



Does the Downward Trend of the Farming Population in Remote and Mountainous Areas Increase the Average Farm Size? A Community Level Data Analysis in Tohoku Region, Japan

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Received 20 January 2020 Accepted 23 May 2020 (*Corresponding Author)

Abstract Over the last several decades, Japan's farming population has gradually decreased and the average age of farmers has risen. The recent agricultural census 2015 indicated that there were 2.09 million people engaged in agriculture, which is a reduction of 60% compared to three decades earlier. The decline in farming populations is robust and is taking place in many agricultural communities in Japan. However, the impacts of the declining farming population differ significantly on the basis of the conditions of farming land. Retirement of aged farmers provides farming opportunities for young, local farmers, consequently leading to an expansion in the size of farms. In fact, the average farm size per household in Japan doubled from 1.05 ha in 1985 to 2.20 ha in 2015. This represents a positive aspect of aging and the decreasing farming population. On the other hand, farmland abandonment has been prominent in the last 30 years, accounting for nearly 10% of total farmland. In the remote and mountainous areas of Japan, maintaining agricultural activities is increasingly difficult, thereby casting doubt on the sustainability of agricultural production and rural communities. In such a case, the average farm size does not increase, weakening rural economies and communities. This study uses approximately 14,000 community-level data in the Tohoku region of Japan and examines the land conditions that induce an increase in average farm size. The land conditions we consider are (1) steepness, (2) elevation, and (3) time-distance from a city. Quantile regression analysis is carried out to identify land conditions and other socio-economic variables associated with average farm size. Our regression analysis indicates that farm size does not necessarily increase where farm sizes are initially small, even in the case of declining farming population. Discussion within agricultural communities to build trust and consensus on distributional conflicts are considered to be an effective countermeasure to increase farm sizes in remote and mountains areas. The empirical evidence suggests the need for varied policy interventions in accordance with land conditions.

Keywords farm size, agricultural community, quantile regression, farmland abandonment

INTRODUCTION

Family farmers in different locations face different constraints to agricultural development. In Asia, it can be generalized that land scarcity has been the most serious constraint, although this can be addressed through increasing land productivity at an initial stage of agricultural development (FAO, 2014). As land productivity increases with the use of fertilizer, pesticide, irrigation, and the use of

modern technology, labor scarcity becomes the next most serious constraint, to which mechanical technologies are adapted to reduce labor cost. As labor moves from the agricultural sector to non-agricultural sectors, increasing labor productivity of the remaining farmers becomes vitally important to maintain farm incomes. This is the second phase of agricultural development. Many Asian countries, including Japan, are now in the second phase of agricultural development (FAO, 2014). Priority has shifted from increasing land productivity to increasing labor productivity and farmers' incomes, which requires increasing farm size. The question to be asked is whether the average farm size has been increasing in accordance with the downward trend of the farming population.

The recent agricultural census 2015 indicated that 2.09 million people engaged in agriculture, which represents a decrease of 60% compared to three decades earlier (MAFF, 2018). The decline in the farming population is robust and is taking place in many agricultural communities in Japan. A declining farming population has both positive and negative impacts on rural communities. On the positive side, there are increased opportunities to expand the farming size because the retirement of aged farmers generally provides farming opportunities with neighborhood and/or young farmers, consequently leading to an expansion in farming size. In fact, the average farm size per household in Japan doubled from 1.05 ha in 1985 to 2.20 ha in 2015 (MAFF, 2018). However, farmland abandonment has also been prominent in the last 30 years, accounting for nearly 10% of total farmland (MAFF, 2018). When farmland is not taken over by farmers of the next generation, maintaining agricultural activities becomes increasingly difficult, thereby casting a doubt on the sustainability of agricultural production and rural communities. It is highly important to preserve the farm and possibly to increase the farm size. Only a few studies have been carried out to examine the correlation among farm size, socio-economic variables, and community variable (Akimowicz. et.al, 2013), empirical analysis with larger datasets is still insufficient. Therefore, this study examines the socio-economic conditions under which farmers in rural communities increase farm sizes. Utilizing GIS datasets for the Tohoku Region of Japan, including elevation, slope, and time-distance to the city, along with other community variables such as the number of community meetings and the percentage of rural population over 65, we investigate the determinants of farm size.

MATERIALS AND METHOD

Data and Agricultural Community

Table 1 Basic statistics

Variable	notation	Mean	s.d.	min	max
Average Farm Size					
Farm size in 2015	y ₂₀₁₅	2.38	1.68	0.075	25
Farm size in 2010	y ₂₀₁₀	2.12	1.42	0.1	25
GIS Variables					
Elevation (100m)	z1	1.425	1.357	0.004	9.055
Slope	z2	2.57	2.58	0	20
Time-distance: 30 to 60 minutes	z3	0.26	0.44	0	1
Time-distance: 60 to 90 minutes	z4	0.04	0.20	0	1
Time-distance: over 90 minutes	z5	0.01	0.08	0	1
Community Variables					
# of community meetings (CM)	x1	14.14	12.02	0	99
# of issues discussed at CM	x2	4.42	1.70	0	6
% of rural population over 65	x3	0.34	0.08	0	1
# of incorporated farm	x4	0.07	0.30	0	5

This study uses Agricultural Census Datasets for 2015 and 2010 for the Tohoku Region of Japan (see Table 1). The total sample is 14,253. The datasets include average farm size, elevation, slope, time-

distance to the nearest city, and community variables. Community variables are included to identify socio-economic characteristics that induce an expansion in farming size. We hypothesize that the number and quality of community meetings, as well as mutual trust within the community, make land transactions easier, thereby contributing to increases in average farm size.

Table 2 shows the average farm size by elevation and slope. It indicates that the average farm size is larger at lower elevations and where farmland is flatter. It also shows smaller increases in average farm size for farmland located in steeper mountainous area. This implies that farmland located in the remote and mountainous areas is more likely to be abandoned rather than handed to the next generation.

Table 2 Change in average farm size by elevation and slope from 2010 to 2015

			Slope (θ): z2			
			(flat)		(steep)	
Elevation (m) : z1	A: Farm Size (ha) in 2015	(high)	2.59	2.14	1.59	1.38
			2.54	1.83	1.68	1.44
			2.08	2.23	1.88	1.63
		(low)	2.76	2.34	1.94	1.82
		(high)	2.35	1.98	1.54	1.31
			2.26	1.69	1.57	1.31
	B: Farm Size (ha) in 2010	(high)	1.84	2.03	1.74	1.53
			2.40	2.07	1.84	1.57
		(low)	10.2	8.1	3.7	5.8
			12.3	8.4	6.6	10.2
			13.3	10.1	7.9	6.9
		(low)	14.9	13.0	5.5	16.5
(A-B)/B*100 (% Change)						

Statistical Analysis

The distribution of farm sizes across agricultural communities is highly skewed and asymmetrical. Therefore, the results from a standard regression analysis (i.e. ordinary least squares) are biased and cannot provide a comprehensive picture of the effect of the independent variables on the dependent variable. In this study, quantile regression analysis is employed to observe the different effects of each explanatory variable along the distribution of the dependent variable. The estimated equation is defined as (1).

$$y_{2015} = \alpha + \beta \cdot y_{2010} + \sum \gamma_i z_i + \sum \delta_j x_j + \varepsilon \tag{1}$$

α is a constant term, and β captures the effect from average farmland size in 2010. γ_i measures the effect of GIS variables on the average farmland size in 2015. x_j represents socio-economic community variables. These are included to examine socio-economic characteristics that are associated with farmland size. Since community variables might be considered as endogenous variables, we report the estimation results with and without the community variables.

RESULTS AND DISCUSSION

Table 3 shows the results of the quantile regression analysis. The effects of average farm size in 2010 on the average farm size in 2015 are dependent on the quantile estimated. With a smaller farm size (quantile 25%), the estimated coefficients turn out to be 0.96-0.97, less than 1.0, meaning that average farm size is more likely to decrease by 3 to 4% every five years. On the other hand, with a larger farm size (quantile 75%), the estimated coefficients are more than 1.0, which indicates that the average farm size increases by about 22% when assuming other variables are constant. Thus, the

aged population and general decrease of the farming population contributes only to agricultural communities where the average farm size is already high. In other words, agricultural communities in the remote and mountainous areas, often with their smaller farm sizes, do not make use of additional farming opportunities, weakening overall agricultural activity.

Table 3 Results of quantile regression

Variable	Dependent variable: Average farm size in 2015					
	With community variable			Without community variable		
	Quantile			Quantile		
	25%	50%	75%	25%	50%	75%
Average farm size in 2010	0.960*** (177.06)	1.081*** (187.98)	1.222*** (160.64)	0.967*** (166.13)	1.083*** (188.37)	1.223*** (161.94)
Elevation	-0.007*** (-2.79)	-0.009*** (-3.24)	-0.013*** (-3.03)	-0.008** (-2.46)	-0.009*** (-3.02)	-0.013*** (-3.18)
Slope	-0.008*** (-7.03)	-0.006*** (-4.78)	-0.007*** (-3.14)	-0.009*** (-6.4)	-0.007*** (-4.64)	-0.006*** (-3.11)
Time-distance: 30 to 60	0.008 (1.02)	-0.005 (-0.58)	-0.007 (-0.57)	0.005 (0.6)	-0.007 (-0.84)	-0.004 (-0.32)
Time-distance: 60 to 90	-0.007 (-0.29)	-0.001 (-0.08)	0.016 (0.51)	-0.031 (-1.26)	-0.003 (-0.19)	0.031 (1.06)
Time-distance: over 90	0.017 (0.36)	0.033 (0.93)	0.045 (0.64)	0.019 (0.52)	0.037 (0.7)	0.054 (0.66)
# of meetings	0.002*** (8.71)	0.001*** (3.69)	0.0005 (0.90)			
# of issues discussed	0.006*** (2.80)	0.002 (0.91)	0.001 (0.37)			
% of population over age 65	-0.239*** (-6.25)	-0.063 (-1.65)	0.092 (1.34)			
# of incorporated farmland	0.025* (1.85)	0.012 (0.75)	0.006 (0.36)			
Constant	0.046*** (2.62)	0.011 (0.61)	0.008 (0.26)	0.009 (0.81)	0.015 (1.40)	0.049*** (3.03)
Pseudo R ²	0.561	0.617	0.632	0.559	0.616	0.632
N	14,235			14,235		

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

This study investigates geographic and socio-economic conditions that induced an increase in farm size in rural Japan. Community level data analysis indicates that the average farm size does not necessarily increase as the farming population decreases, particularly where the average farm size is initially small. Some farmland in the remote and mountainous areas of Tohoku Region has been abandoned rather than passed down to the next generation. Farmland on steeper slopes at higher elevations is more expensive to operate than in the lowland, meaning that consolidating farmland does not provide sufficient economic benefits in mountainous areas. Our regression analysis also shows that frequent community gatherings to discuss local issues and the establishment of incorporated farmland within the community would help increase the farm sizes. Fostering trust through engagement reduces transaction costs and encourages the establishment of cooperatives or incorporated farms, which may account for an increase in farm size.

Furthermore, the effects of elevation and slope on average farm size are always negative and

significant, particularly at the 25% quantile (smaller farm size). Land condition represented by steepness and a mountainous area always impair the expansion of farm size. Lower elevation and flatter farming areas are key conditions that accelerate land transactions, thus resulting in higher average farm sizes.

The sign of the percentage of people above 65 years of age is positive at the 75% quantile and negative and significant at the 25% quantile. The retirement of aged farmers generally provides opportunities for younger farmers. Such opportunities are not taken advantage of where the average farm size is generally smaller (25% quantile). The sign of the number of incorporated farms turns out to be positive and significant only at the 25% quantile, indicating that the small number of incorporated farms in the highlands may contribute to the expansion in farm size through consolidating farmland within the community.

Both the number of community meetings and the number of issues discussed in these meetings have a positive effect on the average farm size at the 25% quantile. It is important to note that discussion within the agricultural community allows for building mutual trust and mitigating distributional conflict, thus leading to a reduction of overall transaction costs.

CONCLUSION

This study investigates geographic and socio-economic conditions that fostered an increase in average farm sizes in rural Japan. Community level data analysis indicates that the average farm size does not necessarily increase as the farming population decreases, particularly where average the farm size is still small. Some farmland in the remote and mountainous areas have been abandoned rather than handed to the next generation. Farmland on higher slopes at higher elevation is more expensive to operate than in the lowlands, meaning that consolidation of farmland does not provide sufficient economic benefit. Our regression analysis also shows that frequent community gatherings to discuss local issues and establishment of incorporated farms within the community would help increase the farming size. Fostering trust through discussions has reduced transaction costs and encouraged the establishment of cooperatives or incorporated farm, possibly resulting in an increase in farming size.

ACKNOWLEDGEMENTS

This work was supported by JSPS KAKENHI Grant Number JP17K07986.

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