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Retirement Age and Population Aging: A Cross-Country Empirical Study of OECD Members and Implications for China

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Abstract. Population aging puts pressure on pension systems, yet countries facing similar demographic conditions adopt different retirement-age arrangements. Drawing on historical institutionalism and a retirement-incentive framework, this study uses cross-sectional ordinary least squares models to examine 38 OECD member countries. The dependent variable is the normal retirement age for men in 2024. The explanatory variables are the old-age-to-working-age ratio, remaining life expectancy for men at age 65, and public pension expenditure as a share of GDP. A sensitivity analysis assesses Turkey's influence, and model residuals inform comparative case studies of Denmark and South Korea. In the full sample, population aging and remaining life expectancy are positively associated with the normal retirement age, whereas public pension expenditure is negatively associated with it. Excluding Turkey reduces both demographic coefficients, which no longer reach the 5% significance level; the negative association with pension expenditure remains. Turkey's influence highlights the limits of purely demographic explanations. Denmark's normal retirement age exceeds the fitted value, consistent with its rules linking pension eligibility to life expectancy. South Korea's normal retirement age falls below the fitted value, but this does not imply earlier actual exit from the labor market. Combining cross-national statistical evidence with institutional comparisons, the study offers a framework for interpreting China's gradual retirement-age reform, with particular attention to pension sustainability, formal retirement rules, and employment among older workers.

Keywords: population aging, retirement age, pension system, cross-national comparison, China

1. Introduction

Population aging creates sustained pressure to adjust pension systems. If pension eligibility rules and other conditions remain unchanged, increased life expectancy requires pension resources to cover a longer period. Low fertility, meanwhile, changes the future age structure and the relative sizes of the potential contributor and older populations [1, 2]. Countries facing similar demographic pressures nevertheless adopt different retirement-age arrangements. In this study's 2024 sample, the normal retirement age for men ranges from 52 in Turkey to 67 in Denmark, Iceland, and Norway,

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among other countries. These differences raise three related questions: How are population aging, longevity, and public pension expenditure associated with the normal retirement age across countries? How do differences not fully captured by macro-level indicators relate to pension rules and labor market arrangements? What insights do these comparisons offer for understanding China's retirement-age reform?

Existing research explains retirement-age arrangements at several levels. Demographic transition theory examines changes in mortality, fertility, and age structure, while the life-cycle hypothesis addresses resource allocation between working life and retirement. Together, these perspectives explain demographic support pressures and resource needs during retirement [1, 3]. Recent retirement-age models distinguish the roles of birth rates, survival probabilities, and age-related productivity, showing that different demographic changes need not produce identical age adjustments [4]. These approaches clarify the pressures for adjustment but cannot, by themselves, determine a country's normal retirement age. To examine how such pressures translate into institutional responses, this study combines the policy feedback perspective of historical institutionalism with a retirement-incentive framework. Policy feedback emphasizes how vested rights, long-term commitments, and policy updates shape institutional continuity and change; research on policy drift adds further insight [5, 6]. The retirement-incentive framework links pension eligibility and changes in benefit accrual from continued work to labor market exit decisions. Behavioral research also suggests that the statutory retirement age can serve as a reference point beyond its financial implications [7, 8]. The resulting framework connects demographic and longevity pressures, institutional responses, and retirement arrangements and behavior, linking demographic explanations to specific institutional mechanisms.

This study makes three contributions. First, it compares 38 OECD member countries using a standardized measure of the normal retirement age for men and three explanatory variables. A single model incorporates demographic structure, longevity, and public pension expenditure to examine their conditional associations with retirement age. Second, sensitivity analysis of Turkey's influential observation and residual-based case studies of Denmark and South Korea clarify the limits of macro-level statistical explanations. Institutional evidence helps interpret differences that the model does not capture. Third, distinguishing normal pension eligibility, separation from employment, and actual labor market exit provides a comparative perspective on retirement age, pension finances, and employment among older adults in China. The study draws primarily on existing data and case studies, using theoretical literature to guide variable selection and the discussion of mechanisms. Cross-sectional associations are neither interpreted as causal effects nor used to estimate an optimal retirement age.

2. Theoretical framework and research hypotheses

This section draws on demographic transition, life-cycle resource allocation, policy feedback, and retirement incentives to develop six hypotheses or propositions. H1–H3 concern the conditional cross-sectional associations of the three explanatory variables with the normal retirement age. H4–H6 guide institutional analyses of Turkey, Denmark, and South Korea, respectively. Because the theoretical framework was developed through exploratory analysis, these statements do not constitute prespecified confirmatory tests of causal relationships. Statistical residuals identify cases for further examination; they do not establish specific institutional mechanisms.

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2.1. Demographic pressures and the normal retirement age

Demographic transition theory suggests that low fertility and increased life expectancy jointly alter the age distribution, potentially increasing the support needs of older people relative to the working-age population [1]. The demographic dependency ratio, however, is not the ratio of pension recipients to actual contributors. Employment, pension enrollment, and benefit rules also shape the balance between pension revenue and expenditure [2]. Moreover, chronological age does not fully capture differences in health and work capacity within an age group [9]. This study therefore uses the number of people aged 65 and older per 100 people aged 20–64 as an indicator of demographic pressure, rather than a direct measure of the burden on pension funds. Other things being equal, a larger potential recipient population may create pressure to extend contribution periods or delay benefit receipt, although the response depends on existing rules. H1: Controlling for remaining life expectancy for men at age 65 and public pension expenditure, the old-age-to-working-age ratio is positively associated with the normal retirement age for men.

2.2. Longevity pressure and the normal retirement age

The life-cycle hypothesis emphasizes the allocation of consumption and savings between working life and retirement, with the length of retirement playing a central role [3]. If retirement ages and benefit rules remain unchanged, increased longevity requires fixed pension resources to cover a longer expected lifespan. Recent models also link survival probabilities to resource allocation in retirement, although their optimal retirement age differs from the institutional age examined here [4]. Delayed retirement is one possible response to this constraint; changes in savings, benefits, and fiscal contributions are other options. This study focuses on longer contribution periods and later retirement ages as potential institutional responses. It measures longevity using remaining life expectancy for men at age 65, which is distinct from healthy life expectancy and the actual duration of benefit receipt. H2: Controlling for the old-age-to-working-age ratio and public pension expenditure, remaining life expectancy for men at age 65 is positively associated with the normal retirement age for men.

2.3. Public pension expenditure and institutional adjustment mechanisms

Frameworks for adjusting pension parameters consider contributions, the beneficiary-to-contributor ratio, benefits, and fiscal resources, treating retirement age as one of several adjustment mechanisms [2]. Recent comparative research finds that the relationship between pension expenditure and employment among older people varies across systems and population groups. Expenditure indicators therefore require institutional interpretation, although the employment rates and expenditure per older person used in that research differ from the indicators examined here [10]. Some systems may retain earlier retirement arrangements and bear the associated public expenditure, while others may contain expenditure by delaying retirement. Under similar demographic conditions, public pension expenditure and retirement age may therefore be negatively associated. This is an exploratory expectation, rather than an established universal pattern. Earlier retirement may itself increase expenditure, and expenditure as a share of GDP does not directly measure fiscal subsidies or benefit generosity. H3: Controlling for the old-age-to-working-age ratio and remaining life expectancy for men at age 65, public pension expenditure as a share of GDP is negatively associated with the normal retirement age for men.

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2.4. Existing benefit rules and the limits of macro-level explanations

From a policy feedback perspective, existing welfare arrangements generate expectations of entitlement, long-term commitments, and constraints on subsequent reforms [5]. Institutional research also shows that policy outcomes can change when economic and demographic conditions shift without corresponding updates to rules. Although this research directly addresses old-age poverty, its institutional perspective can inform retirement-age analysis without establishing why a particular country adopts a given age [6]. The model used here does not include the timing of initial enrollment, eligibility criteria for specific groups, or transition rules. Similar macro-level indicators may therefore coexist with different normal retirement ages. Turkey's influential observation provides a reason to examine its institutional context, rather than grounds for treating it as an error and excluding it. Other omitted factors and model specifications may also generate prediction discrepancies. H4: Differences in existing pension eligibility criteria and transition rules may cause the normal retirement age to deviate from the level predicted by demographic indicators and public pension expenditure alone.

2.5. Life expectancy-linked mechanisms and retirement age adjustments

Linking retirement age to life expectancy creates a rule-based connection between longevity and pension eligibility. Comparative research on Nordic countries distinguishes adjustments to benefit calculation, entitlement accrual, and retirement age, describing Denmark's approach as a systemic response that links retirement age to life expectancy [11]. Other research shows that indexation methods depend on how pension entitlements accrue and the benefit objectives of the system, and must therefore be assessed within specific program designs [12]. Outcomes also depend on the starting age, implementation date, size of adjustments, and transition arrangements. The existence of indexation alone does not imply that a country's retirement age will exceed a model's predictions. This study uses Denmark's positive residual to examine consistency with its institutional arrangements, rather than to estimate the effect of life expectancy linkage. H5: Where rules linking retirement age to life expectancy are consistently implemented, increased longevity can be accommodated through institutional adjustments toward a higher normal retirement age. This mechanism may help explain why Denmark's retirement age exceeds the value predicted by the macro-level model.

2.6. Retirement transitions and actual labor market exit

The retirement-incentive framework links pension eligibility and the benefits of continued work to labor market exit decisions. Behavioral studies also suggest that the statutory retirement age can serve as a reference point [7, 8]. A recent South Korean study examined a historical reform that raised the age for full pension benefits from 60 to 61. It found delayed retirement but less clear evidence of changes in employment, consumption, or savings. The estimates remain uncertain and do not establish an absence of responses across all groups [13]. Leaving a job, beginning to receive a pension, and ultimately exiting the labor market may thus occur at different stages. Focusing only on the normal retirement age overlooks these transitions and actual employment conditions, particularly when work after job separation accrues benefits under different rules or when inadequate pension income coexists with continued employment. H6: When the age of separation from an employer, the normal pension eligibility age, and the rules governing benefit accrual during continued work are not aligned, the normal retirement age may diverge from the actual age of labor market exit.

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3. Research design

3.1. Data sources

This study uses country-level CSV files previously compiled for analysis in R. The sample comprises 38 member countries of the Organization for Economic Co-operation and Development (OECD), with each country constituting one observation. Normal retirement age and public pension expenditure follow standardized OECD definitions. Population and life expectancy indicators originate from the United Nations' World Population Prospects 2024, as incorporated into the data system. The data extract corresponds to the OECD's 2025 pension indicators. The dependent variable and population indicators refer to 2024. Public pension expenditure is measured using the latest available values: 2021 for 25 countries, 2022 for 7, and 2023 for 6. The analysis uses the three specified explanatory variables throughout. The main model includes all 38 countries, while the sensitivity model excludes Turkey and includes 37. These database names identify the original data sources; the data are not attributed to the journal articles cited elsewhere in the text.

3.2. Variable specification

3.2.1. Dependent variable

The dependent variable is the normal retirement age (NRA) for men in 2024, measured in years. It is the age at which a worker continuously employed full-time since age 22 can receive benefits from all relevant mandatory pension programs without early-claiming penalties. This pension eligibility measure assumes a standardized career path. It differs from the employer-defined age of separation from employment, the earliest age for receiving partial pension benefits, and the actual age of labor force exit. Using the measure for men consistently avoids creating an artificial retirement age by averaging institutional ages across groups. This choice improves comparability across countries, but the analysis does not cover retirement arrangements for women or different occupational groups.

3.2.2. Explanatory variables

The model includes three explanatory variables. Remaining life expectancy for men at age 65 (LE65), measured in years, is the expected number of additional years of life for a man who has reached age 65 under current mortality rates. It serves as an indicator of longevity pressure. The old-age-to-working-age ratio (OADR) equals the population aged 65 and older divided by the population aged 20–64, multiplied by 100. It measures the number of older people per 100 working-age people, rather than their share of the total population or the actual ratio of pension recipients to contributors. Public pension expenditure as a share of gross domestic product (GDP) (PEN) includes public cash expenditure on old-age and survivors' pensions. It measures the aggregate scale of public pension resources, rather than pension fund balances, government deficits, or individual replacement rates. Table 1 summarizes the definitions and units.

Table 1. Variable definitions and measurement units

Variable Type	Variable and Symbol	Operational Definition	Unit
Dependent Variable	Normal retirement age for men (NRA)	Age in 2024 at which a worker with the standardized career path can receive mandatory old-age pension benefits without early-claiming penalties	years
Explanatory variable	Remaining life expectancy for men at age 65 (LE65)	Remaining life expectancy in 2024 for men who have reached age 65	years

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Table 1. (continued)

Explanatory variable	Old-age-to-working-age ratio (OADR)	Population aged 65 and older in 2024 / Population aged 20–64 × 100	People aged 65 and older per 100 people aged 20–64
Explanatory variable	Public pension expenditure (PEN)	Public cash expenditure on old-age and survivors' pensions / GDP × 100; latest available value for 2021–2023	%

3.3. Descriptive statistics

All four variables have 38 nonmissing observations; Table 2 summarizes their distributions. The normal retirement age for men has a median of 65 years and a mean of 64.652 years, ranging from 52 to 67. Turkey's value is markedly lower than those of other countries, contributing to a mean below the median. Mean remaining life expectancy for men at age 65 is 18.462 years, the mean old-age-to-working-age ratio is 32.629, and mean public pension expenditure is 8.050% of GDP. This variation enables cross-national comparison, although differences in reference years and institutional meaning must be considered when interpreting the indicators.

Table 2. Descriptive statistics for the study variables

Variable	N	Minimum	Median	Mean	Standard Deviation	Maximum
Normal retirement age for men (years)	38	52.000	65.000	64.652	2.550	67.000
Remaining life expectancy for men at age 65 (years)	38	14.950	19.010	18.462	1.620	20.860
Old-age-to-working-age ratio	38	14.050	33.815	32.629	8.248	54.930
Public pension expenditure as a share of GDP (%)	38	2.900	7.370	8.050	3.539	16.180

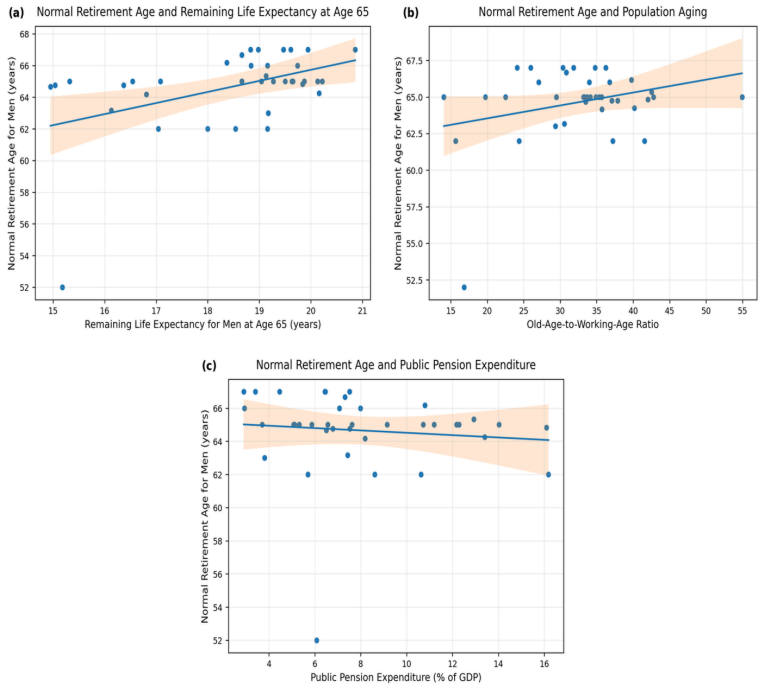


Figure 1. Bivariate relationships of normal retirement age with demographic indicators and public pension expenditure

Note: (a) Remaining life expectancy for men at age 65; (b) Old-age-to-working-age ratio; (c) Public pension expenditure as a share of GDP. The sample comprises 38 OECD countries. Source: Author's calculations using the original OECD and United Nations data.

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Figure 1 provides a preliminary view of linear relationships by plotting men's normal retirement age against LE65, OADR, and PEN. The lines show univariate OLS fits, and the shaded areas indicate 95% confidence intervals for the fitted means. In the full sample, the correlations of LE65, OADR, and PEN with NRA are 0.44, 0.29, and −0.10, respectively; the correlation between OADR and PEN is 0.63. Turkey's retirement age of 52 is substantially lower than those of other sample countries, suggesting that influential observations may affect the correlations and fitted lines. These plots are therefore descriptive. They do not establish causality, and a lack of significance in a univariate model alone is not sufficient grounds for removing a specified explanatory variable.

4. Empirical analysis

4.1. Main regression results

4.1.1. Univariate OLS models

Univariate ordinary least squares (OLS) models first estimate the association of each explanatory variable with the normal retirement age. Equation (1) shows the model for life expectancy; the other two models replace LE65 with OADR and PEN, respectively. All models use the same 38-country sample, and Table 3 reports the results. The life expectancy coefficient is 0.699 ($p = 0.005$; $R^2 = 0.197$): a one-year difference in remaining life expectancy is associated with an approximately 0.70-year difference in normal retirement age, on average. The OADR coefficient is 0.088 ($p = 0.083$), which does not reach the 5% significance level, while the pension expenditure coefficient is −0.071 ($p = 0.557$). The univariate association with life expectancy is comparatively clear, but Turkey's influence and the relationships among the explanatory variables require further examination.

$$\mathrm{NRA}_i = a_0 + a_1 \mathrm{LE65}_i + \varepsilon_i \tag{1}$$

In Equation (1), i indexes countries, NRA_i denotes the normal retirement age for men in 2024, and $\mathrm{LE65}_i$ denotes remaining life expectancy for men at age 65. α_0 is the intercept, α_1 is the bivariate regression coefficient, and ε_i is the model's error term. Because the equation compares countries, α_1 does not estimate the change in retirement age caused by a change in life expectancy within a country.

Table 3. Univariate OLS regression results

Explanatory Variables	Coefficient	p-value	R^2
Remaining life expectancy for men at age 65 (years)	0.699	0.005	0.197
Old-age-to-working-age ratio	0.088	0.083	0.081
Public pension expenditure as a share of GDP (%)	-0.071	0.557	0.010

Note: The dependent variable is the normal retirement age for men. All models include 38 countries. Source: Author's calculations using the original CSV data.

4.1.2. Multivariate OLS models

Equation (2) includes all three explanatory variables to estimate their conditional associations with the normal retirement age, holding the other included variables constant. Table 4 reports estimates for the full sample and for the sensitivity sample excluding Turkey. The latter supplements, rather than replaces, the main analysis. In the full sample, the coefficients for LE65, OADR, and PEN are

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0.589, 0.147, and −0.292, respectively, and all reach the 5% significance level. R^2 is 0.341, and adjusted R^2 is 0.283. Conditional on the other included variables, a one-year increase in remaining life expectancy is associated with an approximately 0.59-year higher normal retirement age. A 10-unit increase in OADR, equivalent to 10 additional people aged 65 and older per 100 people aged 20–64, is associated with an approximately 1.47-year higher retirement age. A one-percentage-point increase in public pension expenditure as a share of GDP is associated with an approximately 0.29-year lower retirement age.

$$\mathrm{NRA}_i = \beta_0 + \beta_1 \mathrm{LE65}_i + \beta_2 \mathrm{OADR}_i + \beta_3 \mathrm{PEN}_i + \varepsilon_i \tag{2}$$

In Equation (2), OADR_i denotes the old-age-to-working-age ratio, and PEN_i denotes public pension expenditure as a share of GDP. β_0 is the intercept, while β_1, β_2, and β_3 are the conditional coefficients for the three explanatory variables, respectively. The remaining symbols are defined as in Equation (1). The model does not measure all institutional characteristics or identify the causal effects of policy implementation; its fitted values summarize statistical relationships within the sample.

Table 4. Multivariate OLS results and sample sensitivity analysis

Variables	Full OECD sample	Sample excluding Turkey
Intercept	51.346*** (4.135)	59.628*** (2.699)
Remaining life expectancy for men at age 65 (years)	0.589** (0.224)	0.267* (0.140)
Old-age-to-working-age ratio	0.147** (0.056)	0.066* (0.035)
Public pension expenditure as a share of GDP (%)	-0.292** (0.129)	-0.219*** (0.078)
R^2	0.341	0.272
Adjusted R^2	0.283	0.205
Model p-value	0.0024	0.0140
N	38	37

Note: Standard errors of the coefficient estimates are reported in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.10. The dependent variable is the normal retirement age for men. Source: Author's calculations using the original CSV data.

Public pension expenditure has a weak association with retirement age in the univariate model but a negative conditional association after adjustment for demographic variables. Because population aging is itself correlated with expenditure, the bivariate relationship may combine demographic and institutional differences. The multivariate model estimates a conditional statistical association without identifying a specific policy mechanism. Previous research suggests that the meaning of expenditure varies across pension systems [10]. The negative coefficients observed here may reflect early retirement arrangements, benefit design, or the relative roles of public and private pensions. Reverse causality is also possible, so the results do not establish that higher expenditure causes earlier retirement. After excluding Turkey, the coefficients for LE65, OADR, and PEN are 0.267, 0.066, and −0.219, with p-values of 0.0656, 0.0704, and 0.0083, respectively. Both demographic coefficients decrease, while the negative association with expenditure persists in this sensitivity analysis.

4.1.3. Standardized coefficients and collinearity checks

To facilitate comparison across variables measured in different units, all variables were standardized separately within the 38-country and 37-country samples. Table 5 reports the results. The

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standardized coefficients for LE65, OADR, and PEN are 0.374, 0.474, and −0.406 in the full sample, and 0.284, 0.360, and −0.539 after excluding Turkey. Because the standard deviations differ between samples, these comparisons should be read alongside the unstandardized coefficients in Table 4. A change in a standardized coefficient does not, by itself, indicate a stronger effect. The full-sample variance inflation factors (VIFs) are 1.04, 1.71, and 1.66, respectively, suggesting no severe linear multicollinearity. These diagnostics support retaining the three specified variables but do not rule out omitted variables, reverse causality, or misspecification.

Table 5. Standardized coefficients for both samples and full-sample vifs

Variable	Standardized β: full sample	Standardized β: excluding Turkey	VIF: full sample
Remaining life expectancy for men at age 65 (years)	0.374	0.284	1.04
Old-age-to-working-age ratio	0.474	0.360	1.71
Public pension expenditure as a share of GDP (%)	-0.406	-0.539	1.66

4.2. Influential observations and sensitivity analysis

Cook's distance measures the influence of an individual observation on the regression fit. The threshold of 4/n, approximately 0.105, is used as a preliminary guide, not an automatic criterion for excluding observations. Turkey's Cook's distances are 1.845, 1.692, and 0.460 in the univariate models for life expectancy, population aging, and pension expenditure, respectively. Latvia and Lithuania are only slightly above the threshold in the life expectancy model, at approximately 0.12. Turkey remains in the full sample, and a separate model excluding it is estimated for sensitivity analysis. The normal retirement age measure depends on specified career paths and applicable eligibility rules. Turkey's unusually low value therefore warrants examination of eligibility criteria and historical rules, rather than being treated as a data error simply because it differs from demographic expectations.

Excluding Turkey reduces the LE65–NRA correlation from 0.44 to 0.31 and the OADR–NRA correlation from 0.29 to 0.04, while the PEN–NRA correlation changes from −0.10 to −0.31. The corresponding univariate coefficients are 0.293, 0.007, and −0.127, with p-values of approximately 0.060, 0.813, and 0.060. Together with Table 4, these results show that demographic associations are sensitive to sample composition and do not establish that demographic pressure mechanically determines retirement age. Turkey's influence highlights the limits of macro-level explanations and motivates examination of institutional arrangements. Sensitivity analysis is used to assess these limits, not to obtain more significant results. Turkey's atypical value offers a starting point for examining H4, but the analysis cannot attribute all deviations to a single institutional mechanism.

Diagnostics for the multivariate model excluding Turkey show some curvature in the residuals-versus-fitted plot and deviations in both tails of the normal Q–Q plot. South Korea, Luxembourg, and Slovenia have particularly large negative residuals. These plots do not establish that the assumptions of linearity, homoscedasticity, and normality all hold. Conventional p-values are therefore interpreted as exploratory evidence conditional on the model assumptions and reported alongside coefficient direction, magnitude, and sensitivity to sample composition. The study does not add endogeneity tests or more complex models, and its interpretation remains limited to associations rather than causal effects.

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5. Comparative case studies based on model residuals

5.1. Criteria for case selection

A residual is defined here as observed NRA minus fitted NRA. A positive residual indicates an observed age above the fitted value; a negative residual indicates an age below it. Figure 2 uses the 37-country model excluding Turkey to reduce its influence on the comparative benchmark. Denmark's observed NRA is 67 years, compared with a fitted value of approximately 65.41, yielding a residual of +1.59 years. South Korea's observed NRA is 63 years, compared with a fitted value of approximately 65.85, yielding a residual of −2.85 years. Denmark does not have the largest positive residual, but its rules linking retirement age to life expectancy are directly relevant to this study. South Korea has the largest negative residual in this model. Case selection considers both residual direction and theoretical relevance; neither criterion constitutes a formal statistical test. The dashed line marks equality between observed and fitted values. Fitted ages are statistical benchmarks, not recommended or optimal retirement ages.

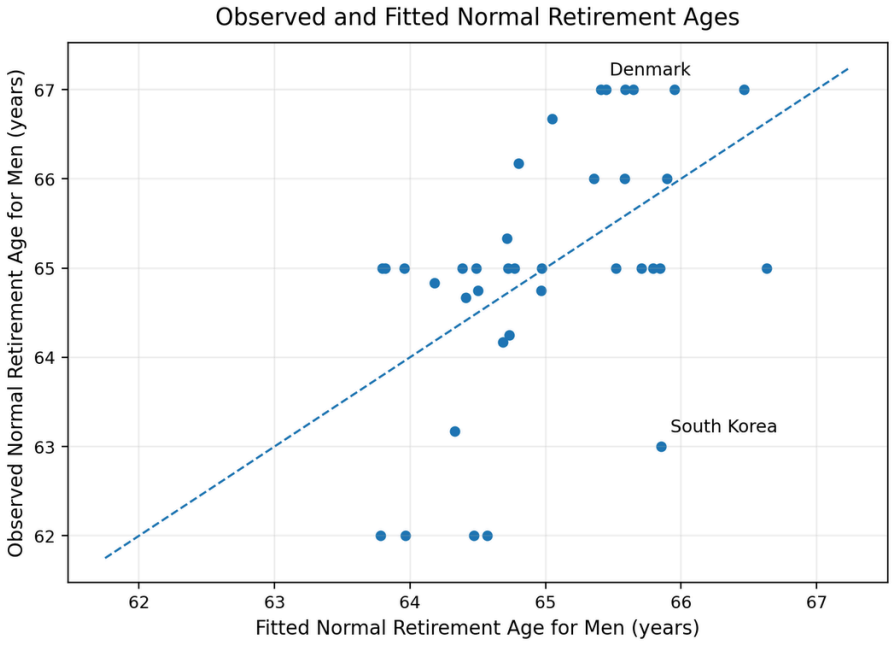


Figure 2. Observed and fitted normal retirement ages for men (excluding Turkey)

Note: Fitted values come from the three-variable model for 37 countries excluding Turkey. The dashed line marks equality between observed and fitted values. Denmark and South Korea are highlighted as comparative cases because of their theoretical relevance. Source: Author's calculations using the original CSV data.

5.2. Denmark: normal retirement age above the model prediction

5.2.1. Denmark's retirement age system

In the 2024 data, Denmark's normal retirement age for men is 67, approximately 1.59 years above the fitted value. The analysis examines how demographic indicators are incorporated into existing benefit rules. Comparative studies of Nordic pension systems distinguish responses to longevity through benefit calculation, entitlement accrual, and retirement-age adjustment. Denmark relies primarily on a mechanism linking retirement age to life expectancy [11]. This mechanism operates

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within a system combining public and occupational pensions. Public pension expenditure as a share of GDP therefore cannot, by itself, characterize total pension resources or determine retirement age.

5.2.2. Mechanisms linking life expectancy to retirement age

Existing research describes Denmark's reform as a systematic adjustment of pension eligibility age in response to changes in life expectancy, rather than a strategy relying solely on financial incentives to work longer. Its arrangements involve periodic parliamentary decisions and a relatively long advance notice period. Life expectancy linkage therefore does not mean immediate adjustment without procedural requirements [11]. For this study, the key implication is that similar longevity indicators can translate into different retirement-age arrangements through different institutional pathways. Linkage ratios, entitlement accrual objectives, and transition mechanisms still shape outcomes, so average life expectancy alone cannot determine a single normal retirement age [12].

5.2.3. Institutional interpretation of Denmark's positive residual

Denmark's positive residual after adjustment for the three macro-level indicators is consistent with the institutional response described in H5. The study does not estimate the causal effect of life expectancy linkage, however, and cannot attribute the entire 1.59-year difference to that mechanism. The case adds institutional context absent from the model: long-term arrangements can link pension eligibility to changes in life expectancy beyond current demographic ratios. Nordic studies also address differences in work capacity and the conditions needed to sustain longer employment. The Danish case therefore does not imply that all older workers can extend their working lives without constraints [11].

5.3. South Korea: normal retirement age below the model prediction

5.3.1. Multiple age arrangements in South Korea's retirement system

South Korea's normal retirement age for men is 63 in the 2024 data, approximately 2.85 years below the fitted value. Its arrangements involve three distinct stages: separation from an employer, eligibility for pension benefits, and final labor force exit. A single age cannot adequately describe all three. Research on South Korea's pension system indicates that retirement-age provisions can end employment in a worker's original position. Changes introduced in 2016–2017 prevented employers from setting that age below 60; this does not mean that all workers must stop working entirely at 60 [13]. The employer-level retirement age is conceptually distinct from the pension eligibility age of 63 measured in this study.

5.3.2. Normal retirement age and actual labor market exit

Pension eligibility age determines when benefits become available; employer-defined retirement age limits the original employment relationship; and actual labor market exit age marks the end of labor market participation. These ages are distinct. Research on a historical South Korean reform finds that raising the age for full pension benefits from 60 to 61 delayed benefit receipt, while changes in labor supply were less clear. Because the study concerns specific birth cohorts and some estimates lack precision, it does not establish that all South Korean pension reforms have no employment effects [13]. This evidence informs the retirement-transition interpretation in H6. The study's micro-level causal estimates are not used as explanatory coefficients in the present model.

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5.3.3. Pension adequacy and employment in old age

A lower normal retirement age does not necessarily allow individuals to stop working earlier with adequate pension income. System maturity, contribution histories, and benefit levels shape the role of pensions in retirement income. Recent South Korean research identifies the system's limited maturity and relatively low replacement rate as possible contextual explanations for the observed behavioral responses [13]. Continued employment after retirement may reflect pension resources, individual preferences, or employment opportunities. Normal retirement age alone therefore cannot establish benefit generosity, and employment among older adults cannot be attributed solely to inadequate pensions.

5.3.4. Institutional interpretation of South Korea's negative residual

South Korea's negative residual shows that the three macro-level variables do not fully account for its normal retirement age. It does not establish that South Korean workers actually leave the labor market earlier than workers elsewhere. The case motivates closer examination of pension eligibility rules, employer-level job separation, and incentives for continued work. The potential divergence between normal retirement age and actual labor market exit is consistent with H6, but the study does not identify a single arrangement that explains the −2.85-year residual. The analysis focuses on the cross-national position of normal retirement age in 2024, rather than constructing a separate model of retirement behavior in South Korea.

5.4. Comparative analysis of Denmark and South Korea

Relative to the same sensitivity model, Denmark's observed normal retirement age is above the fitted value, while South Korea's is below it. Their institutional evidence points to different explanations. Denmark illustrates how regulatory mechanisms incorporate changes in life expectancy into pension eligibility age. South Korea illustrates how pension eligibility can diverge from job separation and actual labor force exit. These cases complement the macro-level analysis without establishing that either country pursues a single policy objective or has a superior overall pension system. Together, they help explain the links between demographic pressures, institutional responses, and retirement arrangements, subject to limitations arising from case selection, omitted variables, and unidentified mechanisms.

6. Implications of cross-national experience for China's retirement age reform

6.1. Historical background to China's retirement-age arrangements

China is examined as an external comparative case and is not included in the 38-country regression. The compiled four-variable dataset does not provide a complete set of comparable observations for China and the OECD sample; this does not imply that relevant Chinese data are unavailable. The pre-reform retirement ages of 60 for men and 50 and 55 for two categories of women provide the historical starting point for understanding gradual adjustments. Evidence from the China Health and Retirement Longitudinal Study shows differences in actual retirement patterns between urban and rural residents, associated with pension and economic resources. A uniform statutory retirement age thus cannot capture the full range of employment experiences [14]. This evidence provides institutional background; the study does not explain why the historical age arrangements persisted over time.

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6.2. China's current and future population aging pressures

Using the OECD and United Nations population metrics adopted in this study, China has approximately 23.1 people aged 65 and older per 100 people aged 20–64 in 2024. The medium-scenario projection for 2054 is approximately 64.2; this is a projected value, not an observed outcome. Compared with the OECD sample mean of 32.629, China's current ratio does not capture its future trajectory. Retirement rules observed at a particular time may therefore address pressures over a different policy planning horizon, which current cross-sectional models cannot fully capture. This comparison illustrates the study's interpretive limits; China's future population projections are not included in the OLS analysis.

6.3. China's reform to gradually raise retirement ages

China announced its retirement-age reform in 2024, with implementation beginning in 2025. Recent studies describe a gradual increase from 60 to 63 for men and from 50 and 55 to 55 and 58, respectively, for the two categories of women. They also discuss flexible retirement options and changes to the minimum contribution period [15]. This study focuses on the gradual, cohort-based transition and its flexibility, without presenting a monthly implementation schedule or estimating the reform's effects. The adjustment rules and decision procedures differ from Denmark's long-term linkage to life expectancy. The South Korean comparison further suggests that changes in formal retirement age alone cannot explain changes in older workers' actual employment and pension income.

6.4. Delayed retirement and the sustainability of the pension system

Recent Chinese studies model delayed retirement and other pension arrangements while distinguishing formal and informal workers. They link retirement-age adjustments to fiscal revenue and expenditure, labor supply, and differences across groups, with conclusions conditional on the models and scenarios used [15]. The negative expenditure coefficient estimated here cannot quantify the fiscal benefits of China's reform or identify an optimal policy option. The discussion therefore considers retirement age, contribution rates, and benefit arrangements within a common institutional framework. Findings from external models provide context rather than substituting for this study's empirical evidence.

6.5. Distributional effects across different worker groups

The implications of retirement-age adjustments may differ across insured groups and categories of workers. Relevant studies distinguish employee and resident pension arrangements and classify formal and informal groups by their pension coverage. These categories are not equivalent to urban and rural household registration status [15]. Survey evidence also links pension resources to health, family responsibilities, and actual retirement patterns [14]. Extending employment in a formal position, taking another job after leaving an original position, and continuing to earn income while receiving a low pension represent different forms of working longer. These distributional distinctions inform the institutional comparison; the study does not separately examine broader urban–rural pension issues.

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7. Conclusions and policy recommendations

7.1. Conclusions

First, for H1, the old-age-to-working-age ratio has a positive conditional association with men's normal retirement age in the full sample (coefficient = 0.147; $p \approx 0.013$). Excluding Turkey reduces the coefficient to 0.066 ($p \approx 0.070$). The full-sample result is consistent with the hypothesized direction, but the magnitude and significance of the association depend on sample composition. It therefore does not establish that population aging necessarily corresponds to a higher normal retirement age in every country.

Second, for H2, remaining life expectancy for men at age 65 has a positive conditional association with normal retirement age in the full sample (coefficient = 0.589; $p \approx 0.013$). Excluding Turkey reduces the coefficient to 0.267 ($p \approx 0.066$). The direction is consistent across specifications, but this alone does not establish robustness to sample composition. Longevity is a macro-level indicator in this study, not a direct measure of individual healthy life expectancy, actual contribution periods, or the duration of pension receipt.

Third, for H3, public pension expenditure as a share of GDP is negatively associated with normal retirement age after adjustment for the two demographic indicators. The coefficient is −0.292 in the full sample and −0.219 after excluding Turkey; both reach the 5% significance level. These results support H3 within the two sample specifications. Expenditure may reflect benefit rules and patterns of benefit receipt, and reverse causality remains possible. The association therefore does not establish that increased expenditure causes earlier retirement.

Fourth, for H4, Turkey is influential in all three univariate models, and the demographic associations weaken when it is excluded. This sensitivity shows that interpretation of the macro-level model depends on sample composition and motivates closer examination of specific eligibility requirements and historical rules. H4 guides institutional analysis; the results do not identify the effect of any particular rule. Turkey is therefore retained in the full sample and in the methodological discussion, rather than excluded solely because it differs from model predictions.

Fifth, for H5, Denmark's normal retirement age for men in 2024 is approximately 1.59 years above the fitted value from the 37-country model. Its rules linking retirement age to life expectancy are consistent with an institutional-response explanation. The case illustrates how established procedures incorporate longevity indicators into eligibility rules. It does not establish that the linkage mechanism explains the entire positive residual, and the fitted age is not a policy target for Denmark.

Sixth, for H6, South Korea's normal retirement age is approximately 2.85 years below the fitted value. Pension eligibility, separation from employment, and actual labor force exit nevertheless represent distinct institutional and behavioral stages. The case is consistent with divergence among these ages, but a lower normal retirement age does not necessarily imply a shorter actual working life. Together, the South Korean and Danish cases suggest that comparisons relevant to China should examine the links among age rules, pension resources, and actual employment conditions.

7.2. Policy recommendations and limitations of applicability

Following the first conclusion, demographic indicators can identify potential pension pressures, but interpretation also requires evidence on employment, pension coverage, and the actual relationship between beneficiaries and contributors. Institutional research treats higher employment, broader coverage, and changes in eligibility criteria as distinct adjustments [2]. Policy analysis should

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therefore examine what the same demographic ratio implies under different employment and coverage conditions, rather than derive a uniform retirement-age target from that ratio alone.

Following the second conclusion, incorporating longevity into retirement rules requires distinguishing average remaining life expectancy from health and work capacity. Recent research shows that chronological age does not fully correspond to physiological function [9]. Assessing common age rules across occupations and groups therefore requires more than average life expectancy data. Because this study does not estimate differences in healthy life expectancy, it cannot specify an optimal increase in retirement age for all workers.

Following the third conclusion, retirement age, contribution rates, benefits, and fiscal resources represent different instruments for sharing pension costs. Existing research discusses these instruments and the institutional conditions governing their use [2, 15]. The negative expenditure coefficient suggests that they should be interpreted jointly, but it does not identify a universally optimal choice between raising retirement age and expanding fiscal expenditure. Specific proposals require separate assessment of fiscal, benefit, and distributional consequences, which cannot be inferred directly from this cross-country OLS analysis.

Following the fourth conclusion, institutional comparisons should account for the cohorts covered, historical eligibility criteria, and transition rules. Influential observations should not be excluded automatically as exceptions. Research on policy feedback and policy drift shows how existing rules interact with changing conditions [5, 6]. For China, this calls for a clear distinction between historical starting points and current transition arrangements. The study does not rank alternative transition schemes or explain reforms in other countries on the basis of Turkey alone.

Following the fifth conclusion, Denmark offers a comparative example of long-term rules and advance notice. Research indicates that life expectancy indexation must be assessed alongside entitlement accrual objectives, implementation procedures, and differences in work capacity [11, 12]. These considerations can inform analysis of the timing of China's gradual transition and the management of expectations, without prescribing Denmark's age thresholds or indexation ratios. The study does not quantify the fiscal or demographic effects of such mechanisms in China and therefore cannot use them to rank policy options.

Following the sixth conclusion, the South Korean case shows why pension eligibility adjustments must be considered alongside job retention, employment after retirement, and continued entitlement accrual [13]. Chinese studies also link pension resources to retirement patterns across groups [14, 15]. Vocational training, employment protection, and job quality for older workers are therefore relevant to the relationship between formal retirement rules and actual behavior. This study does not test the effects of these measures; their assessment requires independent labor market evidence.

7.3. Limitations and future directions

First, this exploratory study uses a small cross-sectional sample. It does not identify causal effects or fully account for macro-level, institutional, and group differences. The countries are not randomly selected from the global population, so the conclusions apply primarily to the observed OECD sample. Residual-based case studies suggest possible mechanisms without establishing that all unexplained differences are institutional. Consistency with H4–H6 also does not constitute independent causal testing.

Second, public pension expenditure data refer to different years from 2021 to 2023, whereas the other variables refer to 2024. The male retirement-age and life expectancy measures cannot be generalized to women or specific occupational groups. Basic diagnostics also suggest limitations in the linear specification and residual distribution. Future research could examine employment and

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pension coverage over longer periods using consistent definitions. The present analysis remains limited to three explanatory variables and the specified models to maintain alignment among the research question, data, and evidence.

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