0.0245*			-0.00913	-0.0000376	0.00481	0.0279
				(0.0122)			(0.0196)	(0.0141)	(0.0164)	(0.0183)
N	14472	14472	14490	13238	13615	14403	5458	8336	13615	13607

Note: Increased number of horses, deaths and births, land transfer, and migration are dummies for if such event occurred during the base year t (when the adjusted land deficit was measured) and year $t+1$. Year dummies are included. Robust standard errors are clustered by household in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3. OLS/Fixed effects estimates on land adjustment

	Owned-land				Adjusted land deficit				Unadjusted land deficit			
	All samples	Participants only	All samples	Participants only	All samples	Participants only	All samples	Participants only	All samples	Participants only	All samples	Participants only
	OLS	OLS	FE	FE	OLS	OLS	FE	FE	OLS	OLS	FE	FE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A. Land rental (dep. var. = net area of land rented-in)												
Owned-land (*koku*)	-0.250***	-0.620***	-0.557***	-0.843***								
	(0.0512)	(0.0702)	(0.0521)	(0.0483)								
Land deficit (*koku*)					0.304***	0.641***	0.531***	0.803***	0.239***	0.608***	0.537***	0.837***
					(0.0576)	(0.0711)	(0.0442)	(0.0411)	(0.0494)	(0.0708)	(0.0496)	(0.0476)
Observations	14472	4161	14472	4161	14472	4161	14472	4161	14472	4161	14472	4161
R-squared	0.318	0.635	0.408	0.628	0.357	0.659	0.433	0.650	0.312	0.630	0.398	0.623
B. Land transfer (1 year interval) (dep. var. = net area of land acquired)												
Owned-land (*koku*)	-0.0219***	-0.453***	-0.0621***	-0.858***								
	(0.00421)	(0.0752)	(0.00647)	(0.0816)								
Land deficit (*koku*)					0.0243***	0.472***	0.0524***	0.816***	0.0215***	0.452***	0.0608***	0.862***
					(0.00425)	(0.0716)	(0.00501)	(0.0776)	(0.00410)	(0.0760)	(0.00616)	(0.0828)
Observations	13486	478	13486	478	13486	478	13486	478	13486	478	13486	478
R-squared	0.033	0.539	0.052	0.684	0.035	0.547	0.049	0.672	0.033	0.539	0.051	0.687
C. Land transfer (10 years interval) (dep. var. = net area of land acquired)												
Owned-land (*koku*)	-0.207***	-0.527***	-0.562***	-0.987***								
	(0.0410)	(0.0605)	(0.0540)	(0.0666)								
Land deficit (*koku*)					0.221***	0.548***	0.465***	0.949***	0.205***	0.529***	0.553***	0.996***
					(0.0425)	(0.0623)	(0.0470)	(0.0781)	(0.0398)	(0.0605)	(0.0505)	(0.0637)
Observations	1262	399	1262	399	1262	399	1262	399	1262	399	1262	399
R-squared	0.202	0.510	0.401	0.644	0.209	0.517	0.364	0.629	0.201	0.513	0.399	0.651

Note: Each panel reports separate estimates. See Tables A2–A4 in Appendix for full results. The dependent variable is the net area rented-in (in *koku*) (negative if rented-out) for Panel A, net area acquired (*koku*) (negative if released) at 1-year intervals (i.e., during year t and $t+1$) for Panel B, and net area acquired (*koku*) (negative if released) at 10-year intervals (i.e., during year t and $t+10$) for Panel C. The key independent variable is area owned (*koku*) or adjusted (or unadjusted) land deficit (*koku*) in year t. Other controls for all panels include: head age, head age squared, female head (dummy), household status dummy (*mizunomi*, and others; reference = *honbyakusho*), *bunke* (dummy), number of horses, number of household members by sex–age category in year t, and year fixed effects. In addition, in Panels B and C, the number of household members born and died during the observation interval by sex–age category is also included. Samples for Panel C are households observed every 10 years after 1740 (1720 and 1730 are excluded because data for 1730 is missing). Robust standard errors are clustered by household in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix

Table A1. Linear projection of area owned or operated

	Owned	Owned	Operated	Operated
	(1)	(2)	(3)	(4)
Head's age	-0.0381	-0.0238	-0.0926*	-0.0756*
	(0.0476)	(0.0404)	(0.0451)	(0.0382)
Head's age squared	0.000317	0.000172	0.000636	0.000464
	(0.000506)	(0.000420)	(0.000475)	(0.000387)
Female head	0.128	0.0965	-0.223	-0.262
	(0.411)	(0.420)	(0.417)	(0.418)
Status: Mizunomi	-9.233***	-9.309***	-3.829***	-3.916***
	(0.423)	(0.396)	(0.421)	(0.401)
Status: Others	-3.975**	-4.200***	-2.809*	-3.080**
	(1.323)	(1.260)	(1.207)	(1.154)
Bunke	-2.585***	-2.388***	-1.104	-0.867
	(0.731)	(0.625)	(0.734)	(0.630)
Number of horses	3.989**	2.827***	4.994***	3.595***
	(1.364)	(0.470)	(1.317)	(0.437)
Number of female members age <10	0.305	0.213	0.496*	0.382
	(0.228)	(0.246)	(0.228)	(0.239)
Number of male members age <10	0.532*	0.466	0.924***	0.843***
	(0.247)	(0.238)	(0.258)	(0.243)
Number of female members age 10-14	0.581*	0.611**	0.707**	0.741***
	(0.233)	(0.227)	(0.227)	(0.213)
Number of male members age 10-14	0.882***	0.760**	1.208***	1.058***
	(0.249)	(0.252)	(0.257)	(0.272)
Number of female members age 15-54	0.853***	0.895***	1.561***	1.612***
	(0.225)	(0.231)	(0.230)	(0.233)
Number of male members age 15-54	0.426	0.482*	0.899**	0.967***
	(0.286)	(0.243)	(0.294)	(0.254)
Number of female members age >55	0.587*	0.728**	1.200***	1.371***
	(0.288)	(0.280)	(0.309)	(0.307)
Number of male members age >55	-0.0948	0.0126	0.457	0.583
	(0.477)	(0.335)	(0.498)	(0.349)
Number of non-kin members		1.423		1.717*
		(0.778)		(0.748)
Constant	8.317***	8.342***	6.006***	6.043***
	(1.320)	(1.314)	(1.169)	(1.143)
Observations	14490	14490	14494	14494
R-squared	0.510	0.545	0.476	0.528

Note: Observations are pooled for all years. Year dummies are included. Robust standard errors are clustered by household in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A2. Estimates on net area of land rented-in

	Owned-land				Adjusted land deficit				Unadjusted land deficit			
	All samples	Participants only	All samples	Participants only	All samples	Participants only	All samples	Participants only	All samples	Participants only	All samples	Participants only
	OLS	OLS	FE	FE	OLS	OLS	FE	FE	OLS	OLS	FE	FE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Owned-land (*koku*)	-0.250***	-0.620***	-0.557***	-0.843***								
	(0.0512)	(0.0702)	(0.0521)	(0.0483)								
Land deficit (*koku*)					0.304***	0.641***	0.531***	0.803***	0.239***	0.608***	0.537***	0.837***
					(0.0576)	(0.0711)	(0.0442)	(0.0411)	(0.0494)	(0.0708)	(0.0496)	(0.0476)
Head's age	-0.0657**	-0.0665	-0.0284	-0.0464	-0.0420	-0.0262	0.00959	-0.00533	-0.0660**	-0.0693	-0.0326	-0.0456
	(0.0219)	(0.0554)	(0.0213)	(0.0429)	(0.0226)	(0.0534)	(0.0219)	(0.0402)	(0.0219)	(0.0552)	(0.0213)	(0.0435)
Head's age squared	0.000421	0.000230	0.0000959	0.000201	0.000257	-0.0000268	-0.000162	-0.0000642	0.000431	0.000265	0.000161	0.000209
	(0.000238)	(0.000594)	(0.000237)	(0.000469)	(0.000241)	(0.000565)	(0.000237)	(0.000429)	(0.000238)	(0.000591)	(0.000235)	(0.000469)
Female head	-0.312	-0.931	-0.132	-0.119	-0.220	-0.690	0.0223	0.207	-0.282	-0.946	-0.0846	-0.183
	(0.282)	(0.796)	(0.259)	(0.623)	(0.265)	(0.742)	(0.238)	(0.559)	(0.281)	(0.798)	(0.258)	(0.624)
Status: Mizumomi	3.117***	3.359**	0.994	1.536	3.787***	5.101***	3.148***	4.101***	3.209***	3.470**	1.219*	1.551
	(0.583)	(1.150)	(0.591)	(0.879)	(0.460)	(0.976)	(0.434)	(0.714)	(0.567)	(1.159)	(0.567)	(0.879)
Status: Others	0.184	0.338	-2.133*		0.902**	0.990	-0.236		0.217	0.275	-2.046*	
	(0.459)	(1.368)	(1.020)		(0.347)	(1.109)	(1.006)		(0.461)	(1.428)	(1.036)	
Bunke	0.840**	1.109			0.915***	1.211			0.873**	1.176		
	(0.281)	(0.836)			(0.273)	(0.777)			(0.282)	(0.845)		
Number of horses	2.011***	3.583***	0.996***	1.778***	1.236***	1.909**	-0.505*	-0.232	1.970***	3.537***	0.989***	1.717***
	(0.274)	(0.631)	(0.201)	(0.451)	(0.359)	(0.667)	(0.200)	(0.403)	(0.271)	(0.634)	(0.206)	(0.453)
Number of female members age <10	0.257	1.188***	0.308*	1.074***	0.161	0.665*	0.104	0.392	-0.345*	-0.264	-1.049***	-0.927***
	(0.141)	(0.335)	(0.128)	(0.297)	(0.127)	(0.305)	(0.113)	(0.269)	(0.170)	(0.354)	(0.148)	(0.274)
Number of male members age <10	0.526***	1.417***	0.350**	0.793**	0.334*	0.845*	-0.0221	0.0393	-0.0578	-0.0222	-0.963***	-1.201***
	(0.137)	(0.383)	(0.114)	(0.244)	(0.146)	(0.391)	(0.117)	(0.255)	(0.185)	(0.457)	(0.158)	(0.318)
Number of female members age 10-14	0.261	0.929	0.326	1.154**	0.0827	0.235	-0.0397	0.247	-0.346	-0.530	-1.039***	-0.823*
	(0.173)	(0.484)	(0.174)	(0.372)	(0.162)	(0.428)	(0.166)	(0.336)	(0.196)	(0.450)	(0.201)	(0.360)
Number of male members age 10-14	0.549***	1.842***	0.442**	1.518***	0.300*	1.051*	-0.0582	0.460	-0.0442	0.418	-0.892***	-0.489
	(0.148)	(0.463)	(0.134)	(0.350)	(0.145)	(0.449)	(0.130)	(0.355)	(0.182)	(0.482)	(0.170)	(0.388)
Number of female members age 15-54	0.928***	2.222***	0.673***	1.488***	0.479***	0.992**	-0.114	-0.0878	0.305	0.729*	-0.719***	-0.545
	(0.158)	(0.396)	(0.139)	(0.304)	(0.134)	(0.339)	(0.125)	(0.284)	(0.158)	(0.364)	(0.167)	(0.303)
Number of male members age 15-54	0.581***	1.859***	0.733***	1.809***	0.336*	1.096**	0.229	0.826**	0.00386	0.445	-0.572**	-0.175
	(0.147)	(0.438)	(0.116)	(0.299)	(0.135)	(0.419)	(0.117)	(0.286)	(0.166)	(0.480)	(0.173)	(0.340)
Number of female members age >55	0.751***	2.017***	0.759***	1.499***	0.405*	1.104**	0.153	0.326	0.148	0.562	-0.576**	-0.510
	(0.194)	(0.470)	(0.175)	(0.424)	(0.177)	(0.408)	(0.158)	(0.355)	(0.203)	(0.448)	(0.192)	(0.418)
Number of male members age >55	0.527*	1.448*	0.865***	1.847***	0.325	0.963	0.487**	1.212**	-0.0600	0.0238	-0.455*	-0.112
	(0.238)	(0.683)	(0.173)	(0.475)	(0.230)	(0.652)	(0.169)	(0.453)	(0.244)	(0.731)	(0.201)	(0.507)
Constant	-0.224	-2.679	4.048***	2.479	-1.395	-4.951**	0.925	-0.595	0.0178	-2.112	4.845***	3.487*
	(0.809)	(1.828)	(0.934)	(1.455)	(0.712)	(1.661)	(0.815)	(1.308)	(0.834)	(1.871)	(0.956)	(1.485)
Observations	14472	4161	14472	4161	14472	4161	14472	4161	14472	4161	14472	4161
R-squared	0.318	0.635	0.408	0.628	0.357	0.659	0.433	0.650	0.312	0.630	0.398	0.623

Note: The dependent variable is the net area rented-in (in *koku*) (negative if rented-out). Year dummies are included. Robust standard errors are clustered by household in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A3. Estimates on net area of land acquired: 1-year interval

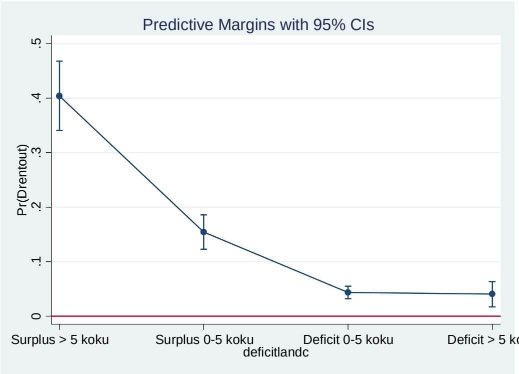
	Owned-land				Adjusted land deficit				Unadjusted land deficit			
	All samples	Participants only	All samples	Participants only	All samples	Participants only	All samples	Participants only	All samples	Participants only	All samples	Participants only
	OLS	OLS	FE	FE	OLS	OLS	FE	FE	OLS	OLS	FE	FE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Owned-land (*koku*)	-0.0219***	-0.453***	-0.0621***	-0.858***								
	(0.00421)	(0.0752)	(0.00647)	(0.0816)								
Land deficit (*koku*)					0.0243***	0.472***	0.0524***	0.816***	0.0215***	0.452***	0.0608***	0.862***
					(0.00425)	(0.0716)	(0.00501)	(0.0776)	(0.00410)	(0.0760)	(0.00616)	(0.0828)
Head's age	0.00896	0.386***	0.0131*	0.316*	0.0110*	0.369**	0.0168**	0.298*	0.00892	0.385***	0.0126*	0.317*
	(0.00491)	(0.115)	(0.00590)	(0.133)	(0.00501)	(0.118)	(0.00593)	(0.142)	(0.00492)	(0.115)	(0.00590)	(0.132)
Head's age squared	-0.000103*	-0.00436***	-0.000135*	-0.00318*	-0.000118*	-0.00403**	-0.000160*	-0.00270	-0.000102*	-0.00436***	-0.000128*	-0.00317*
	(0.0000518)	(0.00122)	(0.0000619)	(0.00146)	(0.0000526)	(0.00124)	(0.0000619)	(0.00155)	(0.0000519)	(0.00122)	(0.0000617)	(0.00145)
Female head	-0.0167	-0.114	-0.0134	0.508	-0.00923	-0.207	-0.000332	-0.163	-0.0137	-0.0931	-0.00804	0.415
	(0.0414)	(0.962)	(0.0511)	(1.201)	(0.0410)	(0.956)	(0.0494)	(1.221)	(0.0413)	(0.958)	(0.0509)	(1.183)
Status: Mizumomi	0.149**	3.667**	0.0278	-1.015	0.220***	5.058***	0.312***	1.793	0.152**	3.677**	0.0433	-1.182
	(0.0537)	(1.194)	(0.0929)	(1.504)	(0.0431)	(0.994)	(0.0754)	(1.360)	(0.0530)	(1.197)	(0.0899)	(1.496)
Status: Others	-0.0739*	-1.469	-0.149	-8.630**	-0.00696	-0.125	0.101	-6.891*	-0.0732*	-1.481	-0.148	-8.952**
	(0.0361)	(1.651)	(0.0860)	(2.897)	(0.0248)	(1.718)	(0.0577)	(2.819)	(0.0358)	(1.656)	(0.0851)	(2.855)
Bunke	0.0299	0.388			0.0410*	0.321			0.0315	0.439		
	(0.0200)	(0.605)			(0.0191)	(0.594)			(0.0199)	(0.606)		
Number of horses	0.138***	1.446*	0.0430	0.480	0.0683*	0.140	-0.107**	-1.534	0.136***	1.443*	0.0426	0.530
	(0.0311)	(0.689)	(0.0352)	(0.886)	(0.0333)	(0.656)	(0.0364)	(0.937)	(0.0310)	(0.685)	(0.0354)	(0.884)
Number of female members age <10	0.0231	0.859	0.0500	1.062	0.0147	0.482	0.0265	0.299	-0.0312	-0.201	-0.105**	-0.988
	(0.0256)	(0.561)	(0.0309)	(0.714)	(0.0251)	(0.531)	(0.0289)	(0.663)	(0.0277)	(0.565)	(0.0320)	(0.729)
Number of male members age <10	0.0380	0.677	0.0428	0.690	0.0216	0.299	0.00248	0.101	-0.0144	-0.390	-0.107***	-1.426*
	(0.0210)	(0.460)	(0.0218)	(0.548)	(0.0207)	(0.452)	(0.0205)	(0.579)	(0.0222)	(0.485)	(0.0241)	(0.568)
Number of female members age 10-14	0.0453	1.359	0.0785*	1.422	0.0302	0.823	0.0395	0.439	-0.00908	0.261	-0.0763*	-0.680
	(0.0297)	(0.749)	(0.0310)	(0.884)	(0.0291)	(0.748)	(0.0300)	(0.911)	(0.0301)	(0.743)	(0.0338)	(0.945)
Number of male members age 10-14	0.0344	1.510	0.0520	1.222	0.0132	0.882	-0.000843	-0.0753	-0.0187	0.422	-0.0994*	-0.955
	(0.0400)	(0.886)	(0.0411)	(0.844)	(0.0393)	(0.888)	(0.0402)	(0.932)	(0.0393)	(0.844)	(0.0399)	(0.840)
Number of female members age 15-54	0.0500*	0.669	0.0507*	0.438	0.0128	-0.0642	-0.0295	-0.930	-0.00582	-0.390	-0.107***	-1.553*
	(0.0208)	(0.472)	(0.0255)	(0.622)	(0.0200)	(0.471)	(0.0260)	(0.663)	(0.0212)	(0.477)	(0.0319)	(0.600)
Number of male members age 15-54	0.0119	0.533	0.0400	1.838**	-0.00800	-0.0168	-0.0123	0.520	-0.0400	-0.493	-0.109***	-0.207
	(0.0208)	(0.464)	(0.0238)	(0.604)	(0.0210)	(0.474)	(0.0233)	(0.643)	(0.0231)	(0.514)	(0.0277)	(0.677)
Number of female members age >55	0.0428	1.468*	0.0541	1.987**	0.0130	0.844	-0.0102	0.728	-0.0113	0.410	-0.0973**	-0.130
	(0.0267)	(0.650)	(0.0336)	(0.747)	(0.0268)	(0.657)	(0.0330)	(0.773)	(0.0274)	(0.650)	(0.0354)	(0.742)
Number of male members age >55	-0.00590	0.894	0.0294	1.661*	-0.0216	0.399	-0.00963	0.440	-0.0588*	-0.168	-0.120***	-0.461
	(0.0242)	(0.616)	(0.0247)	(0.772)	(0.0237)	(0.618)	(0.0245)	(0.813)	(0.0236)	(0.630)	(0.0279)	(0.866)
Number of female members born	-0.0251	-0.495	-0.0380	0.239	-0.0261	-0.773	-0.0417	-0.169	-0.0245	-0.459	-0.0372	0.227
	(0.0558)	(1.311)	(0.0561)	(1.439)	(0.0558)	(1.224)	(0.0563)	(1.425)	(0.0557)	(1.311)	(0.0558)	(1.455)
Number of male members born	0.160**	2.341	0.166**	0.496	0.156**	2.265	0.156**	-0.192	0.158**	2.333	0.162**	0.421
	(0.0578)	(1.237)	(0.0565)	(1.462)	(0.0581)	(1.314)	(0.0570)	(1.650)	(0.0578)	(1.235)	(0.0567)	(1.423)
Number of female members age <10 died	-0.0704	-4.246	-0.0828	-3.171	-0.0747	-4.256	-0.0898	-2.336	-0.0676	-4.094	-0.0751	-2.985
	(0.0867)	(2.921)	(0.0901)	(5.508)	(0.0870)	(3.007)	(0.0900)	(5.692)	(0.0867)	(2.880)	(0.0898)	(5.343)
Number of male members age <10 died	-0.0829	-1.408	-0.0970	-2.661	-0.0816	-1.194	-0.0930	-2.567	-0.0808	-1.408	-0.0923	-2.507
	(0.0689)	(2.289)	(0.0724)	(2.394)	(0.0681)	(2.335)	(0.0709)	(3.097)	(0.0692)	(2.290)	(0.0730)	(2.372)
Number of female members age 10-14 died	0.0228		-0.0484		0.0159		-0.0440		0.0239		-0.0524	
	(0.103)		(0.164)		(0.100)		(0.140)		(0.0998)		(0.153)	
Number of male members age 10-14 died	1.465	6.202	1.522	11.17***	1.443	5.462	1.483	10.91**	1.461	6.199	1.514	11.73***
	(0.801)	(3.680)	(0.806)	(2.850)	(0.801)	(4.224)	(0.812)	(3.513)	(0.801)	(3.735)	(0.809)	(2.810)
Number of female members age 15-54 died	-0.184*	-0.575	-0.172*	-0.248	-0.183*	-0.472	-0.171	-0.0812	-0.183*	-0.558	-0.169	-0.241
	(0.0921)	(3.411)	(0.0871)	(4.137)	(0.0921)	(3.352)	(0.0869)	(3.449)	(0.0919)	(3.387)	(0.0872)	(4.030)
Number of male members age 15-54 died	0.00973	1.557	0.0174	1.373	0.00984	1.056	0.0175	0.605	0.00958	1.534	0.0179	1.472
	(0.130)	(2.073)	(0.125)	(2.546)	(0.130)	(2.121)	(0.127)	(2.666)	(0.130)	(2.060)	(0.125)	(2.468)
Number of female members age >55 died	-0.0782	-2.443	-0.0735	-5.417	-0.0768	-1.640	-0.0716	-2.869	-0.0787	-2.235	-0.0758	-4.958
	(0.0582)	(4.355)	(0.0586)	(5.362)	(0.0581)	(4.426)	(0.0584)	(4.117)	(0.0581)	(4.380)	(0.0586)	(5.227)
Number of male members age >55 died	0.00327	1.081	-0.00532	1.380	0.00651	1.168	0.00672	1.709	0.00332	1.058	-0.00550	1.374
	(0.0536)	(2.666)	(0.0531)	(2.932)	(0.0534)	(2.574)	(0.0532)	(2.260)	(0.0536)	(2.590)	(0.0531)	(2.743)
Constant	0.165	-7.259*	0.535	-2.805	0.0530	-7.865**	0.155	-3.872	0.194	-6.903*	0.640*	-1.536
	(0.258)	(2.842)	(0.273)	(3.768)	(0.257)	(2.941)	(0.263)	(3.931)	(0.259)	(2.844)	(0.274)	(3.772)
Observations	13486	478	13486	478	13486	478	13486	478	13486	478	13486	478
R-squared	0.033	0.539	0.052	0.684	0.035	0.547	0.049	0.672	0.033	0.539	0.051	0.687

Note: The dependent variable is the net area acquired (in *koku*) (negative if released) in 1-year intervals. Year dummies are included. Robust standard errors are clustered by household in parentheses. *** p<0.01, ** p<0.05, * p<0.1

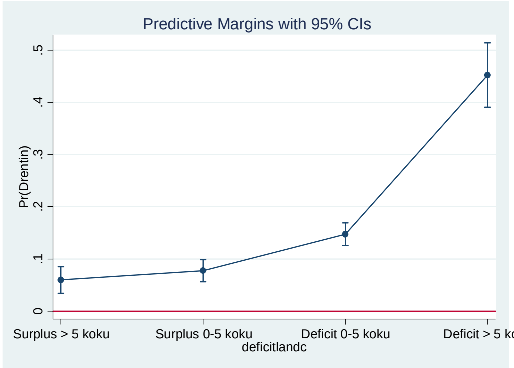
Table A4. Estimates on net area of land acquired: 10-year intervals

	Owned-land				Adjusted land deficit				Unadjusted land deficit			
	All samples	Participants only	All samples	Participants only	All samples	Participants only	All samples	Participants only	All samples	Participants only	All samples	Participants only
	OLS	OLS	FE	FE	OLS	OLS	FE	FE	OLS	OLS	FE	FE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Owned-land (*koku*)	-0.207***	-0.527***	-0.562***	-0.987***								
	(0.0410)	(0.0605)	(0.0540)	(0.0666)								
Land deficit (*koku*)					0.221***	0.548***	0.465***	0.949***	0.205***	0.529***	0.553***	0.996***
					(0.0425)	(0.0623)	(0.0470)	(0.0781)	(0.0398)	(0.0605)	(0.0505)	(0.0637)
Head's age	0.0415	0.223*	0.0790*	0.289*	0.0653	0.252*	0.134**	0.367**	0.0403	0.223*	0.0741	0.298*
	(0.0374)	(0.103)	(0.0385)	(0.119)	(0.0386)	(0.105)	(0.0420)	(0.134)	(0.0375)	(0.101)	(0.0393)	(0.119)
Head's age squared	-0.000624	-0.00290*	-0.000959*	-0.00299*	-0.000802	-0.00303**	-0.00141**	-0.00364*	-0.000609	-0.00289*	-0.000889*	-0.00303*
	(0.000409)	(0.00114)	(0.000419)	(0.00133)	(0.000418)	(0.00116)	(0.000454)	(0.00146)	(0.000410)	(0.00113)	(0.000426)	(0.00132)
Female head	0.0258	-0.127	0.187	-0.361	0.0892	-0.220	0.192	-0.550	0.0484	-0.191	0.217	-0.407
	(0.387)	(1.231)	(0.428)	(1.423)	(0.385)	(1.244)	(0.434)	(1.403)	(0.387)	(1.231)	(0.428)	(1.414)
Status: Mizumomi	1.704**	4.342***	1.285	-0.762	2.425***	6.002***	4.017***	2.723	1.698**	4.341***	1.387	-0.853
	(0.598)	(1.101)	(0.938)	(1.459)	(0.507)	(0.987)	(0.792)	(1.438)	(0.595)	(1.101)	(0.917)	(1.438)
Status: Others	-0.735	-0.664	-2.092*	0.108	-0.000559	0.0937	0.890*	2.521	-0.735	-0.678	-2.102*	-0.0790
	(0.461)	(0.651)	(1.033)	(1.886)	(0.325)	(0.656)	(0.407)	(1.934)	(0.473)	(0.681)	(0.849)	(1.899)
Bunke	-0.0424	-0.660			0.0587	-0.487			-0.0273	-0.634		
	(0.215)	(0.520)			(0.204)	(0.508)			(0.214)	(0.514)		
Number of horses	1.648***	3.241***	0.705*	1.653*	1.091***	1.951**	-0.467	-0.698	1.644***	3.242***	0.747*	1.740*
	(0.295)	(0.636)	(0.313)	(0.763)	(0.304)	(0.628)	(0.308)	(0.746)	(0.297)	(0.641)	(0.317)	(0.764)
Number of female members age <10	-0.0640	-0.180	0.265	0.766	-0.0928	-0.394	0.195	0.548	-0.587*	-1.461**	-1.171***	-1.606*
	(0.217)	(0.526)	(0.207)	(0.651)	(0.214)	(0.504)	(0.199)	(0.597)	(0.246)	(0.558)	(0.221)	(0.629)
Number of male members age <10	-0.0390	-0.214	0.0984	0.227	-0.123	-0.441	-0.136	-0.154	-0.542**	-1.510***	-1.282***	-2.219***
	(0.193)	(0.464)	(0.176)	(0.514)	(0.190)	(0.462)	(0.169)	(0.533)	(0.201)	(0.443)	(0.167)	(0.520)
Number of female members age 10-14	0.0286	0.395	0.136	0.303	-0.117	-0.368	-0.186	-1.162	-0.494	-0.920	-1.308***	-2.223**
	(0.244)	(0.660)	(0.221)	(0.709)	(0.242)	(0.649)	(0.237)	(0.780)	(0.253)	(0.632)	(0.270)	(0.681)
Number of male members age 10-14	0.336	1.621*	0.426	1.686*	0.157	0.954	-0.00162	0.680	-0.184	0.293	-0.991***	-0.841
	(0.245)	(0.705)	(0.240)	(0.731)	(0.236)	(0.699)	(0.236)	(0.716)	(0.244)	(0.704)	(0.257)	(0.756)
Number of female members age 15-54	0.261	0.206	0.136	0.143	-0.0858	-0.622	-0.571**	-1.277*	-0.274	-1.116**	-1.310***	-2.330***
	(0.149)	(0.379)	(0.161)	(0.533)	(0.154)	(0.375)	(0.190)	(0.615)	(0.170)	(0.377)	(0.239)	(0.553)
Number of male members age 15-54	0.0607	0.657	0.144	0.985*	-0.221	-0.271	-0.495**	-0.544	-0.448*	-0.620	-1.245***	-1.459**
	(0.167)	(0.429)	(0.151)	(0.497)	(0.169)	(0.444)	(0.183)	(0.589)	(0.180)	(0.425)	(0.202)	(0.510)
Number of female members age >55	0.576*	1.474	0.771*	1.531	0.267	0.596	0.136	0.188	0.0644	0.185	-0.623	-0.991
	(0.280)	(0.795)	(0.311)	(0.859)	(0.277)	(0.795)	(0.319)	(0.924)	(0.282)	(0.797)	(0.347)	(0.892)
Number of male members age >55	-0.173	-0.724	0.00252	-0.878	-0.356	-1.039	-0.450	-1.324	-0.671*	-2.029**	-1.356***	-3.299***
	(0.258)	(0.709)	(0.224)	(0.736)	(0.257)	(0.697)	(0.242)	(0.749)	(0.259)	(0.711)	(0.249)	(0.744)
Number of female members born during inverval	0.299	0.682	0.147	0.647	0.343	0.595	0.217	0.442	0.298	0.686	0.142	0.718
	(0.175)	(0.411)	(0.144)	(0.457)	(0.177)	(0.402)	(0.155)	(0.459)	(0.176)	(0.412)	(0.147)	(0.461)
Number of male members born during inverval	0.346*	1.577**	0.323	1.650**	0.337*	1.408**	0.312	1.371*	0.336*	1.564**	0.291	1.701**
	(0.170)	(0.474)	(0.175)	(0.517)	(0.167)	(0.481)	(0.174)	(0.549)	(0.170)	(0.473)	(0.176)	(0.520)
Number of female members age <10 died during inverval	-0.0677	-0.879	-0.0614	-1.431*	-0.0901	-0.722	-0.0742	-1.177	-0.0452	-0.859	-0.00543	-1.461*
	(0.298)	(0.604)	(0.255)	(0.709)	(0.308)	(0.627)	(0.275)	(0.720)	(0.299)	(0.602)	(0.250)	(0.687)
Number of male members age <10 died during inverval	-0.0726	-0.111	-0.170	-1.497	-0.0956	-0.00965	-0.215	-1.110	-0.0574	-0.0976	-0.140	-1.475
	(0.273)	(0.674)	(0.270)	(0.907)	(0.267)	(0.675)	(0.266)	(0.936)	(0.274)	(0.681)	(0.275)	(0.927)
Number of female members age 10-14 died during inverval	1.513*	3.332	0.883**	3.546	1.512*	3.992*	1.084	5.525***	1.563*	3.707	0.936**	4.287
	(0.628)	(2.494)	(0.327)	(2.266)	(0.762)	(1.589)	(0.737)	(1.332)	(0.633)	(2.701)	(0.341)	(2.609)
Number of male members age 10-14 died during inverval	1.806*	4.277	2.189*	6.563*	1.852*	4.629	2.504*	7.302*	1.773*	4.263	2.072*	6.368*
	(0.806)	(2.734)	(0.916)	(2.662)	(0.826)	(2.798)	(0.969)	(2.821)	(0.805)	(2.700)	(0.912)	(2.591)
Number of female members age 15-54 died during inverval	-0.107	-1.059	-0.0219	-0.424	-0.0995	-0.920	0.0239	0.0709	-0.117	-1.141	-0.0417	-0.473
	(0.272)	(0.874)	(0.235)	(0.935)	(0.274)	(0.917)	(0.248)	(0.924)	(0.270)	(0.866)	(0.232)	(0.930)
Number of male members age 15-54 died during inverval	-0.223	-2.222*	-0.249	-1.068	-0.263	-2.472*	-0.387	-1.399	-0.231	-2.281*	-0.275	-1.031
	(0.302)	(0.913)	(0.294)	(1.025)	(0.303)	(0.965)	(0.303)	(1.042)	(0.300)	(0.893)	(0.290)	(1.031)
Number of female members age >55 died during inverval	-0.119	0.578	-0.0566	0.620	-0.130	0.526	-0.0706	0.857	-0.144	0.513	-0.123	0.505
	(0.281)	(0.749)	(0.251)	(0.823)	(0.280)	(0.730)	(0.255)	(0.821)	(0.280)	(0.746)	(0.249)	(0.815)
Number of male members age >55 died during inverval	0.289	1.058	0.374	0.417	0.255	0.786	0.373	-0.116	0.278	0.998	0.340	0.292
	(0.263)	(0.673)	(0.241)	(0.858)	(0.266)	(0.674)	(0.254)	(0.893)	(0.263)	(0.672)	(0.242)	(0.851)
Constant	-0.154	-2.345	3.866***	2.022	-1.490	-4.561	-0.330	-3.252	0.146	-1.645	4.803***	3.167
	(0.921)	(2.455)	(1.044)	(2.539)	(0.918)	(2.461)	(0.940)	(2.943)	(0.927)	(2.403)	(1.056)	(2.557)
Observations	1262	399	1262	399	1262	399	1262	399	1262	399	1262	399
R-squared	0.202	0.510	0.401	0.644	0.209	0.517	0.364	0.629	0.201	0.513	0.399	0.651

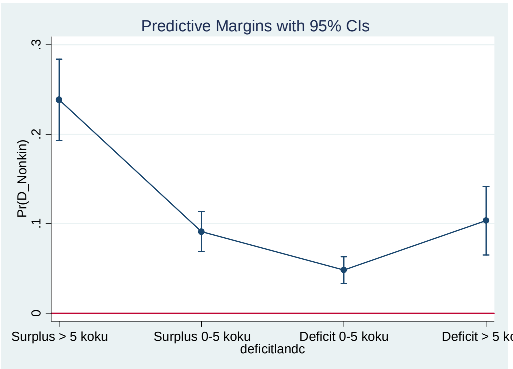
Note: The dependent variable is the net area acquired (in *koku*) (negative if released) in 10-year intervals. Year dummies are included. Robust standard errors are clustered by household in parentheses. *** p<0.01, ** p<0.05, * p<0.1



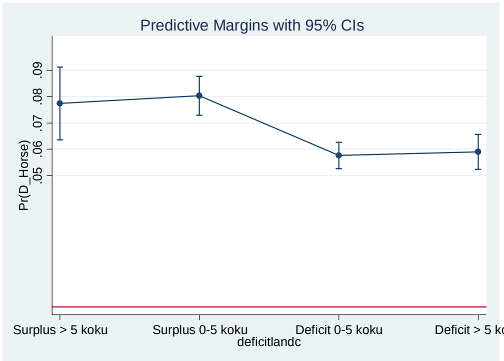
Rent-out



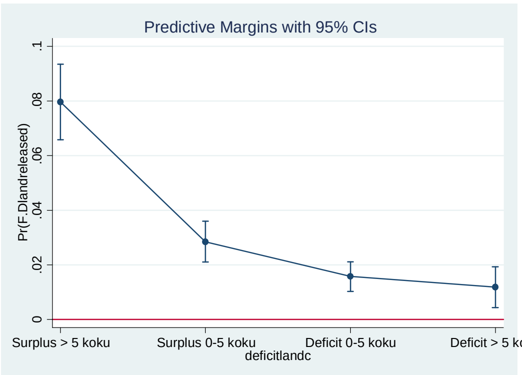
Rent-in



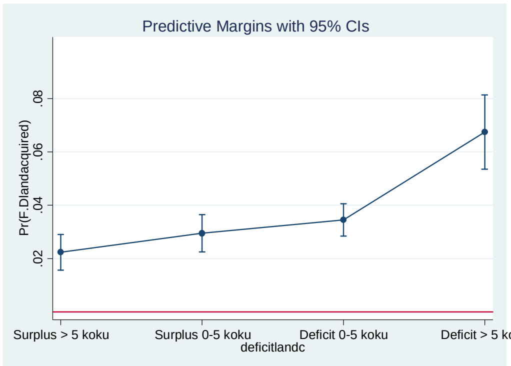
Employ non-kin member



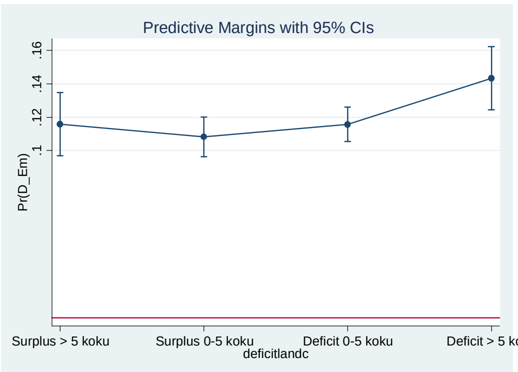
Increase number of horses



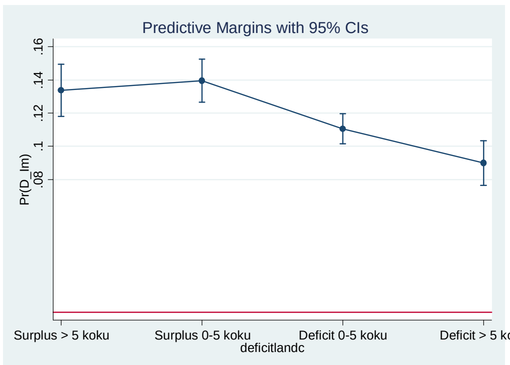
Release land



Acquire land



Out-migration of kin members



In-migration of kin members

Figure A1. Average predicted probabilities of adopting factor-ratio stabilization strategies