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Institutional innovation and policy support to facilitate small-scale farming transformation in China

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Abstract

While the Asian food economy has been experiencing significant transitions, it is widely believed that little transformation has occurred in farm land operation. However, the recent rapid emergence of middle and large-size farms in many regions of China is striking, as is the increase in size of operational units. The overall goal of this article is to understand small-scale farm transformation in China based on a unique dataset surveyed in Northeast and North China. The results show that the institutional innovation through establishing land transfer service centers to promote land rental markets and reduce transaction costs, policy support to speed up land consolidation, and farm mechanization services are major driving forces in the recent evolution of China's farm operations. The article concludes with policy implications on small-scale farming transformation in China and the rest of world and identifies research issues for further study.

JEL classifications: D13, D23, O31, O38

Keywords: Farm size; Institution; Policy; Small farm; Transformation

1. Introduction

Asian food economy has been experiencing significant transitions. Driven by income growth and demographic change (e.g., urbanization), consumption patterns have changed toward more high value products such as meats, vegetables, and fruits (Bai et al., 2010; Gulati et al., 2007). In addition, agrifood markets and value chains have experienced rapid transformation because the 1990s (Reardon and Timmer, 2007). In response to these changes, agricultural production structures have also changed. The share of cereals in total crop areas decreased from 41% in 1980 to 34% in 2013 in Asia (FAO, 2015a, 2015b). Livestock production has grown faster than crop production. The value share of livestock in crop and livestock production increased from 18% in 1980 to 30 % in 2013 (FAO, 2015a, 2015b).

However, over the same period, little transformation appears to have occurred in Asian farm size. Asia is the home of nearly 90% of the world's small farms (less than 2 hectares), average size of farms has been falling in almost every country (IFPRI, 2015). For example, according to the World Census of Agriculture, the average farm size in India declined from 2.7 ha in 1960 to 1.3 ha in 2013. Between 1960 and 2003, the average farm size in Indonesia also decreased from 1.2 ha to 0.97 (FAO, 2013). The limited available evidence on average farm area in China from international sources suggests a decline in farm size of around 10%, from 0.67 to 0.6 ha between 2000 and 2010 (Lowder et al., 2014).

In the literature, there is a long-standing debate on farm size and productivity. A notion of "small is beautiful" was early observed in Russian agriculture by Chayanov (1926) and after that the inverse relationship between farm size and productivity was proved and expanded in other literatures (Deininger and Byerlee, 2012; Dyer, 1996; Lipton, 1993). But recently, there is rising evidence of small may not necessarily be beautiful. Small farms have faced increasing challenges in meeting diversified demands for safe, nutritious food, for lacking capacity to respond to opportunity and coping with rising risks from globalization and trade liberalization and from climate change (HLPE, 2013; Hazell, 2005; Huang et al., 2008). Recently, the literature tends to agree that efforts to help smallholders should focus on assisting them to either move up or move out of farming (FAO, 2015a, 2015b; IFPRI, 2015).

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China, with an average farm size of less than 1 ha and nearly 40% of the world's small farms, was not an exception from falling average farm size until recently. Despite rapid growth in agriculture, the manufacturing and service sectors expanded even faster, which resulted in the agricultural share of GDP falling from 30% in 1980 to less than 10% after 2013 (NBSC, 2015). Within agriculture, significant transformation has also occurred in favor of high-value products such as vegetables, fruits, livestock, and fishery due to the changes in food consumption patterns resulted mainly from income growth and urbanization (Huang et al., 2014). However, the estimates based on rural household survey show that average size of farms appears to have declined from 0.73 ha in the early 1980s to 0.53 ha in 2003 (NBSC, 1985–2005).

However, the rapid emergence of middle (a few hectares) and large operational units (tens and hundreds of hectares) recently in many regions of China is striking. Based on data from the Ministry of Agriculture, cultivated land transfer has been accelerated since the late 2000s. By the end of 2013, nearly 53 million (or 23%) rural households rented out their cultivated land, which accounted for 26% of total cultivated land under the household responsibility system (MOA, 2014).[1] Although common practice had involved transferring land among relatives and friends within a village and nearly equal numbers of land rent-in and rent-out households (Huang et al., 2012), land transfer between non-relatives has been increasing since early 2000s (Hui et al., 2015). Further, land has tended to move to new operators in recent years. For example, of rented-out land in 2013, about 20% was transferred to farmers' professional cooperatives, more than 9% to firms or companies, and the rest to individual households, especially those belonging to newly-named Family Farms (MOA, 2014).[2]

Because the emergence of new approaches to farm land operation is only a recent phenomenon, little information is available on China's changing farm structure in the international literature. The overall goal of this paper is to understand the change of small-scale farm transformation recently in China and its policy implications. To achieve this goal, we have the following four specific objectives: (1) to document the changes in farm operational structure in the past three decades, (2) to examine major factors that have driven the recent changes (or why these changes did not occur until recent years?), and (3) to assess the policy implications for China and other developing countries, and (4) to identify research issues for further study.

Because of data availability, we focus our empirical analysis on Northeast and North China, the major grain production regions in the country. The results show that the recent changes in farming operations have been notably rapid, a sharply different from what appears to have occurred in any other Asian countries characterized by small-scale farms. Important factors affecting the above changes are institutional innovations that create effective land rental markets that reduce the transaction costs of land transfer, policy support to speed up land consolidation, and farm mechanization services. However, while the above changes generally raise labor productivity, there are also concerns about land productivity and food security.

The article is organized as follows. The next section introduces the data used in this study. Section 3 presents the overall trend in average farm size and changes in composition of farm sizes at national level and in the studied regions. Section 4 discusses major institutional changes, policy support for farm operational restructuring in recent years and mechanization services. Section 5 quantitatively analyzes the impacts of land rental institutional innovation, policy support, market-based mechanization services, and other factors on farm operational size transformation. The last section concludes with policy implications of farm size transformation in China and the rest of world, and identifies remaining research issues for further study in the future.

2. Sampling approach and data

The primary dataset used in this study is from a farm operational survey in Northeast and North China (NE & NC) conducted by the Center for Chinese Agricultural Policy (CCAP) in 2013. It covers three provinces in Northeast China (Heilongjiang, Jilin, and Liaoning) and three provinces in North China (Hebei, Shandong, and Henan). This survey focused on changes in farm size and productivity and factors affecting farm size in the past 10 years (2003–2013).

As both Northeast and North China are major grain production regions,[3] the survey focused on rice, wheat, and maize farms. In Northeast China, two rice-dominated and two maize-dominated counties were randomly selected from each province. In North China, three counties were randomly selected from each study province where maize and wheat are major crops (winter wheat + maize cropping system).

Within each county, the following stratified random sampling approach was followed. First, we divided all townships into two groups: with above and below-average levels of land consolidation. Then one township from each group was randomly selected in each county. Second, following the same approach, one village with more than average and one with less than average land consolidation was randomly selected from each township. Finally, 10 households were selected as follows: all households in each village were divided into two groups, small and large farms,[4] then 7 households from the small farm group and 3

[1] Currently, we estimate that the shares of cultivated land in state-owned farms, household responsibility system and village collectives reserved are about 5%, 93%, and 2%, respectively.

[2] To distinguish larger operational units from general household farms with small-scale land and to promote land consolidation, many provinces have set threshold sizes for farms to be Family Farms.

[3] Grain production in these 6 provinces accounted for 42% of China's total grain production in 2013 (NBSC, 2014).

[4] In North China, farms with cultivated land area of more than 50 mu (or 50/15 ha, about 3.33 ha) are considered as large farms, whereas this number

households from the large farm group were randomly selected. If the total number of large farm households was less than 3, we added the number of small farm households needed to make up a total of 10 from each village. In addition, we also aimed to select up to two land cooperatives and/or companies in each selected township.[5] In total, the sample covers 845 households from 84 villages in 42 townships of 21 counties in Northeast and North China. In addition, we also surveyed 55 cooperatives and 4 companies from these 21 counties.

Surveys were conducted at township, village, and household levels. At township level, we collected information on major policies that may have affected land consolidation and data on the shares of farms by cultivated land size, the latter are used to create sample weights for estimation of sample means and statistical analysis. Village-level survey focused mainly on village characteristics and crop production.

As our samples are for Northeast and North China only, to have an overview of changes on farm size over time for the nation as a whole and to compare our studied regions with national trends, we use the other two datasets. The first is the Rural Household Income and Expenditure Survey conducted by the National Bureau of Statistics of China (NBSC; or RIES dataset) and the other is from the Rural Land and Labor Survey conducted by CCAP since 2000 (or RLLS dataset). RIES is a nationally representative survey with an average sample of about 60,000 rural households each year. NBSC publishes average cultivated land per capita of rural household and the rural household population. The RLLS dataset is also a nationally representative sample with three survey rounds in 2000, 2008, and 2013. It includes a full panel of 1,149 households from 58 villages in six provinces (Hebei, Liaoning, Shaanxi, Zhejiang, Sichuan, and Hubei provinces) that represent six agricultural production regions in China.[6] We use these two sources to generate the average area of cultivated land per rural household (column (a), Table 1).

However, the average farm size per rural household, the number often interpreted as average farm size in China, must be underestimated because the rural population includes both farming and nonfarming households. To correct for this problem, we use the RLLS dataset to estimate the percentage of rural households without farming activities (e.g., households fully renting out their farm land or fully engaged in other activities). Based on this dataset, we estimate the percentage of rural households living in rural areas but without crop production or without cultivated land (column (b), Table 1). With data presented in columns (a) and (b), we estimate the actual average farm size over time in China (column (c)).

Table 1
Estimates of average farm size (ha) in China and the Northeast and North China regions

	Estimating average farm size in China			
	Average farm size using all households living in rural, based on RIES dataset (a)	Percentage of households living in rural without farming, based on RLLS dataset (b)	Estimated average farm size in China by this study, based on (a) and (b) (c)	Average farm size in Northeast and North China regions (d)
1985	0.73			
1990	0.67			
1995	0.65			
2000	0.55	4.6	0.58	
2001	0.55	4.6	0.58	
2002	0.55	5.2	0.58	
2003	0.53	6.4	0.57	0.92
2004	0.55	7.8	0.59	0.97
2005	0.57	8.4	0.62	1.00
2006	0.58	9.1	0.63	1.02
2007	0.57	10.3	0.64	1.03
2008	0.58	11.8	0.66	1.03
2009	0.61	15.2	0.72	1.17
2010	0.61	17.1	0.73	1.41
2011	0.60	18.6	0.73	1.61
2012	0.61	19.8	0.76	1.72
2013	0.61	20.7	0.78	1.73

Notes: Data in column (c) are adjusted farm size excluding households living in rural but either fully rent out or gave up their land or lost land due to land acquisition. The formula used is: $c = a/(1 - b/100)$.
Data in column (d) are based on surveys in 6 provinces in Northeast and North China.

3. Evolution of small-scale farms and major driven forces

3.1. Overall trends of farm size in China and the studied regions

Our study shows that average farm sizes based on RIES declined gradually between 1985 and 2003 China (column (a), Table 1), which is consistent with the observation by Fan and Chan-Kang (2005) using official data. However, based on the RLLS dataset, we estimate that the percentage of households living in rural areas without crop farming activities increased from less than 5% in 2000 to about 21% in 2013. These households remained in rural areas but worked fully on nonfarm rural employment. Estimation without excluding these households obviously underestimates the average size of farm operational units.

Our new estimates show that, for the nation as a whole, although average farm size fell gradually in the 1980s and 1990s, it stabilized in the early 2000s and then has started to rise since the middle 2002 (column (c), Table 1). Although the rise in average farm size was only about 0.20 ha between 2003 and 2013, this was an increase of 37%, with most of that increase occurring since 2005. This measure of average farm size reached 0.78 ha by 2013.

increases to 100 mu (or about 6.67 ha) in Northeast China due to the difference in land endowment between these two regions.

[5] There are some townships without any land cooperative or company, so the number ranged from 0 to 2 in each surveyed township.

[6] Based on the first two rounds of RLLS, a serious of papers have been published. For details of the sampling approach, see Brandt et al. (2004) and Gao et al. (2012).

Table 2
Percentages of nonfarming households and rural households with rent-in or rented-out land in China, 2003–2013

	Percentage of rural households		
	No crop farming at all	Rent out their land	Rent in land from others
2003	8.6	15.7	11.5
2004	10.7	17.8	13.1
2005	12.0	19.1	12.5
2006	13.4	20.6	14.6
2007	15.4	22.4	16.5
2008	17.5	24.6	18.4
2009	21.0	24.4	7.8
2010	23.2	25.5	8.5
2011	24.9	26.5	8.7
2012	26.4	27.5	9.7
2013	27.9	29.3	10.8

Source: Authors' analyses based on RLLS dataset.

For the study areas in NE&NC, our measure of average operational farm size was substantially larger in 2003, and the rate of expansion in average farm size has been considerably more rapid, with a near doubling (88 percent increase) between 2003 and 2013 (column (d), Table 1). Average farm size in NE&NC is large than the national average mainly due to relatively abundant land resources in Northeast China. For NE&NC as a whole, average farm size was about 60% higher than the national average in the early 2000s. However, the region has witnessed a more remarkable farm size transformation recently, with an increase of average farm size from 1.03 ha in 2008 to 1.73 ha in 2013, a rise of nearly 70% in 5 years.

A close look at the dynamics of rural households and the land rental market further reveals where and how cultivated land has been consolidated. As the RLLS is a full panel dataset including both households living in rural area and those who have migrated to urban or other rural areas for off-farm employment, we are able to estimate the percentages of rural households that have no crop farming activity at all (column 1, Table 2); that have rented out part or all of their land (column 2); and that have rented in land from other farmers (column 3). The difference between column 1 of Table 2 and column (b) of Table 1 is the percentage of households that have migrated to urban areas. The results show that migration has been rising, which has helped to reduce the growth of farming households over time. For example, in 2003, the percentage of nonfarming households was 8.6% (column 1, Table 2), which was close to the percentage of households living in rural areas without farming (6.4%, column (b), Table 1), but this difference has gradually increased over time. By 2013, this difference had reached 7.2% (27.9–20.7). There are two explanations: in the early period, migrants often left their partners at home to take care of farming activity and children. But recently, there is an increasing trend for whole-family migration. Moreover, when the rental market was not well developed in the early 2000s, even when all household members were working away from home, some might return home during the busy farming season or ask their relatives and/or friends to take care of their land.

The dynamics of rural transformation are also vividly reflected in land rental markets. For example, in the early 2000s, the number of farm households renting out land was only slightly higher than the number of rent in land households (columns 2 and 3, Table 2). However, the ratio of these two numbers (renting out vs renting in households) reached nearly 3 times (29.3% vs. 10.8%) in 2013, indicating more land has been consolidated to the fewer households who decided to stay in farming.

Table 3
The composition of farms and average farm size by type and size of farms in Northeast and North China in 2003, 2008, and 2013

	Composition of farms by farm type and size (%)			Average farm size (ha)		
	2003	2008	2013	2003	2008	2013
Cooperatives with land consolidation:	0	0.0007	0.14	–	55	216
(a) Paid rent only	0	0.0005	0.12	–	67	138
(b) Shared profit only	0	0	0.01		–	128
(c): Both (a) and (b)	0	0.0002	0.01		43	500
Company	0	0	0.01	–	–	109
Household farm	100	99.9993	99.85	1.7	2.2	4.5
<1 ha	73.3	68.5	59.5	0.5	0.5	0.5
1–2 ha	15.7	17.2	18.8	1.4	1.4	1.4
2–3 ha	6.6	8.6	12.7	2.4	2.4	2.3
3–7 ha	4.1	5.4	8.1	4.4	4.6	4.4
7–15 ha	0.2	0.2	0.5	9.7	9.7	9.9
15–30 ha	0.0	0.0	0.1	18.0	19.2	19.0
30–70 ha	0.0	0.0	0.1	30.4	30.4	40.4
>70 ha	0.0	0.0	0.02	–	–	260

Note: All numbers in this table are weighted averages.
Source: Authors' survey.

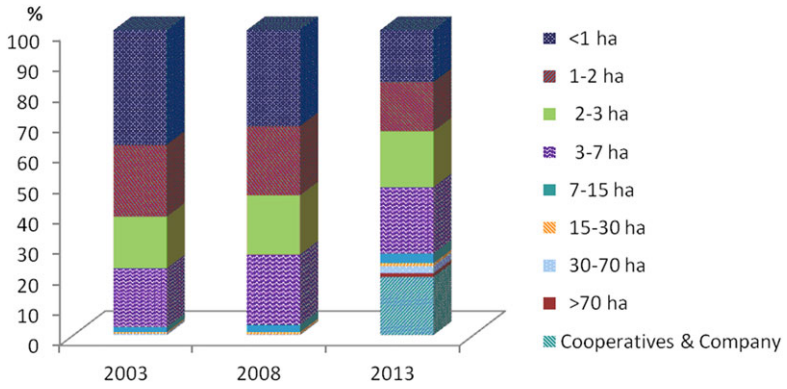

Fig. 1. Cultivated land share by farm size or type of farm in Northeast and North China.

3.2. Evolution of farm size in Northeast and North China

Table 3 presents the composition of farms and average farm size by type of farms and size of household farms in NE&NC. We divide all farms into three types, land cooperatives, companies, and household farms. Land cooperatives are a new production organization operated often within a village. When it is formed farmer participation should, in principle, be voluntary. Unfortunately, we have no information to show how many land cooperatives followed this principle in our studied areas. A cooperative is normally managed and operated by villagers who can either hire village members or laborers from outside their village to work on farming activities. Cooperatives can be divided into the following three groups: members paid land rent only, members paid shared profit only, and members paid a combination of land rent and shared profit.

The most striking finding is emergence of land cooperatives and company run farms. Although the share of these farms in the total number of farms is minimal, it has been rising rapidly and reached 0.14% and 0.01% for cooperatives and farm companies, respectively, in 2013 (Table 3). In 2013, average farm size reached 216 ha for cooperatives and 109 ha for companies. As the number and size of these farms rose, their share in total land area increased from negligible in 2008 to nearly 20% in 2013 (Fig. 1).

Within household farms, significant changes have also occurred in average farm size and the composition of farms by the area of their operation. In the last 10 years, average farm size increased by 165%, from 1.7 ha in 2003 to 4.5 ha in 2013 (row 6, Table 3). Most of this increase occurred between 2008 and 2013. It is worth noting that the rising farm size is not due to expanding cultivated land but directly results from the following two changes. The first is a fall in the number of farms, a trend similar to that presented in the column 1 of Table 2. The second is the fall in the share of small and the increase in the share of larger farms over time. For example, the percentage of households with less than 1 ha of land was 73.3% in 2003, and this decreased to 68.5% in 2008 and 59.5% in 2013 (row 7). However, the percentage of households farming more than 1 ha increased in every category of household farms ranged from 1 to 2 ha to more than 70 ha (rows 8–14, Table 3). Similar to all trends discussed above, the changes in composition of different land sizes of farms have accelerated since 2008.

3.3. Driving forces of small-scale farming transformation

There could be many reasons behind the changes in the size and composition of farms presented above. In addition to the rapid rise in wages since the middle 2000s, which may induce mechanization and land consolidation, we discuss three other forces that have rapidly evolved recently but have not been documented and assessed in the literature. They are as follows: (1) land transfer service, an institutional innovation to reduce farmers' transaction cost of land operational rights transfer; (2) policy support for land consolidation; and (3) farm mechanization services.

3.3.1. Land transfer service center

These land transfer centers are likely the most innovative institutional arrangement in rural China in recent years.[7] Previously, land operational right transfers occurred mainly among friends and relatives due to lack of formal rental markets (Gao et al., 2012). To facilitate land operational right transfers and consolidation, various cultivated land transfer service centers or platforms have been created by local governments. Most of these land transfer service centers or platforms were established at township level and, in some cases, larger networking platforms pooling rental information across townships have also been set up at county level.[8] Major mandates of these land trans-

[7] In China, while farmers have land contract rights, the property rights (or ownership) to their farm land belong to the village collective. Sale of cultivated land by farmers is prohibited by law. Only the original households in the village are entitled to the land contract rights that were set up in 1979-1984 for 15 years and renewed for another 30 years in the late 1990s. So transfer of land among farmers involves neither the property right nor the contract rights but operational right within the contracted period (Brandt et al., 2004).

[8] There are two explanations for establishing the land transfer service center at township rather than villages. First, from the supply size, establishing a land transfer service center requires some necessary conditions such as office space, service facilities, scale of service, staff, and operational budget. The township is

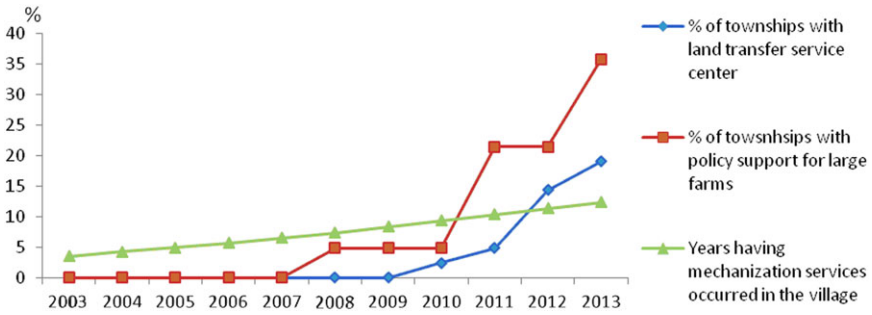

Fig. 2. Percentages of townships with land transfer service center and policy support for large farms, and years with mechanization service in the village in NE&NC.

fer service centers (LTSCs) are as follows: (1) conducting land rental market survey and collecting information on people willing to rent out their land; (2) facilitating land operational right transfers by providing clients information on location, area, major characteristics, and suggested prices for each piece of land to be rented out; (3) preparing formal land contracts when land transfer transactions are completed and keeping land transfer contract file records; and (4) being responsible for land transfer contract dispute mediation.

In the 42 townships of our study area, the first land transfer service center was established in 2010 and the number of these services increased rapidly in the following three years. By 2013, the number of townships with LTSCs had increased to 8, accounting for about 20% of the total townships in our sample.

3.3.2. *Policy support for large farms*

To facilitate farm land consolidation, the government also provides policy support for large farms in major grain production counties in our study areas. While the supporting policies differ between provinces and counties, they generally include: (1) providing loan guarantees and subsidized loans for land rental payments and purchasing inputs when farm size is expanded; (2) subsidizing investment in irrigation, drainage, and storage infrastructure; and (3) direct subsidies for purchasing large machinery and agricultural insurance. Based on recall estimates from our survey, the above support policies appeared in two townships in 2008, nine (or 21.4%) in 2011, and fifteen (or 35.7%) in 2013 (Figure 2).

3.3.3. *Accessing mechanization service*

The provision of mechanization services started many years ago in China. These paid services include mainly land preparation and harvest, but in some areas they also expand to other field operations such as planting/sowing and fertilizer and pesticide applications. The providers of these mechanization services include individual farmers or farmers' machinery cooperatives/companies within or outside villages. The farmers' machinery cooperatives and companies often sell their mechanization services across large areas, even across provinces, sometimes for months at a time (Yang et al., 2013). Based on our survey data, we found that mechanization services have been available in every village since 2008. To distinguish the mechanization service among villages, we create a variable called years having mechanization services available in the village. The results suggest that, on the average, villages had 3.5 years of these mechanization services in 2003, 7.3 years in 2008, and more than 12 years of mechanization services in 2013 (Fig. 2).

Table 4
Land transfer service, policy support for large farms, mechanization services, and farm size in Northeast and North China in 2003–2013

	Average farm size (ha)	
	Unweighted	Weighted
Townships with land transfer service center		
Yes	23.2	2.1
No	3.5	1.2
Townships with policy support for large farms		
Yes	12.1	2.3
No	3.5	1.2
Years having mechanization services		
<7	3.1	1.1
7–14	3.9	1.2
>14	7.9	2.0
Off-farm wage (yuan/day)		
<50	2.6	1.0
50–100	5.5	1.5
>100	12.2	3.6

Source: Authors' survey.

3.4. *Institutions, policies, market, and farm size*

Table 4 examines the relationship between farm size and the three factors discussed above. As we would expect, the survey data show that land transfer services and farm size are strongly positively associated in 2013. For example, sampled farms in the townships with a land transfer service center had a weighted average farm size of 2.1 ha (or 23.2 ha unweighted) in 2013,

the lowest government hierarchy and has ability to offer the land transfer service. Currently, few villages in China have the above capacity. Second, farmer prefers to have a formal land contract that is made at township government office and witnessed by government officials who are also responsible for land transfer contract dispute mediation.

whereas it was only 1.2 ha (or 3.5 ha unweighted) for farms in townships without a land transfer service center (Table 4).[9]

There is also a large difference in average farm size between the farms in townships with and without policy support for large farms (rows 3 and 4, Table 4). The weighted average farm size in townships with policy support (2.3 ha) was nearly twice that in townships without policy support (1.2 ha). The last six rows in Table 4 further show a positive relationship between average farm size and the number of years with mechanization service and between average farm size and off-farm wage rates.

4. Econometric analysis on determinants of farm size

4.1. Empirical model and estimation measure

Because the descriptive analysis presented above does not control for the influence of other factors, an econometric model is specified to examine the impact of the major driving forces on farm size:

$$\begin{aligned} H_{hijt} = {} & a_0 + a_1 L_{jt-1} + a_2 P_{jt-1} + a_3 S_{ijt-1} \\ & + \left(a_4 + a_5 L_{jt-1} + a_6 P_{jt-1} + a_7 S_{ijt-1}\right) C_{hijt} + a_8 T_t \\ & + a_9 W_{ijt} + a_{10} F_{ijt} + a_{11} A_{hijt} + a_{12} D + \varepsilon_{hijt}, \end{aligned}$$

where H_{hijt} represents the farm size (ha) of the hth farm in the ith village, and the jth township at year t during 2003–2013. L_{jt-1} is a binary variable, which equals 1 when the township j had a land transfer service center in the previous year, 0 otherwise. P_{jt-1} is a dummy variable with a value of 1 if township j had policy support for large farms and 0 otherwise, also lagged one year. S_{ijt-1} denotes the number of years mechanization services had been available in the village, lagged one year. To test whether the impacts of L, P, and S differ between household farming and cooperative/companies, a dummy variable for cooperative/company (C_{hijt}) and interaction terms of C_{hijt} with L, P, and S are included in the model. To control for other factors, the model also includes the following variables: (1) T_t, a time trend variable to capture the overall change over time (e.g., macroeconomic factors other than wages); (2) W_{ijt}, the daily off-farm wage (yuan/day) deflated by the rural consumer price index and measured at village level; (3) F_{ijt}, the average cultivated land per household at the village level; (4) A_{hijt}, a vector of variables reflecting household characteristics, including age (years) and education (years) of the household head; and (5) D, a set of provincial dummy variables to control for non-time varying unobservable regional differences. a_k ($k = 1, \ldots, 12$) are the coefficients to be estimated. The term ε_{hijt} is the specific error term and is assumed to be subjected to independent identical distribution. Summary statistics of the dependent and independent variables are in Table A1.

In estimation, we made two efforts to avoid likely endogeneity problems. First, as we explained above, three of the explanatory variables were lagged one year. Second, we applied a household fixed effect (FE) model to estimate the above model based on unbalanced panel data from 2003 to 2013, including balanced panel data for all household farms in 2003–2013, and companies and cooperative data in recent years.

In addition, we made several efforts to better understand farm size change and check the robust of the estimation results. First, when using the FE model, all non-time varying variables such as household characteristics and provincial dummies were dropped. To provide a robustness check on the impacts of major driving factors and to gain information on the impact of household characteristics on farm size, we also estimated the model using OLS. Second, model residuals appeared to be autocorrelated, we corrected for autocorrelation in all regressions. Third, given each village had 10 households, the standard errors were corrected for village cluster effects. Forth, because mechanization service and time trend variables as well as the variables between institution/policy and their interaction terms with cooperative/company have relatively high collinearity, the model was estimated with four alternative specifications (see columns 1–4, Tables 5 and 6). Finally, in all regressions, including both OLS and FE models, weighted regression was applied as our data are from a stratified random sample.

4.2. Estimation results

In general, the signs of all estimated coefficients are consistent with expectations and most are statistically significant in the four specifications of the model under OLS (Table 5) and FE estimation (Table 6). Here, we highlight several key findings based on the results presented in Tables 5 and 6.

The most important result is that the estimated coefficients for key driving factors show that their impacts on farm size are positive and robust among different specifications and between OLS and FE estimations. These driving factors include creating land transfer service centers, providing policy support for large farms, and mechanization service.

The estimated coefficients for land transfer service centers are positive and statistically significant in all estimations (row 1 in Tables 5 and 6). Holding all other things constant, creating a land transfer service center in a township increases average farm size by 1.23 ha in FE estimation (column 1, Table 6). The magnitude of this impact is remarkable as it is more than the average farm size in 2009 (1.17 ha, column (d), Table 1) before the land transfer service center was established in the NE & NC regions.

Policy support targeted at large farms also generates significant impact on farm size as it has encouraged some farmers to increase their farm sizes to a level entitled for this policy support. The estimated coefficient for the policy support variable suggests that farm size can be raised by 1.83 ha (column 1,

[9] The large difference between the unweighted and weighted sample means is due to the stratified sampling approach used in this study. That is, the sampled farms with extremely large farm sizes have a very small weight in the whole population (or farms).

Table 5
Multivariate analysis of farm size (ha) 2003–2013, weighted OLS regression

	(1)	(2)	(3)	(4)
With land transfer service center ($t-1$)	1.85**	1.63**	1.63**	1.31*
	(2.27)	(2.07)	(2.07)	(1.72)
With policy support for large farms ($t-1$)	2.34**	2.20**	2.20**	1.90**
	(2.57)	(2.45)	(2.45)	(2.12)
Years having mechanization services	0.06***	0.06***	0.06***	0.02
	(3.85)	(3.96)	(3.90)	(0.90)
Cooperative or company dummy	168.48**	45.18*	-27.04	-27.61
	(2.50)	(1.89)	(0.75)	(0.76)
Interaction terms of cooperative or company with:				
Land transfer service center ($t-1$)		217.17***	216.19***	216.82***
		(3.93)	(4.10)	(4.10)
Policy support for large farms ($t-1$)		97.79**	76.39*	76.71*
		(2.35)	(1.81)	(1.82)
Years having mechanization services			5.82*	5.84*
			(1.98)	(1.99)
Time trend				0.15***
				(3.45)
Off-farm wage	0.02**	0.02**	0.02**	0.004
	(2.05)	(2.00)	(2.00)	(0.45)
Average cultivated land per household in village	−0.16	−0.18	−0.18	−0.21
	(0.29)	(0.32)	(0.31)	(0.37)
Age of household head	−0.02**	−0.02**	−0.02**	−0.03***
	(2.33)	(2.27)	(2.27)	(2.65)
Education of household head	0.05**	0.05**	0.05**	0.05**
	(2.38)	(2.39)	(2.41)	(2.14)
Province dummy				
Jilin	−2.11***	−2.05***	−2.05***	−1.79***
	(3.35)	(3.26)	(3.25)	(2.94)
Liaoning	−2.36***	−2.28***	−2.27***	−2.09***
	(5.32)	(5.16)	(5.15)	(4.93)
Hebei	−3.03***	−3.01***	−3.00***	−2.97***
	(3.96)	(3.95)	(3.94)	(4.04)
Shandong	−2.74***	−2.72***	−2.70***	−2.70***
	(3.12)	(3.10)	(3.09)	(3.14)
Henan	−2.80***	−2.76***	−2.74***	−2.90***
	(3.02)	(2.98)	(2.97)	(3.21)
Constant	3.36***	3.33***	3.31***	−304.64***
	(3.22)	(3.21)	(3.19)	(3.42)
R^2	0.165	0.241	0.246	0.248

Notes: Absolute values of *t*-ratio in parentheses.
*, **, *** indicate statistically significant at the 10%, 5%, and 1%, respectively. The sample size used in regression is 9,444.

Table 6) after this policy was implemented. This impact indeed is more than average farm size in 2013 in the study areas (column (d), Table 1).

The impact of mechanization services on farm size is also positive and statistically significant (column 1, Tables 5 and 6). An additional year of mechanization service increased farm size by 0.12 ha in FE estimation (row 3, Table 6). This result is not difficult to understand because farmers can manage more crop land when key farm activities such as land preparation, crop planting, and harvest can be conducted by machinery companies/cooperatives.

The estimated coefficients for the interaction terms between cooperative or company structure and the three driving variables show that there is evidence of larger impact of institutions and policy on cooperative/company than the household farms (columns 2–4, Tables 5 and 6). For example, the estimated coefficients for the interaction term between cooperative or company and a land transfer service center are positive and statistically significant in all three specifications in OLS estimation (row 5, Table 5) and one of three specifications in FE estimation (row 4, Table 6). The positive and statistical significant coefficients for the interaction terms are also found in both policy support for large farms and mechanization service under OLS estimation (rows 6 and 7, Table 5) and in mechanization service under FE estimation (row 6, Table 6). Fewer statistically significant coefficients for the interaction terms in specifications 3 and 4 in FE estimation are likely due to the high correlation among several variables as mentioned earlier, and also

Table 6
Multivariate analysis of farm size (ha) 2003–2013, weighted FE regression

	(1)	(2)	(3)	(4)
With land transfer service center ($t-1$)	1.23*	1.22*	1.22*	1.20*
	(1.71)	(1.70)	(1.70)	(1.69)
With policy support for large farms ($t-1$)	1.83**	1.83**	1.83**	1.83**
	(2.02)	(2.02)	(2.02)	(2.03)
Years having mechanization services	0.12**	0.12**	0.12**	0.09
	(2.09)	(2.09)	(2.08)	(0.73)
Interaction terms of cooperative or company with:				
Land transfer service center ($t-1$)		58.78*	20.32	20.35
		(1.67)	(0.67)	(0.67)
Policy support for large farms ($t-1$)		4.89	−12.30	−12.31
		(0.23)	(0.56)	(0.56)
Years having mechanization services			16.32**	16.32**
			(2.55)	(2.55)
Time trend				0.03
				(0.19)
Off-farm wage	0.02	0.02	0.02	0.02
	(1.01)	(1.01)	(1.01)	(0.72)
Average cultivated land per household in village	1.66	1.66	1.65	1.60
	(1.16)	(1.16)	(1.15)	(1.07)
Constant	−1.32	−1.32	−1.35	−58.89
	(1.14)	(1.15)	(1.17)	(0.19)
R^2	0.038	0.039	0.040	0.040

Notes: Absolute values of *t*-ratio in parentheses.
*, **, *** indicate statistically significant at the 10%, 5%, and 1%, respectively. The sample size used in regression is 9,444.

suggest that the regression may still involve a serious endogeneity problem.

The estimated coefficient for off-farm wages is positive but not statistical significant in the FE model, whereas it is positive and statistically significant in 3 of 4 models in the OLS estimation (row 9, Table 5). This implies that farmers in the village with higher off-farm wage have more incentive to increase their farm size than farmers in the village with lower off-farm wage. But for a given farm (FE model), the insignificant impact of rising off-farm wage in the village over time on farm size still needs a further study.

Although the results from the OLS estimation could be bias on the impacts of the first three variables on farm size due to the likely endogenous problem, the estimated coefficients for household characteristics do provide interesting findings. Statistically significant and negative coefficient for the age of farm's head implies that youth tends to have a large farm size. Interestingly, more educated farmers also tend to have larger farm size.

5. Discussion, conclusions, and implication

Driven mainly by demand change due to income growth and urbanization, market liberalization, and supply chain change, Asian agricultural structure and rural employment have been changing rapidly. However, the agricultural transformation has generally been seen as associated with declining average farm size. Although there has been a long debate on the efficiency of small-scale farms, recent literature tends to agree that the small-scale farms are facing increasing challenges in improving their competitiveness and generating enough income to support farm households.

Like nearly all other countries in Asia, China experienced a gradual fall in average farm size until the early 2000s. Although standard measures of farm holding show a continuing decline in farm size between 2000 and 2010, measures of the size of operational units of the type presented here show a different picture, with the average size of farm operating units growing by more than one third in China as a whole and almost 90 percent in NE & NC between 2003 and 2013. The recent rise on average farm operating size, particularly the rapid growth in medium- and large-scale farms—is exceptional.

This study shows that several driving forces have shaped China's unique farm operational evolution. These include institutional innovations through establishing land transfer service centers to promote land rental, policy support for land consolidation, and innovative mechanization services for millions of family farms. They have assisted some small-scale farms to scale up their farming operations and helped other small-scale farmers to rent out land and move to off-farm employment. These driving forces have been accompanied by the emergence of large-scale farms operated by land cooperatives and companies. Although the number of these farms is still small, their share in total cultivated land has increased rapidly in recent years.

The results of this study have several policy and research implications for China and the rest of world. First, there are

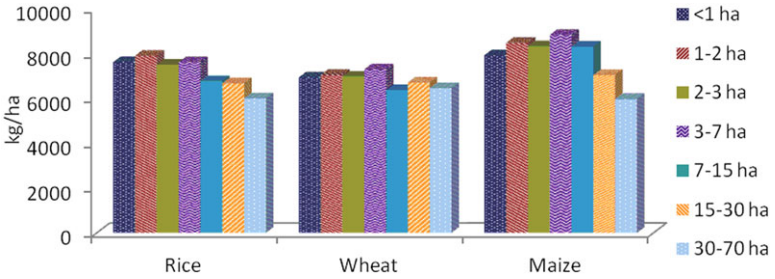

Fig. 3. The relationship between farm size and crop yield in 2013.

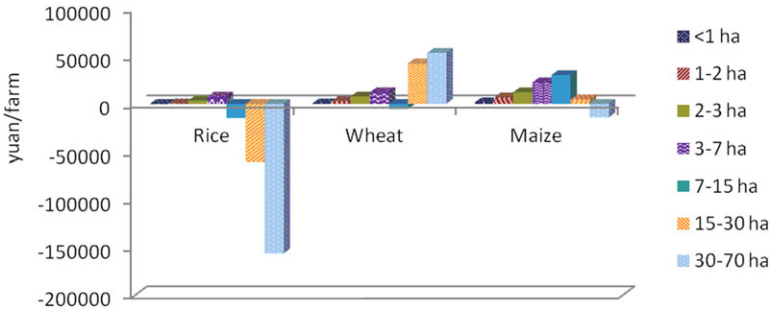

Fig. 4. The relationship between farm size and total profit per farm in 2013.

potential market failures in farm operational transformation because of high land transaction costs (Kimura et al., 2011). Therefore, institutional and policy intervention are needed, especially in situations such as China where sale of farm land is restricted. With rising rural populations, average farm size is expected to continue falling in many developing countries in Asia. China's recent experience shows that land rental markets can play an important role in consolidating farm operational units. Services of this type may also play roles in other countries such as helping landless farmers to access land, assisting some small-scale farms shift to off-farm employment, and enlarging the size of the small-scale farms that decide to stay in farming.

Second, in order to facilitate land transfer and consolidation, it is necessary to amend China's Land Law by formally separating land operational rights from the current contract rights. Although land transfer has been occurring among farmers since the late 1980s and has also been encouraged by the government, there is no legal document that defines the rights of farmers with the land contract and the rights of farmers who operate the rented in land after the land transfer. Good news is that, in 2015 a central government policy document first indicated that China plans to legally separate operational rights from contract rights. It is worth noting that this new institutional change will not only further facilitate land consolidation, but also have important implications for both equity and productivity. On one hand, there are more than two hundred million rural households who have the long term land contract rights in China. On the other hand, land can be consolidated to those farmers who decide to stay in farming and are confident they can earn a profit from farming after paying for land rental at market prices. This kind of institutional arrangement is likely to achieve both land distributional and land use efficiency goals.

Third, enlarging the size for small-scale farms through market based mechanization services is an alternative and maybe also effective way to improve farming productivity. This type of mechanization service can also overcome capital constraint in purchasing and improving utilization of machineries.

Fourth, the impacts of China's recent movement on the small-scale farm transformation on food security, farm employment, and farmer's income need further investigation. Although there is no doubt that labor productivity can be increased significantly with farm size expansion and mechanization, there are potential concerns on land productivity and profitability with significant increases in farm size. Using the same dataset, Huang and Ding (2016) has showed that there is evidence of an inverse U-shaped relationship between farm size and land productivity or profitability as well as total profit per farm in rice, wheat, and maize production in China (also see Figures 3 and 4).[10] These findings suggest that although the small is not necessary best, excessively large farm size could even be worse. Having appropriate farm sizes operated by households might be a path of farm operational evolution which China should follow, and policy should perhaps support the small farms that plan to move to this farm size of farms rather than excessively large farms.

[10] This inverse U-shape relationship differs from the previous study by Wang et al. (2014), the latter showed that there is a positive relationship between farm size and productivity. But Wang et al. (2014) is based a dataset that covers 2000–2008, which has nearly no large farm. So their sample is completely located in the first part of the inverted U-shape relationship curve.

Finally, there also is clearly a number of issues that need for further study. Although the finding on the inverse U-shape relationship is interesting, the reasons behind this relationship should be further explored. This study focuses in Northeast and North China, the major grain production regions. Whether the trend of land consolidation observed in these regions will be followed by other regions in China is another interesting and important research issue. Moreover, as we mentioned early, given the likely endogeneity of the land transfer service and policy support, a further effort should be made to find the effective instrument variables in the econometric analysis.

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Appendix

Table A1
Simple means and standard deviations of all variables used in regression

Variables	Mean	Standard deviation
Farm size (ha)	4.2	0.2
With land transfer service ($t-1$) (1 = Yes; 0 = No)	0.04	0.002
With policy support for large farms ($t-1$) (1 = Yes; 0 = No)	0.09	0.002
Years having mechanization services (years)	7.6	0.06
Cooperative or company dummy (1 = Yes; 0 = No)	0.02	0.001
Off-farm wage (yuan/day)	53.5	0.2
Average cultivated land per household in the village (ha/household)	0.9	0.006
Age of household head (year)	46.5	0.1
Education of household head (year)	7.9	0.03

Note: The number of observation is 9,444.
Source: Author's survey.

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