Examining the Income Inequality and Aging in Taiwan

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Abstract

Taiwan distinguishes itself as one of the few Asian countries to experience demographic transition ahead of projections. Understanding how Taiwan's rapidly evolving age demographics affect income inequality is crucial. Analyzing income inequality with three distinct metrics, we examine the relationship between population aging and income inequality in Taiwan, using the Augmented Autoregressive Distributed Lag test. Our study reveals an inverse relationship, indicating reduced income inequality as the population ages. Factors such as elderly property acquisition, cultural norms favoring families to live together, and advancements in healthcare contribute to this trend. Encouraging elderly employment emerges as a crucial strategy to address income inequality among seniors. Additionally, economic factors like real GDP per capita and trade openness show negative associations with income inequality, suggesting policy avenues for intervention. While outward foreign direct investment is positively associated with income inequality, promoting inclusive growth-focused FDI could help mitigate this issue. Overall, policies supporting economic growth and equitable trade distribution hold promise for reducing income inequality in Taiwan.

Keywords: Population aging, income inequality, Taiwan

JEL Classification: O11

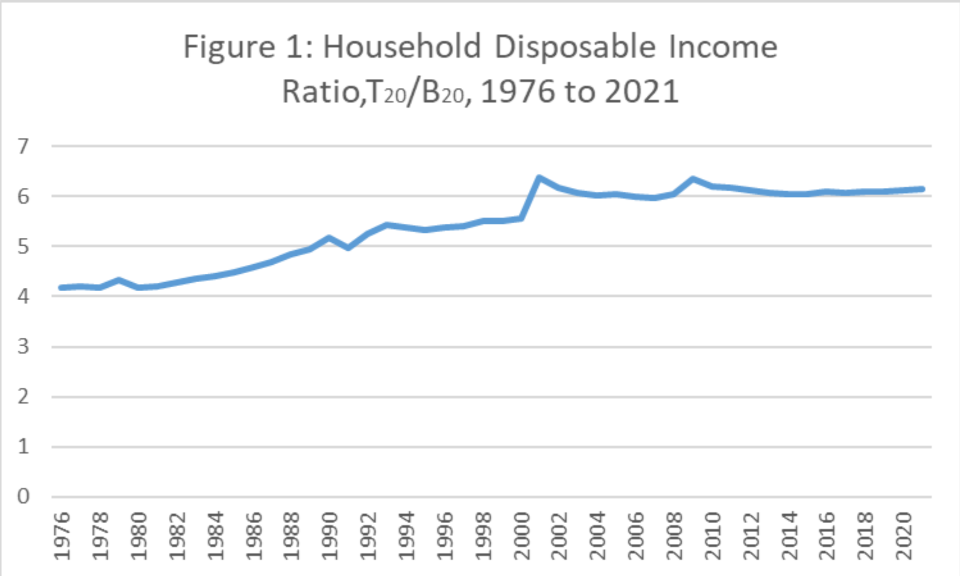
1. Introduction

Addressing income inequality stands as a crucial Sustainable Development Goal (SDG) for governments. And even more so, economists have been notably intrigued by the issue of income inequality within context of development for an extended period of time. Prior studies examining the causes of income inequality focus on exploring factors such as globalization, stagnant wages in the labor market, unequal distribution of land, and high inflation. As the global demographic shifts into an aging population, one consequential issue highlighted by this trend is the potential worsening of income inequality. This stems from the fact that elderly individuals often rely on limited sources of income, primarily stemming from their employment. Therefore, the increase in the proportion of this demographic cohort may lead to a widening gap in income levels, suggesting a positive correlation between aging and income inequality. This correlation has been observed in both developed and developing countries (Barretti et al., 2000; Bishop et al. 1997; Jantti, 1997; Cameron 2000; Zhong 2011; Kang & Rudolf, 2016; Chen et al., 2018; Dong et al., 2018; Hwang et al., 2021; Zhang et al., 2021). While some scholarly works suggest a positive relationship between aging and income inequality, others, as illustrated by Alimi et al. (2017), argue that aging serves to moderate income inequality. Meanwhile, certain studies, such as that by Andriopoulou *et al*. (2017) and Chong and Ka (2019) advocate that aging might have minimal or negligible impact on income inequality. The influence of aging on income inequality continues to be a topic of ongoing discussion, lacking a conclusive agreement. The rapid aging of the populations has drawn considerable attention from policymakers to the effects of population aging on income inequality, particularly as many nations are undergoing this demographic transition sooner than expected.

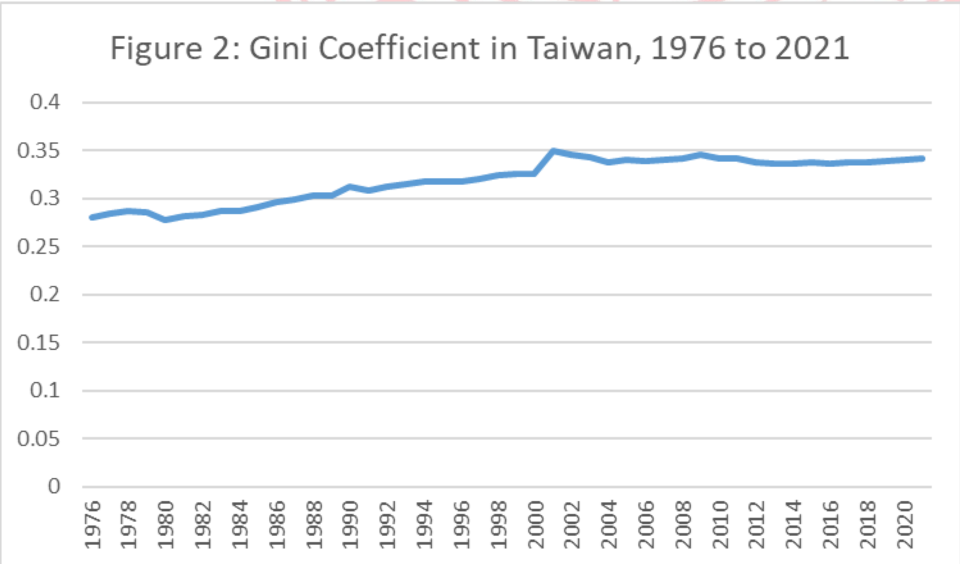
Like other developed countries in Asia, Taiwan is witnessing a trend of aging population (Goh et al. 2023). The proportion of the elderly population in Taiwan surpassed 14% in 2018, turning Taiwan into an Aged Society.[1] Rapid aging is evident as the decline in fertility persists alongside improvements in longevity, with projections indicating that the elderly population will exceed 20% by 2025, transitioning Taiwan into a super-aged society within a decade. This transition outpaces the speed of Japan, known as the world's most aged nation, which took 12 years to achieve a similar status (ILC-Japan, 2013). The rapid growth of the elderly population is expected to worsen income inequality in Taiwan (Lin et al. 2015). As depicted in Figure 1, during the 1980s, the top 20% of households earned four times more than

[1] According to the definition of the United Nations and the WHO, a country is classified as an aging state if the elderly people aged 65 years and above are over 7%. Over 14% are identified as an aged society, while those above 21% are categorized as super-aged society.

the lowest 20%, a gap that gradually widened to more than six times since the early 2000s. Since then, this ratio has persisted at approximately six times in Taiwan up to the present day.



The Gini coefficients presented in Figure 2 further corroborate this finding. The trend in Gini coefficients reveal a consistent pattern of increasing inequality. There was a slight decline in inequality from 1964 to 1975. Before1988, the Gini coefficient consistently stayed below 0.30, but rose to 0.325 in 1999, and further increased to 0.35 in year 2001, hoovering below 0.35 thereafter.



However, some economists challenge the notion that the aging population is responsible for the increase in the Gini coefficient in Taiwan. Upon retirement, elderly households typically anticipate a decrease in employment-related sources of income, but they may see an increase in retirement income, such as pension funds and returns from assets (Quinn, 1985). In their study titled, "Taiwan's Wealth Gap 2004-2014: An Estimate Based on Individual Asset Registration Data", Lien et al. (2021) revealed a trend of wealth concentration among individuals aged 50 and above in Taiwan between 2004 and 2014. This concentration is primarily driven by real estate holdings, which serve as a major contributor to wealth accumulation in Taiwan. The elderly population tends to accumulate wealth through real estate ownership, while younger individuals typically have fewer assets at their disposal.

In this paper, we apply an augmented autoregressive distributed lag (A-ARDL) technique using an error-correction model to examine whether increasing income inequality has a relationship with an expanding proportion of the elderly population in Taiwan in the long run. Despite the growing concern about income inequality trends in Taiwan, there has been an exploration into the potential impact of an aging population on income inequality. Theoretically, the increase in the elderly population could potentially worsen income disparity as they typically have limited or no income. Our primary finding aligns with Lien's observation, suggesting that the aging demographic in Taiwan has decelerated the overall growth of income inequality, contrary to findings in some other countries that suggests a positive relationship between aging and income inequality. Notably, this conclusion holds true across various measures of income inequality, such as the Gini coefficient, the income ratio between the top 20% and the bottom 20% of households, or a novel index assessing income inequality.

The remainder of the paper is organized as follows. Section 2 outlines the literature review and the theoretical framework. Section 3 discusses the methodology employed. Section 4 presents the empirical findings, and concluding remarks are summarized in Section 5.

2. Literature Review

Despite the growing concern about the upward trajectory of income inequality in Taiwan, there has been limited focus on considering the aging population as a potential determinant of income inequality has received scanty attention. Several studies have identified alternative determinants, besides aging, as the primary sources of income inequality in Taiwan. For example, Lee (2008) delves into the dispersion of household income in Taiwan from multiple perspectives, including the effects of single-parent families, shifts in economic structure from agricultural to the services sector, and the changes in political leadership and institutional policies. The study reveals that the increase in single-parent families deteriorates the overall income share, indicating a worsening income inequality scenario with more of these family structures. Conversely, the larger share of the service sector and increased privatization tend to improve income disparity. Additionally, the study suggests that the new political governance and policy reforms post-2000 have exacerbated income inequality. Similarly, Yemane (2016) examines the long-run and causal relationship between defense expenditure and income distribution in Taiwan for the period from 1976–2011. The evidence suggests that directing more resources toward defense expenditure may worsen income inequality in Taiwan, as observed over the period from 1976 to 2011.

Our literature review uncovered several studies examining the influence of demographic transition on income inequality in Taiwan. For instance, Chu and Jiang (1997) investigate how the demographic transition affects the family income inequality index. Given the prevalent practice of married couples residing with extended family members (e.g., their parents or siblings) in Taiwan, resulting in increased income earners within extended households, it becomes crucial to understand how the evolving age structure and widespread extended families impact Taiwan's unique pattern of family income inequality indexes. Chu and Jiang (1997) discovered that the age structure's effects reduced family earnings inequality between 1980 and 1990. However, Zhong (2011) criticizes this finding, arguing that the study overlooks other pertinent explanatory variables such as education levels, industrialization, and social security systems. Manson and Lee (2003) corroborate Chu and Jiang's (1997) findings, exploring how aging affects inequality through the family support system, primarily manifested in multi-generation extended households in Taiwan. They find that the extended family plays a more significant role in the old-age support system in Asia compared to the West. Using the Survey of Family Income and Expenditure in Taiwan, the authors observe an increase in extended living arrangements due to aging, which has a greater effect than previously identified compositional effects. Thus, they conclude that aging has mitigated income inequality in Taiwan. Schultz (1997) examines the impact of the demographic transition on income inequality trends, noting that only the cohort aged 35 to 54 has marginally contributed to increasing income inequality across all ages.

Lin et al. (2015) propose that if Taiwan's regional inequalities are spatially correlated, studies that have not accounted for regional spatial factors may exhibit biased results. They reassess the relationship between population aging and income inequality from a spatial perspective, analyzing data from 1998 to 2006 using fixed-effect panel data analysis. The study identifies a high level of spatial clustering across Taiwan's 22 regions. After controlling for spatial dependence, they discover a positive association between aging and inequality in Taiwan.

3. Theoretical Perspective

Aging serves as the primary variable in our model. As previously noted, countries experiencing an aging population are poised to experience greater overall income inequality, given this demographic segment either lacks income, or earns a modest one. This positive association between aging and inequality is elucidated by the Life Cycle Hypothesis (LCH), which posits that individuals typically commence with limited wealth. As they progress into their working years, they allocate a portion of their income toward savings until retirement, at which juncture they draw upon these accumulated savings. However, the conventional understanding of LCH has been questioned by economists. The Wealth Decumulation Puzzle suggests that older individuals are depleting their wealth (dis-saving) at a slower rate than expected due to concerns about longevity risk and the potential future high medical expenses. As a result, the seniors might postpone reducing their wealth and conceivably extending their working years beyond retirement. Horioka and Watanabe (1997) contend that this precautionary behavior holds the potential to mitigate income inequality.

Another crucial factor influencing income inequality is per capita income, in line with Kuznets' hypothesis. According to this hypothesis, income inequality demonstrates an inverted "U" pattern, initially rising and then declining with the increase in per capita income. As a country undergoes development and experiences economic expansion, its per capita income increases, accompanied by a rise in income inequality. However, as per capita income continues to increase, income inequality begins to decrease, leading to a negative long-run relationship between per capita income and income inequality. Many studies support Kuznets' hypothesis, which argues that a country's economic growth impacts the level of income inequality (Ogus Binatli, 2012; Goh et al., 2023).

In addition to income growth, economic openness plays a crucial role in influencing income inequality. The three primary indicators of economic openness include trade openness, as well as inward and outward foreign direct investment (FDI). Stolper and Samuelson's (1941) theorem posits that trade openness can lead to improved income distribution. International trade tends to benefit unskilled workers while potentially disadvantaging capital owners and skilled workers. Consequently, greater trade openness could result in a relative wage increase for unskilled labor compared to skilled labor, thereby improving a country's income distribution (see Rafael and Quan, 2003). On the other hand, the theoretical effects of FDI on income inequality vary widely and depend significantly on the motives behind FDI and the economic and educational development levels of both the host and parent countries. In a labor-abundant host country, the presence of labor-intensive foreign multinational corporations may stimulate the employment of unskilled workers, thereby improving income inequality within the host economy (Couto, 2018). On the other hand, in a capital-abundant host country, the presence of capital-intensive foreign multinationals may promote the employment of skilled labor, exacerbating income inequality (Couto, 2018). In addition, if multinational corporations can operate more cost-effectively in a host country, outward FDI may lead to increased unemployment among low-skilled workers, worsening income inequality in the parent country unless these low-skilled workers are willing to enhance their skills through education and training to adapt to technological changes (Çelik and Basdas, 2010). In sum, the expected impact of inward and outward FDI on income inequality could be either positive or negative, dependent largely on the motives behind FDI and the economic and educational development levels of the host and parent countries.

Drawing from the preceding discussion on the theoretical framework, we put forth the following empirical model for the present study:

$$IE_t = \alpha_0 + \alpha_1 age_t + \alpha_2 lrgdppc_t + \alpha_3 trade_t + \alpha_4 IFDI_t + \alpha_5 OFDI_t + \varepsilon_t \qquad (1)$$

where *IE* is the income inequality index, age is the ratio of elderly population to the total population, *lrgdppc* represents the per capita real gross domestic product expressed in natural logarithmic form, while *trade*, *IFDI,* and *OFDI* are the trade openness, the inflows and outflows of foreign direct investment, respectively, and ϵ_t is the regression residual.

4. Data and Methodology

This paper examines the influence of aging on income inequality in Taiwan. To accomplish this, annual data spanning various variables are utilized: The income inequality (designated as *IE*) serves as the dependent variable, while the independent variables encompass the old dependency ratio (*age*), defined as the ratio of individuals aged 65 or older (considered dependents) to those aged between 15 and 64, the natural logarithm of per capita real GDP (*lrgdp*), trade openness (*open*) measured by the sum of exports and imports of goods and services as a share of gross domestic product, inward direct investment (*ifdi*), and outward direct investment (*ofdi*). Data is sourced from the National Statistics covering the period from 1976 to 2022, selected due to consistent inequality measurement during this timeframe.

Various metrics are employed to gauge income inequality. In addition to the widely used Gini coefficient, this study also incorporates income gap, represented by the ratio the highest 20% household income to the lowest 20% (B_{20}/I_{20}). Sitthiyot and Holasut (2020) commented that the Gini index may overlook disparities at the extremes of income distribution, whereas the income share ratios fail to address mid-level inequality. They noted that countries sharing the same Gini index may exhibit different levels of income inequality, emphasizing the importance of considering variations in income gaps between the richest and the poorest segments. To address these limitations, Sitthiyot and Holasut (2020) propose an alternative inequality measurement approach. Their method, straightforward in design, combines the Gini index with the income shares of the top 10% and the bottom 10% to construct a composite index, as formulated below:

$$I_i = \frac{\sqrt{Gini_i^2 + \left[\left(1 - \left(\frac{B_{10}}{T_{10}}\right)_i\right)^{\frac{1}{4}}\right]^2}}{\sqrt{2}}, 0 \leq I_i \leq 1$$

This study employed three indices to assess income inequality, namely, Gini coefficient, the income gap and the composite index proposed by Sitthiyot and Holasut (2020).

4.1 Unit Root and the Augmented ARDL Tests

The cointegration framework proves highly effective in analyzing the income inequality model specified in equation (1) to determine potential long-run relationship between income inequality and aging. Specifically, we adopt the Augmented ARDL(A-ARDL) method, which accommodates variables with mixed order of integration, aligning well with the characteristics of Taiwanese data. Initially, unit root tests such as the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) tests are conducted to ascertain the presence of a unit root across all variables. The Akaike Information Criterion (AIC) guides the selection of the optimal lag for the ADF test, while the Bartlett Kernel (Newey-West) method is used in the

PP test for its spectral estimation and bandwidth determination. Subsequently, upon obtaining the optimal ARDL model, we employ the A-ARDL cointegration testing methodology.

The A-ARDL with an unrestricted Error-Correction model is presented in the following equation below:

$$\Delta y_t = \alpha + \delta_1 y_{t-1} + \delta_2 \mathrm{x}_{1,t-1} + \sum_{i=1}^{p} \xi_i \Delta y_{t-i} + \sum_{j=0}^{q} \xi_j \Delta x_{1,t-j} + + \sum_{l=1}^{s} \theta_l DUM_{t,l} + \varepsilon_t \qquad (2)$$

where i, j, and k are indices of lags $i = 1, 2, \dots, p$; $j = 0, 1,2, \dots, q$; $k = 0,1,2, \dots, r$; t denotes the time periods $t = 1,2, \dots, T$; y_t is the dependent variable; $x_{1,t}$ is the independent variable; $DUM_{t,l}$ is a dummy variable to account for breaks in the data. Dummy variables are typically used to accommodate country and global shocks such as oil price fluctuations, recessions, bursting of economic bubbles, and financial crises. The dummy variable has a value of 1 for the year of event occurrence and zero otherwise. The dummy variables are determined on a national basis, which involves the graphing of the residual errors and manual examination for structural breaks, with the dummy for the specific year(s) added accordingly.

The A-ARDL technique comprises the classic bounds cointegrating framework by Pesaran *et al*. (2001), which involves an F-test on the lagged level variables and a t-test on the lagged level of the dependent variable and extends the method by including another F-test on the lagged level independent variable(s) as introduced by McNown *et al*. (2018). These three tests are vital to relax the reliance on the Pesaran *et al*. (2001) requirement of *I*(1) dependent variable due to the low power risk of unit root tests (Goh *et al*., 2020). This allows for a robust conclusion on the status of cointegration conclusions and rules out degenerate cases *(*Sam *et al*., 2019).

The null hypotheses for all the three tests are defined as follows:

(i) F-test on the lagged level of all variables: H_0: $\delta_1 = \delta_2 = \delta_3 = 0$, against H_1: $\delta_1, \delta_2, \delta_3 \neq 0$
(ii) t-test on the lagged level of the dependent variables: H_0: $\delta_1 = 0$, against $\delta_1 < 0$
(iii) F-test on the lagged level of the independent variables: H_0: $\delta_2 = \delta_3 = 0$, against H_1: $\delta_2, \delta_3 \neq 0$

McNown et al. (2018) and Sam et al. (2019) state that if the null hypotheses (i) and (ii) are rejected while the null hypothesis (iii) is not, the case is classified as a *degenerate lagged independent variable*. Failure to reject the null hypothesis (iii) alone would imply the dependent variable is integrated at order zero (Goh *et al*., 2020). On the other hand, if the null hypothesis (ii) cannot be rejected while hypotheses (i) and (iii) are rejected, then the *degenerate lagged dependent variable* case applies. Only after all three hypotheses are rejected, a valid cointegration can be concluded. The critical values for the overall F-test and the t-test concerning the dependent variable are sourced from Narayan (2004) due to the small sample size. Meanwhile, the critical values for the F-test on the lagged level of the independent variable are extracted from Table 3 (unrestricted intercepts and unrestricted trends) in a study conducted by Sam *et al*. (2019).

Once there is evidence of cointegration, the long-run cointegration equation is estimated from the unrestricted ECM (Goh *et al*., 2020). Based on Equation (2), when $\Delta y_t = 0$, then $\Delta x_{1t} = 0$ in the equilibrium state implies that for x_1, the long-run coefficients are $-(\delta_2/\delta_1)$.

5. Results

Despite the A-ARDL test can detect an I(0) dependent variable, the cointegration test is not applicable when I(2) or higher variables are present. Therefore, it is essential to ascertain the integration properties of a series before conducting the A-ARDL test. We applied the unit root tests, and the results are presented in Table 1. Both the ADF and PP tests show that *Gini*, *income gap*, and the *composite index,* which are the variables representing income inequality, respectively, are stationary after first differencing. The independent variables, namely, *lrgdppc*, *open*, *ifdi* and *ofdi*, either exhibit stationary at level or become stationary after first differencing. Additionally, the unit root test for demographic variables (*aging*) confirms that they become stationary only after a second differencing, or $I(2)$. Since variables integrated at order two cannot cointegrate with $I(1)$ series, the demographic variables are first differenced to obtain the growth of demographic variables to align the integration of order one with that of the other independent variables, consistent with the approach adopted by Goh et al. (2020).

Table 1: Unit Root Test

Test at Level			Test at 1st difference			Test at 2nd difference		
	ADF	**PP**		**ADF**	**PP**		**ADF**	**PP**
Dependent Variable			**Dependent Variable**			**Dependent Variable**		
Gini	-1.35(T,0)	-1.28(T)	*gini*	-7.42***(c)	-7.43***(c)	*Gini*		
Income gap	-1.71(T,0)	-1.55(T)	*Income gap*	-8.18***(c)	-8.30***(c)	*Income gap*		
composite	-1.30(T,0)	-1.17(T)	*composite*	-7.81***(c)	-7.81***(c)	*composite*		
Independent variable			**Independent variable**			**Independent variable**		
Age	-2.56(T,1)	-3.10(T)	*age*	-0.49(c,1)	-0.03(c)	*Age*	-2.63*(c,1)	-4.51***(c)
Lrgdppc	-0.88(T,9)		*lrgdppc*	-3.82**(c,1)		*lrgdppc*		
Ifdi	-1.99 (c,1)	-1.82(c)	*ifdi*	-6.69(c,0)	-6.69(c)	*Ifdi*		
Ofdi	-3.51**(T,0)	-3.38**(T,0)	*ofdi*			*Ofdi*		
Open	-1.54(T,0)	-1.48 (T,0)	*open*	-2.66*(c,3)	-8.22(c,0)	*Open*		

Notes: ADF = Augmented Dickey-Fulle; PP = Phillips-Perron. ***Rejection of the unit root hypothesis at 1% significant level. **Rejection of the unit root hypothesis at 5% significant level. *Rejection of the unit root hypothesis at 10% significant level. The optimal lag length is determined by the modified Akaike. The Newey-West Bandwidth is used in the PP test to determine the truncation lags of the variables used to obtain white-noise residuals.

Next, we implement the A-ARDL test. It is important to determine the optimal lag order ρ of the underlying Unrestricted Error Correction in equation (2). Consequently, ρ was selected based on the Akaike Information Criterion (AIC). Given our relatively small sample size, we set ρ = 4 as the maximum lag length to ensure sufficient degrees of freedom for econometric analysis. The general-to-specific method that removes insignificant lags is applied, hence, the final model could be different from the theoretical model. We carried out several diagnostic tests for the final model, including tests of autocorrelation (denoted by LM(2) and LM(4)), normality (denoted by the Jarque-Bera, JB test), and heteroscedasticity (denoted by the Breusch-Pagan-Godfrey (BPG)), ensuring that the error term conforms to the white noise assumptions.

Estimates of the A-ARDL cointegration tests are presented in Table 2. Despite using different proxies of income inequality, the results indicate that income inequality is cointegrated with the set of independent variables. As illustrated in Table 2, both the overall F-statistics and t-test for the dependent variable, along with the F-test for the independent variables, surpass the upper bound critical values at the 5% and 1% significance levels. This suggests that aging and all the proxies for income inequality variables were cointegrated. Given this cointegration, we proceeded to estimate long-run regressions for these income inequality proxies, as showcased in Table 3.

Tabe 2: A-ARDL Cointegration Test

Independent Variable	Dependent Variable		
	gini	Income gap	composite
gini(-1)	-0.305*** (0.082)		
Income gap (-1)		-0.497*** (0.06)	
composite (-1)			-0.331*** (0.047)
Δold(-1)	-0.288*** (0.533)	-0.349*** (0.10)	-0.002** (0.001)
lrgdppc(-1)	-0.907*** (0.278)	-0.556*** (0.08)	-0.004*** (0.000)
ofdi(-1)	0.297*** (0.070)	0.130*** (0.02)	0.001*** (0.000)
open(-1)	-0.009*** (0.003)	-0.003*** (0.001)	-0.000*** (0.000)
ΔΔold(-1)	1.026** (1.065)	0.659* (0.268)	0.007*** (0.002)
ΔΔold(-2)		0.724** (0.288)	
Δofdi(-1)	-0.232*** (0.06)	-0.136*** (0.023)	-0.001*** (0.00)
Δofdi(-2)	-0.104* (0.053)	-0.082*** (0.023)	-0.000** (0.000)
Δopen(-1)	0.014** (0.004)	0.007*** (0.001)	0.000*** (0.000)
Δopen(-2)		0.003* (0.001)	
Δifdi(-2)	-0.368*** (0.130)		
Δifdi(-3)	-0.650*** (0.180)		
Constant	2.988*** (0.419)	-1.562*** (0.305)	0.198*** (0.026)
Dummies	Dum80, DUM90, Dum91, Dum01	Dum01, Dum90, Dum91	Dum01, Dum80, Dum90, Dum91, Dum93
Diagnostic Checking			
R^2	0.912	0.907	0.94
Adjusted R^2	0.875	0.864	0.91
AIC			
$LM(1)$	0.07(0.78)	0.08 (0.76)	0.57(0.44)
$LM(2)$	5.55(0.14)	3.30(0.19)	3.05(0.21)
JB(p)	0.52(0.77)	2.94(0.23)	1.51(0.47)
Q(12)	15.31(0.99)	14.04(0.29)	8.96(0.70)

ARDL test-statistics			
Overall F test	11.75***	17.93***	19.66***
t-dependent	-4.90**	-7.854***	-7.01***
F test independent	14.05***	14.76***	11.11***

Notes: DU## is the dummy variable defined as one at a specific year and zero for other years. Q (12) indicates the Q-statistic at lag 12; JB(p) represents the Jarque-Bera statistic for the normality test at lag p. LM (p) refers to the Breusch-Godfrey Lagrange Multiplier at lag p. F_1 is the overall F-statistic; t is the t-statistic for lagged of the dependent variable; F_2 is the F-statistic for lagged of the independent variable. *,**, *** represent 10%, 5% and 1% level of significance, respectively.

Table 3: Long-Run Cointegrating Equations

	Gini	Income gap	composite
age	-0.934* (0.2167)	-0.701*** (0.171)	-0.008* (0.0025)
lgdppc	-2.97*** (0.247)	-1.118*** (0.049)	-0.0145*** (0.000)
open	-0.030** (0.0082)	-0.007*** (0.002)	-0.000*** (0.000)
ofdi	0.974*** (0.2167)	0.262*** (0.051)	0.004*** (0.000)

Notes: Standard errors of estimated coefficients are reported in parenthesis. *, **, *** indicate statistical significance at 10%, 5%, and 1% levels, respectively.

The long-run coefficients estimated from the cointegration regression provide deeper insights into the income inequality index and its key determinants. As depicted in Table 3, it is evident that the aging population exerts a significantly negative effect on income inequality for several reasons, a consistent finding across all income inequality proxies. Senior citizens may have diligently saved or invested over their lifetimes, enabling them to earn income from their property investments. In the context of Taiwanese cultural practices, Tung et al. (2006) affirm that it is customary for families to live together, and it is common for younger generations to offer financial support to their elders. As a result, this dynamic could lead older individuals to have access to financial assistance from their families. Whereas those elderly individuals living alone mostly relied on government support, ensuring they have enough income to meet their basic needs and reducing income inequality among the elderly population. Advancements in healthcare and lifestyle have improved the health and activity levels of many elderly individuals, allowing them to work beyond retirement age, especially if they lack sufficient savings or pensions. Notably, the extent of this impact varies across different proxies used. To further gauge the magnitude of the aging effect on income inequality, we use the standard deviation of typical demographic shocks, as suggested by the long-run relations.[2] For instance, when the income inequality is measured using the Gini coefficient, a one standard deviation increase in the old age dependency ratio is expected to lead to a decrease (computed as 3.893*-0.943= -3.671) by 3.67 percentage points in income inequality. Similarly, for income inequality measured by income ratio, a one standard deviation increase in the old age dependency ratio is expected to reduce income inequality by approximately 2.73 percentage points (computed as 3.893*-0.701). However, when the income inequality is measured using the composite index, the impact of the old age dependency ratio is expected to decrease in income inequality by a much smaller margin, approximately 0.0311 percentage points (computed as 3.893*-0.008).

Besides, the findings indicate a negative relationship between the per capita real GDP (LRGDPPC) and income inequality. Specifically, when Gini is as the dependent variable, a one percent increase in LRGDPPC will lead to a 0.0297 percent decrease in Gini.[3] Similarly, a one percent increase in LRGDPPC is associated with a 0.0118 percent decrease in income ratio and a 0.0001 percent decrease in the composite index. The negative sign of *lrgdppc* conforms to the downward sloping portion of the Kuznets curve; suggesting that as per capita real income rises, income inequality of a country tends to diminish. Likewise, our analysis reveals that trade openness is significant and negative, suggesting that expanding an economy's trade activities may lead to a reduction in income inequality in the long run. The long-run coefficient associated with trade openness is notably small, ranging from 0.000 to 0.03. Conversely, outward FDI is a positive and statistically significant relationship, with estimated values ranging from 0.00 to 0.97. However, the insignificance of *ifdi* suggests that the presence of multinational corporations operating in Taiwan has no discernible long-run impact on income inequality. In sum, our findings highlight the nuanced effects globalization components – trade openness, FDI inflows, and outflows – on income inequality in Taiwan.

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[2] The standard deviation for the aging variable is 3.893.

[3] LRGDPPC is estimated in logarithmic form, but the dependent variable is in ratio, the coefficient of this variable is multiplied by 0.01 to obtain the approximate percentage change. Hence, the coefficient of the *lrgdppc* is -0.0297, i.e., a 1 percent change in *lrgdppc* is associated with a change in the Gini index by 0.0297 percentage points. Similar computation for income gap index and composite index.

5. Conclusion and Policy Implications

Taiwan distinguishes itself as one of the few Asian countries that have undergone demographic transition earlier than anticipated. Thus, understanding the potential influence of Taiwan's rapidly evolving age demographics on its distinctive family income inequality indices becomes crucial. Employing three metrics of income inequality, we conducted an empirical analysis to explore the long-run relationship between aging and income distribution in Taiwan spanning from 1976 to 2022, using the A-ARDL cointegration test. Based on the evidence presented, several conclusions and policy implications can be drawn regarding the long-run relationship between population aging, economic factors, and income inequality in Taiwan. Our findings indicate that there was a long-run relationship among the variables, with aging demonstrating a significant negative impact on income inequality, suggesting as the population ages, income inequality generally decreases. The following factors contribute to the emergence of this inverse relationship. The primary demographic acquiring properties comprises elderly individuals, who have earned and saved enough over the years for property investments. They not only could benefit from the appreciation in property values over time but also their investment in properties allow them to generate property income as they age and retire. Moreover, the cultural practice of cohabiting with aging parents also attribute to the inverse relationship between aging and income inequality. In Taiwan, it is typical for families to reside together and for offspring to provide financial assistance to their parents. As a result, this could mean older individuals could have access to financial support from their families. Furthermore, with improvements in healthcare and lifestyle, many older individuals enjoy better health and increased activity levels than previous generations, allowing them to remain employed beyond their retirement age, particularly if they lack adequate savings or pensions. In this regard, advocating for increased elderly employment can play a pivotal role in alleviating income inequality among the elderly. Policymakers might consider implementing strategies to enhance job prospects for seniors, such as facilitating training and skill enhancement programs, promoting age-inclusive workplace cultures, and providing incentives to companies to attract and retain older workers.

The study also highlights the importance of economic factors in influencing income inequality trends in Taiwan. For instance, per capita real GDP and trade openness are found to have a negative relationship with income inequality, implying that economic growth and international trade contribute to reducing income disparities. This indicates that policies aimed at promoting economic growth, such as investment in infrastructure, innovation, and human capital development, as well as encouraging trade (while ensuring that the trade benefits are fairly distributed among various sectors of society), can help alleviate income inequality in Taiwan. The findings from this study reveal that an increase in outward FDI is linked to higher income inequality. While outward FDI can promote overall economic growth, it may also widen income disparities within the country. Policymakers should provide incentives to direct outward FDI towards activities that promote inclusive growth and mitigate income inequality.

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