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Demographic Change and Inequality in the Korean Farm Income

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Abstract: This study examines the impact of demographic shifts on income inequality among farm households over an 18-year period, from 2003 to 2021. Our principal aim is to determine whether changes in income inequality are driven more by intra-group changes in age/household size groups or by changes between these groups. Furthermore, the study aims to understand which age/household size groups are associated with changes in income inequality. The methodology of this study involves using the generalized entropy (GE) index, which allows for the decomposition of inequality within and between population subgroups. The study divides the total population into subgroups based on age and household size and analyzes both static and dynamic inequality. Results show that (i) the within-group effect for static farm income inequality is more significant than the between-group effect. (ii) On the other hand, for changes in inequality (dynamic inequality), the between-group effect in the case of age and the within-group effect in the case of household size are important. (iii) Changes in income inequality are more related to structural changes in the age group of farmers than to the size of household.

Keywords: population aging; income inequality; decomposition method; farm income; farm structure

Citation: Min, S. Demographic Change and Inequality in the Korean Farm Income. *Agriculture* **2023**, *13*, 1832. https://doi.org/10.3390/agriculture13091832

Academic Editor: Yasuo Ohe

Received: 8 July 2023
Revised: 21 August 2023
Accepted: 29 August 2023
Published: 18 September 2023

1. Introduction

Patterns of household income inequality can emerge differently depending on household characteristics, such as the industry they are in. Recently, due to the expansion of import opening in the agricultural sector, the commercialization and specialization of agricultural management, and the aging of the agricultural population, the issue of farm household income inequality continues to be raised [1].

As market competition for agricultural products intensifies, it is inevitable that income disparities will occur among farm households. However, excessive income inequality can cause negative effects in terms of agricultural sustainability and rural economic recovery [2]. In other words, deepening inequality in farm household income can cause instability in rural communities and act as a factor for low-income earners to leave rural areas. If income inequality is a short-term phenomenon caused by a temporary income shock, it can be reduced by insurance measures or subsidies to compensate for the fall in income in the event of a natural disaster.

However, should income inequality continue to expand, it can deepen social and economic instability in rural areas, such as the expansion of relative loss among farm households and the resultant labor force exodus. The government's policy on farm household income has been focused on enhancing income and alleviating income instability, and no appropriate measures have been taken to address the issue of income inequality between farming households.

The analysis of the level of inequality in income and the main items that cause such inequality can be said to be necessary for the sustainable development of society [3] (reduce inequality within and among countries is Goal 10 of the Sustainable Development Goals (SDG 10). The specific goal related to income is: "By 2030, progressively achieve and sustain

income growth of the bottom 40 percent of the population at a rate higher than the national average."). Therefore, in this study, we used the Korea National Statistical Office's Korea Farm Household Economic Survey to examine changes in inequality in farm household income. In particular, this paper aims to examine the relationship between changes in household composition and total income inequality in Korea through the decomposition of static and dynamic factors in the inequality index.

Both domestically and internationally, demographic structures are undergoing significant changes. The size of families decreases as a society industrializes and urbanizes [4]. Population aging is caused by a decrease in the birth rate and an increase in life expectancy. These factors also contribute to changes in household structure, resulting in a reduction in household size. Therefore, the impact of such changes on the national economy has become a major area of research, with various studies examining their effects on income inequality, as seen in this study.

Zhong's study [5] in rural China suggests that population aging due to the one-child policy led to a decrease in working-age household members, contributing to an increase in income inequality in rural areas. Chen et al. [6] also found that population aging contributes to increased income and consumption inequality within societies. Wang et al. [7] confirmed a positive relationship between aging and income inequality due to a decrease in the labor share of elderly workers. Alimi et al. [8] examined New Zealand and noted that the effect of reducing aging inequality was not significant in metropolitan areas where the rate of aging is slower.

Household size and structure, as well as education levels, play a significant role in income inequality. Bigotta et al. [9] used decomposition methods to analyze income inequality and found that education and household size were major contributors to income inequality in both rural and urban areas. Peichl et al. [10] and Kim et al. [11] highlight that the trend toward smaller households also influences changes in income distribution and can lead to increased income gaps. Wędrowska and Muszyńéska [12] found that household owners' ages had a smaller impact on income inequality in Poland compared to education levels. Sung [13] found that differences in household heads' education levels and household size were major contributors to income disparities between urban and rural areas in Korea. Muszyńéska and Wędrowska [14] show significant structural differences among households in EU-15 countries that distinguish the Mediterranean and Northern European regions in particular and show that inequality levels may vary accordingly.

Overall, the relationship between demographic changes and income inequality is complex and varies based on the specific characteristics of each country or region. Factors such as population aging, household size, education levels, and employment sector can interact in different ways to shape income distribution patterns. The studies highlight the need for empirical analysis tailored to each region's unique circumstances to understand the underlying dynamics of income inequality and demographic change.

According to the Korea National Statistical Office, the proportion of farm households aged 65 or older in Korea increased from 18.3% in 1990 to 55.9% in 2020, while the proportion of farm households aged under 40 decreased from 14.6% to 1.2% [15]. As a result, the average age of agricultural owners rose from 58.3 in 2000 to 66.1 in 2020 [15]. The proportion of domestic farms with one person increased from 13.1% in 2000 to 20% in 2020, while the proportion of farms with six or more persons decreased from 6.4% in 2000 to 1.2% in 2020 [15]. As a result, the average number of household members per farm household decreased from 2.9 in 2000 to 2.2 in 2020 [15]. Considering that the proportion of the nation's total elderly population is 17.1%, domestic agriculture is more serious due to an aging population and changes in the household structure.

Despite these demographic characteristics of rural areas, there were not many studies that considered changes in population (household) composition in recent studies that analyzed the income inequality of Korean farm households. Heo [1] analyzed the degree of contribution of income sources to the income inequality among farm households through the Shapley value decomposition of the Gini coefficient. Lee et al. [2] used the Gini

coefficient to analyze farm household income inequality and decomposed the inequality by farm types during 2008 to 2017. Yoon and Jang [16] examined the income mobility of farm households and investigated the determinants of income mobility in Korea. Kim et al. [11] attempted to quantify the impact of household changes on income inequality by decomposing the inequality index as in this study but, unlike in this study, it was analyzed by urban households. Therefore this analysis represents an endeavor to derive implications for agricultural policies addressing income redistribution through a consideration of these demographic changes.

2. Materials & Methods

2.1. Decomposition Method of Income Inequality by Demographic Structure

The inequality decomposition method can produce various results depending on the characteristics of the selected inequality index, so it is important to select an inequality index suitable for the inequality decomposition method. The indices that measure inequality include the Gini coefficient, the Atkinson index, the entropy index, generalized entropy inequality measures, the Atkinson index, and the mean log deviation. Since each has different characteristics, it is necessary to select an appropriate index according to the purpose of analysis.

The method of decomposing income inequality by population subgroup follows the methodology presented by previous literature [10,12,17]. In this study, the generalized entropy (GE) index, which can be decomposed by population subgroup and income source, is used to analyze the relationship between population (household) structure and income inequality.

Since the GE index can be decomposed into inequality within and between groups, as well as by income source like the Gini coefficient [18], it is the most suitable for the purpose of this study. It can be called an inequality index, and the GE index is defined as follows.

$$I_c = \begin{array}{l} \frac{1}{c(c-1)} \sum_{i=1}^{n} \frac{w_i}{\sum_{i=1}^{n} w_i} \left[\left(\frac{y_i}{\overline{y}} \right)^c - 1 \right] \; for -\infty < c < +\infty,\ c \neq 0, 1, \\ \sum_{i=1}^{n} \frac{w_i}{\sum_{i=1}^{n} w_i} ln\left(\frac{y_i}{\overline{y}} \right) \; for\ c = 0, \\ \sum_{i=1}^{n} \frac{w_i}{\sum_{i=1}^{n} w_i} \frac{y_i}{\overline{y}} ln\left(\frac{y_i}{\overline{y}} \right) \; for\ c = 1. \end{array} \tag{1}$$

The coefficient c is a weight for the income class, and the smaller c is, the more sensitively the change in income of the lower income class is captured [19]. In this study, c = 0 was selected to further emphasize the change in the income of the low-income class. Dividing the total population into k population subgroups gives $k \in \{i, \cdots, K\}$, the inequality index I_0 can be decomposed as:

$$I_0 = \sum_{k=1}^{K} \frac{\sum_{i \in k} w_i}{\sum_{i=1}^{n} w_i} I_{0k} + \sum_{k=1}^{K} \frac{\sum_{i \in k} w_i}{\sum_{i=1}^{n} w_i} ln\left(\frac{\overline{y}}{\overline{y}_k} \right) = \underbrace{\sum_{k=1}^{K} v_k I_{0k}}_{(Within)} + \underbrace{\sum_{k=1}^{K} v_k \, ln\left(\frac{\overline{y}}{\overline{y}_k} \right)}_{(Between)}, \tag{2}$$

$\sum_{i \in k} w_i$ is the weight, v_k is the weight of subgroup k, and $\overline{y_k}$ denotes the average income of subgroup k, respectively. Thus, subgroup inequality is $I_{0k} = \sum_{i \in k} \left(\frac{w_i}{\sum_{i \in k} w_i} \right) ln(\overline{y}_k / y_i)$, and total inequality can be defined as the sum of inequality within a group (W) and inequality between groups (B). If the equation is simplified by difference, the following dynamic decomposition equation of inequality is created [20], and dynamic inequality can be decomposed into A, B, C, and D.

$$\begin{array}{rl} \Delta I_0 = I_0^{t+1} - I_0^t \approx & \underbrace{\sum_{k=1}^{K} \overline{v}_k \cdot \Delta I_{0k}}_{(A)} + \underbrace{\sum_{k=1}^{K} \overline{I}_{0k} \cdot \Delta v_k}_{(B)} \\ & + \underbrace{\sum_{k=1}^{K} [\overline{\lambda}_k - ln\overline{\lambda}_k] \cdot \Delta v_k}_{(C)} + \underbrace{\sum_{k=1}^{K} \left(\overline{\theta}_k - \overline{v}_k \right) \cdot \Delta ln\overline{y}_k}_{(D)} \end{array} \tag{3}$$

$\lambda_k = \hat{y}_k/\overline{y}$ is the ratio of the average income of group k to the average income of the total population, $\theta_k = v_k\lambda_k$ is the income ratio of group k ($\because v_k$= population ratio), respectively, and the bar indicates the average value of the two periods.

Term A is the change in inequality within a population subgroup (ΔI_{0k}). The population composition ratio is fixed as the average value ($\overline{v}_k$) and it represents the contribution to inequality change caused entirely by changes within population subgroups, as it is derived from changes in population composition. Thus, changes in inequality within groups that account for a large share of the total population play a more important role than changes in inequality within groups that occupy a relatively small share of the total population.

Term B is demographic change (Δv_k) on inequality within a population subgroup. Since the change in the population proportion is the determinant of term B, the inequality within the group is fixed at the average value ($\overline{I}_{0k}$), calculated as the change in inequality within the group. Therefore, as the proportion of groups with relatively high levels of inequality increases, overall inequality also increases.

Term C is demographic change (Δv_k) on inequality between population subgroups. The ratio of group average income to total average income (λ_k) can change, and changes in population composition ratio determine the direction of change in inequality. Therefore, it represents the sum of the contributions to the change in total inequality resulting from the increase or decrease in the proportion of groups with higher or lower average income relative to total average income.

Term D shows the contribution to the inequality of changes in the average income of a population subgroup ($\Delta ln\overline{y_k}$). Since the difference between the ratio of population subgroup income to total income and the ratio of population subgroup to total population is fixed ($\overline{\theta}_k - \overline{v}_k$), the log change of the average income of a population subgroup plays an important role. The greater the share of a group's income relative to its share of the population, the greater the impact of a change in the average income of that group on total income inequality.

Terms B and C, which respond to changes in the share of population subgroups, can be used to determine the impact of changes in demographic structure on overall inequality.

2.2. Data

The data used in this study are data from 2003 to 2021 from the Farm Economy Survey released by Statistics Korea, which is Korea's official national statistical organization. This data collection provides detailed information on the amount and cost of a household's farm and nonfarm activities, and the information was investigated by an employee of the National Statistical Office. As the data set deals with net income from both farm and nonfarm sectors of agricultural households, it allows for the estimation of income inequality at the agricultural household level.

In the Farm Household Economic Survey, there is an observed value (farm household) with a negative (−) income. This is when expenditure is greater than income from agricultural or nonfarm income. The Gini coefficient used for the analysis of income inequality in this analysis generally has a value between 0 and 1, but when the average income is negative, the Gini coefficient can have a value greater than 1. Therefore, it is necessary to adjust the values of observations with negative income for analysis. Depending on the researcher's judgment, these observations are either removed or all income sources of farm households with negative (−) income are treated as zero. However, in the latter case, there is a possibility that the actual phenomenon may be distorted by treating government transfer income as zero, for which negative (−) income cannot appear. Therefore, in this paper, among the income sources constituting farm household income, agricultural income or nonfarm income, which is shown as negative (−) income, is treated as 0, and then farm household income is recounted and used for analysis [2]. The data used for the generalized entropy (GE) index analysis are data from the 2003, 2013, and 2021 Farm Household Economic Surveys, and observations with negative (−) income were excluded from the analysis. The evaluation function form of the generalized entropy family used in

this analysis is the form of an exponential function with income as the base. If the base of the exponential function is negative, the function value has an imaginary number value, not a real number value, so negative income cannot be used in the generalized entropy index series [1].

Regarding the change in the composition ratio by age group of owners, the proportion of farm households aged 70 or older increased significantly, while the proportion of those owned by individuals in their 40s and 50s decreased significantly. In Table 1, the change in the composition ratio by age group from 2003 to 2013, the age group that showed the largest increase was farm households aged 70 or older, which increased by 16.9%p to 38.4% from 21.5% in 2003. On the other hand, the share of farm households in their 40s was 6.4% in 2013, a decrease of 11.8%p from 18.2% in 2003, the largest decrease. Likewise, during the period from 2013 to 2021, the age group that showed the largest increase was farm households aged 70 or older, which was 52.4%, an increase of 14.0%p from 38.4% in 2013. The share of farm households in their 50s was 10.1%, an 11.1%p decrease from 21.1% in 2013, the largest decrease.

Table 1. Farm household income average and farm household share by farm owner's age.

Owner's Age	2003		2013		2021		2003 to 2013		2013 to 2021	
	Income (KRW 10,000)	Farm Household-Share (%)	Income (KRW 10,000)	Farm Household-Share (%)	Income (KRW 10,000)	Farm Household-Share (%)	Income Change Rate (%)	Farm Household-Share Change (%p)	Income Change Rate (%)	Farm Household-Share Change (%p)
40s	3608	18.2	4384	6.4	8436	2.1	21.5	−11.8	92.4	−4.3
50s	3436	24.2	5629	21.1	7373	10.1	63.8	−3.0	31.0	−11.1
60s	2601	36.2	3562	34.1	5699	35.5	37.0	−2.1	60.0	1.4
70+	1789	21.5	2241	38.4	3687	52.4	25.2	16.9	64.5	14.0

Note: Percentage point (%p) is used when comparing two different percentages. Therefore, it refers to the difference in Farm House-hold-Share calculated at two points in time. This may differ from KOSIS's aggregation result as it was counted excluding samples with income less than 0.

Looking at changes by age group of owners, the age group that showed the largest increase from 2003 to 2013 was in their 50s, with 56.29 million KRW, a 63.8% increase from 34.36 million KRW in 2003 (Table 1). On the other hand, farm household income for those in their 40s showed the lowest rate of increase at 43.84 million KRW, a 21.5% increase from 36.08 million KRW in 2003. Conversely, in the period from 2013 to 2021, the income of those in their 40s increased by 92.4% from 43.84 million KRW in 2013 to 84.36 million KRW, the highest rate of increase. Farm household income in their 50s showed the lowest rate of increase at 73.73 million KRW, a 31.0% increase from 56.29 million KRW in 2013.

In the change of composition ratio of farmers by household size, the proportion of farm households of other sizes, excluding two-member households, decreased (Table 2). In terms of the change in the composition ratio by household size between 2003 and 2013, the group with the largest increase was the two-person farm household, which increased by 14.5%p to 66.1% from 51.6% in 2003. Four-person farms decreased by 5.5%p from 13.3% in 2003 to 7.7%, followed by five-person farms by 4.3%p, six-person or more farms by 2.8%p, and three-person farms by 1.9%p. During the period from 2013 to 2021, the group with the largest increase was two-person farms, which accounted for most of the total farms at 76.8%, an increase of 10.6%p from 66.1% in 2013. Three-person farms accounted for 14.3%, a decrease of 6.1%p from 20.4% in 2013, 1.9%p for six-person or more farms, 1.4%p for four-person farms, and 1.3%p for five-person farms.

When analyzing the change in farm household income by household size, the average income increased in all groups, and the rate of increase in income was especially high for farm households with four members. Farm households with the largest increase in the household size in all years are four-person farm households, and farm household income in 2013 increased by 51.4% compared to 2003 and farm household income in 2021 increased by 53.4% compared to 2013. On the other hand, the income of two-person farm households

from 2003 to 2013 increased by 27.5% from 22.47 million won in 2003 to 28.66 million won, showing the lowest rate of increase. During the period from 2013 to 2021, the household size with the lowest growth rate was three-person farms, which increased by 40.4% from 44.74 million KRW in 2013 to 62.81 million KRW.

Table 2. Farm household income and farm household share by household size.

Owner's Age	2003		2013		2021		2003 to 2013		2013 to 2021	
	Income (KRW 10,000)	Farm Household-Share (%)	Income (KRW 10,000)	Farm Household-Share (%)	Income (KRW 10,000)	Farm Household-Share (%)	Income Change Rate (%)	Farm Household-Share Change (%p)	Income Change Rate (%)	Farm Household-Share Change (%p)
2 members	2247	51.6	2866	66.1	4216	76.8	27.5	14.5	47.1	10.6
3 members	3012	22.2	4474	20.4	6281	14.3	48.5	−1.9	40.4	−6.1
4 members	3524	13.3	5337	7.7	8184	6.3	51.4	−5.5	53.4	−1.4
5 or more members	3988	12.9	5647	5.8	8381	2.7	41.6	−7.1	48.4	−3.1

Note: Percentage point (%p) is used when comparing two different percentages. Therefore, it refers to the difference in Farm House-hold-Share calculated at two points in time. This may differ from KOSIS's aggregation result as it was counted excluding samples with income less than 0.

3. Empirical Results

3.1. Income Inequality Analysis by Demographic Characteristics (Static Analysis)

In this section, the degree of income inequality by demographic characteristics (age of the owner and household size) in 2003, 2013, and 2021 is analyzed using the generalized entropy index. This analysis yields static results by examining the contribution through the decomposition of farm household income inequality (measured by the entropy index) at each time point. It focuses on the owner's age and the size of the farm household as grouping criteria rather than assessing dynamic changes in inequality. The absolute contribution within a group is computed by multiplying the inequality index for each group by its corresponding population share. The summation of absolute contributions within and between groups constitutes the total entropy index of farm household income. The concept of relative contribution pertains to the proportion of absolute contributions within each group and between groups, as part of the overall value of the farm household income inequality index.

3.1.1. Analysis by Farm Owner's Age

As of 2021, looking at the inequality by age group of farm owners, the age group with the greatest income inequality in all age groups is under the age of 40, and the age group with the smallest is over 70. In 2003, 2013, and 2021, the inequality of the group under the age of 40 was 0.270, 0.272, and 0.284, which is larger than that of other age groups, and shows a gradually increasing trend (Figure 1). On the other hand, the inequality of the over 70 group increased in 2013 compared to 2003, and then decreased in 2021 compared to 2013.

Farm household income inequality is more affected by the farm household income gap within the same age group (group) than the farm household income gap between age groups (Table 3). In all years, the contribution of differences within the same age group (group) to total inequality is about 80% or more, and farm household income inequality is mostly caused by differences within age groups.

The age group with the highest contribution to total farm household income inequality differs by year. In 2003, the age group with the highest contribution to income inequality was in their 60s, and in 2013 and 2021, those in their 70s and over. In particular, the contribution rate of those in their 70s and older increased over time. This is because the proportion of elderly farmers in their 70s and older increased significantly (30.8%p) from 21.5% in 2003 to 52.3% in 2021, and these results are in line with the study of Lee et al. [2]. The contribution rate of farmers aged 70 or older increased by 22.8%p from 17.4% in 2003 to

40.2% in 2021. In the case of the age group of 40 or younger, income inequality is the largest, but the proportion of the population is smaller than that of other age groups, so the overall income inequality is the least affected. The relative contribution of farm households in their 40s or younger decreased by 17.1%p from 19.3% in 2003 to 2.2% in 2021. The population share also decreased by 16.1%p from 18.2% in 2003 to 2.1% in 2021.

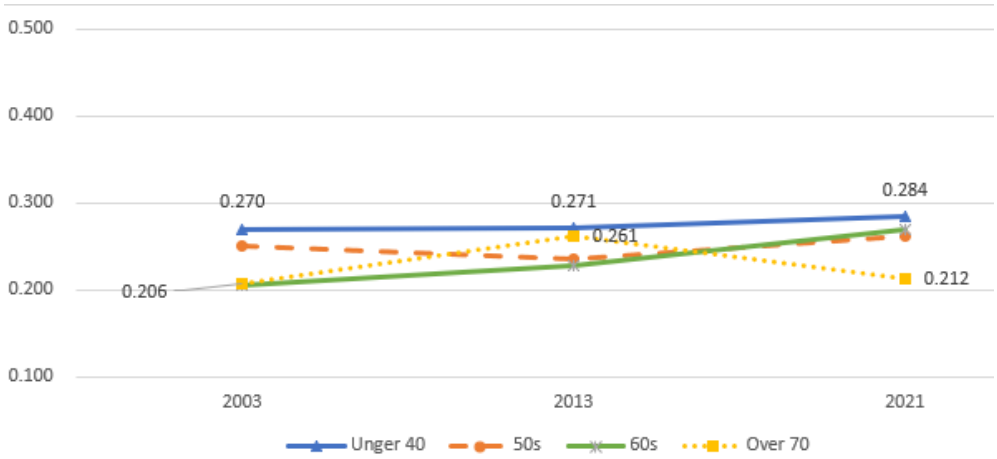

Figure 1. Trends in farm household income inequality by owner's age.

Table 3. Decomposition of farm household income inequality by owner's age.

Year	Owner's Age	Group Inequality	Population Share	Absolute Contribution		Entire Inequality (A + B)	Relative Contribution	
				Within Group	Between Groups		Within Group	Between Groups
				(A)	(B)			
2003	under 40	0.270	18.200	0.050	0.029	0.259	19.3	11.2
	50s	0.251	24.100	0.061			23.6	
	60s	0.204	36.200	0.074			28.6	
	70+	0.206	21.500	0.045			17.4	
2013	under 40	0.272	6.400	0.018	0.062	0.309	5.8	20.1
	50s	0.235	21.100	0.050			16.2	
	60s	0.227	34.100	0.078			25.2	
	70+	0.262	38.400	0.101			32.7	
2021	under 40	0.284	2.100	0.006	0.036	0.276	2.2	13
	50s	0.261	10.100	0.027			9.8	
	60s	0.269	35.500	0.096			34.8	
	70+	0.212	52.300	0.111			40.2	

3.1.2. Analysis by Household Size

In terms of the inequality by number of household members, in all years, farm households with two members had the highest inequality (Figure 2). The income inequality of the two-person group increased and decreased to 0.240 in 2003, 0.309 in 2013, and 0.260 in 2021, showing higher inequality than other groups. The trend of farm household income inequality by household size is different, and the group that continuously decreased is farm households with five or more people. The income inequality of the two-person and four-person groups increased and decreased, while the income inequality index of the three-person group decreased and then increased. The income inequality of farm house-

holds with five or more members is on the decline, with 0.215 in 2003, 0.160 in 2013, and 0.143 in 2021.

Figure 2. Trends in farm household income inequality by household size.

Farm household income inequality is more influenced by the income gap within the same group than by the income gap between groups based on household size (Table 4). Throughout all the years, the contribution of the level of income inequality within the same group to the total inequality was approximately 90% or more, which is greater than the contribution of the difference in income within the age group (about 80% or more).

Table 4. Contribution to farm household income inequality by household size.

Year	Household Size (Number of Members)	Group Inequality	Population Importance	Absolute Contribution		Entire Inequality (A + B)	Relative Contribution	
				Within Group (A)	Between Groups (B)		Within Group	Between Groups
2003	2 members	0.240	51.6	0.124	0.025	0.259	47.9	9.7
	3 members	0.230	22.2	0.051			19.7	
	4 members	0.238	13.3	0.032			12.4	
	5 or more members	0.215	12.9	0.028			10.8	
2013	2 members	0.309	66.1	0.204	0.036	0.308	66.2	11.7
	3 members	0.197	20.4	0.041			13.3	
	4 members	0.255	7.7	0.020			6.5	
	5 or more members	0.160	5.8	0.009			3.2	
2021	2 members	0.260	76.8	0.200	0.028	0.276	72.5	10.1
	3 members	0.247	14.2	0.036			13.0	
	4 members	0.155	6.3	0.010			3.6	
	5 or more members	0.143	2.6	0.004			1.4	

The group that contributes the most to total farm household income inequality is the group of farm households with two members, and this contribution is on the rise. Among farm households with two members, there is also a significant level of income inequality within the group. Due to the larger share of total farm households belonging to this group compared to other groups, it appears to have a substantial impact on overall income inequality.

The contribution to inequality of households with two household members is gradually increasing, from 47.9% in 2003 to 66.2% in 2013 and 72.5% in 2021. In particular, although the inequality of two-person households in 2021 (0.260) decreased compared

to 2013 (0.309), the proportion of farm households increased by 10.7%p during the same period, contributing to overall income inequality. A small number of household members means that there is a high possibility that the working population in a household is small and, according to previous studies, income inequality within a group increases as the number of employed persons in a household decreases [11].

On the other hand, the group with the lowest contribution is the group with five or more household members, and the contribution is gradually decreasing. This is because both the income inequality and share of households with five or more members have decreased. The contribution of farm households with five or more members to total inequality decreased by 9.4%p from 10.8% in 2003 to 1.4% in 2021. The share of farm households with five or more members decreased by 10.3%p from 12.9% in 2003 to 2.6% in 2021.

3.2. Analysis of Changes in Income Inequality by Demographic Characteristics (Dynamic Analysis)

While the preceding section entailed a static analysis of each time point, this section adopts a dynamic approach to examine how income inequality based on demographic characteristics has evolved over time. The analysis of changes in income inequality by demographic characteristics is based on Equation (3) presented in the analysis methodology. Equation (3) shows that the alteration in income inequality between two time points, t and t + 1, can be elucidated by decomposing it into four components (A, B, C, D).

A and B account for changes in income inequality within a group, while C and D depict changes in income inequality between groups (Table 5). The change in income inequality over the two periods is decomposed into the pure inequality change effect (A), the allocation effects (B and C), and the relative income effects (D) between groups [20].

Table 5. Components of changes in income inequality.

	Within Group Component		**Between Groups Component**	
	A	**B**	**C**	**D**
explanation	Changes in income inequality within a group	Impact of demographic change on inequality within groups	Impact of demographic change on inequality between groups	Changes in income between groups
Classification of effects	pure inequality change effect	Effects of change in group composition		Effect of change in relative income between groups

Since terms B and C capture the effects of changes in population composition on changes in inequality within/between groups, respectively, the sum of terms B and C can be identified as the effect of changes in population structure (changes in group composition) on changes in total income inequality. In the dynamic analysis, we present the contribution rate of group composition change (B + C) in the total change in income inequality to examine the extent to which changes in the demographic structure affect changes in overall income inequality.

3.2.1. Analysis by Farm Owner's Age

According to the analysis results by age group of owners, the increase in income inequality between 2003 and 2013 was mostly caused by changes in inequality within groups (A) and changes in relative income between groups (D) rather than changes in the share by age group (Table 6). The change in inequality within a group (A) and the change in relative income between groups had a positive (+) effect on the increase in total income inequality, and the sum of the relative contributions of the two effects was 89.8%, which is a major factor in the change in total inequality.

Table 6. Periodized results from dynamic decomposition of income inequality by age groups.

Classification of Effects		2003–2013		2013–2021		Contribution Rate Change
		Absolute	Relative	Absolute	Relative	(%p)
A	pure inequality change effect	0.022	44.9	−0.003	9.1	−35.8
B + C	Effect of change in group composition	0.005	10.2	−0.011	33.3	23.1
	B	−0.004	−8.2	−0.003	9.1	17.3
	C	0.009	18.4	−0.008	24.2	5.8
D	(Effect of change in relative income between groups)	0.022	44.9	−0.019	57.6	12.7
ΔI_0	(Changes in aggregate inequality)	0.049	100	−0.033	100	0

Note: Percentage point (%p) is used when comparing two different percentages. Therefore, this figure means the difference in relative contribution percentage by item.

Between 2003 and 2013, the effect of change in group composition (B + C) accounted for 10.2% of total inequality change, which is not very large. This is because the influence sign was different depending on whether it was the effect of change in group composition within/between groups. In other words, the effect of the change in the share by age group on the change in inequality within a group (B) reduced the total income inequality, but the effect (C) on the change in inequality between groups increased the total income inequality.

The decline in income inequality between 2013 and 2021 arises primarily from changes in relative income between groups (D). Changes in relative income between groups reduced overall income inequality, with a contribution of 57.6%. This is because the average income share ($\bar{\theta}_k$) of farmhouses aged 70 or older in 2013 and 2021 is greater than the population share average ($\bar{v}_k$), and the average income in 2021 increased compared to 2013 due to an increase in transfer income (Equation (3) and See D_k in Table 7).

Table 7. Decomposition of the changes in income inequality in different age groups.

	Age of Farm Owner	A_k	B_k	C_k	D_k	$\frac{(B_k+C_k)}{\Delta I_0}\times 100$
2003–2013	Aged 40 years or under (0~40)	0.000	−0.032	−0.121	0.006	−312.24
	50s	−0.004	−0.007	−0.033	0.044	−81.63
	60s	0.008	−0.005	−0.021	−0.004	−53.06
	Aged 70 years or over	0.017	0.039	0.184	−0.025	455.10
2013–2021	Aged 40 years or under (0~40)	0.001	−0.012	−0.048	0.010	181.82
	50s	0.004	−0.027	−0.123	0.024	454.55
	60s	0.014	0.003	0.014	0.015	−51.52
	Aged 70 years or over	−0.022	0.033	0.149	−0.067	−551.52

Note: $\frac{(B_k+C_k)}{\Delta I_0}$ refers to the influence of structural changes (shares change) in each group on changes in overall income inequality.

During the same period, the contribution rate of the group composition change effect (B + C) was 33.3%, which was 23.1%p higher than the effect of change (10.2%) between 2003 and 2013. Additionally, changes in group composition within and between groups all work in the direction of reducing overall income inequality. In terms of the change in the contribution rate of the four effects to the total change in income inequality, the pure inequality change effect (A) decreased the most in the contribution rate during the period 2013–2021 compared to the period 2003–2013, and the effect that increased the most was

the change in group composition The effect is the effect on inequality within the group (B). The contribution rate of the change in income inequality (A) within the group to the change in income inequality between 2013 and 2021 was 9.1%, which is a 35.8%p decrease from the 2003 to 2013 period (44.9%). On the other hand, the effect (B) of changes in group composition on intra-group inequality during the period from 2013 to 2021 was 9.1%, which is a 17.3%p increase from the period from 2003 to 2013 (−8.2%).

Between 2003 and 2013, changes in the composition of other groups, with the exception of farm households whose owners are in their 70s or older, mitigated the increase in overall income inequality. The group that had the greatest impact on reducing inequality was the age group of business owners in their 40s or younger. Although the level of inequality is higher in the group of owners aged 40 or younger compared to other groups, the share decreased between 2003 and 2013, serving as a factor in reducing overall income inequality. On the other hand, in the case of the group with owners aged 70 or older, the income inequality and share within the group increased between 2003 and 2013, acting as a factor that deepened the overall level of income inequality.

Between 2013 and 2021, changes in the share of those in their 40s and younger and those in their 50s contributed to fall in inequality, while changes in the share of those in their 60s and 70s and older mitigated the fall in inequality (contributed to deepening income inequality). The decrease in the share of those in their 40s and younger and those in their 50s, which show greater income inequality within the group compared to other age groups, has an impact on reducing overall income inequality. In addition, in 2021, the income inequality within the group for those in their 40s and younger and those in their 50s were alleviated compared to 2013. On the other hand, in the 60s, both the income inequality and the population share increased, exacerbating overall income inequality. In the case of the 70+ group, income inequality decreased in 2021 compared to 2013. Nonetheless, the share has increased significantly, serving as a factor that deepens overall income inequality.

3.2.2. Analysis by Household Size

According to the analysis results by household size, most of the changes in income inequality between 2003 and 2013 were caused by changes in inequality within groups (A) and the income gap between groups (D) (Table 8). The influence of income inequality within a group was 64.6%, and the influence of the average income gap between groups was 33.3%.

Table 8. Decomposition of effects on changes in income inequality in groups by household size.

Classification of Effects		2003–2013		2013–2021		Contribution Rate Change (%p)
		Absolute	Relative	Absolute	Relative	
A	Pure inequality change effect	0.031	64.6	−0.034	106.3	41.7
B + C	Effect of change in group composition	0.001	2.1	0.002	−6.3	−8.4
	B	0.009	18.8	0.009	−28.1	−46.9
	C	−0.008	−16.7	−0.007	21.9	38.6
D	Effect of change in relative income between groups	0.016	33.3	0	0	−33.3
ΔI_0	Changes in aggregate inequality	0.048	100	−0.032	100	0

Note: Percentage point (%p) is used when comparing two different percentages. Therefore, this figure means the difference in relative contribution percentage by item.

The main factor for the change in income inequality between 2013 and 2021 was the change in inequality within groups (A), as in the previous period, but the influence of change in income between groups decreased. The impact of income inequality within the group was 106.3%, an increase of 41.7%p compared to the previous period. On the other hand, the influence of the difference in average income between groups decreased to 0%.

The contribution rate of the group composition change effect (B + C) is not large at 2.1% for the period 2003–2013 and −6.3% for the period 2013–2021. This is because the influence of changes in group composition by household size on inequality within and between groups, similar to the results of age analysis, offset each other.

Between 2003 and 2013, changes in the composition of groups other than farm households with two members had the effect of mitigating the increase in overall income inequality (Table 9). The group that had the greatest impact on reducing inequality was the group with five or more household members. This is because groups with five or more household members have a lower level of inequality than other groups, and between 2003 and 2013, the group's share of total farm households increased, which acted as a factor in mitigating overall income inequality. The contribution rate of the increase in the proportion of farm households with two members in the total income inequality was the highest at 392.96%. This is due to the increase in the share of two-person farm households, where income inequality within the group rose between 2003 and 2013. Obviously, population subgroups that are characterized by smaller household size exhibit greater within-group inequality than others. Thus, the increase in the relative size of these groups has significantly contributed to the overall increase in income inequality.

Table 9. Decomposition of the effects by household size.

	Household Size (Number of Members)	A_k	B_k	C_k	D_k	$\frac{(B_k+C_k)}{\Delta I_0} \times 100$
2003 –2013	2 members	0.041	0.040	0.148	−0.028	392.96
	3 members	−0.007	−0.004	−0.019	0.014	−47.39
	4 members	0.002	−0.014	−0.059	0.015	−151.42
	5 or more members	−0.005	−0.013	−0.078	0.015	−191.45
2013 –2021	2 members	−0.035	0.030	0.108	−0.044	−428.97
	3 members	0.009	−0.014	−0.063	0.016	237.36
	4 members	−0.007	−0.003	−0.016	0.017	58.66
	5 or more members	−0.001	−0.005	−0.036	0.011	126.37

Note: $\frac{(B_k+C_k)}{\Delta I_0}$ refers to the influence of structural changes (shares change) in each group on changes in overall income inequality.

Between 2013 and 2021, changes in the composition of other groups, except for farm households with two members, have an impact on reducing overall income inequality. The group that had the greatest impact on reducing inequality was the three-person group. From 2013 to 2021, the inequality level of the three-person group increased, unlike other groups, but the share decreased, which serves as a factor in reducing overall income inequality. On the other hand, the increase in the share of the two-person group intensifies overall income inequality. Although the income inequality of two-person farm households has decreased, the reduced inequality is still higher than that of other groups, and the increase in the share of groups with high inequality increases the overall income inequality.

4. Summary and Conclusions

This study examined the mechanism by which the income inequality of farmers changes from 2003 to 2021 (about 20 years), focusing on demographic changes. To do this, this paper examined the impact of household owner age and household size groups on the level of income inequality(static) and its changes over time(dynamic).

The effect of demographic characteristics on income inequality by time period is summarized as follows. Farm income inequality have decreased, and this is the result of being influenced by inequality within a group rather than inequality between groups. The contribution rate of income inequality within a group to total income inequality is about 80% or more for the age of the owner and about 90% or more for the household size.

Therefore, in order to reduce income inequality, policies that focus on resolving income inequality within a group rather than income inequality between groups are needed.

Income inequality was most pronounced within the 40s or younger age group; however, their contribution to the overall income inequality diminished due to a decrease in their proportion. In contrast, the percentage of elderly farmers (aged 70 or older) experienced a significant increase of 30.9 percentage points, rising from 21.5% in 2003 to 52.4% in 2021. Consequently, their contribution to income inequality amplified over time. Regarding the analysis based on household size, the group that contributed the most to the overall farm income inequality was the two-member households, and this trend has been gradually ascending. Conversely, the group with the lowest contribution consisted of households with five or more members, and their contribution has been on the decline.

As a result of the analysis of changes in income inequality (dynamic analysis), the effect of change in relative income between groups is the greatest, and the effect of change in group composition has increased, but it is in the 30% range. When looking at the effect by age group, the effect of the change in the proportion of the 70s or older group is the greatest. As a result of the analysis by household size, the effect of changing inequality within the group is the largest, and unlike the analysis by age group, the effect of changing group composition decreases. Upon examining the effect with respect to household size, the most substantial impact arises from the alteration in the proportion within the group with two household members.

The aforementioned conclusion indicates that shifts in the population (household) composition within the agricultural sector (such as aging and smaller families) are intertwined with the income distribution. This underscores the necessity for income distribution policies to be implemented while taking into account population and household composition.

The findings of this study offer several tangible policy implications that have the potential to alleviate income inequality among farmers. Firstly, given our research indicating that income inequality is most prominent among farmers aged 70 and above, it would be advantageous to consider implementing income transfer policies aimed at reducing this disparity. Such policies could encompass pension schemes or targeted subsidies for this particular age group. Secondly, recognizing that income inequality is most significant among smaller households, it is advisable to focus policy efforts on increasing the income of two-member farm households. This could involve providing financial assistance or resources that facilitate the cultivation of labor-intensive, high-yield crops, making them a viable option for smaller households. Thirdly, since younger farmers exhibit a notable level of income inequality, introducing policies to address this disparity is essential. Educational programs on efficient farming techniques and marketing strategies, or subsidies for innovative farming equipment, could be effective measures.

Furthermore, considering the existing agricultural policy aimed at encouraging the participation of young farmers, it is recommended that these initiatives be coupled with measures to mitigate income inequality among these newcomers to the farming sector. One potential approach is the implementation of mentorship programs that connect experienced farmers with newcomers, fostering knowledge sharing and the acquisition of skills that enhance the income prospects of younger farmers.

Meanwhile, it is crucial to acknowledge the limitations of this paper. Firstly, a definitive causal relationship between household structure and income inequality cannot be asserted. Additionally, there exists the potential for omitted variable bias in this analysis. Despite not being fully encompassed in this study, influential factors like technology adoption and farmers' education level can significantly influence farm income equality, as previously mentioned. In future research, these factors should be incorporated to attain a more comprehensive comprehension of income inequality among farm households.

Funding: This research received no external funding.

Data Availability Statement: The data described in this article are openly available in the Microdata Integrated Service at https://mdis.kostat.go.kr/, accessed on 30 August 2022.

Conflicts of Interest: The author declares no conflict of interest.

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