Global Evaluation of Health and Sustainability of Pension System

Jiayang Feng *

School of Mathematics and Statistics, The University of Melbourne, Melbourne, Australia

* Corresponding Author Email: jiayang.feng@student.unimelb.edu.au

Abstract. Under increasing demographic pressure and fiscal stress, pension systems face growing concerns over structural level. Understanding both the drivers of pension expenditure and the structural resilience of pension institutions is crucial for informed reform. This study investigated expenditure dynamics and sustainability from 2010 to 2022 in OECD countries. Panel data regression was utilized to construct a customized OLS model: pension expenditure model, finding that GDP growth reduces pension spending, while fiscal deficits increase pension expenditure significantly. Notably, aging ratio and investment return show weak or insignificant effects, suggesting potential indirect pathways through fiscal channels. Then, a Pension System Resilience Index (PSRI) is developed by integrating five indicators: coverage rate, aging ratio, investment return. Entropy weighting and principal component analysis (PCA) are used to calculate two sets of comparable resilience scores. The results revealed strong cross-country heterogeneity among top-performing countries (e.g., Sweden, Switzerland), but substantial divergence among middle-tier systems, reflecting different structural strengths and weaknesses. The study provided an integrated evaluation framework evaluation for pension reform by combining expenditure modeling with resilience evaluation. It not only offers an integrative tool for assessing pension system health but also contributes to international policy discussions by highlighting both the fiscal pressures and institutional capacities shaping sustainable retirement systems under long-term demographic change.

Keywords: Pension system; OECD countries; Sustainability.

1. Introduction

In recent decades, pension systems across OECD countries have undergone continuous pressure due to aging populations, structural economic shifts, and tightening fiscal conditions [1]. The convergence of these challenges has made the sustainability and adaptability of pension arrangements a central focus of both academic reforms. For example, changes in retirement age, contribution rates, and benefit formulas. However, the evolution of demographic conditions and growing heterogeneity of welfare regimes have led to a more sophisticated understanding of pension dynamics. This study recognizes that evaluating pension systems requires a multidimensional approach. Therefore, major strands of research points to the drivers of pension expenditure and the adaptive capacity of pension regimes.

The first strand focuses on explaining variations in public pension spending across countries and over time. According to the early theoretical models raised by Razin et al .[2], pension expenditure is dynamic relating to government spending and inter-generational transfer. The empirical study has shown that variables such as aging ratio, GDP growth, fiscal deficit, and investment return significantly influence pension expenditure levels. The panel data regression model is used in Mussida and Sciulli's research to further reinforce the explanatory power of macro-fiscal indicators [3]. It also identifies cross-country variation in sensitivity to business cycles. Even though political variables exist in pension systems, but they are found to exert relatively minor influence in institutionalized welfare states. Therefore, political effects can be ignored.

In parallel, the second strand of research has examined the institutional configurations and adaptive capacity of pension systems. Many institutional follows foundational typology, comparative studies have refined the framework by classifying regimes based on re-distributive logic, fiscal constraints, and incentive structures [4]. These typologies reveal the diversity of pension system design but are limited in capturing how systems respond to external shocks [5]. Therefore, the concept of resilience of pension system is raised by institutional literatures published by World Bank, Mercer. It is defined as the ability of a system to absorb, adapt, and transform in response to stress, resilience provides a useful lens for evaluating pension system stability under demographic and economic pressures. Resilience measurement involves the construction of composite indices incorporating demographic, fiscal, and institutional indicators, which include relating variables such as aging ratio, coverage rate, investment return, replacement rate, and public pension expenditure. Since the given variables are across multiple dimensions, objective weighting methods like entropy weighting, principal component analysis (PCA) have been widely adopted to avoid subjectivity in assigning importance to individual indicators and allowing cross-country comparisons of institutional robustness [6].

Even though both strands have contributed important insights, relatively few studies have integrated these frameworks into a unified framework. Most existing research either focuses on explaining variation in pension spending or on classifying the structural features of pension systems, but not both. This disconnect limits our ability to understand how spending pressures interact with institutional preparedness.

To address this, this study adopted an integrated evaluation framework approach. This study constructed panel regression model using OECD data to identify key factors influencing pension expenditure first. Then, pension system resilience index was constructed to derive the composite resilience scores which enable comparative evaluation of each country's pension system adaptability. By integrating these two strands of literature, this study contributed to a more holistic understanding of pension system sustainability. The regression model offers explanatory power for fiscal and demographic drivers of pension spending, while the resilience index provides a structural lens to evaluate institutional robustness. They allow for the identification of both financial pressures and adaptive capacities, informing more targeted and sustainable pension reforms. In a global environment characterized by accelerated aging and economic uncertainty, such an integrated perspective is essential for designing resilient and equitable pension systems.

2. Method

2.1. Data Sources

In order to investigate which factors influencing pension system the most, this study collects data from public online websites such as OECD (https://www.oecd.org/en.html), World Bank (https://www.worldbank.org/ext/en/home), and IMF (https://www.imf.org/en/Home). By merging datasets together, it is more efficient to analyze the result (Shown in Table 1).

Table 1. Institutional Public Pension Data

Dataset	Data Source	Description
Pension Expenditure	OECD	Pension spending as a percentage of GDP.
GDP Growth	World Bank	Annual growth rate of GDP, reflecting overall economic performance.
Aging Ratio	World Bank	Proportion of the population aged 65 and over relative to the total population.
Fiscal Deficit	IMF	Government fiscal balance as a percentage of GDP.
Pension Replacement Rate	OECD	Ratio of pension income to pre-retirement earnings, indicating benefit adequacy.
Pension Coverage Rate	OECD	Percentage of the working-age population covered by a pension scheme.
Pension Investment Return Rate	OECD	Average annual return rate of pension fund investments.
Pension Age	OECD	Statutory or effective age at which individuals become eligible for pensions.
Unemployment Rate	World Bank	Share of the labor force that is without work but actively seeking employment.
Government Debt Rate	World Bank	Total central government debt as a percentage of GDP.

2.2. Self-defined Modelling

2.2.1 Pension Expenditure Model

Pension Expenditure Model is based on OLS (Ordinary Least Square) method [7], for choosing the unknown parameters in a linear regression model by principle of least squares: minimizing the sum of the squares of the differences between the observed dependent variable in the input dataset and the output of the (linear) function of the independent variable. In addition, panel data regression is applied in the study in order to explore the relationship between pension expenditure, population aging and economic cycle. Panel data regression analyzes two-dimensional (typically cross sectional and longitudinal) panel data so that it is suitable to apply this in country and year dimension data-set. The common panel data regression model is

$$y_{it} = a + bx_{it} + \epsilon_{it} \tag{1}$$

where y_{it} is the dependent variable, x_{it} is the independent variable, a and b are coefficients, i and t are indices for individuals and time.

2.2.2 Hausman Test and RE/FE Effects

The Hausman test [8] is widely used in panel data analysis to assess the consistency of random effects estimators in the presence of possible correlation with individual effects. If the explanatory variables are correlated with the unobserved individual effects (p-value < 0.05), null hypothesis is rejected and FE model is preferred. Otherwise, if there is no such correlation (p-value > 0.05), RE model is appropriate for failing to rejecting the null.

$$H = (\hat{\beta}_{FE} - \hat{\beta}_{RE})' \cdot [Var(\hat{\beta}_{FE}) - Var(\hat{\beta}_{RE}))^{-1} \cdot (\hat{\beta}_{FE} - \hat{\beta}_{RE}) \tag{2}$$

The random effects model considers individual-level heterogeneity but treats it as a random variable, assuming it is uncorrelated with the regressors. Compared to FE, the RE model is more efficient, but this relies on the strict exogeneity assumption. They mathematical expressions are similar to the panel data regression:

$$Y_{it} = \alpha + \beta X_{it} + u_i + \varepsilon_{it} \tag{3}$$

where u_i is the individual-specific random effect, ε_{it} is the time-specific error term. RE models apply Generalized Least Squares (GLS) to deal with the composite error structure, which is used when there is a non-zero amount of correlation between the residuals in the regression model to improve statistical efficiency and reduce the risk of drawing erroneous inferences. Therefore, the regression model applying in Pension Expenditure Model relating to population aging and economic cycle is:

$$PSM_{it} = \alpha + \beta_1 \cdot Aging\ Ratio_{it} + \beta_2 \cdot GDP\ Growth_{it} + \beta_3 \cdot Fiscal\ Deficit_{it} + \beta_4 \cdot Investment\ Return_{it} + u_i + \varepsilon_{it} \tag{4}$$

The fixed effects model assumes that each individual possesses unobserved time-invariant characteristics that may be correlated with the explanatory variables. The FE model eliminates these individual effects to focus on estimating the "net effect" of the variables of interest.

$$Y_{it} = \alpha_i + \beta X_{it} + u_i \tag{5}$$

Where α_i represents the individual fixed effects, X_{it} is the time-varying explanatory variables. The core of the FE model lies in eliminating α_i, typically done through demeaning or including dummy variables. Therefore, the regression model relating to population aging and economic circle does not have to include u_i in formula (5).

2.3. Pension Resilience Index

Pension resilience evaluates the level of consistency of different countries' pension system. The study utilizes self-defined index "Pension Resilience Index" in order to evaluate the difference between each country in a structural way.

2.3.1 Theoretical Foundations

Institutional resilience theory aims to possess the capacity to absorb shocks, maintaining functionality and recover in the face of external disturbances. Pension systems are tested whether they can maintain regular pension payments, adjust institutional parameters in response to demographic shift, and whether they have sufficient fiscal reserves or funding mechanisms to buffer against risks. In parallel, social security sustainability framework suggests that pension systems must fulfill three core objectives: adequacy that ensures a basic standard of living for the elderly people; sustainability that avoid undue fiscal or intergenerational burdens; adaptability that allows institutional adjustments to economic changes.

Accordingly, the Pension Resilience Index is structured with five dimensions – demographic pressure, institutional design, fiscal stability, investment/accumulation capacity and adaptive capacity.

2.3.2 Weighting Model

In order to weight each indicator relating to the given theory indicator, normalization and standardization are needed because most weighting methods require standardized and positively oriented inputs for comparability. In this study, PCA and Entropy are used as the method to determine the weight of each indicator, and contribute to the final index. According to the weights, final aggregation formula is promoted with the method of Weighted Sum Model.

Weighted Sum Model is the best known and simplest multi-criteria decision analysis (MCDA) / multi-criteria decision-making method for evaluating a number of alternatives in terms of a number of decision criteria.

$$WSM_i = \sum_{j=1}^{n} w_j \cdot X_{ij} \tag{6}$$

Where X_{ij} is the jth standardized index, w_j is the corresponding weighting. Since the study includes 5 dimensions, meaning n = 5, it is also essential to weight each individual index.

Principal Component Analysis (PCA) is a dimensionality reduction technique used to extract a few uncorrelated principal components from a set of correlated variables. PCA is used to identify representative combinations of indicators, and assign weights based on the variance contribution of each principal component.

$$Set = FeatureVector^T * StandardizedOriginalSet^T \tag{7}$$

$$W_i = \frac{\lambda_i}{\sum \lambda} \tag{8}$$

Where PCA set computes the eigenvalues and eigenvectors of its covariance matrix to form principal components, and W_i is the weight by using the variance contributions. It is featured to be fully data driven, to avoid subjective bias, eliminates multicollinearity and redundant indicators, and allows dimensionality reduction. However, it is difficult to be explained due to principal components are abstract combinations, and not ideal when theoretical clarity or explicit policy dimensions are needed.

Entropy Weight Method (EWM) is a concept from information theory that measures uncertainty. In index weighting, higher variation implies more information, thus greater weight. Therefore, the EWM objectively evaluates each indicator's discriminatory power across observations and assigns weights accordingly.

$$E_i = -\frac{\sum_{j=1}^{n} p_{ij} \cdot In\, p_{ij}}{In\, n} \tag{9}$$

$$W_i = \frac{1-E_i}{\sum_{i=1}^{m}(1-E_i)} \tag{10}$$

Where E_i is the entropy for each indicator and W_i is the calculation method of weight.

3. Result

3.1. Key Drivers of Public Expenditure in Pension Systems

3.1.1 Exploratory analysis

The exploratory data analysis on related variables shows that there are difference in aging population between countries. In addition, the GDP growth and investment return rate analysis illustrates that there exists significant fluctuations. This implies there are institutional structural differences in pension systems across countrie (shown in Table 2).

Table 2. Descriptive Statistics Analysis

Variables	Mean	Std	Min	Max	25%	50%	75%
Expenditure	7.80	3.60	2.07	14.85	6.01	7.10	10.79
Aging Ratio	17.07	4.15	10.28	26.63	14.66	18.16	19.19
GDP Growth	2.76	3.07	-7.09	24.61	1.75	2.40	3.32
Investment Return	4.00	4.66	-8.30	18.48	1.81	4.17	7.22
Fiscal Deficit	81.88	47.64	12.39	210.35	49.52	74.55	101.51

3.1.2 Correlation Comparation

After calculating descriptive statistics analysis, correlations are calculated in a correlation matrix. This model mainly focuses the relation of expenditure with other variables. Expenditure and aging ratio are positively correlated (0.22), which indicates a moderate relation between two variables. Fiscal Deficit and expenditure are strongly positively correlated (0.50), it implies that the expenditure may heaven the fiscal burden. Conversely, GDP growth is negatively correlated (-0.26), it promotes that GDP growth has a suppressive effect on pension expenditures. Despite other three variables, investment return and expenditure have tiny correlation (-0.0076), which indicates that they affect little on each other (shown in Table 3).

Apart from analyzing correlation of expenditure and other four variables, the correlation matrix for these four variables is also meaningful. If they have high correlation with each other, then it may influence the accuracy of the correlation with expenditure. All other correlations between four variables are around 0.10, while correlation of aging growth and fiscal deficit is moderate (shown in Table 3).

Table 3. Variable Correlation Matrix

	Expenditure	Aging Ratio	GDP Growth	Investment Return	Fiscal Deficit
Expenditure	1.0000	0.2228	-0.2654	-0.0076	0.5020
Aging Ratio	0.2228	1.0000	-0.1685	-0.1456	0.3820
GDP Growth	-0.2654	-0.1685	1.0000	-0.1213	-0.1693
Investment Return	-0.0076	-0.1456	-0.1213	-0.1213	0.0001
Fiscal Deficit	0.5020	0.3820	-0.1693	0.0001	1.0000

3.1.3 Hausman Test Outcome

The Hausman test result is 2.22e-27 with p value 1, this determines that RE effect formula is chosen, which is more efficient when explanatory variables uncorrelated with individual effects.

3.1.4 OLS Regression Analysis

Table 4 illustrates outcomes of OLS regression. The R- Squared is equal to 0.286, which implies that the model can explain 28.5% of the pension expenditure (moderate level). The probability of F-test is smaller than 0.001 (7.17E-07), showing that the regression model is valid for its statistical significance. Moreover, the results indicate that GDP growth has a significant and negative effect on pension expenditure ($\beta = -0.221$, $p < 0.05$), suggesting that stronger economic growth helps reduce pension burdens. Fiscal deficit exerts a strong and positive influence ($\beta = 0.035$, $p < 0.001$), indicating that expanding fiscal imbalances are associated with rising pension costs. Aging ratio and investment return are statistically insignificant, implying that their effects may be indirect or delayed, especially in systems where benefits are not directly tied to investment performance.

Table 4. OLS Regression Results

Variable	Coefficient	Std. Error	t	p > |t|	95% CI (Lower)	95% CI (Upper)
Aging Ratio	0.01	0.08	0.09	0.93	-0.15	0.17
GDP Growth	-0.22	0.10	-2.16	0.03	-0.42	-0.02
Fiscal Deficit	0.04	0.02	1.67	0.09	-0.01	0.08
Investment Return	-0.02	0.07	-0.34	0.74	-0.16	0.11
Constant	5.50	1.48	3.72	0.00	2.57	8.43
R-Squared	0.29	-	-	-	-	-
Adj. R-Squared	0.26	-	-	-	-	-
F-test	10.04	-	-	-	-	-
Prob (F-test)	7.17E-07	-	-	-	-	-

3.2. Cross-Country Comparison of Pension Resilience Indexes

3.2.1 Entropy Weight

The final weights derived from the entropy method (Table 5) are as follows:

Table 5. OLS Entropy Weight

Expenditure	Deficit	Coverage Rate	Investment Return	Aging Ratio
0.2362	0.1644	0.3901	0.0974	0.112

The results indicate that coverage rate is the most influential indicator. This highlights the critical role of institutional inclusiveness and system accessibility in determining pension resilience. Systems with higher participation rates are not only more powerful socially, but also better equipped to adapt under demographic and fiscal stress. Expenditure and Fiscal Deficit together account for approximately 40% of the index, capturing the financial efficiency and fiscal sustainability aspects. Systems with lower pension burdens and reduced reliance on deficit financing exhibit stronger resilience. While Aging Ratio contributes a smaller part, reflecting limited cross-country variation in demographic pressure during the sample period. Investment Return has the lowest weight, suggesting that financial performance does not affect resilience as strongly as structural or fiscal variables.

3.2.2 PCA Weight

The following PCA Weight (Table 6) is meaningful because of the difference in weighting variables:

Table 6. PCA Weighting

	PC1	PC2	PC3	PC4
Expenditure	-0.6214	0.0102	0.2584	0.7322
Deficit	-0.6741	-0.1992	-0.069	-0.4697
Coverage Rate	-0.282	0.8778	-0.2177	-0.2091
Investment Return	-0.0522	-0.1807	-0.9386	0.2893
Aging Ratio	-0.2778	-0.3963	-0.013	-0.3402
Variance Contribution Rate of each Principal Component				
percentage	0.4508	0.2145	0.1344	0.1198

The result outputs four principal components by using the loading matrix, whichreveals how each variable contributes to the latent components. The first principal component explains 45.1% of the total variance and is mostly deriven by expenditure and deficit. This reflects fiscal pressure, highlighting how systems with lower pension expenditure and stronger fiscal positions tend to have higher structural resilience level. The second principal component accounts for 21.5% of variance, which is dominated by coverage rate. It captures institutional inclusiveness and denotes how broader coverage contributes positively to a system's resilience. The other principal components are dominated by investment return, and aging ratio. The lower percentage illustrates that it only takes a small partition in accounting for resilience index.

3.2.3 Resilience Index and Ranking

To better classify the long-term performance of national pension systems, this study groups countries into clusters based on resilience rankings andvolatility across the years from 2014 to 2019.

Japan and Lithuania show the largest increses in resilience. Japan recorde a 20% increase in entropy index and 29% increase in pca index, which indicates that Japan may have comprehensive improvement across fiscal, demogarphic, and institutional dimensions. Lithuania similarly achieved dual gains, reflecting the country probability have a stead expansion in system coverage and financial stability. In contrast, Canada, Australia and the USA, often perceived as stable middle-ranked systems, experienced resilience erosion. The countries recorded negative changes in entropy entropy and even steeper declines in PCA. This suggests structural stagnation or fiscal slippage is appearing in these countries. Among the low ranking countries, France and Greece shew marginal improvements , remaining structurally increasing or vulnerable. Surprisingly, the UK, classified as low ranking countries in early years exhibited slight upward trends in both PCA and entropy index, which indicate the potential positive reform momentum in recent years. Furthermore, Sweden, Switzerland and Sweden, classified as high ranking countries shew moderate and consistent upward movement, indicating the high coverage rate, sufficient pension spending's and corresponding favourable system. While countries including Belgium, Spain remained relatively flat or declined—despite ranking in the middle group.

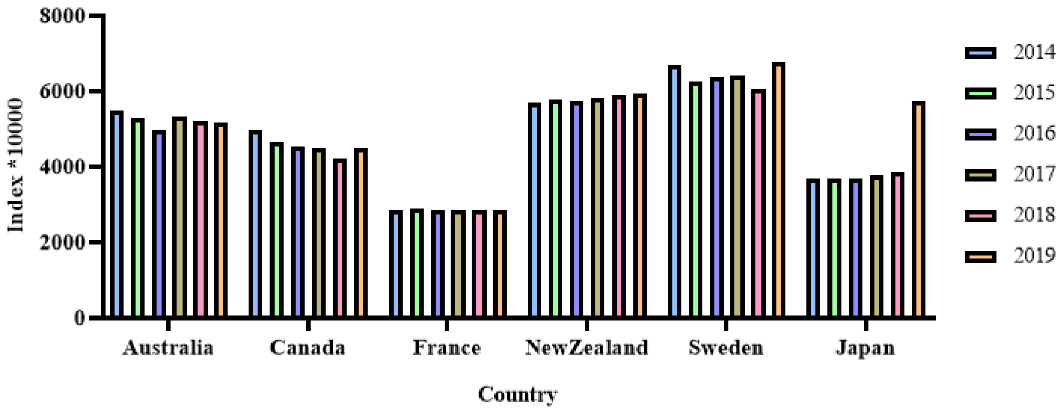

Fig. 1 Representative OECD Countries' Pension Resilience Index

This analysis proves that resilience is not fixed. Even stable or high-ranking countries can decline without structural adaptation, while low ranking countries can improve through reforms. Tracking these longitudinal changes helps policymakers identify whether systems are strengthening over time or becoming increasingly vulnerable beneath a superficially static ranking.

4. Discussion

4.1. Health Evaluation on Pension Expenditure

Pension expenditure typically measured as % of GDP. High pension expenditure as a share of GDP can signal long-term fiscal sustainability challenge. Pension expenditure of Italy accounts for 15% of its GDP in long term (highest in OECD countries), whic raises concern from IMF about is fiscal sustainability in 2022 [9]. In addition, expenditure reflects benefit adaquacy and elderly poverty. Low pension expenditure may indicate in adequate provision, risking high old-age poverty. Conversely, excessive expenditure can crowd out other social priorities. This can be proved by the case from Korea that Korean public pension expenditure si 2.9% of the total GDP, resulting 43% of the poverty rate over people older than 65.

GDP growth not only enlarges the fiscal space for pension financing but also reduces the relative burden (as % of GDP) even as real spending grows. GDP growth has increased government revenue, contribution bases and employment quality, providing material guarantees for pension payments. Faster economic growth provides a dual benefits, which enhances the contribution base and releases the relative weight of public pension expenditures. Poland experienced a sustained GDP growth of more than 5% in the late 2000s. Even as aging continually intensifies, the proportion of pension expenditure in GDP has not risen significantly [10].

GDP growth is the macroeconomic backdrop influencing all other variables. Demographic and fiscal pressures are more manageable in high-growth environments. Conversely, low growth amplifies pension risks [11]. The negative impact of the aging ratio can be reduced by growth; fiscal deficit can lead to an improvement in tax revenue due to growth; Investment returns are even better during periods of high growth.

4.2. Reasons Impacting Pension Resilience Index

In both PCA and Entropy weighting model, pension expenditure and coverage rate are the key factors dominating the pension resilience. This match with the theories in pension expenditure model that expenditure promotes the health of pension system. Despite of expenditure, coverage rate is also essential for system sustainability. High coverage rate implies a broader risk-sharing mechanism. It is a manifestation of social stability, income balance and institutional trust. Insufficient institutional coverage will weaken the resilience and legitimacy of the pension system. In Chile, the private accumulation system has insufficient coverage, and a large number of informal employees are unable to participate in insurance, causing the crisis protesting against pension system. Sweden as high-ranking countries, is structured with notional defined contribution and automatic balancing mechanism. They frequently adjust the pension replacement rate to cope with population and economic changes. Japan is ranked as moderate with the economic background of high aging population and slow economic growth rate. It maintains controllable expenditures through policy tools so that they are not top ranked and low ranked. While France has structured with PAYG and civil servant advantage system, which promotes complex system with large resistance and heavy burdens. This is also the reason France gets a low rank in resilience index [10].

5. Conclusion

This study conducted a comprehensive evaluation of pension systems in OECD countries by constructing a dynamic pension expenditure model and a Pension System Resilience Index (PSRI). Empirical analysis reveals that GDP growth has a significant negative effect on pension expenditure ($\beta = -0.221$, $p < 0.05$), indicating that a 1 percentage point increase in GDP growth leads to an average 0.22 percentage point decrease in pension expenditure as a share of GDP. This effect operates through three main channels: first, by expanding the tax base, enabling government revenue to grow faster than pension expenditure; second, by increasing employment rates and the number of pension insurance contributors; third, by promoting capital market development and enhancing returns on pension fund investments. Poland serves as a case in point, where annual GDP growth averaged 5.2% from 2005-2008 while pension expenditure remained stable at around 10% of GDP, validating this mechanism.

Analysis of fiscal variables demonstrates a strong positive correlation between fiscal deficits and pension expenditure ($\beta = 0.035$, $p < 0.001$), meaning that a 1 percentage point increase in fiscal deficit ratio leads to a 0.035 percentage point rise in pension expenditure share. This relationship is particularly evident in Italy, which in 2019 recorded both the highest fiscal deficit (4.5%) and pension expenditure (15.6% of GDP) among OECD countries. Further analysis suggests fiscal imbalances drive up pension spending through two pathways: governments tend to increase pension expenditure to maintain social stability during economic downturns, while high deficits crowd out other social welfare expenditures, making pensions the primary welfare instrument.

For system resilience assessment, the study developed a PSRI incorporating five dimensions. Entropy weighting analysis shows pension coverage rate carries the highest weight (0.3901), followed by expenditure share (0.2362) and fiscal deficit (0.1644). These findings are strongly supported by OECD country data: Sweden, with 98% coverage and automatic balancing mechanisms, scores 0.82 (out of 1) on the PSRI, ranking first; while Chile, with less than 60% coverage despite having only 7.2% expenditure share, scores just 0.41, ranking near the bottom. Principal component analysis further confirms that the first principal component (explaining 45.1% of variance) is mainly driven by expenditure and deficit indicators, while the second component (21.5% variance) reflects coverage differences..

This research fills a methodological gap by integrating econometric modeling and composite index construction into a unified evaluation of pension systems, offering both dynamic and structural perspectives. Despite its contributions, the study faces limitations. The dataset only includes OECD countries with available data from 2014–2019, limiting its generalizability. The index relies on five indicators, which may not fully capture political, intergenerational, or behavioral aspects of resilience. Furthermore, the public data source was not fully filled and updated. Future research could incorporate governance quality, reform timing, or machine learning techniques to enrich the model.

References

[1] Rouzet Dorothée, Sánchez Ana C., Renault Thomas, Roehn Oliver. Fiscal challenges and inclusive growth in ageing societies. OECD Economic Policy Papers, 2019, (27): 1-69.

[2] Razin Assaf, Sadka Efraim, Swagel Phillip. The aging population and the size of the welfare state. Journal of Political Economy, 2002, 110(4): 900-918.

[3] Armingeon Klaus, Bonoli Giuliano. The politics of pension reform: Institutions and policy change in Western Europe. Journal of European Public Policy, 2006, 13(7): 1037-1054.

[4] Myles John, Pierson Paul. The comparative political economy of pension reform. In: The New Politics of the Welfare State, 2001: 305-333.

[5] Faghih Nasrollah, Sazegar Maryam. A taxonomy of country performance based on GDP and innovation indicators for the Group of Twenty (G20). In: Globalization and Development: Economic and Socio-Cultural Perspectives from Emerging Markets, 2019: 163-200.

[6] Zhao Wei, Chen Ning. Does old-age security promote rural residents' consumption? A decomposition based on contribution and replacement rates. Economic Analysis and Policy, 2024, 82: 817-830.

[7] Zdaniuk Bozena. Ordinary least-squares (OLS) model. In: Encyclopedia of Quality of Life and Well-Being Research, 2024: 4867-4869.

[8] Kelley Pace R., LeSage James P. A spatial Hausman test. Economics Letters, 2008, 101(3): 282-284.

[9] Alami Ilias, Alves Camila, Bonizzi Bruno, et al. International financial subordination: a critical research agenda. Review of International Political Economy, 2023, 30(4): 1360-1386.

[10] Formosa Marvin. The Madrid International Plan of Action on Ageing: Continental and Western Europe 20 years later. In: The United Nations Madrid International Plan of Action on Ageing, 2023: 41-53.

[11] Magwape Mpho. Agenda Setting and Decision Making under the OECD/G20 IF and the WTO–Developing Countries and Reform. Intertax, 2024, 52(4).