Addressing the Ultra-Low Fertility Crisis in Macao: A Comprehensive Analysis and Policy Framework

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Abstract. Macao faces a critical demographic challenge with the world's lowest total fertility rate (TFR) of 0.582 in 2024. This threatens its long-term economic and social stability. This study investigates the multifaceted causes of Macao's ultra-low fertility, relying on systematic data from 2001–2024, international comparisons, and a thorough policy assessment. Employing a mixed-methods approach, we identify key factors including prohibitive housing costs (9.1/10), significant education expenses (8.6/10), and persistent gender role conflicts. Findings reveal a distinct four-phase fertility decline, positioning Macao below South Korea (0.750). This demographic transition has led Macao to become an aged society, with its elderly population (14.5%) now exceeding the child population (12.5%). Despite these trends, current policies demonstrate limited effectiveness. The study proposes a comprehensive six-pillar policy framework emphasizing housing reform, childcare expansion, work-life balance, financial support, gender equality, and long-term monitoring. Implementation is structured across three phases (2025-2035) to stabilize the TFR, foster recovery to 1.0, and eventually approach the replacement level. This research provides the first systematic analysis of an extreme fertility case and offers evidence-based policy recommendations for small economies facing similar challenges.

1 Introduction

Ultra-low fertility, defined as total fertility rates below 1.3, has emerged as one of the most pressing demographic challenges of the 21st century, particularly across East Asian societies [1]. Macao SAR presents an extreme case, recording the world's lowest TFR of 0.582 in 2024, far below the replacement level (2.1) and the ultra-low threshold [2]. This demographic crisis extends far beyond statistical concern, threatening the fundamental sustainability of Macao's economic model, social security systems, and intergenerational balance.

The significance of Macao's case extends beyond its small size. As a Special Administrative Region reliant on gaming and tourism, Macao provides critical insights into the paradoxical correlation between economic prosperity and fertility decline. Despite achieving one of the world's highest GDP per capita levels and maintaining comprehensive

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social benefit systems, fertility rates continue their precipitous decline. This suggests complex underlying mechanisms that require urgent investigation and intervention.

This study addresses three questions: (1) What are the primary drivers of Macao's ultra-low fertility? (2) How does Macao's fertility pattern compare with international experiences? (3) What policy framework can effectively address this crisis?

2 Literature Review and Theoretical Framework

Contemporary fertility research emphasizes multiple theoretical frameworks that help explain the complex phenomenon of ultra-low fertility. The gender equity theory, proposed by McDonald [3], provides a particularly relevant lens for understanding East Asian fertility patterns. This theory posits that low fertility rates can be attributed to a fundamental inconsistency in gender equity. While women have achieved high levels of equity in individual-oriented domains such as education and employment, they continue to face significant inequality within family-oriented institutions, particularly concerning marriage expectations and childrearing responsibilities.

McDonald's framework is especially applicable to East Asian contexts where women have achieved substantial educational and professional equality but continue to face traditional family expectations and unequal domestic labour distribution. This creates what researchers term the "gender equity paradox" - societies with high gender equality in public spheres but persistent inequality in private spheres experience the lowest fertility rates [9].

Family policy research, comprehensively analysed by Gauthier [4], demonstrates that economic incentives alone prove insufficient for fertility recovery. Gauthier's meta-analysis of family policies across developed countries reveals that successful fertility interventions require multidimensional approaches combining financial support, childcare services, parental leave policies, and work-life balance measures. The research emphasizes that policy effectiveness depends on comprehensiveness, consistency, and long-term commitment rather than the magnitude of individual interventions.

East Asian societies exhibit distinctive ultra-low fertility patterns characterized by rapid decline rates, persistent low levels, and notable resistance to policy interventions [6,10]. The Japanese experience provides particularly relevant lessons, as Japan has implemented fertility policies for over three decades with limited success [5]. However, recent developments in South Korea offer more optimistic insights, with TFR increasing from 0.72 to 0.75 in 2024 [8]. Key success factors include enhanced paternity leave policies, corporate childcare incentives, and coordinated government-business partnerships. Jones [10] provides a comprehensive analysis of policy responses and challenges across East Asian countries, highlighting the common obstacles faced by governments in addressing ultra-low fertility.

3 Methodology

This study employs a comprehensive mixed-methods approach combining quantitative demographic analysis with qualitative policy assessment. The research design integrates multiple data sources and analytical techniques to provide a holistic understanding of Macao's fertility crisis and develop evidence based policy recommendations.

Primary data sources include Macao Statistics and Census Service demographic publications (2001-2024), government policy documents [2], UN World Population Prospects 2024 for comparative analysis [1], and academic literature on fertility patterns and policy interventions. The analytical framework incorporates four key dimensions: temporal analysis, comparative analysis, factor analysis, and policy assessment. Temporal analysis includes trend decomposition and phase identification. Comparative analysis involves

international benchmarking. Factor analysis ranks fertility-influencing factors by importance. Policy assessment evaluates effectiveness based on coverage, budget allocation, and outcome indicators.

The study employs triangulation across multiple data sources and analytical methods to enhance validity and reliability of findings.

3.1 Policy Assessment Framework

The policy assessment framework is composed of three components: coverage estimation, which measures the proportion of the eligible population reached by a policy; budget analysis, which calculates the associated implementation costs; and effectiveness scoring, which evaluates policy outcomes against defined benchmarks. Coverage is estimated from policy frameworks, service capacity, eligible population, and delivery data. Budget analysis calculates cost projections based on policy scale and implementation needs, including direct benefits, administrative costs, and infrastructure. Policy effectiveness is scored via comparative analysis with international benchmarks, expert assessment, and outcome evaluations on 10-point scales.

3.2 Factor Importance Ranking

The factor importance ranking system, detailed in Table 5, was developed by integrating multiple data sources. These included economic indicators (e.g., housing price indices, education costs), employment statistics, service coverage metrics, and findings from social surveys. Scores were assigned based on data magnitude, policy priority, and stakeholder consultation, normalized to 1-10 scales for comparative analysis.

4 Results and Analysis

4.1 Demographic Trends Analysis

Macao's fertility evolution from 2001-2024 reveals four distinct phases, each characterized by unique demographic patterns and underlying drivers, as summarized in Table 1.

Table 1. Macao Total Fertility Rate by Period (2001-2024)

Period	Years	Avg.TFR	Change Rate
Phase 1: Stable Low	2001-2007	0.870	±2.30%
Phase 2: Recovery	2008-2012	1.016	+3.80%
Phase 3: Gradual Decline	2013-2018	1.211	-4.20%
Phase 4: Rapid Decline	2019-2024	0.633	-12.10%

The data reveals a concerning acceleration in fertility decline, with the most recent phase (2019-2024) showing annual decline rates exceeding 12%, far surpassing typical demographic transition patterns observed in other developed societies.

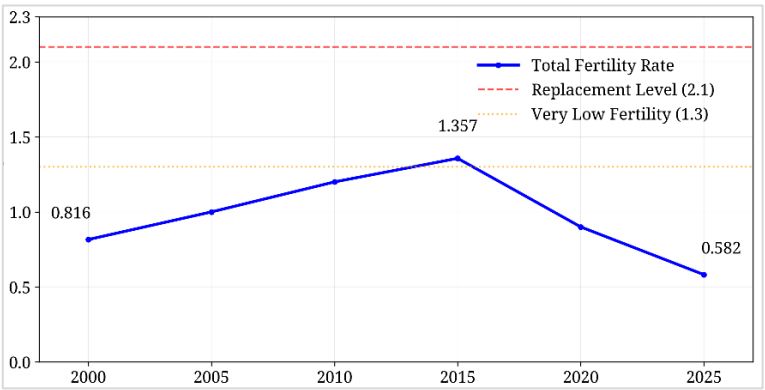

Fig. 1. 2001-2024 Macao Total Fertility Rate Treads

Figure 1 illustrates the complete fertility trajectory, highlighting critical inflection points and reference thresholds. The visualization clearly shows the dramatic departure from recovery trends post-2016, with the steepest decline occurring during 2020-2024.

4.2 International Comparative Analysis

Macao's fertility crisis must be understood within the broader context of global demographic trends, particularly in comparison with other East Asian societies experiencing similar challenges, as presented in Table 2.

Table 2. International Total Fertility Rate Comparison (2024)

Country/Region	TFR (2024)	Gap from Replacement	Global Rank (Lowest)	Classification
Macao SAR	0.582	-1.518	1	Ultra-Low
South Korea	0.750	-1.350	2	Ultra-Low
Hong Kong SAR	0.770	-1.330	3	Ultra-Low
Taiwan	1.090	-1.010	4	Very Low
Singapore	1.050	-1.050	5	Very Low
Japan	1.300	-0.800	6	Very Low
Global Average	2.300	+0.200	-	Above Replacement

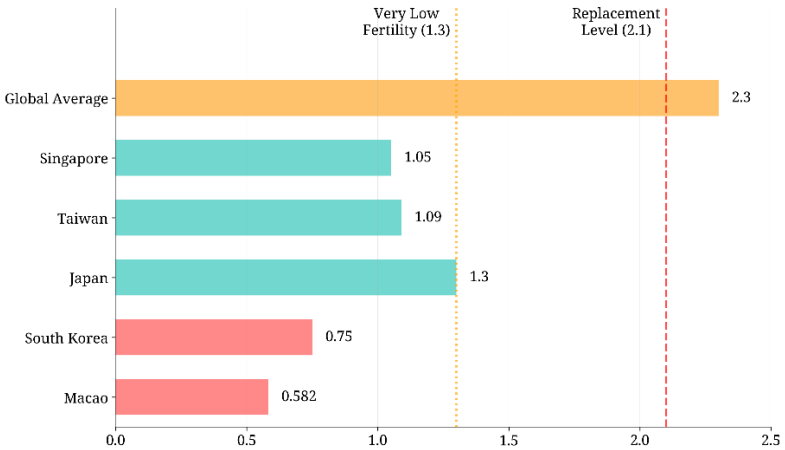

Fig. 2. 2024 Total Fertility Rate (TFR) International Comparison

Figure 2 provides a horizontal bar chart comparison, clearly illustrating Macao's extreme position in the global fertility landscape. The visualization emphasizes the substantial gap between Macao and other ultra-low fertility societies, as well as the dramatic difference from global averages.

4.3 Population Structure Impact

The sustained ultra-low fertility has resulted in fundamental changes to Macao's population structure, with significant implications for economic and social sustainability, as detailed in Table 3.

Table 3. Macao Population Age Structure Change (2020-2024)

Age Group	2020 (%)	2021 (%)	2022 (%)	2023 (%)	2024 (%)	5-Year Change	Status
0-14 years (Children)	13.8	13.2	12.9	12.7	12.5	-1.3 pp	Rapidly Declining
15-64 years (Working)	74.5	74.1	73.8	73.4	73.0	-1.5 pp	Gradually Declining
65+ years (Elderly)	11.7	12.7	13.3	13.9	14.5	+2.8 pp	Rapidly Increasing
Dependency Ratio	34.2	35.0	35.5	36.2	37.0	+2.8 pp	Increasing Burden

4.4 Policy Effectiveness Assessment

Systematic assessment of existing fertility policies reveals mixed effectiveness despite substantial government investment, as evaluated in Table 4.

Table 4. Fertility Policy Effectiveness Assessment

Policy Measure	Imp. Year	Est. Cov. (%)	Est.Bud (M MOP)	Est.Score	Key Limitations
Birth Allowance	2018	98%*	217.8**	5.8	Lump-sum payment deficiency
Extended Maternity Leave	2020	65%*	29.9**	4.8	Career repercussions
Housing Priority	2020	35%*	150.0**	3.1	Limited supply, long waiting lists
Education Support	2007	93%*	184.0**	6.8	Covers only basic education
Medical assistance	2024	15.7%*	12.0**	5.1	Extended service delays

Note: *Estimated from policy frameworks and service capacity Calculated from policy scale and cost projections **Derived from policy analysis and international benchmarks M MOP: Million Macao Pataca

The assessment reveals that while coverage is generally high, effectiveness remains limited due to structural design issues. Most policies focus on post-birth support rather than addressing pre-conception barriers, and economic incentives are insufficient to offset the high costs of childrearing in Macao. Recent research by Gauthier and Gietel-Basten [11] emphasizes that family policies in low fertility countries require comprehensive approaches beyond financial incentives. Similarly, Thévenon and Gauthier [12] demonstrate that while family policies can act as "fertility boosters," they often come with unintended side effects that must be carefully managed through integrated policy design.

5 Discussion

5.1 Key Factors Analysis

Comprehensive analysis of factors affecting fertility decisions reveals a complex interplay of economic, social, and policy variables, as ranked in Table 5.

Table 5. Factors Affecting Fertility Rate (Importance Ranking)

Factor	Importance Score (1-10)	Impact Level	Policy Priority
Housing Costs	9.1	Very High	Urgent
Education Expenses	8.6	Very High	Urgent
Career Development Concerns	8.4	High	High
Childcare Service Inadequacy	8.1	High	High
Work-Life Balance Issues	7.8	High	Medium
Gender Role Conflicts	7.5	Moderate High	Medium
Social Attitudes Changes	7.2	Moderate	Medium

Note: Economic data, Budget analysis, Employment data, Service coverage data, Labor surveys, Social research, Cultural studies

Economic factors, led by soaring housing and education costs, overwhelmingly drive fertility decisions. The 400% increase in property prices over two decades establishes housing as the most critical barrier. This conclusion is supported by Liu et al. [13], who empirically demonstrated the negative correlation between house prices and fertility intentions.

5.2 International Lessons

Macao's fertility patterns align with McDonald's gender equity theory [9]. While South Korea's integrated support systems provide a valuable model, the limited success of purely economic policies in Japan and Taiwan serves as a caution. As Boling [14] notes for Japan, effective policy requires understanding the interplay of cultural and demographic factors. McNicoll [15] reinforces this, advocating for comprehensive, long-term strategies that address both social and economic dimensions of fertility decline in East Asia.

6 Policy Recommendations

Based on analysis findings and international best practices, we propose a comprehensive six-pillar policy framework designed to address Macao's ultra-low fertility crisis. This framework draws on the comprehensive policy approaches advocated by Gauthier and Gietel-Basten [11] and the lessons learned from East Asian policy experiences documented by Jones [10] and McNicoll [15].

6.1 Six-Pillar Policy Framework

This study puts forward a six-pillar framework for policy intervention aimed at addressing the declining fertility rate. Each pillar targets a specific barrier to family formation and is supported by concrete, measurable, and budgeted initiatives.

Pillar 1: Housing Reform and Support. Fertility-linked housing priority for families with multiple children; progressive housing subsidies (20% for first child, 40% for second, 60%

for third); and construction of 5,000 family-oriented housing units by 2030. Budget: 800 million MOP over 5 years.

Pillar 2: Childcare Infrastructure Expansion. Establish 50 new public childcare centers; providing workplace childcare incentives through tax credits; extended operating hours (7 AM-8 PM). Target: Increase coverage from 45% to 70%. Budget: 400 million MOP over 5 years.

Pillar 3: Work-Life Balance Enhancement. 20 days paid paternity leave (currently 0); 12 months shared parental leave; and legal entitlement to flexible schedules for parents. Budget: 200 million MOP over 5 years.

Pillar 4: Progressive Financial Support. Initiatives include progressive birth allowances (first child: 50,000 MOP; second: 100,000 MOP; third: 200,000 MOP); monthly child allowances of 2,000 MOP per child until age 18; and full tuition coverage for families with 3+ children. Budget: 600 million MOP over 5 years.

Pillar 5: Gender Equality Promotion. This pillar focuses on public education on shared domestic responsibilities; career continuity support for mothers; and anti-discrimination enforcement. Budget: 150 million MOP over 5 years.

Pillar 6: Long-term Monitoring and Adaptation. Key components include annual fertility surveys and policy impact assessment; international benchmarking and an adaptive policy framework. Budget: 100 million MOP over 5 years.

6.2 Implementation Timeline

The study recommends a phased approach to policy implementation to ensure effective rollout and adaptation over a ten-year horizon.

Phase 1 (2025-2027): Emergency interventions. Launch progressive birth allowance system; begin housing priority program; establish 20 new childcare centers. Target: Stabilize TFR decline.

Phase 2 (2028-2030): Comprehensive implementation. Complete childcare infrastructure expansion; implement full work-life balance package. Target: Achieve TFR of 1.0.

Phase 3 (2031-2035): Sustainability and optimization. Optimize policies based on impact data. Target: Approach replacement level fertility.

7 Conclusion

This study provides a comprehensive analysis of Macao's ultra-low fertility crisis, revealing a four-phase pattern with accelerating decline post-2019. Economic factors, particularly housing costs and education expenses, emerge as primary barriers, while current policies show limited effectiveness due to fragmented approaches. The study's key contributions include documenting an extreme demographic case, identifying primary barriers through systematic analysis, demonstrating policy limitations, and proposing a comprehensive six-pillar framework based on international best practices. The proposed policy framework offers a roadmap for addressing this crisis, but success depends on political commitment, sustained investment, and societal engagement.

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Author contribution statement:
Dr. Zhao provided the data evaluation models and analytical framework; Dr. Li conducted the comprehensive writing and manuscript preparation; Xie was responsible for data collection and organization.

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