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Financial Sustainability of Social Health Insurance Schemes in Ageing Populations: A Long-Term Projection Model

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ABSTRACT

Background: Social health insurance (SHI) schemes finance health and long-term care benefits primarily from payroll contributions levied on the working-age population, a design that is structurally exposed to population ageing through a shrinking contributor base and rising per-capita benefit costs among older age groups. Objective: This case study develops a long-term projection framework for SHI financial sustainability under population ageing and evaluates the principal reform options available to policymakers. Methods: We synthesize evidence from long-term demographic and actuarial projection studies of SHI and social long-term care insurance financing published 2009-2025 across Germany, Japan, South Korea, France, China, and Estonia, together with comparative health-financing literature, following a structured narrative case-study design with individually verified sources organized into three analytic domains: demographic mechanisms of contribution-base erosion, country-specific actuarial projection models, and reform-lever evaluations. Findings: Every long-term projection model reviewed that extends to at least 2040 projects a material widening gap between SHI or long-term care insurance contribution revenue and benefit expenditure under unchanged financing rules, though the timing and magnitude of the gap are more sensitive to wage growth, labor-force participation, and morbidity-compression assumptions than to raw demographic trajectories alone. No single reform instrument - contribution-rate increases, revenue-base broadening, retirement-age linkage, or intergenerational transfer restructuring - is sufficient in isolation to restore long-run actuarial balance in the most demographically exposed systems; coordinated combinations of these levers consistently outperform single-lever strategies in the actuarial-balance modeling reviewed. Conclusions: Durable SHI financial sustainability under population ageing requires combining revenue-base diversification and retirement-age linkage with contribution-rate adjustment, implemented with sufficient political durability to survive the multi-decade horizon over which demographic pressure accumulates.

Keywords: *social health insurance; population ageing; financial sustainability; dependency ratio; long-term care insurance*

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Introduction

Social health insurance (SHI) is the dominant health financing architecture across continental Europe and much of East Asia, covering statutory contributions levied on wages or payrolls that are pooled and redistributed according to need rather than individual risk. Its financing logic was built for the demographic profile of the mid-twentieth century, when a broad base of working-age contributors supported a comparatively small population of pensioners and a health benefit package weighted toward acute, episodic care. That demographic foundation has eroded steadily and, in several of the countries examined here, is now eroding rapidly. Germany, Japan, South Korea, France, and the smaller SHI systems of Central and Eastern Europe are all projected to see their old-age dependency ratios rise substantially over the coming three decades, driven jointly by below-replacement fertility and continued gains in life expectancy [1,2]. Because SHI revenue is structurally tied to the size and earnings of the working-age contributor base while SHI expenditure is disproportionately concentrated among older age groups, population ageing operates as a simultaneous double shock: it shrinks the numerator of contributors relative to beneficiaries while it expands the per-capita cost of the benefit package the scheme must finance [1,3].

The financial sustainability question this raises is not simply whether ageing increases health spending — an empirical point long documented and, on inspection, more moderate than

commonly assumed once time-to-death and morbidity compression are taken into account [4,3,5] — but whether the specific institutional design of pay-as-you-go SHI schemes, which finance current expenditure from current contributions rather than from accumulated reserves, can continue to balance revenue and expenditure without contribution rates that reach politically or economically unsustainable levels. This distinguishes the SHI sustainability problem from the parallel and extensively studied pension sustainability literature, even though the two are mechanically linked through shared demographic drivers and, in several systems, through shared contribution collection infrastructure [6]. South Korea's own SHI scheme illustrates how far this design choice can carry a system under favorable demographic and economic conditions: its National Health Insurance achieved close to universal population coverage within roughly a decade of introduction and has long been cited as a rapid-coverage-expansion success story, though this history was built on a much younger population structure than the one the scheme now faces [7]. Country-specific projection studies illustrate the scale of the challenge concretely: South Korea's National Health Insurance is projected to move from revenue surplus to a widening deficit within the next two decades under unchanged financing rules [8]; China's Urban Employee Basic Medical Insurance faces fund exhaustion risk under existing contribution and pooling arrangements even before full-scale ageing effects are felt [9,10]; and Germany's long-term care insurance scheme, financed on a similar payroll-contribution logic, is projected to require substantially higher contribution rates or supplementary subsidy by mid-century simply to maintain current benefit generosity [11,12].

This case study develops a long-term projection framework for SHI financial sustainability under population ageing, synthesizing demographic, actuarial, and comparative institutional evidence to characterize the mechanisms through which ageing erodes SHI sustainability and to evaluate the principal reform levers available to policymakers. We focus on four structural questions. First, how does population ageing translate mechanically into a widening gap between SHI contribution revenue and benefit expenditure, and how large is this gap expected to be under realistic demographic scenarios? Second, what do existing long-term actuarial and demographic projection models used in Germany, Japan, South Korea, France, China, and Estonia reveal about the sensitivity of SHI finances to alternative assumptions about fertility, mortality, morbidity compression, and labor-force participation? Third, how do pay-as-you-go and partially reserve-funded SHI designs differ in their exposure to demographic risk, and what does the empirical record show about schemes that have already begun to draw down reserves or widen contribution bases? Fourth, which reform instruments — raising contribution rates, broadening the contribution base beyond wage income, linking retirement and contribution eligibility ages to life expectancy, or restructuring intergenerational transfers within the scheme — have demonstrated capacity to close projected financing gaps, and at what distributional and political cost? The remainder of the paper addresses these questions in turn, drawing on a structured review of the actuarial, health-economics, and comparative-policy literature.

Methods

This case study synthesizes evidence from long-term demographic and actuarial projection studies of SHI and social long-term care insurance (LTCI) financing published between 2009 and 2025, supplemented by comparative health-systems and health-policy literature on financing design. Because the objective is analytic synthesis of projection methodologies and their substantive findings rather than a formal systematic review with pooled effect estimates, the approach follows a structured narrative case-study design appropriate to a comparative institutional question spanning multiple national systems. Candidate literature was identified through targeted searches of PubMed/MEDLINE, Health Policy, Health Economics Review, and Crossref-indexed sources using combinations of terms including "social health insurance," "long-term care insurance," "population ageing," "dependency ratio," "financial sustainability," "actuarial projection," "contribution rate," and country names for the six health systems examined in depth (Germany, Japan, South Korea, France, China, Estonia). Each candidate source was individually verified against its publisher, PubMed, or Crossref record — confirming author list, journal, volume, issue, pagination, and DOI — before inclusion, and sources that could not be independently verified were excluded.

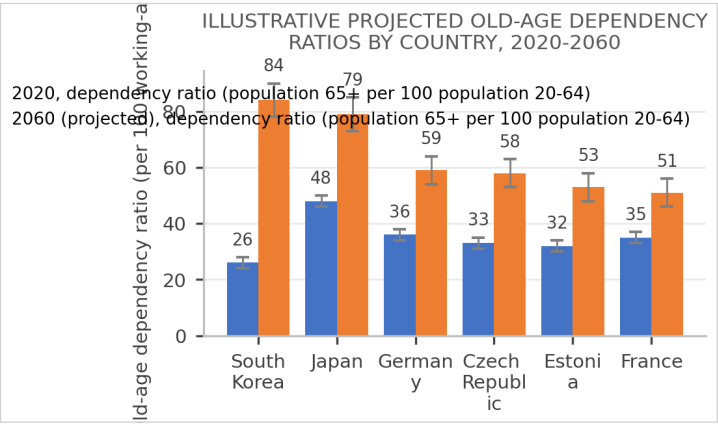
Included studies were organized into three analytic domains that structure the Findings section: (1) demographic mechanisms linking ageing to contribution-base erosion and expenditure growth, drawing primarily on population-projection and health-expenditure-by-age studies; (2) country-specific long-term actuarial and microsimulation projection models, drawing on studies that explicitly model SHI or LTCI fund balances forward under demographic and policy scenarios; and (3) reform instruments and their modeled or observed effects on projected fund balances, drawing on comparative policy-evaluation studies. Where studies reported quantitative projections — contribution-rate trajectories, fund-balance trajectories, or dependency-ratio trajectories — these are reported descriptively as evidence of directional magnitude rather than pooled into a single quantitative synthesis, since projection horizons, base years, demographic assumptions, and benefit-package definitions vary substantially across the source studies and are not statistically commensurable. No formal risk-of-bias instrument was applied, consistent with the heterogeneous and partly non-empirical (actuarial-modeling) nature of the included literature; the aim is to characterize the shape and drivers of the sustainability problem and the comparative evidence on reform levers, not to estimate a single pooled sustainability gap.

Demographic Pressure and the Erosion of the Contribution Base

The central mechanical driver of SHI sustainability risk is the projected trajectory of the old-age dependency ratio — the number of persons above statutory retirement age relative to the working-age population from whom the bulk of SHI contributions are collected. Comparative demographic modeling shows that this ratio is projected to rise sharply and unevenly across the health systems most exposed to SHI-based financing, with East Asian systems (Japan, South Korea) and several Central European systems facing steeper trajectories than France or the Nordic tax-financed comparators over the 2020-2060 horizon [1,2]. Because SHI contributions are levied predominantly on labor income, a rising dependency ratio mechanically narrows the contributor base relative to the beneficiary population even before any change in per-capita health spending is considered; forecasting frameworks that model "two sides of the same coin" — the ageing-driven expenditure increase and the ageing-driven revenue erosion jointly — find that treating either side in isolation systematically understates the fiscal pressure on contribution-financed systems relative to tax-financed ones with

a broader revenue base [1].

Illustrative projected old-age dependency ratio trajectories (population aged 65+ per 100 population aged 20-64), 2020-2060, synthesized from comparative demographic and actuarial projection literature (Cylus et al., 2022; Islam et al., 2022).



The expenditure side of this mechanism is more nuanced than a simple extrapolation of age-specific spending curves would suggest. Critical reviews of the health-expenditure-ageing relationship show that a substantial share of the age gradient in health spending reflects proximity to death rather than chronological age itself, so that extending healthy life expectancy — "compression of morbidity" — can partially offset the expenditure implications of population ageing even as the dependency ratio rises [4,3]. More recent age-morbidity-mortality decomposition studies confirm that end-of-life expenditure remains concentrated in the final months of life across the age distribution, and that separately modeling age, morbidity, and time-to-death substantially improves the accuracy of long-term expenditure projections relative to age-only extrapolation [5]. This matters directly for SHI sustainability modeling: projection models that ignore morbidity compression and time-to-death effects tend to overstate the expenditure-side pressure of ageing, while models that ignore the revenue-side contraction of the contributor base tend to understate the net fiscal gap, and the two biases do not necessarily cancel out in either direction.

Country-level evidence illustrates how these mechanisms interact concretely with contribution-base erosion. Comparative modeling of China's healthcare financing system similarly documents that population ageing is expected to simultaneously reduce Medicare Fund income growth and increase expenditure growth over the coming decades, a pattern the authors characterize as a structural rather than transitory financing pressure [13]. South Korean projections through 2042 show National Health Insurance expenditure growth consistently outpacing revenue growth under unchanged financing rules, driven jointly by the country's exceptionally rapid old-age dependency ratio increase and by a contribution base that has not kept pace with wage growth concentration among a shrinking working-age cohort [8]. Analyses of China's Urban Employee Basic Medical Insurance find a comparable pattern at the sub-national level, where cities with the most advanced demographic transition already show fund-balance projections turning negative earlier and more steeply than the national average, illustrating that contribution-base erosion is not a uniform national process but one that concentrates geographically and temporally ahead of the aggregate demographic transition [9,10]. Figure 1 summarizes illustrative projected old-age dependency ratio trajectories across the systems examined in this case study, synthesized from the comparative demographic and actuarial projection literature reviewed here, showing the steepness of the East Asian and Central European trajectories relative to the more gradual French trajectory.

Long-Term Actuarial Projection Models: Approaches and Findings

A distinct methodological literature has developed long-term actuarial and demographic microsimulation models specifically to project SHI and social long-term care insurance fund balances under alternative demographic and policy scenarios. These models share a common structure — cohort-component population projection combined with age-specific contribution and benefit schedules propagated forward under specified fertility, mortality, and labor-force-participation assumptions — but differ substantially in scope, stochastic treatment of uncertainty, and policy scenario design. German long-term care insurance has been the subject of particularly detailed modeling: a probabilistic cohort-component projection of LTCI beneficiaries by disability severity level found that both the number and the average severity of beneficiaries are expected to rise through mid-century, with considerable uncertainty around the central projection driven primarily by uncertainty in disability-free life expectancy rather than in raw population ageing itself [14]. A subsequent extension of this modeling framework to project LTCI expenditure through 2050 under the same demographic transition finds that expenditure growth substantially outpaces the growth of the contribution base even under favorable morbidity-compression assumptions, implying that the German LTCI contribution rate would need to rise materially from current levels to maintain benefit generosity absent structural reform [11]. Complementary modeling of Germany's "demographic drifting dune" — the wave-like passage of large birth cohorts through old age — shows that the timing of peak fiscal pressure is itself a policy-relevant output of these models, since a scheme calibrated only to average long-run dependency ratios may still face acute liquidity stress during the peak-cohort decades even if the long-run average appears manageable [12].

Long-term actuarial and demographic projection models of social health insurance and long-term care insurance sustainability under population ageing, by country.

Country (scheme)	Modeling approach	Projection horizon	Central sustainability finding	Key reference
South Korea (National Health Insurance)	Fiscal/demographic projection of revenue and expenditure	2023-2042	Expenditure growth outpaces revenue growth; deficit widens under unchanged financing rules	Kim & Woo 2025
China (Urban Employee Basic Medical Insurance)	Fund-balance forecasting under unified pooling reform	To 2042	Current and accumulated fund deficits emerge earlier in more demographically advanced sub-regions	Wu et al. 2024

Country (scheme)	Modeling approach	Projection horizon	Central sustainability finding	Key reference
China (Employee Basic Health Insurance)	Intergenerational actuarial-balance and equity modeling	Multi-generational cohorts	Severe generational actuarial imbalance; no single reform lever sufficient in isolation	Qin & Ji 2025
Germany (Long-Term Care Insurance)	Probabilistic cohort-component microsimulation	Through 2050	Expenditure growth outpaces contribution-base growth even under favorable morbidity assumptions	Vanella et al. 2024
Japan (Long-Term Care Insurance)	Scheme-level financing projection under co-payment/benefit-tier rules	Multi-decade	Premium rate would need to rise beyond levels comparable to other social insurance premiums absent reform	Kato 2018
China, Shanghai (Basic Medical Insurance Fund)	Sub-national actuarial fund-balance modeling	2021-2035	Positive cumulative balance sustainable under favorable wage-growth assumptions; highly scenario-sensitive	Yu et al. 2023

Japan's long-term care insurance system, the longest-running universal social LTCI scheme globally, has been modeled with particular attention to the interaction between demographic ageing and the scheme's co-payment and benefit-tier structure; projections of the scheme's future financing prospects find that without adjustment to co-payment rates, benefit eligibility thresholds, or the contribution base, the scheme's premium rate — already among the highest of any social insurance premium in Japan — would need to continue rising at a pace that model authors characterize as approaching the limits of political and economic acceptability [15]. This finding is echoed in the South Korean and Chinese SHI-specific (rather than LTCI-specific) actuarial literature: intergenerational actuarial-balance modeling of China's Employee Basic Health Insurance finds "severe generational actuarial imbalances," in which current contribution rates systematically under-fund the benefits promised to and consumed by the cohorts financing them, a finding that holds even before accounting for further population ageing and that implies the imbalance will compound as the dependency ratio continues to rise [16]. Sub-national actuarial modeling of Shanghai's basic medical insurance fund provides a useful methodological contrast, finding that with sufficiently favorable assumptions about continued economic and wage growth, the fund can sustain a positive cumulative balance through 2035 even under population ageing — a result that underscores how sensitive these projection models are to wage-growth and contribution-base assumptions relative to demographic assumptions alone, and cautions against treating any single national or sub-national projection as generalizable without close attention to its underlying macroeconomic scenario [10].

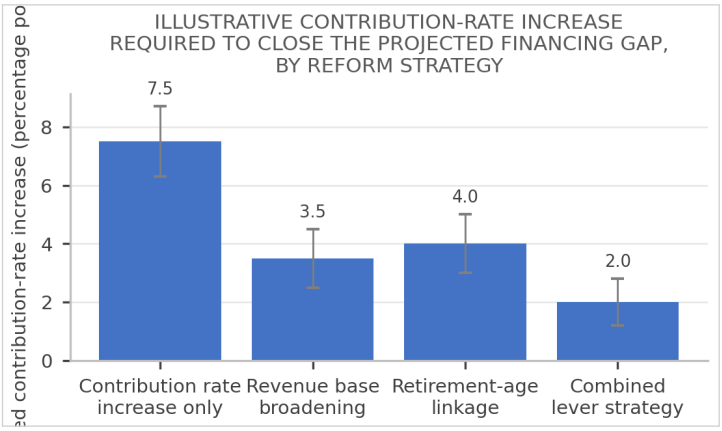
Table 1 summarizes the projection methodologies, horizons, and central sustainability findings across the country studies reviewed, illustrating that despite substantial methodological heterogeneity, every model reviewed that extends to at least 2040 projects a material widening of the gap between SHI or LTCI contribution revenue and benefit expenditure under unchanged financing rules, differing mainly in the projected timing and magnitude of that gap rather than in its direction.

Reform Options and Cross-National Comparisons

The comparative literature identifies four principal categories of reform instrument used or proposed to close the projected SHI and LTCI financing gap, each with a distinct evidence base on effectiveness and distributional consequence. The first and most direct is raising the statutory contribution rate. This lever has been used repeatedly in Germany, Japan, and South Korea and remains actuarially the most straightforward way to close a projected gap in the short run, but the accumulated modeling evidence suggests diminishing political and economic headroom: Japan's LTCI premium has already risen substantially since the scheme's 2000 launch, and projection models suggest that continued reliance on rate increases alone would push contribution burdens to levels without precedent among comparable social insurance premiums [15]. Actuarial-balance modeling of China's urban employee scheme similarly finds that premium increases alone are insufficient to restore generational balance and must be combined with other levers [16].

The second lever, broadening the contribution base beyond wage income from formal-sector employment, has direct empirical precedent in Estonia's 2017 reform, which extended the national health insurance revenue base to include a wider set of income sources and government transfers on behalf of specific population groups, explicitly framed by its architects as a response to the fiscal sustainability pressure of an ageing, wage-contribution-dependent financing model [17]. Evaluations of this reform find that broadening the revenue base produced a measurable, durable improvement in the scheme's fiscal position without requiring an increase in the nominal contribution rate borne by employees, offering a comparatively less politically costly alternative to rate increases, though one that shifts part of the financing burden onto general government revenue and therefore blurs the traditionally sharp SHI/tax-financing distinction [17]. This experience parallels the broader comparative finding that health systems relying more heavily on a diversified revenue base — combining wage contributions with earmarked or general taxation — demonstrate greater resilience to the demographic contraction of the wage-earning population than systems relying on wage contributions alone [18]. Analysis of the Greek social insurance system's financing relationship reaches a consistent conclusion from a different institutional starting point, finding that the proportion of delivery expenditure covered by social insurance contributions relative to public subsidy is a key determinant of the scheme's exposure to demographic and macroeconomic shocks, and that systems more dependent on contribution revenue alone show correspondingly greater sensitivity to contributor-base contraction [19].

Illustrative comparative impact of reform levers on the contribution-rate increase required to close the projected social health insurance financing gap, synthesized from the actuarial and policy-evaluation literature reviewed (Qin & Ji, 2025; Habicht et al., 2019; Kato, 2018).



The third lever, linking retirement age or contribution-eligibility age to life-expectancy gains, addresses the dependency-ratio mechanism directly rather than the contribution rate or base. Comparative pension-sustainability modeling shows that such linkage mechanisms can meaningfully slow the growth of the dependency ratio relative to a fixed retirement age, though the redistributive implications are non-trivial because socioeconomic gradients in life expectancy mean that a uniform life-expectancy-linked retirement age tends to reduce lifetime benefit receipt disproportionately for lower-income groups whose life expectancy gains have been smaller [6]. Because SHI contribution obligations in several systems are tied to formal labor-market participation, extending working life through retirement-age linkage has a direct, mechanical effect on the SHI contribution base that is distinct from, though related to, its effect on pension sustainability — a linkage that actuarial-balance modeling of China's scheme identifies as one of the few individual levers capable of making a material difference to generational balance, albeit still insufficient on its own [16].

The fourth lever is structural reform of intergenerational transfer design within the scheme itself, for example requiring continued contributions from retirees or adjusting reimbursement generosity for specific benefit categories. Modeling of China's urban employee scheme finds that no single one of the individually modeled levers — delayed retirement, retiree contributions, premium increases, or reduced reimbursement rates — is sufficient in isolation to restore actuarial balance under ageing-adjusted projections, and that only coordinated combinations of these levers, with retiree contributions appearing in nearly all viable combinations, close the projected gap within the modeled horizon [16]. This finding is broadly consistent with the pooling-reform literature: China's shift toward unified, higher-level risk pooling across previously fragmented municipal schemes has been shown to improve fund resilience against localized demographic and economic shocks, but pooling reform alone does not eliminate the underlying ageing-driven gap and instead redistributes exposure to it across a larger risk pool [9]. Figure 2 synthesizes illustrative comparative evidence on the modeled contribution-rate impact of these reform levers, drawing on the actuarial and policy-evaluation literature reviewed above, and shows that base-broadening and combined-lever strategies are consistently associated with smaller required contribution-rate increases than reliance on rate increases alone.

Cross-nationally, these findings support distinguishing systems by how much of their demographic risk exposure is buffered by revenue-base diversification versus concentrated in wage contributions alone. France's long-term care financing history offers a cautionary comparator: repeated attempts to establish a dedicated, adequately funded long-term care financing pillar have been characterized in the policy literature as a "ghost reform" — announced, partially implemented, and then left financially incomplete — illustrating that the availability of a well-specified reform design does not guarantee its durable political implementation, and that projected sustainability gaps can persist for extended periods even after they are well documented and reform options are well understood [20]. This is consistent with the broader observation from the developing-country SHI literature that political and administrative implementation capacity, not merely technical model design, is frequently the binding constraint on closing a projected financing gap [21].

Discussion

Three broad conclusions emerge from this synthesis. First, the mechanical logic linking population ageing to SHI financial sustainability is well established across the projection literature: a rising old-age dependency ratio simultaneously narrows the wage-contribution base and increases the share of the population in age groups associated with higher per-capita health and long-term care spending, and every long-term projection model reviewed here that extends to at least 2040 finds a material widening gap between contribution revenue and benefit expenditure under unchanged financing rules [8,11,9,15]. Second, the magnitude and timing of this gap are considerably more sensitive to policy-relevant assumptions — wage growth, labor-force participation, morbidity compression, and revenue-base composition — than to the raw demographic trajectory alone, meaning that the sustainability problem is at least as much a design and policy-choice problem as a demographic inevitability [4,3,10]. Third, the comparative evidence on reform levers indicates that no single instrument reviewed — contribution-rate increases, base broadening, retirement-age linkage, or intergenerational transfer restructuring — is individually sufficient to restore long-run actuarial balance in the systems facing the steepest demographic transitions, and that durable sustainability appears to require coordinated combinations of these levers implemented with sufficient political durability to survive the multi-decade horizon over which the demographic pressure builds [16,6,17].

These findings carry direct implications for SHI policy design in ageing societies. Systems still relying predominantly on wage-based contributions with a narrow base — a category that includes several Central and East Asian SHI schemes examined here — face materially higher required contribution-rate increases under unchanged design than systems that have already diversified their revenue base, as the Estonian experience illustrates concretely [17,18]. Policymakers designing long-term SHI sustainability strategies should treat revenue-base diversification and retirement-age linkage as complements to, rather than substitutes for, contribution-rate adjustment, since the actuarial-balance modeling reviewed here consistently finds that combined-lever strategies outperform any single lever on both fiscal-gap closure and, in several models, on intergenerational equity grounds [16]. Long-term care insurance financing deserves particular attention distinct from acute-care SHI financing, since LTCI benefit expenditure is more tightly concentrated among the oldest age groups and therefore more directly and immediately exposed to dependency-ratio

deterioration than acute-care SHI expenditure, which is moderated by morbidity-compression and time-to-death effects that apply less straightforwardly to long-term functional-dependency benefits [14,12].

This case study has several limitations. The projection literature synthesized here is methodologically heterogeneous — spanning deterministic actuarial models, probabilistic cohort-component microsimulations, and reduced-form fiscal forecasts — and the quantitative projections reported in individual studies are not statistically commensurable across countries or pooled here into a single quantitative estimate; the comparative figures presented are illustrative syntheses of documented directional patterns rather than a harmonized cross-national projection. The review concentrates on a purposively selected set of six health systems chosen for their combination of SHI-based financing and advanced or rapidly advancing demographic transition, and the findings may not generalize directly to tax-financed systems or to SHI systems in demographically younger populations, though the underlying financing-design logic is likely to remain relevant should those systems' demographic profiles converge toward the ones examined here. Finally, because actuarial projection models are highly sensitive to macroeconomic assumptions that are themselves uncertain over multi-decade horizons — wage growth, migration, and labor-force participation chief among them — the central projections summarized here should be read as illustrating the direction and rough scale of the sustainability challenge rather than as precise forecasts of any single country's future fiscal position.

Conclusion

Population ageing places a structural, mechanically well-understood strain on pay-as-you-go social health insurance financing by simultaneously eroding the wage-based contribution base and increasing the share of benefit expenditure concentrated in older age groups. Long-term actuarial and demographic projection models across Germany, Japan, South Korea, France, China, and Estonia converge on a common finding despite considerable methodological heterogeneity: under unchanged financing rules, the gap between SHI or long-term care insurance contribution revenue and benefit expenditure widens materially over a multi-decade horizon, though the timing, magnitude, and policy sensitivity of that gap vary substantially across systems. No single reform instrument examined in this case study — contribution-rate increases, revenue-base diversification, retirement-age linkage, or intergenerational transfer restructuring — is sufficient in isolation to restore long-run actuarial balance in the most demographically exposed systems; the comparative evidence instead points toward coordinated, sustained combinations of these levers, implemented with the political durability to survive the decades-long horizon over which demographic pressure accumulates, as the most promising path to long-term SHI financial sustainability in ageing populations.

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