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FARMLAND HOLDINGS, CROP PLANTING STRUCTURE AND INPUT USAGE: AN ANALYSIS OF CHINA'S AGRICULTURAL CENSUS

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Abstract

This study, based on the data of China's agricultural census of 1997, focuses on the land distribution among rural households and its effects on crop production structure and employment of labor and capital. The Census data show that the size of holdings surprisingly differs among households, and land rental activities has started to play an important role in land allocation. Grain production accounts for 80% of total sown area for each household group, indicating that self-sufficiency in grains production is still an important factor to farmers.

Family members are a dominant source for China's agricultural labor force, regardless of the size of land held in each household. Machinery use in crop production is still not popular, while the scale of land held by households has an impact on the use of machinery in crop production. Moreover, the small land holdings of agriculture may lower labor productivity, even though there are more non-agricultural employment activities among these small scale households.

The paper has been prepared for the International Seminar on China Agricultural Census Beijing, China, September 19-22, 2000.Farmland Holdings, Crop Planting Structure and Input Usage:

Farmland Holdings, Crop Planting Structure and Input Usage: An Analysis of China's Agricultural Census

Land is a major constraint for China's agricultural production given the size of China's population. Even though the area of cultivated land is officially adjusted to 130 million hectare in 1998 according to the Census data (the number of 95 million hectare has been used over the last 40 years), the size of individual household holdings is still quite small, around 1/3 hectare. This study focuses on the land distribution among rural households and its effects on crop production structure, employment of labor, and capital input usage. Understanding these relationships would help to evaluate the growth potential of agriculture in China.

Over the last two decades, China's grain production, as well as production of other agricultural commodities, has undergone rapid growth. As measured by its gross value of production, China's agricultural output increased 3.5 times during this period. Given the farmland constraint, the question arises of whether China's agriculture, especially crop production, can continue this growth pattern in the next decade. To answer this question properly, it is important to understand China's land distribution, input combination, and crop production structure with land scale. Previous studies on these issues are based on statistical data that are either quite aggregated or derived from small sample size surveys that hardly cover the entire nation. This study is based on data from the first agricultural census conducted in early 1997. The Census covers all Chinese households in rural area, non-household agricultural production units, township enterprises, as well as administrative organizations of all villages and towns and also collects numerous data about China's rural and agricultural economy. Specifically, this study is based on a 1% sample of the 200 million households enumerated by the Census.

Conventionally, the rural households and laborers in China's statistical yearbooks are defined according to the household's registration system that prevails in China. According to this system, if a household is registered as a permanent resident in a rural area (having a rural "*hukou*" in Chinese), the household is called a rural household and their family members at working age are called rural laborers regardless of whether they are working in the agricultural sector or some other economic sectors. In the Census, a rural household is defined as one that has been living in a rural area for more than one year when the Census conducted. In the following analysis, this Census's definition for both rural households and laborers are used.

The paper is organized in seven sections. The first section discusses how land is distributed among the rural households. The second section puts more emphasis on land rental activities and its effect on land scale. In section three, the intensity of land use is discussed, followed by a section on different planting structures across various land holding groups. In section five the effects of the land size on the use of intermediate inputs and machinery are discussed while section six focuses on the substitution between labor and capital. A final section provides a summary and conclusion.

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Land Distribution

In the last two decades, China has undergone a series of successful economic reforms in the agricultural and rural economy. After the collective production system was replaced by the household responsibility system (HRS) in early 1980s, farmland has been mainly cultivated by individual households who make planting decisions as well as inputs usage (while the ownership rights of land still nominally belong to collective organizations). According to the Census, there were totally 200 million rural households engaged in agricultural production in 1996, but only 300,000 non- household holdings stated that they owned large farms. With such big number of household holdings, the land area cultivated per household is often quite small. Moreover, the distribution of land is believed to be quite egalitarian as land is contracted to each individual household according the number of family members and workers.

Surprisingly, the census data show that the size of holdings differs among households or per worker. Based on the size of holdings, we divided all households into 10 groups. There are about 10% of the households in the first group and each of them holds less than 0.07 hectares of land (with an average of 0.046 hectares per household). There are 1.6% of the households in the tenth group where size of holdings is above 2 hectares per household and an average of 3.2 hectares. That implies that households in the tenth group hold, on average, 70 times the size of land held by those in the first group. Based on this finding, we developed a land Gini coefficient and Lorenz curve to illustrate this point. The Lorenz curve is often used to describe income distribution among households or people. The distance between the Lorenz curve and the 45-degree line indicates the inequality of the distribution under study. Drawing on this concept, we used the average land size per household (and worker) and percent of the households (and workers) in each group to describe the disparity in land distribution (see figure 1).

Geographic location is often cited as a major reason for cause land size to be different among households. For this reason, we compared the land distribution across the three regions, the East, Central, and West, which are distinguished by geographic location and level of economic development. The East Region has the highest population density region among all regions in China. More than 40% of the national population lives in the East Region; thus, the land size per capita/worker is small. The West Region has the largest land area with the lowest population density. Population density in the Central Region is lower than that in the East but higher than in the West.

Regarding agricultural production, the cultivated land area in the Central Region is larger than that in the other two regions. Figure 2 describes households' cultivated land distribution across the three regions. Among the 10 holding groups we discussed above, households of each group are further identified by the location in each of the three regions. The results show that a significant difference still exists in holding size among the households within a region, given the deviation in the holding size across regions (figure 2). There exists considerable disparity in households' land size between the East and Central or West Regions in the first two groups where land size is under 0.07 and 0.13 hectares per household, respectively. In the East Region, there are 30% of

households that belong to these two groups, while in the Central and West Regions there are only 16 and 19%, respectively. However, once the area of holdings is more than 0.13 hectares, such as in the third through tenth groups, the deviation among the three regions become much smaller, while the deviation among households within a region becomes dominant.

Land Rental Activity

While the Census captures the land distribution among households, it cannot directly provide a satisfactory answer as to why such large deviations in land scale exist among households within a geographically similar region. We further observed another more interesting trend in the land distribution. The Census collected data on land rental activities among households. Each household reported the area of cultivated land that is rented from other households. On average, the size of land rented from other households accounts for less than 3% of the individual household's cultivated land, while 5% of households rented land in 1996. However, the share of rented land in total cultivated land as well as the number of households that are involved in rental activity rises with the land scale of holdings (figure 3). For example, in the tenth group, where size of holdings is above 2 hectares (while the national average is 1/3 hectare), 17% of the households rented land in 1996 and total rented land accounted for 8% of all households' cultivated land. If we further separate the 17% of households that rented land from those that did not rent land, the rented, land accounted for 42% of total cultivated land for these households as a group (figure 4). Most of these households rented less than 50% of the land that they cultivated (see figure 5 for the households in the groups eight through ten). However, there are some households that rented more than 50%; some even rented all of the land that they cultivated. Thus, land rental activity for certain has started to play an important role in land allocation. It is obvious that geographic differences are not the sole reason for such a trend. A further study is merited to take into account other economic and policy factors on this matter.

The Intensity of Land Use and Size of Holdings

The disparity in sown areas across households is smaller than that for cultivated land, as the intensive cultivation is practiced by small land holdings. On average, the ratio of sown area to the cultivated land is 1.5 for all households. This number is slightly lower than that (1.58 - 1.6) reported by China's statistical yearbooks over the last five years, due to the adjustment in the area of cultivated land in the Census. Among the ten holding groups, the multiple cropping indices fall with the size of holdings. In the first group, in which the land size is less than 0.07 hectares per household, the index is 2.2, but it falls to 1 for the tenth group, in which the land size rises to more than 2 hectares per household (figure 6).

The intensity of land use generally depends on weather, rainfall conditions, and planting structure. Southern China has a longer growing season and more rainfall than Northern China. Also, in Southern China, usually two or three crops can be grown within a season while single cropping practices are quite common in Northern China.

Moreover, if additional land is allocated to vegetable growing, the intensity of land use is higher than that if land is only used for grain production. More than 55% of the households with land size above 0.7 hectares are located in the Northeast and Northwest where either the growing season is short (in Northeast) or there is a limited water supply (in Northwest). A low index for multiple cropping among groups eight through ten is hence highly influenced by the growing patterns in these two regions. In the first group, in which the land size per household is below 0.07 hectare, the ratio of vegetable area to total sown area is high, which further increases the intensity of land use.

Besides weather and water constraints, multiple cropping also implies more intensive use of labor and intermediate inputs, such as fertilizers and pesticides. This implies that given weather condition, households with small land size tend to spend more time on farming than the large holdings, as family size is quite similar across regions and family members are a major source for labor supply. We will further examine this trend in the following sections. For this reason, it can be expected that with the rise in labor costs, either land use would become less intensive or the costs of crop production would rise. This will further affect farmers' planting decisions as high value-added crops, such as vegetables, would become more attractive than bulk products, such as grains. Moreover, if the rise in the size of holdings is due to the popularity of land renting from other households, the total sown area would fall at given level of cultivated land. All these trends would affect China's crop output in the future, especially grain production.

Crop Structure and Size of Holdings

Grains account for a similar share of sown area across holding groups

Grain production accounts for a stable share of total sown area for each household, around 80 percent, regardless of the size of holdings. In the first group, in which land size per household is under 0.07 hectares, 70% of the sown area was allocated to grain production. In the next seven groups where land size per household is between 0.07 - 1 hectare, grain production accounted for 80 – 81% of the sown area. When the land size per household rises above 1 hectare in the ninth and tenth groups, grain production accounted for 84 and 85% of the sown area, respectively.

What are the reasons for households to allocate almost the same portion of land to grain production, especially for the households with small land size? As data from the Census reflect 1996's production, self-sufficiency in grain production still counts as an important factor to farmers. In addition, the government's grain bag policy, that provides an emphasis on grain production, has also played an important role. However, to really understand household planting decisions, additional information that is not provided by the Census is needed to study household production behavior.

Cotton production has a regional focus and less relationship with land scale

Cotton accounts for 2.6% of the total sown area. For the first five small holding groups, the ratio of cotton area to the total sown area is small, between 0.51 - 2.4%. For the largest two holding groups, the ratio is also under the average, 2.2 and 1.4%, respectively. In the sixth through eighth groups, the ratio increases to 3.2, 3.9, and 3.6%, respectively. In these three groups, the land size is 0.3 - 1 hectares per household.

Vegetable production and land size

While vegetable accounts for 4.3% of the total sown area, the ratio of vegetable area over total sown area rises with the fall in size of land per household. In the first two groups in which the area of land per household is under 0.07 and 0.13 hectares, the households allocate 17.6 and 9.2% of sown area, respectively, to vegetable production. However, in the two largest holding groups, the ratio falls to 2.1 and 1.3%, respectively.

Usually in the suburb areas of cities, land scale is small for households. Vegetable production is mainly for urban residents and hence households would allocate more sown area to growing vegetables.

Intermediate Input and Machinery Use and Land Size

Similarly as in many other developing countries, due to the small land scale per household, tractors have multiple functions for rural households in China. Thus, it is difficult to distinguish agricultural and non-agricultural uses of a tractor in conventional statistical data. However, in the Census, all households are requested to report the area cultivated and harvested by tractor, which allows this study to report the intensity of machinery use in crop production at the household level.

While machinery use in crop production is still not as popular as in any developed country, the Census data show that scale of land held by households has an impact on the use of machinery in crop production. For example, the ratio of tractor plowed area over household's total cultivated land is 39.4%, but this ratio changes across holding groups. For the first group in which each household has less than 0.07 hectares of cultivated land, about 29% of cultivated land was plowed by tractors. However, in the tenth group in which each household has more than 2 hectares of land, this ratio rises to 47.4%. A similar situation is observed for the machinery used in harvest. The ratio of mechanically harvested area over sown area is 13.7% on average, but it is 4.1% for the first holding group, and 33.4% for the tenth group. While this finding further supports one widely accepted hypothesis that small land scale is a constraint for mechanization in China's crop production, it also indicates that if farmers' land scale rises in the future, it is possible that farmers may substitute machinery use for labor in crop production.

The irrigated area accounts for 13.7% of the total sown area and it rises with holding scale only for the first seven groups in which households hold less than 0.7 hectare of land. The ratio of irrigated area over sown area is 13.2% for the first group

and 22.9% for the seventh group. When the land size per household is above 0.7 hectares, this ratio starts to fall to 12.3 and 8% for the last two groups in which households have more than one of two hectare of land.

The Census data show extensive usage of chemical fertilizers and pesticides by China's rural households. On average, more than 87 and 67% of the sown area was applied with fertilizers and pesticides, respectively. Also, those households who hold more than 0.07 but less than one hectare of land tend to use more than other households. However, the large holdings tend to use less fertilizer and pesticides. For households who hold more than 2 hectares of land, fertilizers and pesticides were applied to 81 and 40% of the sown area, respectively.

Labor Employment and Land Scale

Family members are a dominant source for China's agricultural labor force, regardless of the size of land held in each household. The Census data only capture a small number of permanent and temporary hired workers (0.02 and 0.03, respectively), per household, and among them, hired permanent and temporary agricultural workers are 0.013 and 0.004 per household. Such small numbers may reflect the fact that labor exchange instead of hiring is the main channel for Chinese farmers to employ non-family workers during the busy seasons of agricultural production, such as plowing and harvesting.

Land size affects household's agricultural employment

As family members are mainly involved on activities on their own land, the smaller the size of land held by a household, the less time a family member needs to be involved in farming activities. For those households who hold less than 0.07 hectares of cultivated land, only 29% of family workers need to work full time in agriculture. In this group, non-agricultural employment is high, as more than 54% of family workers are mainly involved in non-agricultural activities. However, once the land scale per household increases to more than 2 hectares, 72% of the family workers are full time in agriculture while non-agricultural employment falls to 5% of its total labor force.

Labor use intensity and land size

Part-time agricultural workers who worked mainly in agriculture accounted for an average of 16 – 23% of the total family workers per household. Some of them are also involved in part-time non-agricultural activities. According to the Census, all household members are asked to report how long in 1996 they were engaged in agricultural and non-agricultural activities, respectively. There are six different time ranges for workers to choose for both agricultural and non-agricultural activities: 0 month, 0 - 1 month, 1 - 2 months, 2 - 4 months, 4 - 6 months, and more than 6 months of a year. There are 36 different combinations of time spending among all labor employment categories. We further converted all part time agricultural employment into full time. We first calculated the number of months engaged in agricultural production for all household members by holding group, and converted these times into full time (more than 6 months) agricultural

workers by group. We then divided the total cultivated land of each group by the converted full time agricultural workers for each group. The results show that the smaller the size of land held by a household, the more labor intensive the crop production in the household. For the first group in which all households hold less than 0.07 hectares of land, the ratio of land and a full time agricultural worker is 0.5, and this ratio rises to 17.6 when the size of land held by a household increases to more than 2 hectares. This implies that, on average, the households who own the smallest size of land employed 35 times more labor per unit of cultivated land than those with the larger scale. This finding shows that small scale of agriculture may lower labor productivity, even though there are more non-agricultural employment activities among these households.

Substitution Between Labor and Capital

We use the tractor to represent the capital employment in crop production to investigate the substitutability between capital and labor in crop production as land scale increases. As the use of the tractor is reported, we choose the ratio of the mechanically plowed area over the full time agricultural worker per unit of land in the first group as *one* to check the deviation of this ratio over different holding groups. We find that the capital and labor ratio significantly rises with the scale of land held by a household. For example, for the group in which households hold more than 2 hectares of land, the capital and labor ratio is 59, or 58 times higher than that for the first group.

While substitutability prevails between capital and labor, the total factor productivity, i.e., the productivity of labor and capital, may still be restrained by the size of land. As the Census did not cover any data on output or economic series such as price information for both inputs and outputs, it is not appropriate to evaluate factor productivity by the Census data exclusively. Our estimate on the relationship between land size and factor productivity is derived solely from the fact that while labor employment per unit of land is 35 times more among the small holders than that for the large holders, the use of capital (tractor) by the small holders is only 70 % lower than that by the large holders (i.e., the tractor use in per unit of land by the large holders is 2.5 times more than that by the small holders).

Summary and Conclusions

This study, based on the data of China's agricultural census of 1997, focuses on the land distribution among rural households and its effects on crop production structure, and employment of labor and capital.

The distribution of land is believed to be quite egalitarian in China as land is contracted to each individual household according the number of family members and workers. Surprisingly, the Census data show that the size of holdings differs among households or per worker. Although land rental activities account for a small potion of household's cultivated land, land rental activities has started to play an important role in land allocation.

Grain production accounts for 80% of total sown area for each household group, indicating that self-sufficiency in grains is still an important factor to farmers. Cotton and vegetables production and land use account for 2.6% of the total sown area, respectively. However, to understand planting decisions, additional information that is not provided by the Census is needed to study household production behavior.

While machinery use in crop production is still not popular, the Census data show that scale of land held by households has an impact on the use of machinery in crop production, which supports the hypothesis that small land scale is a constraint for mechanization in China's crop production.

Family members are a dominant source for China's agricultural labor force, regardless of the size of land held in each household, and hence, the households who own the smallest size of land employed 35 times more labor per unit of cultivated land than those with the larger scale. This finding shows that small land holdings of agriculture may lower labor productivity, even though there are more non-agricultural employment activities among these small scale households.

Fig. 1--Land holding distribution cross households

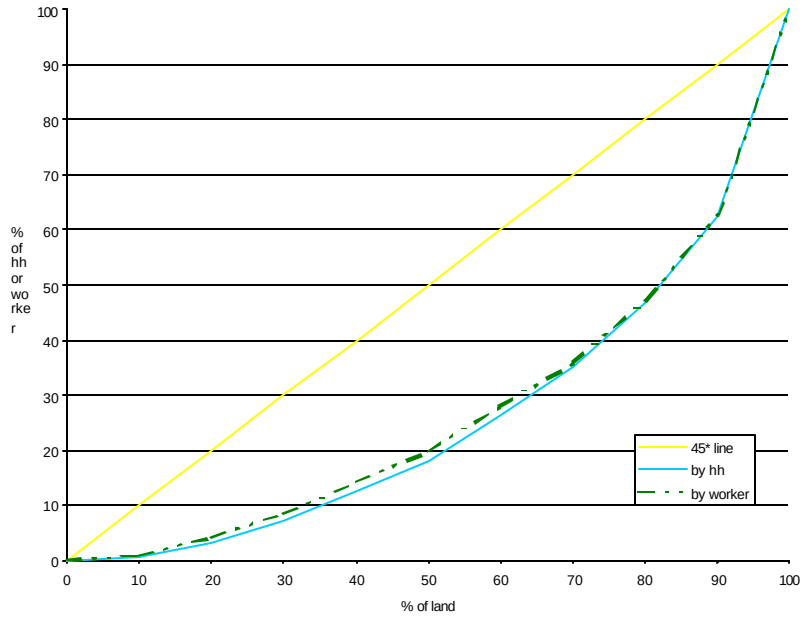


Figure 2: Household distribution by land holding size

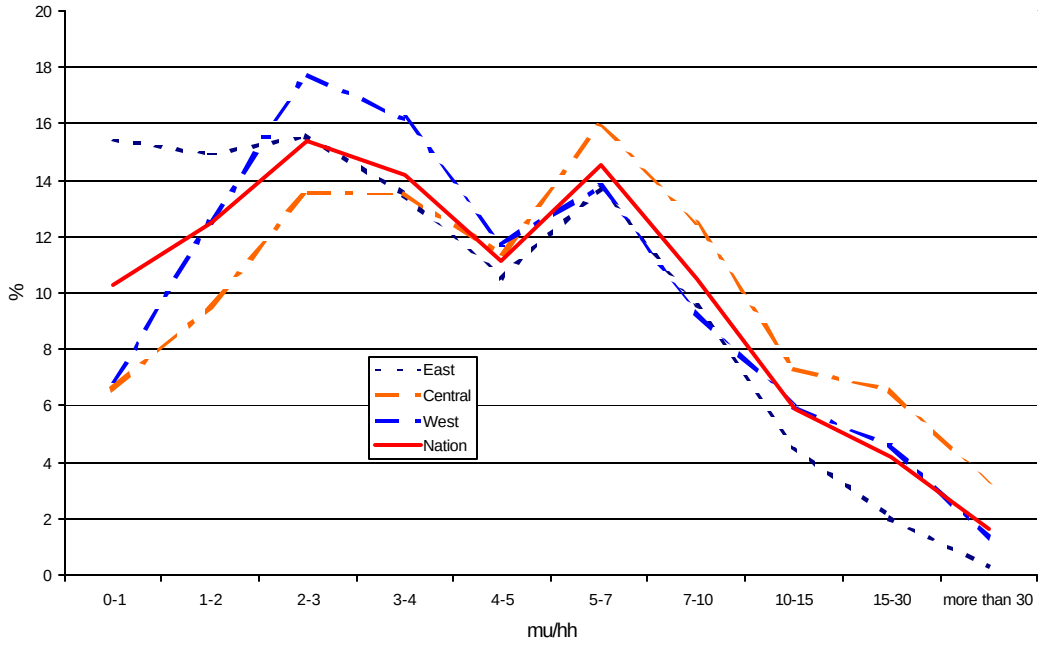
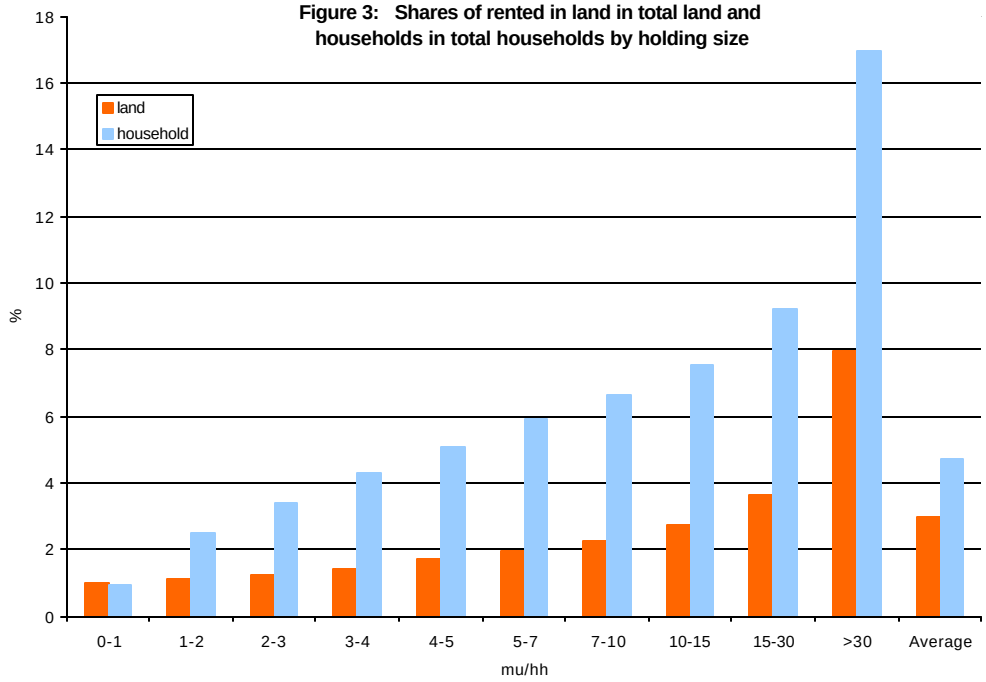


Figure 3: Shares of rented in land in total land and households in total households by holding size



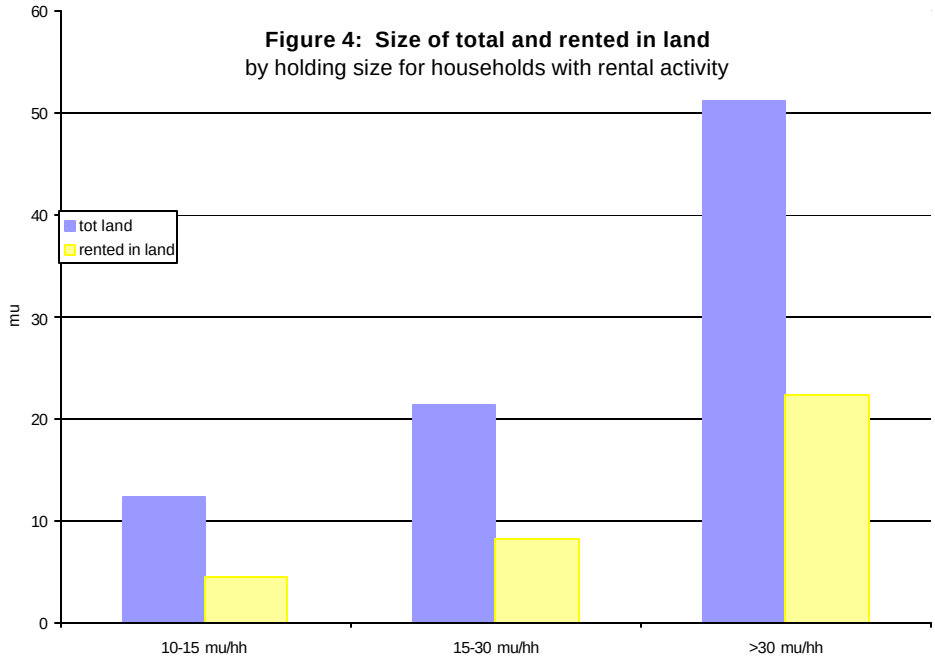


Figure 4: Size of total and rented in land
by holding size for households with rental activity
60
50
40
30
20
10
0
mu
tot land
rented in land
10-15 mu/hh
15-30 mu/hh
>30 mu/hh

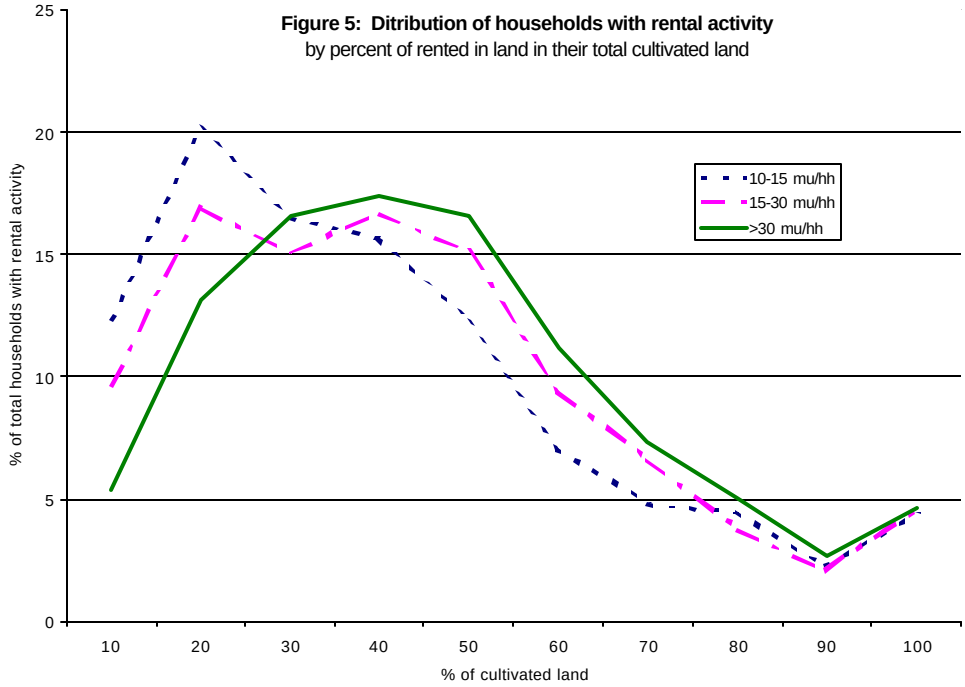


Figure 5: Ditribution of households with rental activity
by percent of rented in land in their total cultivated land
25
20
15
10
5
0
% of total households with rental activity
10-15 mu/hh
15-30 mu/hh
>30 mu/hh
10
20
30
40
50
60
70
80
90
100
% of cultivated land

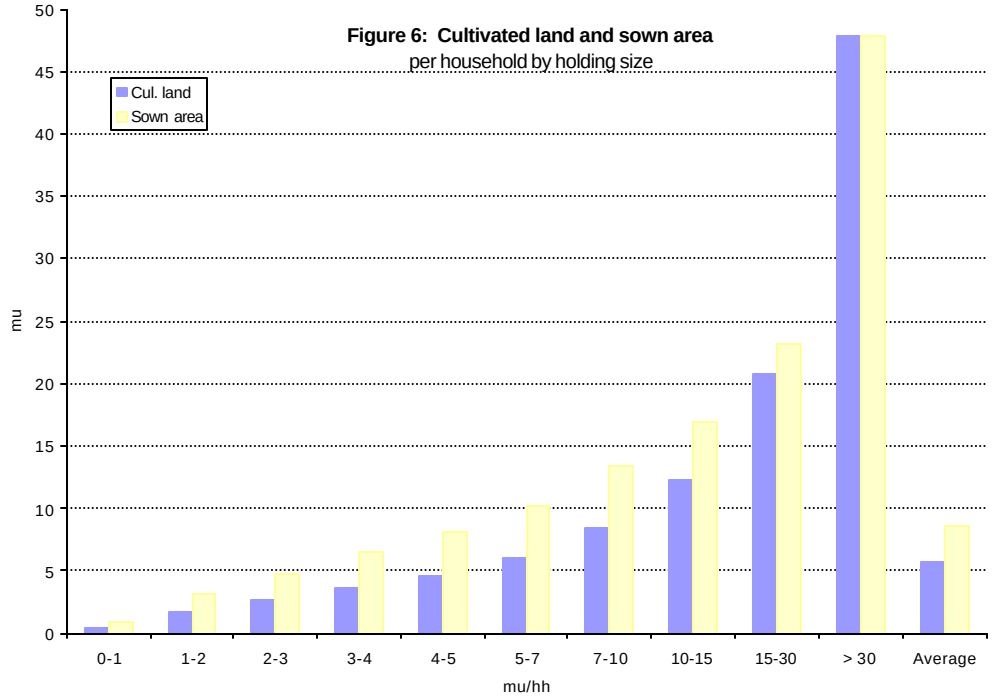


Figure 6: Cultivated land and sown area
per household by holding size
Cul. land
Sown area
mu
50
45
40
35
30
25
20
15
10
5
0
0-1
1-2
2-3
3-4
4-5
5-7
7-10
10-15
15-30
> 30
Average
mu/hh

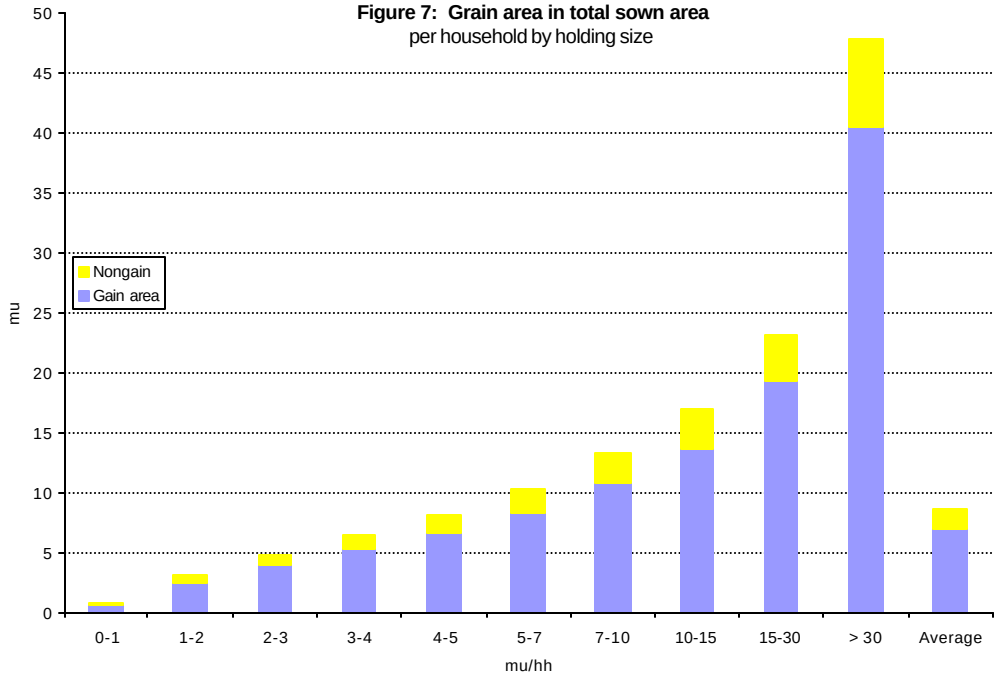


Figure 7: Grain area in total sown area
per household by holding size
Nongain
Gain area
mu
50
45
40
35
30
25
20
15
10
5
0
0-1
1-2
2-3
3-4
4-5
5-7
7-10
10-15
15-30
> 30
Average
mu/hh

Figure 8: Cotton area and ratio in total sown area
per household by holding size

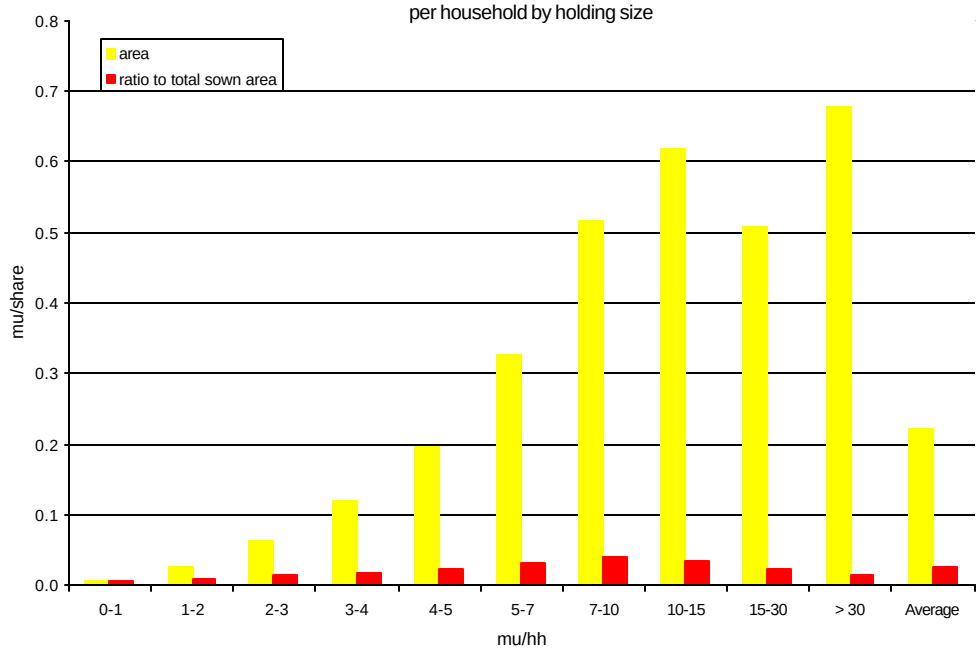


Figure 9: Vegetable area and ratio in total sown area
per household by holding size

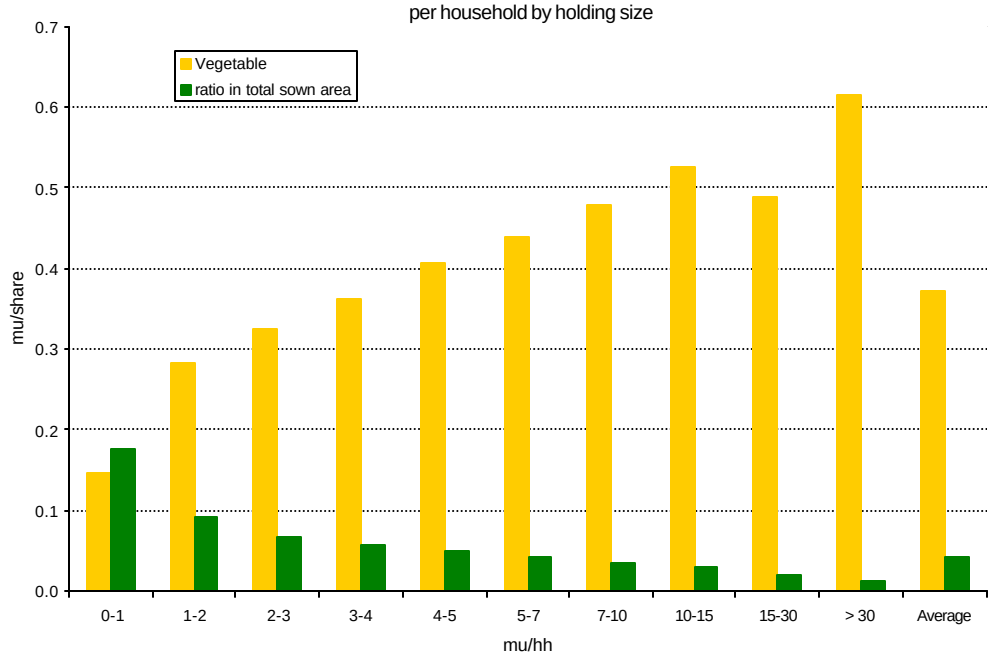


Figure 10: Tractor plowed and irrigated area vs total sown area per household by holding size

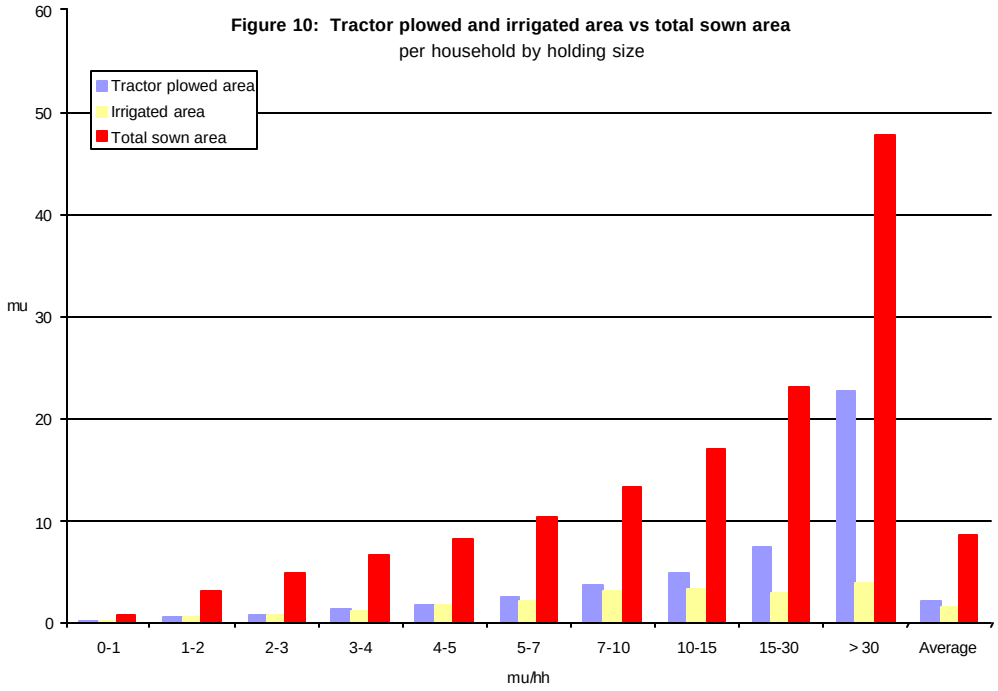


Figure 11: Ratios of fertilzer and pesticide used areas in total sown area by holding size

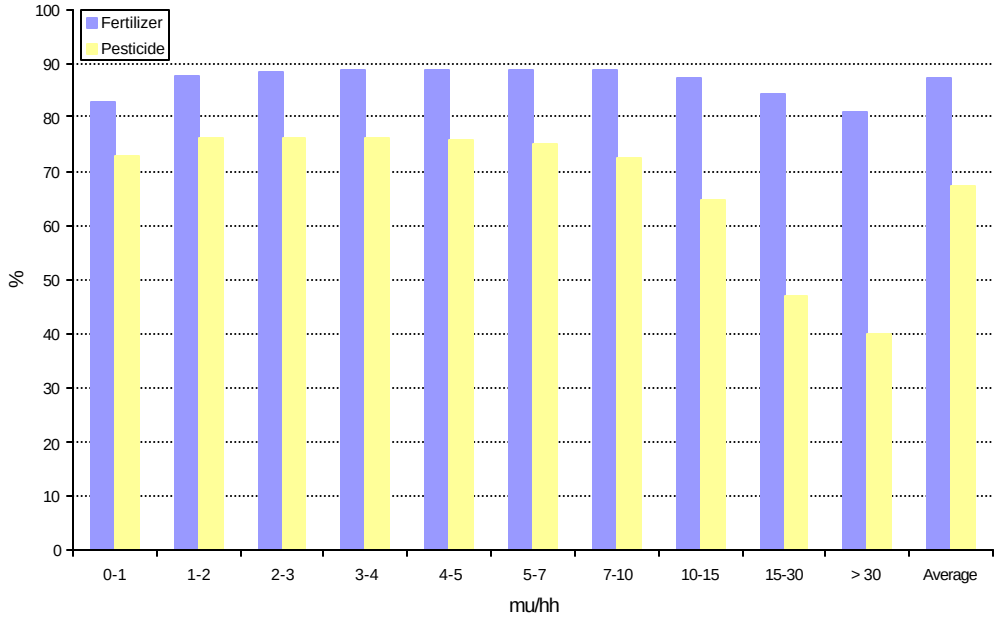


Figure 12: Ratio of full time ag and nonag workers in total family workers
per household by holding size

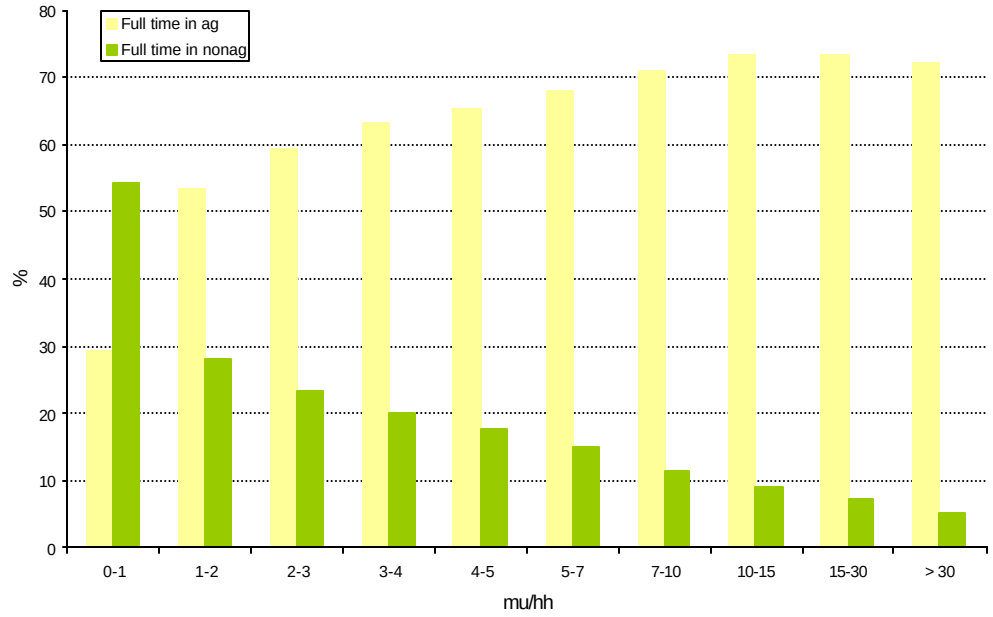
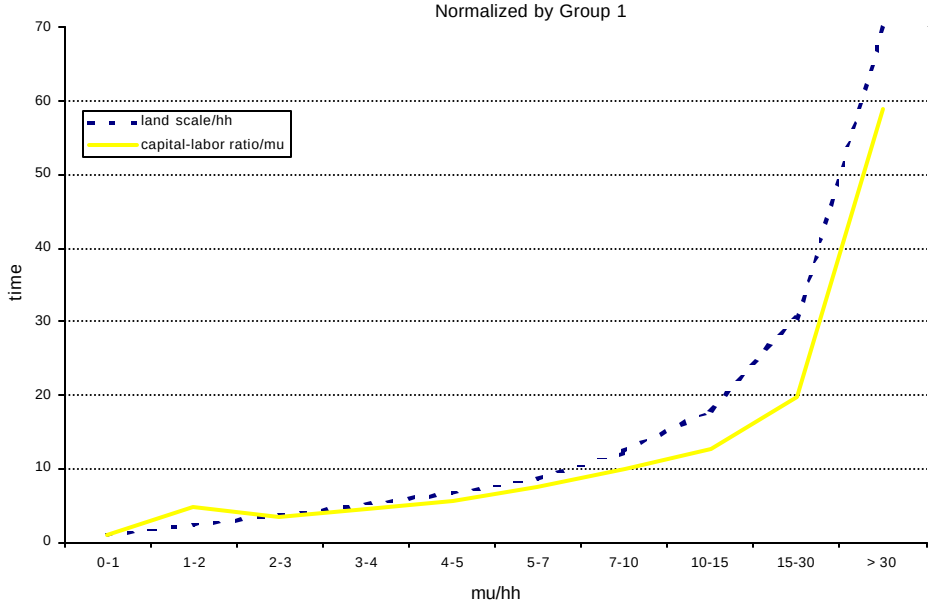


Figure 13: Change in land scale and capital/labor ratio by holding size
Normalized by Group 1



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