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Less-favoured-area payments, farmland abandonment and farm size: evidence from hilly and mountainous areas in Japan*

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A direct payment (DP) scheme for hilly and mountfainous areas has been in place in Japan since 2000. This scheme's objective is to fill the gap in production costs between these less favourable areas and other agricultural locations and prevent abandoned farmland from increasing. Eligible rural communities decide whether to receive DPs, and half of the DP allocation in communities with DPs is distributed for collaborative community activities, with the remaining half allocated directly to farmers. We apply a difference-in-differences approach to examine the effect of these payments on farmland use. Using a large farm-level panel data set from before and after the payments were initiated, we employ a causal framework of analysis with a treatment group and two alternative control groups. We find that the payments led to a slowdown in the increase of abandoned farmland among surviving farms. Moreover, the payments have a marginal positive effect on the operated farm size of surviving farmers. The results imply that direct payment schemes in less-favoured areas play a key role in maintaining farmland.

Key words: abandoned farmland, direct payments, farm size, less-favoured areas.

1. Introduction

Less-favoured areas (LFAs) are areas with unfavourable natural conditions (in terms of altitude, land slope, climate or soil) or hilly and mountainous areas. LFAs are perceived as difficult to farm, consequently causing depopulation and the abandonment of farmland. Therefore, making direct payments (DPs) to farm businesses in LFAs has been a central policy tool to secure farming continuity and prevent farmland abandonment in the European Union (EU) and Japan. LFA measures in the EU have a long history, and the LFA compensatory allowance has been part of the Common Agricultural Policy (CAP) since 1975. Japanese farming households in LFAs

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have also been subsidised since the introduction of a DP scheme for hilly and mountainous areas (HMAs) in 2000, which aims to fill the gap in production costs between LFAs and other areas and prevent increases in abandoned farmland through the maintenance of farm production activities.

Given that the EU and Japan have tried to achieve the protection of natural and human resources in the countryside through DPs, it is natural that more attention has been paid to the effects of DPs in LFAs. However, whether DPs in LFAs ensure continued agricultural land use and prevent land abandonment is not clear (Cooper *et al.* 2006). In particular, as previous studies have conducted analyses via case studies or descriptive statistics, rigorous empirical evidence on the effects of DPs in LFAs on farmland use is limited. The exceptions are two recent studies by Takayama *et al.* (2020) and Ito *et al.* (2019). Takayama *et al.* (2020) use rural community-level panel data in Japan and find that, although DPs for HMAs fostered continued land use and prevented farmland abandonment through the maintenance of farm households and household members, these effects are modest. Ito *et al.* (2019) also focus on Japanese rural communities in a limited number of regions and find that DPs deter farmland abandonment. For both the EU and Japan, there is little to no empirical evidence on farm-level land use in response to DPs in LFAs due to the focus on aggregate data in the previous literature.

It is also widely recognised that, regardless of the DPs in LFAs, the subsidies themselves can influence farmers' decisions by altering expectations about future payments, easing potential credit constraints, altering land values, affecting the risk faced by farmers or altering labour markets (Bhaskar and Beghin 2009). This is likely to change farmers' behaviour and force them to reconsider their degree of participation in agricultural production (Kazukauskas *et al.* 2013). Although the effect is considered to be one of the main drivers of structural change (Ahearn *et al.* 2005; Yee and Ahearn 2005; Roberts and Key 2008), our understanding of how government policies affect the structure of agriculture, most simply characterised by the size of farms, remains limited (Ahearn *et al.* 2005; Happe *et al.* 2008). In particular, there is mixed evidence on the causal relationships between DPs and farmland use (e.g. Roberts and Key 2008; O'Donoghue and Whitaker 2010; Weber and Key 2012). Moreover, regarding LFAs, there is little empirical research on the effect of DPs on farm size. The extent to which DPs in LFAs contribute to the structural change in agriculture is also an indicator of the legitimacy of DPs.

There are two reasons why evidence on the causal effects of DPs is limited. First, there is a quality problem associated with farm-level data sets. The use of farm-level microdata has become the norm, mainly because of its informational richness (Kazukauskas *et al.* 2013). Farm-level microdata provide many observable factors influencing farm structure and, therefore, are the most suitable starting points for identifying the effect of DPs. For example, in the analyses of the EU's CAP, extensive farm-level panel data extracted from the Farm Accounting Data Network's (FADN) database are often used. However, individual longitudinal data are only available in a few countries and are not necessarily sampled in a statistically representative fashion (Roder and Kilian 2008). Second, an econometric challenge complicates the identification strategy. There are many cases where participation in farm programs is voluntary. For example, most types of subsidies in the EU are not assigned randomly because they have eligibility conditions and selection criteria that can be met only by certain types of farms (Nilsson 2017). In most instances, the causes for variations in payments across observationally similar farms are also unclear; this opens the possibility that unobservable factors could be associated with both program participation (or payment levels) and outcomes such as agricultural production (Weber and Key 2012).

Our goal was to empirically assess the effect of DPs for HMAs on farmland use at the farm level in Japan. The first policy-related question we ask is whether the main goal of these DPs for HMAs—preventing farmland abandonment—is achieved at the farm level. The second question is whether DPs for HMAs also affect farm size. We focus on a Japanese case study to exploit an exogenous setting for the receipt of DPs for HMAs. Compared to the DPs for HMAs in the EU, those for HMAs in Japan take a unique form: receipt of DPs is not based on the decisions of farmers but those of rural communities—the smallest unit of society in rural regions. These DPs are characterised by the rural community's voluntary participation in a program meant to realise efficient and sustainable exploitation of natural and human resources on the basis of strict conditionality (Ito *et al.* 2019). The rural communities with sloped farmland are eligible for DPs if they are located in target regions, on the condition that members of the community cooperatively engage in activities related to agricultural production for at least five years. After receiving DPs, according to the government's allocation rule, half of the amount is distributed to community activities through community cooperation, and the remaining half is allocated to farmers in the community. However, rural communities not located in target regions are not eligible for the DPs even if they have sloping farmland. The variation in receipt of DPs at the rural community level has led to the exogenous receipt of DPs by community farmers and provides both a treatment and a control group. The existence of farmers who do not receive DPs allows us to use the policy as a natural experiment to identify the effect of DPs on farm production response. To estimate the impact of DPs on farmland use at the farm level, we apply a difference-in-differences (DID) approach with farm-level panel data before and after DPs were initiated for HMAs. This method allows for controlling unobserved factors that may confound the impact of DPs.

The choice of DPs for HMAs in Japan as a case study has two advantages, other than the exogenous setting for receipt of DPs by farmers. First, we utilise a panel data set and provide detailed information at the farm-household level on the characteristics of farm households. The availability and quality problem associated with farm-level data sets are responsible for the limited causal evidence on the effects of DPs. In this study, our data source for Japan, coupled with an exogenous setting for receipt of DPs by farmers, provides a unique opportunity to empirically analyse the importance of DPs for maintaining farmland. Second, Japan has considered DPs for HMAs as a strategy to maintain the agricultural sector in disadvantaged areas. According to the latest available statistics from Japan's Ministry of Agriculture, Forestry and Fisheries (MAFF), HMAs account for approximately 40.9% of farmland and 40.8% of agricultural output. Although the conservation of the farmland in HMAs is an important issue for food security in Japan, large-scale depopulation of rural areas and farmland abandonment are major problems due to unfavourable natural conditions for agricultural production. Therefore, considering that policymakers worldwide are searching for multimodal interventions for the protection of natural and human resources in the countryside (Ito *et al.* 2019), they should be aware of whether specific types of subsidies affect farmland use.

This study adds to the literature on farm production responses to subsidies. Since the introduction of DPs, the central research issue has been whether they have an impact on farm choices, as well as the ultimate magnitude of this impact (Moro and Sckokai 2013). More precisely, we contribute to the literature in three ways. First, this is the first study to examine the effect of DPs in LFAs at the farm level. It adds to the extant literature by making novel contributions regarding the effects of DPs in LFAs. Second, we examine farm-level data for all farm households located in LFAs. These data include small 'hobby' farms, which capture non-commercial or self-sufficient farmers. By contrast, FADN data in the EU consist of commercial farms selected by introducing a minimum economic threshold size, which may cause sample selection bias. Third, we pay attention to the possible endogeneity of receipt of DPs. Our study has the advantage of overcoming the endogeneity problem and identifying the effect of complex government programs. Since there are no DP measures for the farmers other than the LFA payments during the target period of analysis, we need not identify the effect of DPs other than those for HMAs. We can also exploit a quasi-experimental setting to identify the impact of DPs.

This study builds on Takayama *et al.* (2020) and Ito *et al.* (2019), who also examine the impact of DPs for HMAs on farmland use in Japan. However, it differs from the cited studies in the analysed unit of observation. Using data aggregated at the rural community level, they show that DPs for HMAs prevent the abandonment of farmlands in rural communities. The aggregate regional effects might be different owing to potentially different reactions at the individual level (Storm *et al.* 2015). The limitations of the aggregate data mean that they could not explore the different responses to DPs for HMAs among farmers within the same rural community. They could only identify these aggregated effects of DPs for HMAs in a region, which likely differ from the individual-level effects. By contrast, farm-level studies allow for direct analyses of the effects of DPs on farm behaviour. Using detailed census data at the farm level, we provide empirical farm-level results, which increase the confidence in using regional studies for policy assessments.

2. Policy background in Japan

In Japan, HMAs are generally recognised as LFAs. HMAs have played an important role in Japan's agriculture and, in particular, rural areas. However, the population in HMAs tends to decrease continuously, and the mean age of farmers rises faster than that in other areas. The increasing rate of abandoned farmland area—423,000 ha in 2015—has become a major national issue. Of the total area of abandoned farmland, 54.1% comprises HMAs. The abandonment ratio in HMAs, officially defined as the farmland abandonment area divided by the cultivated area plus the farmland abandonment area, rose from 11.1% in 2000 to 16.7% in 2015, higher than in flatland areas. This is attributed to ageing farmers, lack of successors and poor land productivity resulting from the comparative disadvantage of HMAs.

Under these circumstances, the introduction of DPs for HMAs was announced in August 1999, and they were finally launched in April 2000. DPs for HMAs aim to fill the gap of production costs between HMAs and flat areas, thus preventing increases in the area of abandoned farmland and securing multiphase functions through the maintenance of farm production activities in HMAs. This initiative was the first instance of a 'direct' payment scheme under Japanese agricultural policy. DPs have been revised every five years since 2000, and the fourth phase began in 2015. This policy continues with some minor changes, but the outline of the program has hardly changed. The target regions of DPs for HMAs are LFAs, which are formally designated by eight LFA development laws (e.g. the mountainous area development law, the peninsula development law and the remote island development law), or other areas designated by prefectural governors. DPs for HMAs in Japan take a unique form: rural communities, not farmers, decide the recipients of the subsidy. The receipt of DPs for HMAs depends on whether the rural community with sloped farmlands is located in target regions. If rural communities that are located in the target regions of DPs for HMAs and have farmland consisting of steep or moderate slopes have signed an agreement with a municipality, they receive a fixed amount of subsidies depending on the size of the farmland, on the condition that they maintain agricultural production activities for at least five consecutive years. Subsidy rates for an area are calculated according to the type and gradient of farmland—whether it has steep slopes (paddy fields with a slope higher than 1/20 and dry fields with a slope greater than 15°) or moderate slopes (paddy fields with a slope higher than 1/100 and dry fields with a slope greater than 8°). Thus, in target regions, rural communities with farmland consisting of steep or moderate slopes decide whether to participate in the DPs, given their economic consequences. In 2005, 72% of the rural communities entitled to receive DPs for HMAs opted to receive them (Takagishi and Hashizume

2010). Moreover, even if rural communities have farmland with steep or moderate slopes, those not located in target regions are not eligible for LFA payments. Hence, this study employs farmers who do not receive DPs as the control group.

Total direct payment expenditures reached JPY 77.2 billion in 2017, and DPs for HMAs accounted for the second largest share (34%) of the expenditures. DPs launched in 2007 to promote multifunctionality in agriculture account for the largest share. In 2017, 25,320 rural communities (with 24 farm households on average per agreement) signed contracts with their municipal government, covering a total of 66.3 million hectares (25.9 hectares per rural community). The DPs encompass 40% of the farmlands in HMAs, representing 16% of the farmland in Japan (Ito *et al.* 2019). Until 2010, the Japanese government recommended that more than half the LFA payments should be used for community activities, and the remaining amount should be allocated to community farm members based on the amount of sloping farmland operated by each farmer. Thus, DPs in LFAs require the cooperation of community members since the main crop grown in Japan is rice, for which common pool resources (CPRs) such as irrigation and farm roads are of particular importance. Moreover, such resources have long been collectively managed by farmers in rural communities (Ostrom 1990). A rural community, including small and large farmers, can sustain irrigation facilities and rice cropping (Takayama *et al.* 2018). Since it is difficult for only a few individual farmers to manage farming CPRs, DPs are first granted to the community and restricted to community activities only. The Japanese payment system, grounded in community-based paddy farming, is different from that in the EU, where a subsidy is paid to maintain the activities of individual farming households with eligibility requirements regarding farm size (Shogenji 2003). Since 2011, the policy has stipulated that more than half of LFA payments should be allocated to community farm members. In 2017, 48.3% of total LFA payments were allocated to community activities, and 51.7% to community members (MAFF 2018). In 2017, 34.7% of the total payments allocated to community activities were used for the collective management of CPRs, 7.9% for machines and facilities shared by farm members, and 28.1% were reserved for future activities (Takayama *et al.* 2020).

3. Empirical framework

3.1 Empirical strategy

Our objective was to identify the effect of DPs on farmland use at the farm level in the communities that have received DPs for HMAs. Specifically, we are interested in comparing abandoned farmland and operated farm size when DPs for HMAs are introduced to the counterfactual, that is abandoned farmland and operated farm size when DPs for HMAs are not received in treatment groups at the same time. Since we cannot observe the counterfactual, we must estimate it. A major concern in this estimation is that farmers in the community that received DPs for HMAs could differ from farmers in another that did not receive DPs for HMAs, and these differences may be correlated with farmland use during the target period of analysis. In principle, many types of (unobservable) characteristics that may confound identification vary across farmers but are fixed over the target period. To overcome time-invariant unobserved heterogeneity, we use panel data and a DID approach. This approach compares the change in farmland use in the treatment group before and after DPs for HMAs to the change in farmland use in the control group. By comparing changes, we control for observed and unobserved time-invariant farm household (or community) characteristics that might be correlated with the decision on the introduction of DPs for HMAs and with farmland use. The change in the control farmers is an estimate of the true counterfactual—or of what would have happened to the treated farmers if the rural community had not received DPs for HMAs.

Furthermore, the endogeneity problem can be circumvented by focusing on the mechanism of receipt of DPs for HMAs. The decision to receive DPs for HMAs is based not on the farmers but on the community. Then, the receipt of DPs for HMAs depends on whether the rural community with sloped farmlands is located in target regions. Therefore, rural communities in non-target regions are not eligible to receive DPs for HMAs even if they have sloped farmlands, and consequently, farmers in such communities cannot receive DPs. Moreover, the determination of target regions as LFAs occurs at the municipal level and coincides with the municipality boundary. If the municipality satisfies some specific conditions (e.g. population density, pace of decline in population, size of population, ratio of farmland or upland fields with slopes, and ratio of forest land), rural communities located in the municipality are designated as target regions. However, these specific conditions at the municipality level are not directly linked to farmers' agricultural production decisions. For example, although the conditions of population density, pace of decline in population and size of population should be met, they are municipality-level, nonfarm indicators unrelated to individual farmers' farmland use (Takayama *et al.* 2020). Given such conditions for implementing DPs for HMAs, the existence of farmers who cannot receive DPs for HMAs allows us to use the policy as a natural experiment to identify the effect of DPs on farmland use.

As shown in Table 1, we define farmers in rural communities (with sloping farmlands and receiving DPs) in the target regions as the treated farmer group and two alternative farmer groups as the control groups. This selection of groups is based on the variations in the implementation of DPs across communities, that is the receipt of DPs itself depends on the rural communities' decision-making, rather than that of farmers. The first control groups consist of farmers in a rural community (with sloping farmland and not receiving DPs) in non-target regions (Control Group 1). Thus, the farmers in the rural community cannot receive DPs due to institutional constraints. The second contains farmers in a rural community (with sloping farmland and not receiving DPs) in a target region (Control Group 2). Control Group 2 is used to check the robustness of the results obtained via Control Group 1. The selection of Control Group 2 is based on the fact that, in the target region, the rural community's decision to receive DPs depends on community characteristics such as the presence of farmers as leaders, the distance to the market, and the endowment of farmlands with slope (Takagishi and Hashizume 2010; Takayama *et al*. 2020). Therefore, by using panel data and a DID approach, we control for time-invariant community characteristics that might be correlated with the rural community's decisions to receive DPs.

The DID estimator, the effect of DPs for farmer *i*, is estimated as follows:

$$Y_{it} = \alpha + \lambda DPs_i + \beta Year_t + \delta_D DPs_i Year_t + \theta X_{it} + \varepsilon_{it} \quad (1)$$

Let Y_{it} be the observed outcome variables. Our outcome variable of interest is the abandoned farmland and operated farm size. $Year_t$ captures time or aggregate effects and is equal to 1 if the observations are from the post-treatment survey, and 0 otherwise; DPs_i is a farm-level indicator that is equal to 1 if the farmer is in a community that receives DPs, and 0 otherwise. The coefficient of interest is δ_D, which gives the DID estimate and is interpreted as the effect of DPs on the outcome. X_{it} is a vector of time-varying controls. Specifically, these variables are age and sex of farm household head, successor, spouse, size of owned farmland, share of paddy field, share of farm income, agricultural sales and farming system. Given the endogenous nature of farmers' choices, we would be concerned about including bad controls (Angrist and Pischke 2008). Therefore, we only include age and sex of the farm household head, considered as exogenous variables, in our first

Table 1 Receipt of DPs for HMAs, 2000–2005

	Receipt of DPs for HMAs	Is the majority of the farmland in communities sloped?	In target regions? (LFAs as designated areas under rural promotion legislation)	Number of farmers	Number of farmers in each group / Number of all sample farmers (%)
Treatment Group	Yes	Yes	Yes	228,668	47.7
Control Group 1	No	Yes	No	26,791	5.6
Control Group 2	No	Yes	Yes	223,896	46.7
Total				479,355	100.0

Sources: Census of Agriculture and Forestry (Japan).

specifications and use other controls as a robustness check. ε_{it} is the idiosyncratic error term.

3.2 Data

Farm-level data extracted from the Census of Agriculture and Forestry administered by the MAFF are used. This census has been conducted every five years since 1950 for all farms to measure actual agricultural conditions in Japan. The census includes information on land and labour resources at the farm level. Due to limited data availability, we concentrate on data from 2000, which capture the situation before the introduction of DPs, and from 2005, which capture the effect of DPs. Further, we employ a balanced panel data set, which consists of farms that existed both in 2000 and 2005. Therefore, note that we present the effect of DPs conditional on survival. We are not concerned that part of the farmland adjustment may have already taken place in 2000, because the outline of this DP scheme was published in December 1999 and the scheme was formally launched in April 2000. Our data were collected on 1 February 2000. The period from the formal announcement to data collection is only one month. Therefore, it is difficult for farmers to make any adjustments to the operated farmland in such a short period. Furthermore, participation in the DP scheme is based on community decisions. At the time of data collection, farms did not know whether their community would participate, as the communities had not yet decided. Farmers in Hokkaido and Okinawa prefectures are excluded because the geographical conditions of these areas are different. Farmers in Tokyo and Osaka prefectures are also excluded due to the intense effects of urbanisation in these areas, although the results are sufficiently robust to support the inclusion of such prefectures. Table 1 shows that there are 479,355 farmers in communities where the majority of the farmland is sloped—of these, 47.7% of the farmers are in the treatment group, 5.6% are in Control Group 1, and 46.7% are in Control Group 2.

One of the dependent variables is farm size. We consider operated farmland as the indicator of farm size. Among the productive factors, the availability of farmland is the one that most often limits farm development and is the most suitable as an indicator of farm size (Bartolini and Viaggi 2013). According to the census, the operated farmland is defined as the amount of farmland in operation: the farmland owned by the operator plus farmland rented in minus farmland rented out minus farmland abandoned. To reduce the influence of outliers, we use the natural log to transform the two dependent variables.

Table 2 presents the mean values for the treatment and control groups for each outcome and the control variables used in the analysis over the 2000–2005 period. The top row shows the abandoned farmland area, which reveals that, before the introduction of DPs in 2000, there were no differences in abandoned farmland area among groups. In 2005, abandoned farmland

Table 2 Descriptive statistics of outcomes and control variables

	Treatment Group (n = 228,668)		Control Group 1 (n = 26,791)		Control Group 2 (n = 223,896)	
	2000	2005	2000	2005	2000	2005
Outcomes						
Abandoned farmland (ha)	0.088	0.095	0.090	0.100	0.092	0.100
Operated farmland (ha)	1.037	1.031	1.029	1.016	1.086	1.071
Farmland rented in (ha)	0.154	0.177	0.146	0.173	0.177	0.204
Farmland rented out (ha)	0.041	0.049	0.051	0.060	0.051	0.062
Farmer characteristics						
Age of household head	58.73	62.48	58.66	62.20	59.09	62.76
Male household head (Dummy)	0.96	0.95	0.97	0.96	0.96	0.95
Successor (Dummy)	0.50	0.40	0.62	0.50	0.54	0.43
Spouse (Dummy)	0.88	0.85	0.89	0.87	0.89	0.86
Ratio of paddy field (%)	70.13	71.57	70.28	71.31	68.33	69.61
Owned farmland (ha)	1.01	1.00	1.02	1.00	1.05	1.03
Agricultural sales (JPY)						
$<$ 500,000	0.19	0.23	0.20	0.25	0.20	0.24
500,000 $\leq$ 1,000,000	0.27	0.28	0.27	0.27	0.27	0.27
1,000,000 $\leq$ 2,000,000	0.21	0.18	0.20	0.18	0.20	0.17
2,000,000 $\leq$ 3,000,000	0.14	0.13	0.14	0.13	0.13	0.13
3,000,000 $\leq$ 5,000,000	0.06	0.05	0.06	0.05	0.06	0.05
5,000,000 $\leq$ 7,000,000	0.05	0.05	0.05	0.04	0.05	0.05
7,000,000 $\leq$ 10,000,000	0.03	0.03	0.03	0.03	0.03	0.03
10,000,000 $\leq$ 15,000,000	0.02	0.02	0.02	0.02	0.02	0.02
15,000,000 $\leq$ 20,000,000	0.01	0.01	0.02	0.02	0.02	0.02
$\geq$ 20,000,000	0.01	0.01	0.02	0.01	0.02	0.02
Type of farmer						
Commercial farmer (only farm income)	0.15	0.22	0.11	0.16	0.15	0.21
Commercial farmer (farm income > nonfarm income)	0.13	0.12	0.11	0.12	0.13	0.12
Commercial farmer (nonfarm income > farm income)	0.69	0.65	0.75	0.72	0.69	0.66
Self-sufficient farmer	0.02	0.01	0.02	0.00	0.03	0.01
Farming system						
Rice	0.52	0.49	0.56	0.51	0.52	0.48
Field crop	0.04	0.04	0.03	0.03	0.04	0.04
Vegetable	0.03	0.04	0.04	0.04	0.05	0.05
Fruit	0.09	0.09	0.08	0.08	0.08	0.08
Mixed	0.21	0.18	0.17	0.15	0.20	0.18
Others	0.02	0.02	0.02	0.02	0.02	0.02
No sales	0.09	0.15	0.10	0.17	0.10	0.16

Sources: Census of Agriculture and Forestry (Japan).

among all groups increased. However, in the treatment group, the rate of increase in abandoned farmlands is lower. Furthermore, in 2000, operated farmland—an indicator that measures whether the operated farm size has been maintained under DPs—was about 1 hectare for all groups. In 2005, this level marginally decreased for all groups. However, in the treatment group, the rate of decrease in the operated farmland is lower. This straightforward finding regarding the sample mean may imply that DPs contribute to a slowdown in the increase of farmland abandonment and the decrease of farm size. However, to acquire more rigorous empirical results, we have to control for confounding factors related to farm characteristics.

3.3 Identifying assumption of DID

In Model (1), δ_D is the DID estimate of the effect of DPs on farmland use. The key identifying assumption for this interpretation is that the change in outcomes for farmers without DPs is an unbiased estimate of the counterfactual. While we cannot directly test this assumption, we can observe whether the secular time trends in the control and treatment groups are the same in the periods before the introduction of DPs. If the secular trends are the same in these periods, then it is likely that they would have been the same in the periods after the introduction if the treated groups had not received DPs.

Figure 1 shows the evolution of outcomes for the treated and control groups. The available census data before 2000 are only at the community level. Therefore, we use these data and re-estimate the indicator per farmer. This figure shows that, during the 30 years before the introduction of DPs for HMAs in 2000, farmers' operated farmland in areas that eventually received DPs is at the same level as the operated farmland in communities that did not go on to receive DPs. Abandoned farmland reflects an increasing trend, implying that time trends (and levels) for the treated and control groups are similar (parallel trend in the growth paths).

Furthermore, another identifying assumption is that the stable unit treatment value assumption (SUTVA) requires that potential outcomes be unrelated to the treatment status of other units. In our application, the

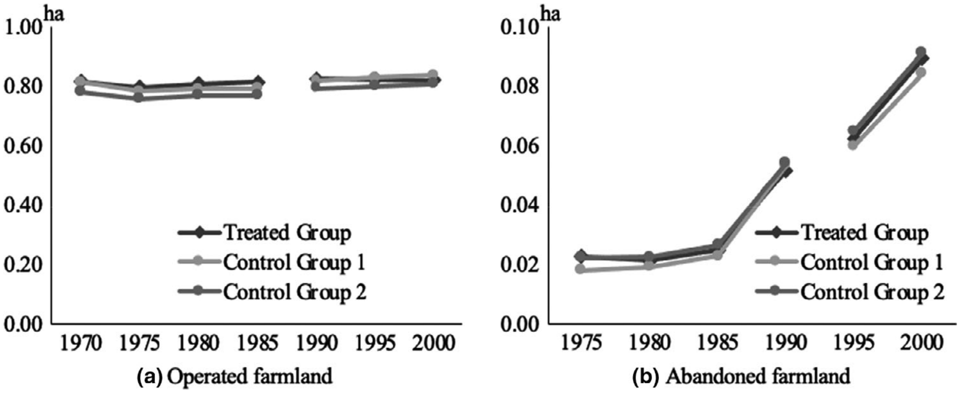

Figure 1 Evolution of Outcomes for Farmers with DPs vs. without DPs before the Introduction of DPs for HMAs. †Source: Rural Community Card, World Census of Agriculture and Forestry (Japan). ‡We could not collect data between 1985 and 1990 since the definition of the variables changed.

condition of SUTVA is that (i) the receipt of DPs by a community affects only the outcome of farmers within the same rural community; that is, there is no externality from farmers in rural communities with DPs to those in rural communities without DPs or to those in other rural communities with DPs; and (ii) the receipt of DPs by someone else in the same community does not affect one's decision regarding farmland use.

We expect condition (i) of SUTVA to hold. The effect of DPs on farmland use is limited to the same community. For example, due to the relative geographical separation of communities in LFAs, farmland in one area is unlikely to be rented out to farmers in other communities. Condition (ii) of SUTVA might not have been fulfilled: the receipt of DPs by someone else in the same community would affect one's decision to change the farm size, which is an outcome of DPs. There are two reasons for the violation of this condition of SUTVA. First, when a farmer leaves farming, the remaining farmers have an opportunity to rent farmland from the exiting farmer to increase their farm size. However, the DPs could reduce this likelihood as they also reduce the number of exiting farmers (Takayama *et al.* 2020). Second, farmers who continue farming in a community with a DP will find it difficult to rent farmland from other operating farmers in the same community because these other farmers will also hope to rent farmland to increase their farm size. Hence, we cannot fully rule out the possibility of spillover or general equilibrium effects within the community affecting our estimates of the effect on operated farm size.

Even if we consider this possible violation of SUTVA from a different angle, it does not threaten the inferential validity of our overall finding. The spillovers within the communities are due to the DPs; the coefficients, therefore, can be viewed as the overall treatment effects of DPs on farm size. In addition, this kind of spillover externality or general equilibrium effects would create a downward bias in our results, causing our measured treatment effects to be a lower bound estimate of the true impacts of DPs in community with DPs. Concerning another outcome of DPs, abandoned farmland, we believe there would be no violation of condition (ii) of SUTVA because the decision of a farmer to abandon farmland is likely to be unaffected by the farmland use of other farmers.

4. Empirical results

4.1 The effect on farmland use

We present the estimation results of Equation (1) for the impact of DPs on farmland use in Table 3. Column 1 reports the results, including exogenous covariates. The DID estimates suggest a strong statistical relationship between DPs for HMAs and abandoned farmland. The coefficients imply that the receipt of DPs is associated with a 7.0% decrease in abandoned farmland. Our concern is that there may be other farm characteristics that

Table 3 DPs and farmland use (vs. Control Group 1)

	Dependent variable			
	Abandoned farmland (1)	Abandoned farmland (2)	Operated farmland (3)	Operated farmland (4)
*DPs * Year*	−0.070***	−0.081***	0.007***	0.008***
	(0.026)	(0.025)	(0.004)	(0.002)
DPs	0.174***	0.241***	−0.004	0.008***
	(0.023)	(0.021)	(0.004)	(0.002)
Year	0.202***	0.191***	0.018***	−0.004
	(0.024)	(0.024)	(0.002)	(0.002)
Age of household head	Yes	Yes	Yes	Yes
Male household head	Yes	Yes	Yes	Yes
Other controls	No	Yes	No	Yes
Number of observations	510,918	510,918	510,918	510,918

Note: ***$P < 0.01$. Standard errors clustered by farm level are reported in parentheses.

vary across time and are correlated with abandoned farmland. For example, the occurrence of farmland abandonment may depend on the type of farmland owned, the presence of successors, or farm size (Ito *et al.* 2016). Therefore, we directly control for several observed time-varying farm characteristics in Column 2 to investigate whether farm characteristics might have caused the reduction in abandoned farmland. The estimated impact of DPs marginally increased to 8.1%, and its statistical significance remained unchanged. These findings are in line with results presented by Ito *et al.* (2019), who find that DPs deter farmland abandonment at the community level. However, our data time frame (2000–2005) and sample differ, as they use data from 2005 to 2010 and community-level data sets in a more limited region. Our results add new evidence regarding the impact of DPs on HMAs.

Column 3 in Table 3 presents the results of the DID estimates of the effect of DPs on the operated farmland. The coefficient on the receipt of DPs in Column 3 is positive and significant. The point estimate implies that the receipt of DPs is associated with a 0.7% increase in farm size. The result of Column 4 in Table 3 controls for the possibility that the impact of DPs on farm size is owing to a change in farm characteristics. The estimated impact of DPs is unchanged.

4.2 Robustness checks

Another concern is that the impact of DPs may not be homogeneous across farmers, but rather, vary by farmer type. For example, small hobby farms obtain non-pecuniary benefits from farming (Key and Roberts 2009). The non-pecuniary benefits may provide an incentive to continue farming irrespective of any benefit from DPs. This may be especially relevant because about half of the LFA payments received by a community are allocated to farm members in the community. As a result, small-scale farming households are not excluded from the DP allocation. Therefore, Table 4 replicates the results presented in Table 3 but excludes small hobby farms, which capture non-commercial or self-sufficient farmers. The results present the DID estimates as a robustness check to show whether our results are sensitive to excluding small hobby farms. In Columns 1 and 2 in Table 4, we report the results of estimating Columns 1 and 2 in Table 3. In the basic model of Column 1 in Table 4, DPs are associated with a 7.1% decrease in abandoned farmland. This estimate does not change when we control for farm characteristics in Column 2. The estimated impact of DPs on abandoned farmland does not change even when we restrict the sample to observations only on commercial farmers. The impact on operated farmland in Columns 3 and 4 is similar to the result in Table 3, which includes small hobby farms. Thus, our results are robust to the use of this subsample.

Another robustness check considers whether our results are sensitive to using the other control group. We formally test whether the time trends for Control Groups 1 and 2 are different by estimating a slightly modified version of Equation (1). We use only the observations of the farmers for Control Groups 1 and 2; that is, we use data from 2000 and 2005 for all the control group farmers. We modify Equation (1) by replacing the treatment dummy with a new dummy that is equal to 1 if the farmer is in Control Group 1, and 0 if he or she is in Control Group 2. In this model, we cannot statistically reject the hypothesis that the dummies of the interaction of the new dummy and fixed year effects are different for Control Groups 1 and 2 at conventional levels of statistical significance in the outcome equation (Table A1 of the Appendix). This implies that the outcomes in Control Groups 1 and 2 have identical time trends (and levels) and validate the control group of farmers in communities that do not receive DPs despite being eligible.

Table 4 DPs and farmland use: excluding small ‘hobby’ farms (vs. Control Group 1)

	Dependent variable			
	Abandoned farmland (1)	Abandoned farmland (2)	Operated farmland (3)	Operated farmland (4)
*DPs * Year*	−0.071**	−0.071**	0.018***	0.010***
	(0.029)	(0.028)	(0.003)	(0.002)
DPs	0.159***	0.234***	−0.020***	0.011***
	(0.025)	(0.024)	(0.004)	(0.002)
Year	0.212***	0.182***	−0.015***	−0.004
	(0.027)	(0.026)	(0.003)	(0.002)
Age of household head	Yes	Yes	Yes	Yes
Male household head	Yes	Yes	Yes	Yes
Other controls	No	Yes	No	Yes
Number of observations	415,762	415,762	415,762	415,762

Note: $^{**}P < 0.05$, $^{***}P < 0.01$. Standard errors clustered by farm level are reported in parentheses.

Table 5 DPs and farmland use (vs. Control Group 2)

	Dependent variable			
	Abandoned farmland (1)	Abandoned farmland (2)	Operated farmland (3)	Operated farmland (4)
Panel A				
*DPs * Year*	−0.057***	−0.079***	0.009***	0.011***
	(0.012)	(0.012)	(0.001)	(0.001)
DPs	0.005	0.057***	−0.018***	−0.002**
	(0.011)	(0.010)	(0.001)	(0.001)
Year	0.182***	0.181***	−0.006***	−0.006***
	(0.009)	(0.009)	(0.002)	(0.001)
Age of household head	Yes	Yes	Yes	Yes
Male household head	Yes	Yes	Yes	Yes
Other controls	No	Yes	No	Yes
Number of observations	905,128	905,128	905,128	905,128
Panel B (excluding small hobby farms)				
*DPs * Year*	−0.074***	−0.083***	0.015***	0.010***
	(0.013)	(0.013)	(0.001)	(0.001)
DPs	0.205***	0.071***	−0.018***	−0.003***
	(0.010)	(0.011)	(0.002)	(0.001)
Year	0.032***	0.186***	−0.009***	−0.003***
	(0.012)	(0.010)	(0.001)	(0.001)
Age of household head	Yes	Yes	Yes	Yes
Male household head	Yes	Yes	Yes	Yes
Other controls	No	Yes	No	Yes
Number of observations	734,534	734,534	734,534	734,534

Note: $^{**}P < 0.05$, $^{***}P < 0.01$. Standard errors clustered by farm level are reported in parentheses.

We re-estimate the main models using farmers of Control Group 2. The DID point estimates of the outcomes are presented in Table 5. We observe that the dummy of the interaction in Columns 1 and 2 is statistically significant and has a negative effect on abandoned farmland and a positive effect on change in farm size; this is consistent with the results in Tables 3 and 4. The estimated impact of DPs does not change when we restrict the sample to observations only on commercial farmers. Moreover, the DID point estimates of the outcomes are very close in magnitude to those for Control Group 1 in Table 3. We use control groups with DID and still obtain causal inferences about the impact of DPs. Therefore, our approach produces robust results. Finally, our results are robust to the selection of the control groups and subsamples (only commercial farmers) in terms of the magnitude and sign of the effect of DPs on farmers' responses to farmland use.

5. Discussion

We showed that the receipt of DPs is associated with a decrease in the abandoned farmland between 5.7% and 8.1%. Considering the increase in abandoned farmland by 11.1% from 2000 to 2005 in the control group, this effect is large, implying that it is enough to slow down the previous trend of increasing abandoned farmland in HMAs. The effect of DPs on farmland abandonment by the surviving farms is not surprising, considering that DPs have been granted to eligible communities on the condition that collaborative community activities are implemented to prevent farmland from being decreased or abandoned. In practice, about half of these DPs are used for community activities. It is mainly for the collective management of CPRs, and farming households receive the benefits arising from community activities. Overall, the cost of farming is reduced for all farmers within a community participating in a DP scheme, resulting in a slowdown in farmland abandonment through the maintenance of farm production activities.

We also provide evidence that the receipt of DPs is associated with a 0.7% increase in farm size in rural communities that receive DPs compared with communities that do not receive them. However, considering the 1.3% decrease in operated farmland per farm household from 2000 to 2005 in the control group, this result implies that the surviving farms in communities with DPs are more likely to slow down the decrease in their farm size than farmers in communities without DPs. We show that farmers in rural communities with DPs have made choices that have affected the pathway by which farm size could be maintained. There is a potential pathway by which the recipients of DPs might have induced changes in farm size. DPs may affect the components of the amount of farmland in operation, which consists of farmland owned by the operator plus farmland rented in minus farmland rented out minus farmland abandoned. It is probably one of the most important causal channels through which DPs can affect farm size. Receiving DPs for the first time is likely to cause a more significant change in farmland use relative to receiving no DPs, since DPs are linked to farming the farmland. There are potentially two pathways by which DPs might affect the composition of operated farmlands. First, slowing down the increase in abandoned farmland, as a component of operated farmland, may be one causal channel. DPs for HMAs aim to prevent the increase in abandoned farmland through the maintenance of farm production activities. Indeed, we find that the increase in abandoned farmlands in communities that received DPs was deterred by about 7%–8%. Thus, considering the increase in abandoned farmlands when communities did not receive DPs, it can be concluded that DPs lead to a slowdown in the increase of abandoned farmland. This effect also results in a slowdown in the decrease in farm size in communities.

Second, an increase in farmland rented in or a decrease in farmland rented out via DPs may lead to a slowdown in the decrease of operated farmlands. In Japan, growth in farm size has progressed via the leasing of farmlands, and not purchase. This trend began after the restrictions on tenancy and transactions to protect tenancy rights were gradually removed from 1970 to promote rationalisation in the land market. More importantly, the introduction of the farmland use promotion project in 1975, under which regulations on tenancy were waived if the local municipality prepared a local land-use project based on the agreement of the transacting parties, accelerated farm size expansion through rental agreements (OECD 2009). Exiting farmers or farmers who employ the gradual process of exiting by reducing the level of production are the source of farmland rented out. However, if there are no tenants for the farmland in rural communities when the farmer leaves the farm, the farmland would be abandoned. Farmers in communities with DPs receive DPs for HMAs if they have eligible farmland, which is linked to farming the farmland (Kazukauskas *et al.* 2013). Thus, DPs exert an 'incentive effect' on farm production (Happe *et al.* 2008). Therefore, farm size in communities with DPs may be maintained by renting in the farmland of exiting farmers within the same rural community. However, such farmlands in communities without DPs would not be rented in, as compared to rural communities with DPs, which leads to abandoned farmlands.

We attempt to identify the effect of DPs on farmland rented in/out that may lead to the change in farm size. We use the same approach as reflected in Table 3 to provide causal evidence of how DPs have impacted farmland rentals. Table 6 shows the DID estimates of the effect of DPs on farmland rented in/out. The DID estimates of interest suggest a strong statistical relationship between DPs and the magnitude of rented-in/out farmland. The coefficients show that farmers receiving DPs are associated with a 5.7% increase in farmland rented in and a 5.0% decrease in farmland rented out. An increase in the renting-in of farmland and a decrease in its renting-out lead to changes in farm size. This farmland rental effect indicates that farmers in communities with DPs are more likely not to decrease farm size through farmland rentals, than farmers in communities without DPs.

However, despite this deterrence effect, the change in farm size owing to DPs is very small in magnitude (0.7% from Column 1 of Table 3). The

Table 6 DPs and farmland rental (vs. Control Group 1)

	Dependent variable	
	Farmland rented in (1)	Farmland rented out (2)
*DPs * Year*	0.057***	−0.050***
	(0.019)	(0.017)
DPs	0.146***	−0.159***
	(0.021)	(0.018)
Year	0.121***	0.111***
	(0.018)	(0.017)
Age of household head	Yes	Yes
Male household head	Yes	Yes
Other controls	Yes	Yes
Number of observations	510,918	510,918

Note: $^{**}P < 0.05$, $^{***}P < 0.01$. Standard errors clustered by farm level are reported in parentheses.

modest impact on farm size may be explained by the lower ratio of rented-in/out farmland to operated farmland (e.g. for the treatment group, the ratio of rented-in/out farmland is 18.8% in 2000). The marginal effect on farmland rental is also one of the causes. DPs induce the maintenance of the number of farm households in communities (Takayama *et al.* 2020). Hence, fewer farmers will leave relative to those in communities without DPs, and less farmland will be supplied to the rental market in the first place. This kind of general equilibrium effects would create a downward bias in our results, causing conservative positive effects of DPs on the farm size of treated farmers over their counterfactuals.

It is important to note that we cannot directly test for a causal relationship between the effect on farmland rentals and operated farmland size. The farmland rental decision is endogenous. Since DPs cause the farmland rental and other farm characteristics to change across multiple dimensions, our estimates capture all these effects and other unobservable factors. Therefore, although we would like to directly test the impact on operated farmland caused by DPs versus farmland rentals, these tests would not be able to provide causal evidence, and their interpretations would be ambiguous. We rely on the direct tests of the impact of DPs on abandoned farmland, operated farmland and farmland rentals to illustrate how DPs have led to changes in farmland use.

6. Conclusions

The key research issue addressed here is the causal effect of DPs in LFAs on farms' responses to farmland use, using a DID approach. The first policy-related question investigated is whether there is an effect of DPs for HMAs on preventing farmland abandonment. The second question is whether there is an effect of DPs for HMAs on farm size. As control groups, we chose farmers in communities with sloped farmland in non-target regions that are not eligible for DPs (Control Group 1) and farmers in communities eligible for DPs but not receiving them (Control Group 2) to separately estimate the causal effects of DPs for HMAs. We use a large farm-level panel data set (for 2000 and 2005) from the Census of Agriculture for Japan. Our findings suggest that during 2000–2005, DPs led to a slowdown in the increase in abandoned farmland among surviving farms. Further, DPs have a marginal positive effect on the operated farm size. Given that farm size decreased during this period, surviving farms in communities with DPs are more likely to slow down the decrease in farm size. Our results are robust to the two control groups and a subsample that excludes non-commercial and self-sufficient farmers.

Further, we show that farms with DPs experienced an increase in rented-in farmland and a decrease in rented-out farmland. This implies that the effect on farm size is driven by not only a decrease in farmland abandonment but also an increase in rented-in farmland and a decrease in rented-out farmland.

However, considering the lower ratio of rented-in/out farmland and the spillover externality or general equilibrium effects within the same community, the impact on farm size could be modest. Nonetheless, this result implies that DP schemes in LFAs play a key role in maintaining farm size.

Our results are relevant to academics and policymakers. This article presents the first evidence on the effect of DPs in LFAs on farms' responses with respect to farmland use. Therefore, our findings have an important implication for policy development as they pertain to the extent to which payments to farmers in LFAs contribute to continued agricultural land use and prevention of land abandonment. DPs have long been criticised because their effect on continued agricultural land use and the prevention of land abandonment is not clear (Cooper *et al.* 2006). However, our results quantify the effects of such DPs, implying that direct payments in LFAs play a role in slowing down the abandoned farmland rate among surviving farmers.

Data availability statement

The data supporting the findings of this study are available from MAFF. However, restrictions apply to the availability of these data, which were used under license for the current study. Thus, they are not publicly available. They are, however, available from the authors upon reasonable request and with permission from MAFF.

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Appendix

Table A1 Control Group 1 versus Control Group 2

	Dependent variable			
	Abandoned farmland (1)	Abandoned farmland (2)	Operated farmland (3)	Operated farmland (4)
Panel A				
*Control Group 1 * Year*	0.013	0.003	0.002	0.003
	(0.026)	(0.025)	(0.003)	(0.002)
Control Group 1	−0.169***	−0.170***	−0.002***	−0.010***
	(0.023)	(0.021)	(0.004)	(0.002)
Year	0.178***	0.182***	−0.018***	−0.007***
	(0.009)	(0.009)	(0.001)	(0.001)
Age of household head	Yes	Yes	Yes	Yes
Male household head	Yes	Yes	Yes	Yes
Control variables	No	Yes	No	Yes
Number of observations	501,374	501,374	501,374	501,374
Panel B (excluding small hobby farms)				
*Control Group 1 * Year*	−0.002	−0.011	−0.003	−2.537E−04
	(0.029)	(0.028)	(0.003)	(0.002)
Control Group 1	−0.126***	−0.147***	0.001***	−0.014***
	(0.026)	(0.024)	(0.005)	(0.003)
Year	0.200***	0.185***	−0.008***	−0.003***
	(0.010)	(0.010)	(0.001)	(0.001)
Age of household head	Yes	Yes	Yes	Yes
Male household head	Yes	Yes	Yes	Yes
Control variables	No	Yes	No	Yes
Number of observations	403,508	403,508	403,508	403,508

Note: $^{**}P < 0.05$, $^{***}P < 0.01$. Standard errors clustered by farm level are reported in parentheses.