論文の内容の要旨

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論文題目 Impact of Rural-Urban Migration In Thailand: An Economic Study on the Aging of Rice Farmers
（タイにおける農村から都市への移民の影響：米農家の高齢化局面での経済学的研究）

Urbanization and migration have long been discussed in academic society, as well as their effects to agriculture. However, most of the studies are from micro viewpoint and use qualitative methods. Unfortunately, there is hardly research examining the aging problems in agricultural population in Thailand

Therefore, this dissertation's initiation is to examine whether and how inter provincial migration creates aging agriculture, and project future aging problems of agricultural population in Thailand in macro viewpoint as well as prob able issues they would encounter in 2040. It begins with examining root causes and factors of changes in both urban population and agricultural population of the country since 1980. Accordingly, future non-agricultural worker numbers and agricultural worker numbers by age group and sex are projected to analyze trends of both sectors. Then, rice productivity functions are estimated to examine the influence of aging on rice labor--productivity. Before coming to conclusion, several aspects due to aging problems in agricultural society and how Thai farmers adapt to the phenomenon are further scrutinized and discussed.

Inter-Provincial Migration and Aging Agriculture

Per-capita GDP of all 76 provinces in Thailand, and in-migrant percentage over last five years of 1990 and 2010 were plotted and it was found that there was a linear positive relation between the two variables in both periods. Confirmed by the statistical parameter, it can be concluded that per-capita GDP majorly influences provincial level in-migration in a positive way.

This study found that there were two main impacts of rural-urban migration on agricultural population in Thailand: less agricultural worker percentage, and higher aging agricultural worker proportion. Out-migrants leave agricultural sector and enter modern sectors in urban provinces via migration. Negative 22.8 percent was the changes in agricultural worker percentages of the whole country, whereas municipal population percentage rose by 27.17 percent. Consequently, Rural-urban migration changed age structures of agricultural population in rural area. Most of out-migrants who were

previously in agricultural sector were young adults. Thus, the move-out ones would make the elderly proportion of agricultural worker. As can be seen by scatter diagram in Figure 1, a good association was found between out-migration percentages from the last 30 years, and changes in aging agricultural worker percentages. It is seen that provinces with high average out-migrant percentage also had a huge gap in percent aging workers, and vice versa. Correlation coefficient of the two variables was 0.61, so the positive relation is moderate strong. Continually young and middle-aged workers have been leaving the agricultural sector in their origin provinces for modern sectors in urbanized provinces, resulting in more percentages of aging agricultural workers.

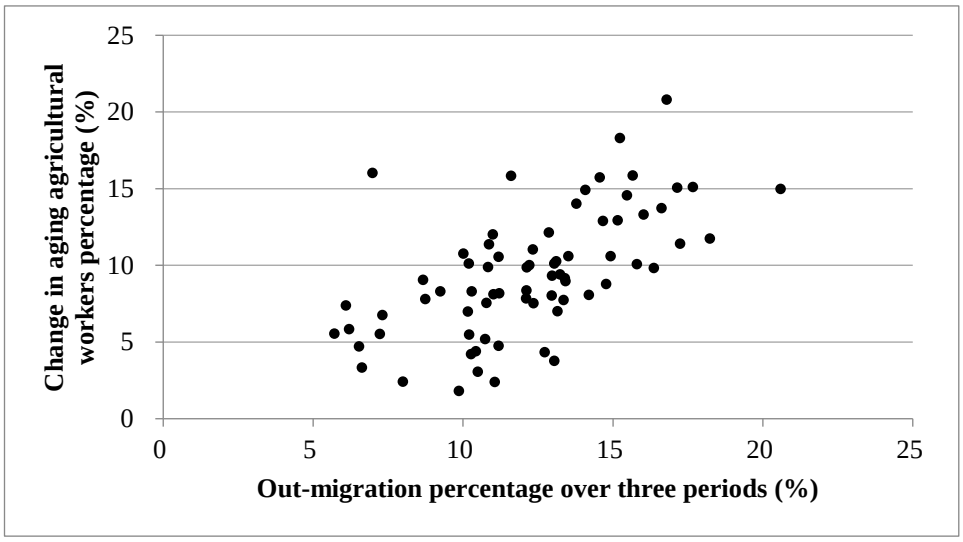


Figure 1 Associations between out-migration and aging proportion of agricultural workers over three periods

Projection of Thailand's Agricultural Population to 2040

To accomplish an agricultural worker population structure by age and sex to year 2040, there are 5 main elements to consider. Figure 2 presents the conceptual framework of this study. According to the framework, there are three main steps in this study: projecting the numbers of total workers, projecting the number of non-agricultural workers, and calculating the number of agricultural workers in 2040. Elements considered are death rate, survival rate, working population percentage, worker moving rate (in-out of the agricultural sector), and agricultural sector entry rate. These elements are explained in the following steps.

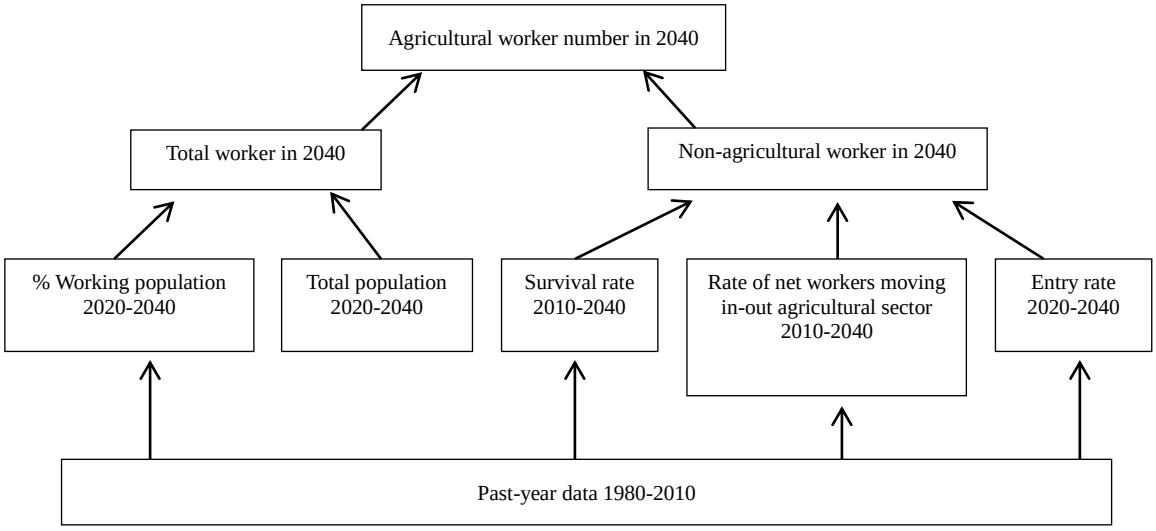


Figure 2 The conceptual framework of agricultural worker projection

According to the conceptual framework, the following are detailed procedure needed for finding past trends of workers moving in-out of the non-agricultural sector by age group and sex.

1. Past-year survival rates of each age group and sex of the whole population from 1980 to 1990, 1990 to 2000, and 2000 to 2010 are calculated.

$$ {}^{10}_{0}SVR = (SVR_0)(SVR_1)(SVR_2) \dots (SVR_9) $$

; ${}^{10}_{0}SVR$ refers to ten-year-interval survival rate in a specific age group and sex

2. Percent net workers moving in-out of the non-agricultural sector by age group and sex are calculated from the following formula:

$$ {}^{10}_{0}\%NM = \frac{{}_5NAW_{x+10} - {}_5SVW_x}{{}_5NAW_{x+10}} $$

${}^{10}_{0}\%NM$= % net movement in-out non-agricultural sector, 10 years interval

${}_nSVW_x$= number of survived workers age x to x+n

${}_nNAW_x$ = number of non-agricultural workers in a specific age x to x+n

3. Differences in rate of net worker moving in-out of the non-agricultural sector were analyzed over three periods: 1980-1990, 1990-2000, and 2000-2010. Variations in the percentage of each age group were analyzed to find convincing future trends. A five-year interval rate (${}^{5}_{0}\%NM$) is calculated as follows:

$$ {}_{10}NAW_x = {}_5NAW_x(1 + {}^{5}_{0}\%NM)^2 $$

$$ {}^{5}_{0}\%NM = \sqrt{\frac{{}_5NAW_{x+10} - {}_5NAW_x}{{}_5NAW_x} + 1} - 1 $$

4. The future whole country's survival rate from death, to year 2040 was calculated as:

$$ {}^{5}_{0}PSVR = \frac{{}_{5}POP_{x+5}}{{}_{5}POP_{x}} $$

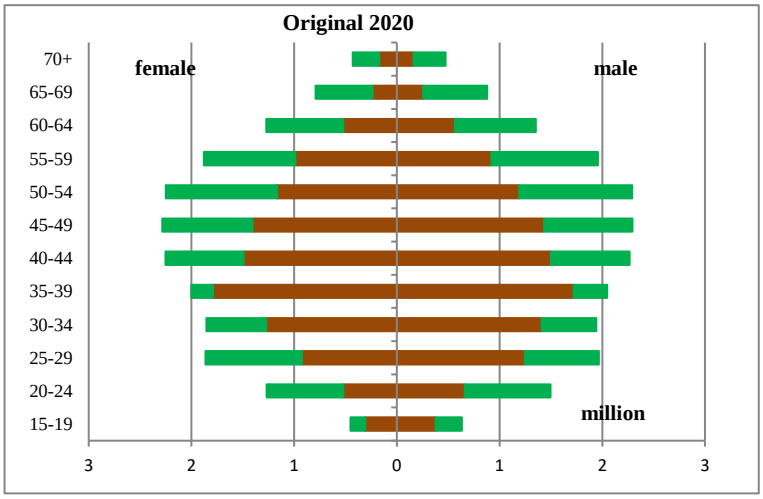
${}^{5}_{0}PSVR$ is future survival rate in five-year interval

${}_{n}POP_{x}$ is number of population age group x to x+n

5. Numbers of non-agricultural worker in 5-year interval from 2015 to 2040 are estimated. The estimation includes the calculated future survival rate and extrapolated percent net worker moving in-out of the non-agricultural sector with the formula below:

$$ {}_{5}NAW_{x+5} = {}_{5}NAW_{x} \times {}^{5}_{0}PSVR \times (1 + {}^{5}_{0}\%NM) $$

The results of agricultural worker projection by age group and sex under optimal conditions from 2015 to 2040 are presented in Figure 3. As seen in the figure, in 2040, total number of agricultural workers decrease to 12.32 from 16.86 million in 2010. The age groups with highest agricultural worker numbers are 40-44 years old for males and females, while those with the lowest numbers are 15-19 years old for both males and females. Thus, the numbers of agricultural workers aged 49 and younger will be 56.13 percent of total agricultural worker numbers. The aging agricultural worker percentage will be 29.86 percent, almost twice as which of non-agricultural sector (15.51 percent). As an overview, there will be 35.32 percent of workers who will be in the agricultural sector in 2040. It can be concluded that in 2040 Thailand would no longer be an agriculture-based country. On limitation is that there are no international and domestic conflicts whish impact economic and social stability of the country.



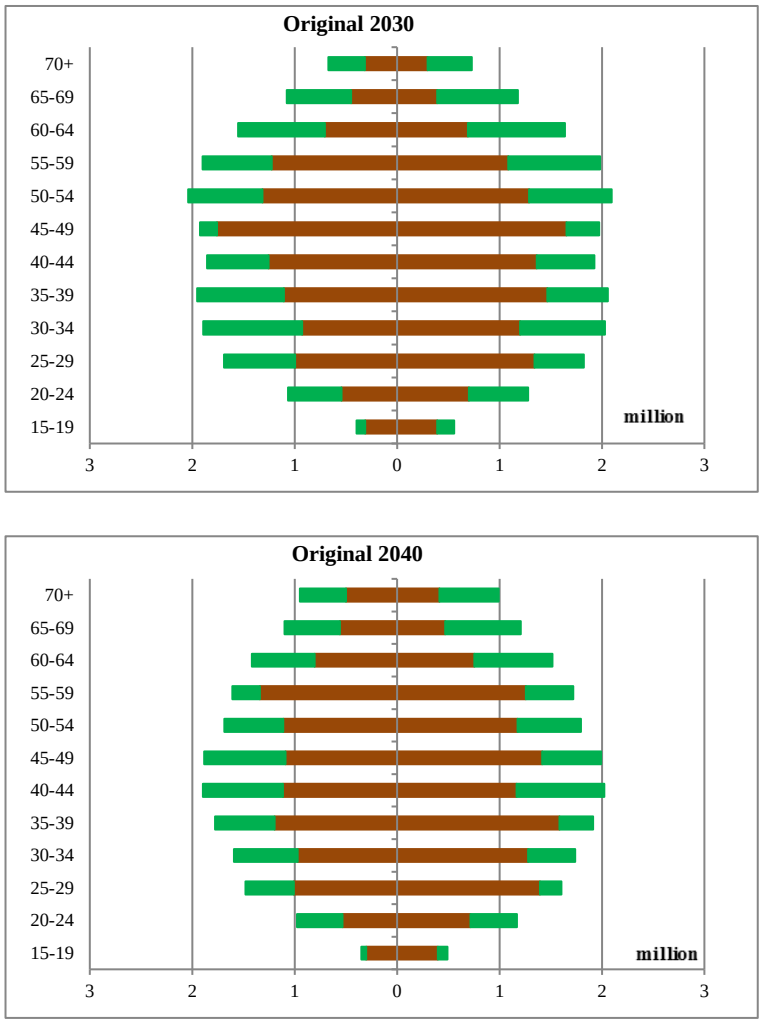


Figure 3 Pyramids of workers in agricultural sector and non-agricultural sector from 2020 to 2040 (Brown color = Non-agricultural workers, Green= Agricultural workers)

Effects of Aging Agricultural Society on Rice Productivity

Quantitatively in macro-viewpoint, this thesis then illustrates how aging impacts rice labor-productivity and how Thai farmers adapt to the aging problems. Panel data analysis is applied for the rice productivity impact estimation as a multiple linear regression. The dependent variable of this function is total rice products per worker--rice labor-productivity. For independent variables, this research concerns five important factors—area, mechanization, chemical fertilizer use, aging ratio of rice workers, and irrigation. Aging ratio equals number of rice workers aged over 60 to rice workers aged less than 60 years old. Mechanization is estimated by summing number of rice farms that report using five main machines for rice production, divided by total number of rice farms in the province. The five main machines are 4-wheel tractor, water pump, engine sprayer, weed extractor, and planter. One rice farm can report using more than one type of machines, so provinces with over 100 percent

mechanization index means more than one type of machines are used per one farm in average.

Percentage of rice farms of all farms in every province are calculated to find 'rice provinces' as target provinces. Then, the percentage must be at least 70 percent to be regarded as a rice province. Acquiring data from National Agricultural Census, there were totally 26 provinces that produced rice mainly in 1993, 2003, and 2013. 21 provinces were in Northeast region, 7 provinces were in Central region, and 5 provinces were in North region.

This study also applies the input-output based Cobb-Douglas function. In mathematical manner, the formula of rice labor-productivity and its factors are as follows.

$$lnR = \beta_0 + \beta_1 lnL + \beta_2 lnF + \beta_3 lnM + \beta_4 lnAg + \beta_5 lnIr$$

While;

$$R = \frac{P}{W} \quad , \quad L = \frac{A}{W} \quad , \quad F = \frac{C}{W} \quad , \quad M = \frac{\Sigma h_i}{H} \quad , \quad Ag = \frac{W_{\geq 60}}{W_{<60}}$$

R = rice labor-productivity (Kg/rice worker)

P = total rice product in the year (Kg)

W = total rice worker (persons)

L = rice planted area per worker (Rai/rice worker)

A = total planted rice area (Rai)

h = number of rice farms reported using machine type i

H = total number of rice farms

F = chemical fertilizer per area

C = total amount of chemical fertilizer used in rice production

Ag = aging ratio

$W_{\geq 60}$ = number of agricultural workers aged over 60

$W_{<60}$ = number of agricultural workers aged under 60

Ir = percent irrigated area (%) = Irrigated area / Total province area

Estimated with fixed effects model, regression results of rice labor-productivity from year 1993 to 2013 are shown in Table 1. Area of rice production came as a necessary input with a general causality. As mentioned in theoretical review, rice farmers had no choice but to buy and use chemical fertilizer owing to inadequate man-power to make organic fertilizers, making the use of chemical fertilizer become more and more undeniable. Mechanization index was also an explainable variable, seeing at t-statistics (2.34). This mechanization index is not a direct input to rice production but is an index explaining overview status of rice farms of each province. As a result, the β_3 coefficient result implies that using one of the four types of machines can nurture labor-productivity of rice farms. With the same direction

of logic, aging ratio is also not a direct input to rice production but is an index explaining overview severity of aging in each province. More and more young farmers had left agriculture making differences in aging proportion among rice provinces due to inter-provincial migration, so aging ratio has a strong negative correlation to rice labor-productivity, even closer than mechanization. Thereby, effective variables of rice labor-productivity in 1993 were area, chemical fertilizer, mechanization, aging, and irrigation.

Table 1 Panel Regression analysis results, with irrigation

Variable	Parameter	Coefficient	t-score
Constant	β_0	5.96	9.22
L	β_1	0.74	4.62
F	β_2	0.19	1.48
M	β_3	0.13	2.34
Ag	β_4	-0.49	-4.29
Ir	β_5	0.19	2.09
R^2 (within)		0.94	
Sample size		78	
Number of groups		26	

Considering all factors in the regression, the negative factor is aging, and the positive ones are namely area per worker, chemical fertilizer input, mechanization, and irrigation. Machinery use and improving irrigation system are the two factors that can help mitigate the negative impact of aging which can be arranged to retain the same productivity, which is generally call “iso-productivity” curve. Figure 4 presents the iso-productivity curve as well as projected curve in 2020, 2030, and 2040. This initial estimation provides a break-through idea for the agricultural economics academia and can be largely improve in future studies.

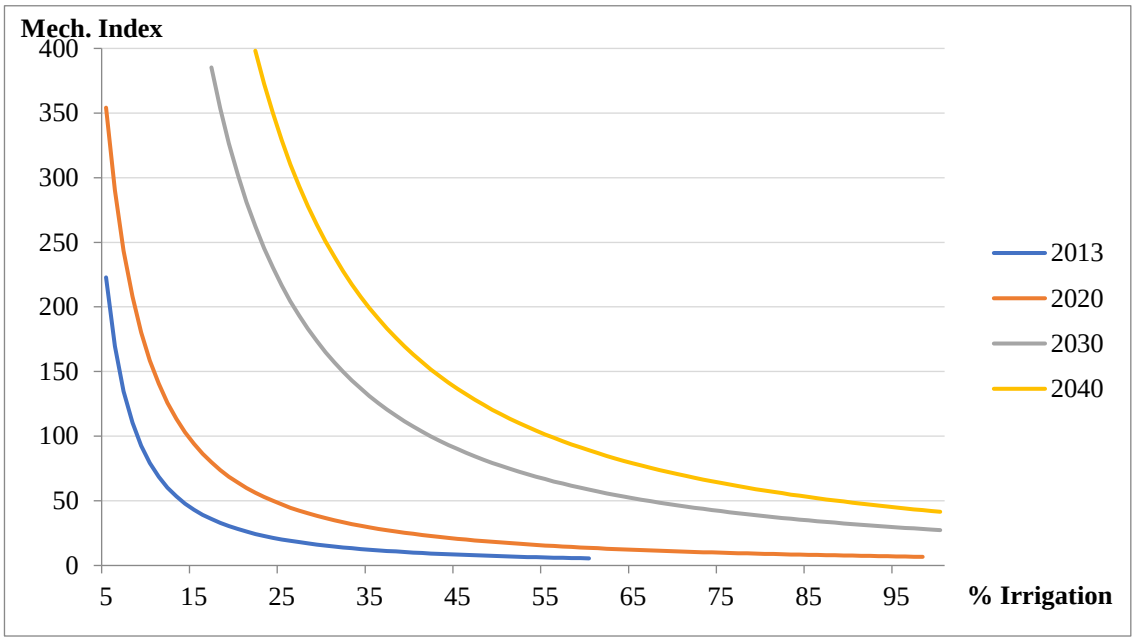


Figure 41 Iso-productivity curves

In conclusion, the population in the non-agricultural sector in Thailand is expected to expand to 2040, while the population in agricultural sector is expected to lessen at least 11.39 percent with more severe aging characteristics. Aging yet impacts rice productivity negatively. To compensate the agricultural labor shortage of young adults, agricultural households need to depend on more machines. Continuing this strategy will make their financial statuses worse due to high expenses. Efficient support policies from the government are to cope with these challenges