The Impact of Population Aging on Consumption Inequality in Taiwan: Evidence from Spatial Analysis

Jr-Tsung Huang and Yun-Ching Chang
National Chengchi University, Taiwan

INTRODUCTION

- The most commonly used indicators for measuring economic well-being are household income and consumption.

- In studies on household economic welfare distribution, both academia and government agencies have traditionally focused on income inequality, with relatively few examining it from the perspective of consumption.

- However, recent research has increasingly incorporated consumption as a metric alongside income. commonly find that consumption-based and income-based measures of economic welfare yield notably different results, with income inequality generally higher than consumption inequality, and their trends not always aligned.

INTRODUCTION

- Recently consumption inequality has been often considered better or more reliable than income inequality for measuring economic well-being and living standards. It is because: consumption

➢ reflects actual living standards

➢ less volatile than income

➢ less affected by tax and transfer policies

➢ more closely linked to welfare economics

- Consumption inequality provides a clearer, more grounded view of how people actually live.

INTRODUCTION

- Income inequality is typically measured using the income Gini coefficient (IGINI), whereas consumption inequality is assessed using the consumption Gini coefficient (CGINI).

- This study uses data from the Survey of Family Income and Expenditure conducted by the Directorate General of Budget, Accounting and Statistics (DGBAS) of Executive Yuan, ROC (Taiwan) from 2011 to 2023 to calculate both Taiwan's CGINI and IGINI from 2011 to 2023 as shown in Figure 1.

INTRODUCTION

- The distribution of household consumption is becoming more equal—lower-income households may be increasing their consumption relative to higher-income ones in Taiwan.
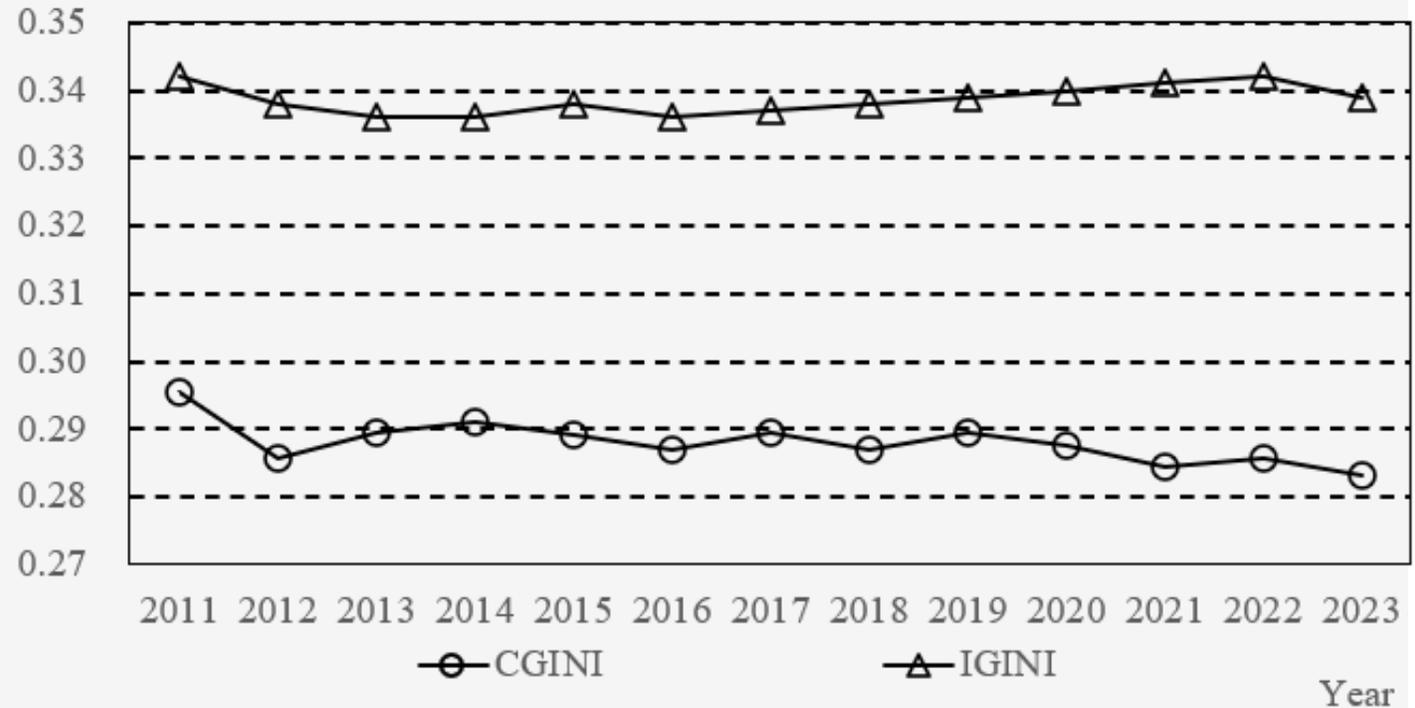

Figure 3-1: Taiwan's CGINI and IGINI (2011-2023)

Source: The Survey of Family Income and Expenditure, DGBAS, various years.

INTRODUCTION

- As the population aging problem becomes more serious, it might contribute to the consumption inequality.

- According to the life cycle hypothesis, individuals adjust their consumption and saving behaviors according to their life stage, and old age usually leads to a decrease in savings and an increase in consumption.

- In addition, high-income elderly can maintain a high quality of life and behave more generous consumption (Kohlbacher and Herstatt, 2011), while low-income elderly experiences a decline in their quality of life due to the burden of medical and living expenses (OECD, 2017).

- Therefore, the population aging can damage the equality of consumption distribution.

INTRODUCTION

- The purpose of this study is to examine the impact of population aging on consumption inequality in Taiwan, using county- and city-level panel data from 2011 to 2023.

- A dynamic spatial autoregressive (DSAR) model is estimated using the generalized method of moments (GMM). The key finding is that a higher proportion of elderly population significantly increases consumption inequality.

INTRODUCTION

- The contributions of this study are as follows:

➢ First, it is the first to calculate the consumption inequality index, CGINI, for each county and city in Taiwan, highlighting regional disparities in consumption inequality.

➢ Second, it is the first to address spatial dependence and the dynamic nature of CGINI using a dynamic spatial econometric model.

➢ Finally, this study adopts a more advanced methodology, providing more reliable results than those found in the existing literature.

INTRODUCTION

- The contributions of this study are as follows:

➢ First, it is the first to calculate the consumption inequality index, CGINI, for each county and city in Taiwan, highlighting regional disparities in consumption inequality.

➢ Second, it is the first to address spatial dependence and the dynamic nature of CGINI using a dynamic spatial econometric model.

➢ Finally, this study adopts a more advanced methodology, providing more reliable results than those found in the existing literature.

IMETHODOLOGY

- Commonly utilized spatial econometric models include the Spatial Autoregressive (SAR) model, the Spatial Durbin Model (SDM), and the Spatial Error Model (SEM).

- Building upon this, Elhorst (2012) extended the model by introducing a year-lagged dependent variable into the panel spatial framework to account for dynamic effects, thereby formulating what is now referred to as the "dynamic panel spatial econometric model."

According to Elhorst (2012), the "dynamic panel SAR" (DPSAR) model can be expressed as follows:

- In Equation (1), $y_{i,t}$ denotes the dependent variable for region i at time t, while $y_{i,t-1}$ represents its one-period lag to capture dynamic effects. x includes the independent and control variables. $\varepsilon_{i,t}$ is the stochastic error term, and μ_i denotes the time-invariant, region-specific effect. The parameters γ and β are coefficients to be estimated. The element $w_{i,j}$ corresponds to the entry in the ith row and j^{th} column of the $N \times N$ spatial weight matrix W, which is defined in Equation (2).

$$y_{i,t} = \gamma y_{i,t-1} + \rho \sum_{j=1}^{N} w_{i,j} y_{j,t} + x_{i,t} \beta + \mu_i + \varepsilon_{i,t}$$

(1)

IMETHODOLOGY

$$W = \begin{bmatrix} w_{1,1} & w_{1,2} & w_{1,3} & \cdots & w_{1,N} \\ w_{2,1} & w_{2,2} & w_{2,3} & \cdots & w_{2,N} \\ w_{3,1} & w_{3,2} & w_{3,3} & \cdots & w_{3,N} \\ . & . & . & \cdots & . \\ . & . & . & \cdots & . \\ w_{N,1} & w_{N,2} & w_{N,3} & \cdots & w_{N,N} \end{bmatrix} \tag{2}$$

- In Equation (2), $w_{i,j} = 1$ if region i and region j are adjacent; and $= 0$, otherwise. The "spatial-dependence matrix" W is row-standardized. Finally, ρ measures the spillover effect from neighboring regions.

- Because the lagged dependent variable $y_{i,t-1}$ is correlated with the time-invariant individual-specific effect μ_i, including both in the model introduces potential endogeneity, which may lead to biased parameter estimates. To address this issue, the present study employs the Generalized Method of Moments (GMM) estimator as proposed by Baltagi, Fingleton, and Pirotte (2014).

IMETHODOLOGY

- Specifically, the differencing approach introduced by Anderson and Hsiao (1982) and further developed by Arellano and Bond (1991) is applied to Equation (1), yielding the transformed model presented in Equation (3).

$$\Delta y_{i,t} = \gamma \Delta y_{i,t-1} + \rho \sum_{j=1}^{N} w_{i,j} \Delta y_{j,t} + \Delta x_{i,t}\beta + \Delta \varepsilon_{i,t} \qquad (3)$$

IMETHODOLOGY

- Arellano and Bover (1995) and Blundell and Bond (1998) extended the GMM framework by distinguishing between the difference GMM and system GMM estimators. In the context of small sample sizes, Soto (2009) argued that the system GMM estimator is more efficient than the difference GMM approach and is associated with a smaller finite sample bias.

- In light of these considerations, the present study employs the system GMM estimator for the estimation of the DPSAR model.

IMETHODOLOGY

- The Empirical Model

  The dependent variable in this study is consumption inequality (*CGINI*), while the primary explanatory variable is population aging (*AGING*). The model also incorporates a set of control variables based on literature, including the proportion of the young population (*YUNG*), average household size (*SIZE*), population density (*POPD*), the share of the population employed in the industrial sector (*INDU*), labor force participation rate (*LFPR*), the ratio of social welfare expenditure to total government expenditure (*SWS*), marriage rate (*MARR*), social increase rate (*SIR*), the middle- and low-income populations (*MLIP*), the consumption tax (*CTAX*), and the self-employed or independent professionals (*SEIP*). Accordingly, based on Equation (1), the empirical specification adopted in this study is formulated as follows.

  where i=1, 2, ..., 20, j =1, 2, ...,20, $i{\neq}j$, and t=2011, 2012, ...,2023.

IMETHODOLOGY

$$CGINI_{i,t}$$
$$= \gamma CGINI_{i,t-1} + \rho \sum_{j=1,j\neq i}^{N} w_{i,j} CGINI_{j,t} + \beta_1 AGING_{i,t} + \beta_2 YUNG_{i,t} + \beta_3 SIZE_{i,t} + \beta_4 POPD_{i,t}$$
$$+ \beta_5 INDU_{i,t} + \beta_6 LFPR_{i,t} + \beta_7 SWS_{i,t} + \beta_8 MARR_{i,t} + \beta_9 SIR_{i,t} + \beta_{10} MLIP_{i,t} + \beta_{11} CTAX_{i,t}$$
$$+ \beta_{12} SEIP_{i,t} + \mu_i + \varepsilon_{it}$$

(5)

- Except for the dependent variable, CGINI, that is calculated by using data from the Survey of Family Income and Expenditure conducted by the DGBAS of Executive Yuan, ROC (Taiwan), explanatory variable and control variable are sourced from the National Statistics, R.O.C. (Taiwan)

IMETHODOLOGY

- **The Dependent Variable**: the consumption inequality of a region. Since the official data of the consumption inequality for each county and city is not available, this study uses data from the Survey of Family Income and Expenditure conducted by the DGBAS of Executive Yuan, ROC (Taiwan) from 2011 to 2023 to calculate the CGINI for 20 counties and cities in Taiwan.

- Table 1 presents the CGINI for 20 counties and cities in selected years. The results indicate that regions with higher levels of consumption inequality are predominantly located in eastern Taiwan, such as Taitung County and Hualien County. This finding suggests a persistent disparity in consumption distribution in eastern Taiwan, where high inequality values consistently cluster in specific areas, highlighting the geospatial concentration of consumption inequality.

IMETHODOLOGY

Table 1: Consumption GINI by County and City in Taiwan (Selected Years)

County	2011	2013	2015	2017	2019	2021	2023
Yilan City	0.325	0.309	0.328	0.333	0.287	0.318	0.311
Changhua County	0.294	0.296	0.309	0.281	0.299	0.289	0.311
Nantou County	0.305	0.305	0.292	0.287	0.308	0.299	0.297
Yunlin County	0.307	0.321	0.308	0.339	0.322	0.316	0.287
Keelung City	0.254	0.258	0.280	0.258	0.262	0.256	0.242
Taipei City	0.248	0.251	0.249	0.241	0.245	0.239	0.228
New Taipei City	0.247	0.243	0.237	0.243	0.241	0.233	0.237
Taichung City	0.268	0.271	0.276	0.273	0.265	0.268	0.278
Tainan City	0.289	0.287	0.302	0.307	0.296	0.311	0.292
Taoyuan City	0.285	0.251	0.263	0.257	0.259	0.272	0.269
Miaoli County	0.312	0.287	0.301	0.273	0.290	0.283	0.289
Chiayi City	0.296	0.276	0.260	0.266	0.281	0.271	0.260
Chiayi County	0.318	0.311	0.300	0.335	0.328	0.320	0.325
Kaohsiung City	0.296	0.296	0.284	0.290	0.285	0.275	0.281
Taitung County	0.293	0.326	0.335	0.307	0.328	0.332	0.346
Hualien County	0.334	0.324	0.321	0.326	0.321	0.317	0.311
Penghu County	0.315	0.295	0.309	0.303	0.308	0.300	0.302
Hsinchu City	0.303	0.283	0.318	0.302	0.288	0.283	0.276
Hsinchu County	0.291	0.302	0.303	0.333	0.284	0.305	0.309
Pingtung County	0.286	0.271	0.267	0.276	0.293	0.282	0.295
Nation	0.295	0.289	0.289	0.289	0.290	0.285	0.283

Source: Various years of Survey of Family Income and Expenditure, the DGBAS of Executive Yuan, ROC (Taiwan).

Note: The CGINI for other years is available upon requests.

METHODOLOGY

- **Explanatory Variable: AGING:** With social advancement, the widespread availability of healthcare, and the extension of average life expectancy, the proportion of the elderly population aged 65 and over in Taiwan has continued to rise.

- In 1993, the elderly population exceeded 7% of the total population, marking Taiwan's transition into an aging society. By 2018, this proportion surpassed 14%, signifying its progression into an aged society.

- According to projections by the National Development Council, Taiwan is expected to become a super-aged society by 2025, with the elderly population surpassing 20% of the total. Furthermore, it is estimated that by 2050, the proportion of elderly individuals will peak at approximately 36.6% of the total population.

METHODOLOGY

- **Explanatory Variable: AGING:** With social advancement, the widespread availability of healthcare, and the extension of average life expectancy, the proportion of the elderly population aged 65 and over in Taiwan has continued to rise.

- In 1993, the elderly population exceeded 7% of the total population, marking Taiwan's transition into an aging society. By 2018, this proportion surpassed 14%, signifying its progression into an aged society.

- According to projections by the National Development Council, Taiwan is expected to become a super-aged society by 2025, with the elderly population surpassing 20% of the total. Furthermore, it is estimated that by 2050, the proportion of elderly individuals will peak at approximately 36.6% of the total population.

METHODOLOGY

- **Control Variable**: The model also incorporates a set of control variables based on literature, including the proportion of the young population (*YUNG*), average household size (*SIZE*), population density (*POPD*), the share of the population employed in the industrial sector (*INDU*), labor force participation rate (*LFPR*), the ratio of social welfare expenditure to total government expenditure (*SWS*), marriage rate (*MARR*), social increase rate (*SIR*), the middle- and low-income populations (*MLIP*), the consumption tax (*CTAX*), and the self-employed or independent professionals (*SEIP*).

METHODOLOGY

Table 2: Definition and Descriptive Statistics of Variables

Variables	Definition	Mean	Std. Dev.	Min	Max	Sign
1. Dependent Variable						
CGINI	The Gini coefficient of consumption calculated from the total consumption expenditure of each household in the Survey of Family Income and Expenditure	0.290	0.028	0.228	0.351	
2. Explanatory Variable						
AGING	Proportion of population aged 65 and above to the total population (%)	14.907	2.024	8.37	22.36	+
3. Control Variables						
$CGINI_{t-1}$	Consumption inequality Lagged by One Period	0.291	0.028	0.228	0.351	+
YUNG	Proportion of population under 14 years old (%)	13.052	2.115	8.5	18.73	+
POPD	Average population per square kilometer	1610.091	2247.98	60.18	9951.48	?
SIZE	Average number of people per household	2.962	0.282	2.1	3.6	−
INDU	Industrial structure ratio of workers (%)	34.057	9.538	16.44	53.52	+
SIR	The ratio of social addition to the mid-year population, that is, the difference between the immigration rate and the emigration rate (‰)	-0.090	5.746	-29.69	17.61	?
MARR	The ratio of the number of marriages during a particular period to the total population during the same period. (‰)	5.644	0.7694	4.21	8.51	−
SWS	The ratio of social welfare expenditure to the annual expenditure structure (%)	14.781	3.001	8.67	25.4	−
LFPR	Labor force percentage of civilian population aged 15 and above (%)	58.356	2.098	50	63.1	−
CTAX	Consumption tax burden (%)	0.0359	0.055	-0.116	0.241	−
MLIP	Proportion of population with low- and middle-income to the total population (%)	1.485	1.097	0.07	4.67	+
SEPI	Percentage of self-employed or independent professionals among the employed (%)	13.799	5.058	7	25.71	+

EMPIRICAL RESULTS

- Before proceeding with the analysis of the empirical results, this study conducts a multicollinearity test, the Arellano-Bond, and the robustness check.

- All Pearson correlation coefficients are below 0.8, suggesting no severe multicollinearity among the explanatory variables. all the variance inflation factor (VIF) values are below the conventional threshold of 10, further confirming the absence of multicollinearity.

EMPIRICAL RESULTS

Table 3: Pearson Correlation Matrix and Variance Inflation Factor (VIF) Estimates

	POPD	AGING	YUNG	INDU	SWS	LFPR	SIZE	CTAX	SIR	MARR	MLIP	SEPI
POPD	1											
AGING	-0.068	1										
YUNG	0.294	-0.790	1									
INDU	-0.260	-0.391	0.494	1								
SWS	0.265	0.411	-0.306	-0.085	1							
LFPR	-0.139	-0.006	0.130	0.489	0.021	1						
SIZE	0.164	-0.684	0.707	0.656	-0.219	0.347	1					
CTAX	0.405	0.294	-0.141	-0.268	0.372	-0.050	-0.064	1				
SIR	-0.142	-0.285	0.265	0.249	0.027	-0.118	0.124	-0.243	1			
MARR	0.239	-0.780	0.646	0.290	-0.175	0.038	0.579	-0.047	0.306	1		
MLIP	-0.340	0.208	-0.370	-0.142	0.052	0.104	-0.179	-0.211	-0.334	-0.344	1	
SEPI	-0.026	-0.011	-0.013	0.064	0.031	0.067	0.042	-0.013	-0.065	0.048	0.004	1
VIF	4.21	7.91	6.27	4.02	1.86	1.62	4.28	1.78	1.65	3.30	1.71	1.03

EMPIRICAL RESULTS

- The Arellano-Bond and Sargan tests are employed to assess whether the differenced error terms exhibit serial correlation and whether the instruments used in the estimation are valid, respectively.

- In Model 1, the Arellano-Bond test statistic for AR (1) rejects the null hypothesis of no first-order autocorrelation, whereas the statistic for AR (2) fails to reject the null, indicating no second-order autocorrelation.

- These results confirm that the DPSAR model is correctly specified under the system GMM framework.

- Furthermore, the Sargan test fails to reject the null hypothesis of valid over-identifying restrictions, thereby supporting the validity of the instruments used in the estimation.

- Robustness checks are reported in Models 2, 3, and 4, each incorporating alternative sets of control variables.

EMPIRICAL RESULTS

- In Model (1) of Table 4, the coefficient of AGING is positive and statistically significant at the 5% level, indicating that an increase in population aging has a significant positive effect on consumption inequality. This finding aligns with the expectations of this study and supports the theoretical framework of the Life Cycle–Permanent Income Hypothesis (LC-PIH).

Table 4: Estimation Results

Variables	Model 1	Model 2	Model 3	Model 4
$CGINI_{t-1}$	2.33×10^{-1} * (1.25×10^{-1})	2.30×10^{-1} * (1.25×10^{-1})	2.51×10^{-1} ** (1.22×10^{-1})	2.51×10^{-1} ** (1.20×10^{-1})
$AGING$	4.10×10^{-3} ** (2.06×10^{-3})	4.10×10^{-3} ** (2.07×10^{-3})	3.75×10^{-3} * (2.07×10^{-3})	3.42×10^{-3} * (1.93×10^{-3})
$YUNG$	1.23×10^{-2} *** (3.48×10^{-3})	1.21×10^{-2} *** (3.51×10^{-3})	1.07×10^{-2} *** (3.77×10^{-3})	1.03×10^{-2} *** (3.63×10^{-3})
$POPD$	-8.43×10^{-6} ** (3.32×10^{-6})	-8.47×10^{-6} ** (3.34×10^{-6})	-9.00×10^{-6} *** (3.21×10^{-6})	-9.94×10^{-6} *** (2.48×10^{-6})
$SIZE$	-2.71×10^{-2} * (1.45×10^{-2})	-2.63×10^{-2} * (1.46×10^{-2})	-2.42×10^{-2} * (1.45×10^{-2})	-2.50×10^{-2} * (1.49×10^{-2})
$INDU$	-6.93×10^{-4} (8.33×10^{-4})	-6.32×10^{-4} (8.41×10^{-4})	-9.33×10^{-4} (7.88×10^{-4})	-7.48×10^{-4} (7.11×10^{-4})
SIR	-4.81×10^{-4} (3.92×10^{-4})	-4.42×10^{-4} (3.89×10^{-4})	-4.84×10^{-4} (3.79×10^{-4})	-4.64×10^{-4} (3.67×10^{-4})
$MARR$	2.77×10^{-3} (5.37×10^{-3})	2.85×10^{-3} (5.40×10^{-3})	2.72×10^{-3} (5.39×10^{-3})	2.34×10^{-3} (5.18×10^{-3})
SWS	-9.13×10^{-4} (9.57×10^{-4})	-9.13×10^{-4} (9.66×10^{-4})	-1.20×10^{-3} (9.34×10^{-4})	-1.20×10^{-3} (9.09×10^{-4})
$LFPR$	2.91×10^{-3} (1.82×10^{-3})	2.84×10^{-3} (1.81×10^{-3})	2.65×10^{-3} (1.77×10^{-3})	2.66×10^{-3} (1.72×10^{-3})
$CTAX$	-4.55×10^{-2} (1.15×10^{-1})	-3.96×10^{-2} (1.16×10^{-1})	-6.26×10^{-2} (1.13×10^{-1})	
$MLIP$	-5.05×10^{-3} (5.82×10^{-3})	-5.72×10^{-3} (5.92×10^{-3})		
$SEPI$	-1.95×10^{-4} (3.10×10^{-4})			
ρ	-0.16 **	-0.15 **	-0.11 *	-0.11 *
Observations	240	240	240	240
AR (1) (*p*-value)	0.00	0.00	0.00	0.00
AR (2) (*p*-value)	0.41	0.43	0.39	0.39
Sargan test (p-value)	0.37	0.36	0.17	0.17

Notes: 1. The symbols *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively, indicating rejection of the null hypothesis that the corresponding coefficient is equal to zero.

2. Values in parentheses represent robust standard errors.

EMPIRICAL RESULTS

- It also reinforces the empirical findings of Deaton and Paxson (1995) and Kang (2009), providing robust evidence in support of Deaton and Paxson's (1995, 1997) conclusion that Taiwan's aging population and declining population growth have exacerbated consumption inequality.

- The coefficient of $CGINI_{t-1}$ is significantly positive, suggesting the presence of a positive dynamic effect of consumption inequality across counties and cities in Taiwan. This implies that a reduction in $CGINI$ in the current period is likely to lead to a further decrease in the subsequent period.

EMPIRICAL RESULTS

- The spatial autocorrelation coefficient (ρ) is estimated to be negative, suggesting that an increase in consumption inequality in one county or city is associated with a decrease in inequality in neighboring regions.

- This may be attributed to the migration of low- and middle-income households from high-inequality areas to nearby regions, which alters the income and consumption structure of adjacent areas, potentially leading to a reduction in their consumption inequality.

EMPIRICAL RESULTS

- The robustness checks confirm that the empirical findings of this study are not sensitive to the inclusion or exclusion of specific control variables. These results provide strong evidence of the reliability and validity of the estimated relationships in the baseline model.

- Among the control variables, the estimated coefficients for POPD and SIZE are statistically negative at the 5% and 10% levels, respectively. The estimated coefficient for YUNG is statistically significant at the 1% level and positively affects CGINI.

- Other control variables—SWS, LPFR, SIR, INDU, CTAX, MARR, and MLIP—do not exhibit statistically significant effects on CGINI.

CONCLUDING REMARKS

- This study investigates the impact of population aging on consumption inequality in Taiwan. The consumption Gini coefficient, calculated using the standard Gini formula and data from the Survey of Family Income and Expenditure conducted by the Directorate-General of Budget, Accounting and Statistics, Executive Yuan, ROC (Taiwan), serves as the dependent variable. The dataset covers 20 counties and cities across Taiwan from 2011 to 2023.

- Four specifications of a Panel Dynamic Spatial Autoregressive (PDSAR) model are estimated.

CONCLUDING REMARKS

- The primary empirical finding reveals that population aging exerts a statistically significant and positive effect on consumption inequality. Additionally, a reduction in consumption inequality in the current period tends to persist into subsequent periods.

- Regarding spatial dependence, the results suggest that an increase in consumption inequality in one county or city is associated with a decrease in inequality in adjacent regions.

CONCLUDING REMARKS

- The primary empirical finding reveals that population aging exerts a statistically significant and positive effect on consumption inequality. Additionally, a reduction in consumption inequality in the current period tends to persist into subsequent periods.

- Regarding spatial dependence, the results suggest that an increase in consumption inequality in one county or city is associated with a decrease in inequality in adjacent regions.

- In light of these findings, policies aimed at mitigating population aging—thereby potentially enabling lower-income households to increase their relative consumption—are critical for promoting a more equitable distribution of household consumption in Taiwan. Such as:

CONCLUDING REMARKS

➢ Enhancing fertility intentions (such as childbirth subsidies, parenting rewards, and tax relief for families with children—as well as through the provision of comprehensive childcare and educational resources.)

➢ Promoting work–life balance via flexible working hours, remote work arrangements, and robust parental leave policies, along with expanding housing and marital support (e.g., home purchase subsidies, social housing programs, and financial assistance for marriage and childbirth-related expenses), also plays a crucial role.

➢ Relaxing immigration criteria to attract and retain foreign graduates by facilitating local employment and residency can help increase the young immigrant population.

CONCLUDING REMARKS

- Reducing the pace of population aging not only contributes to expanding the labor force but, as evidenced by the findings of this study, also plays a critical role in alleviating consumption inequality. Therefore, addressing the challenges posed by population aging should be regarded as a paramount policy priority for the Taiwanese government.