The Healthcare Sustainability Gap: Microfoundations and Dynamic Policy Regimes

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Abstract

This paper develops a dynamic general equilibrium model where healthcare systems face dual constraints: an upper threshold determined by economic sustainability and a lower threshold arising from political acceptability. Healthcare production incorporates both expected outcomes and option value under uncertainty, while preferences exhibit reference dependence with empirically-grounded loss aversion. We prove that the gap between these thresholds partitions the policy space into three qualitatively distinct regimes. In negative gap regimes, where social demands exceed economic capacity, standard efficiency policies reduce welfare, and resolution requires either reference management or innovation-driven capacity expansion. The model's multi-dimensional reference formation process, combining historical experience, social comparison, and forward-looking expectations, generates testable predictions about cross-country expenditure persistence, asymmetric reform dynamics, and the coexistence of fiscal and adequacy crises. Our comparative statics analysis reveals how loss aversion, distributional concerns, and productivity shocks affect gap dynamics and policy effectiveness.

Keywords: Healthcare economics, reference-dependent preferences, option value, dynamic regimes, political economy
JEL Classification: I11, H51, D91, O43

1 Introduction

Healthcare systems present a fundamental theoretical puzzle that challenges standard public economics frameworks. Unlike other public goods, healthcare exhibits a systematic empirical pattern where countries with similar economic fundamentals sustain persistently different expenditure levels—ranging from 8% to 18% of GDP across OECD economies—while simultaneously generating complaints of both fiscal unsustainability and social inadequacy (OECD, 2024a,b). This dual dissatisfaction suggests that healthcare systems operate under constraints that are qualitatively different from those assumed in standard public goods theory, where a benevolent planner faces a single optimization problem subject to resource constraints.

The existing literature has approached healthcare spending determination through three distinct theoretical traditions, each addressing only partial aspects of the problem. The optimal growth literature, exemplified by Hall and Jones (2007) and Ehrlich and Yin (2014), treats healthcare as an input into utility and production functions, deriving spending levels

through standard dynamic optimization. The political economy literature, including, among others, Becker (1983), Immergut (1992),Steinmo and Watts (1995) and Grossman and Helpman (2001), emphasizes institutional factors and interest group dynamics but treats preferences as fixed and does not provide microfoundations for how political constraints emerge from individual behavior. This literature could be useful to explain cross-country variation in healthcare institutions but cannot explain why similar institutional structures generate different spending levels or why healthcare reforms face systematically stronger resistance than equivalent reforms in other sectors.

The behavioral economics literature, pioneered by Kahneman and Tversky (1979) and formalized by Kőszegi and Rabin (2006), has established that individual preferences exhibit reference dependence and loss aversion, but these insights have not been systematically integrated into models of aggregate healthcare spending or political economy. Viscusi and Huber (2012) demonstrate these effects specifically in health risk valuation, but the implications for macroeconomic healthcare policy remain unexplored.

We argue that these literatures have failed to address a fundamental theoretical problem: healthcare systems face dual optimization problems that cannot be reduced to a single constraint. The economic constraint emerges from healthcare's role as both a consumption good providing direct utility and an investment good affecting future productive capacity. The political constraint arises from the fact that healthcare outcomes are evaluated relative to endogenous reference points that incorporate historical experience, social comparisons, and expectations about technological progress. These constraints are not merely different expressions of the same underlying optimization problem but reflect fundamentally distinct economic mechanisms.

This insight motivates our central theoretical innovation: the healthcare sustainability gap, defined as the difference between the maximum economically sustainable healthcare expenditure and the minimum politically acceptable level. This gap represents more than an accounting identity—it captures the policy space available to governments and determines which policy interventions are theoretically feasible. Positive gaps indicate standard welfare maximization applies, zero gaps require precise dynamic coordination, and negative gaps create impossibility regions where no feasible allocation satisfies both constraints simultaneously.

The theoretical framework we develop makes three fundamental contributions to the literature. First, we provide rigorous microfoundations for both the economic and political constraints by incorporating two key innovations that existing models have either ignored or treated separately. On the production side, we model healthcare as generating both expected outcomes and option value under uncertainty, formalizing why healthcare systems optimally maintain apparent excess capacity that pure efficiency models would eliminate. This option value component is theoretically crucial because it explains the empirical puzzle of why healthcare systems appear inefficient by static measures (Anderson and Poullier, 1999; WHO, 2000; Anderson et al., 2003) while being optimal in dynamic settings with uncertain health shocks (Levaggi et al., 2012; Camejo et al., 2017; Philipson and Zanjani, 2014; de Mello-Sampayo, 2024). On the preference side, we incorporate reference-dependent utility into a dynamic political economy framework. This is not merely a behavioral add-on but fundamentally alters the structure of the political constraint. Unlike standard models where political support is a monotonic function of objective outcomes (Kramer, 1971; Fiorina,

1981), we argue in line of (Persson, 2024; Lleras et al., 2019; Passarelli and Del Ponte, 2020) that reference dependence creates discontinuous political support functions with asymmetric responses to gains and losses. Loss aversion amplifies the political cost of benefit reductions relative to equivalent expansions, generating the empirical pattern of asymmetric reform resistance that standard models cannot explain.

Second, we prove that the interaction between economic and political constraints creates qualitatively distinct policy regimes that require different theoretical approaches. In positive gap regimes, the political constraint is slack and standard welfare maximization applies. In zero gap regimes, both constraints bind simultaneously, requiring dynamic coordination between economic adjustment and reference adaptation. In negative gap regimes, no feasible allocation satisfies both constraints, necessitating either reference management to reduce political demands or innovation to expand economic capacity before traditional efficiency reforms become theoretically viable.

This regime classification solves a theoretical puzzle that has persisted in the literature: why economically sound healthcare reforms often fail politically even when they promise clear efficiency gains. The answer is that in negative gap regimes, efficiency improvements that ignore the political constraint actually reduce social welfare by creating unsustainable political tensions. This result inverts the standard presumption that efficiency improvements are always welfare-enhancing and provides theoretical foundations for understanding when and why political considerations should dominate economic efficiency in policy design.

Third, we characterize the dynamic evolution of the sustainability gap and establish conditions for multiple equilibria. The gap evolves according to a system of differential equations where the upper threshold responds to productivity growth, capital accumulation, and health technology advances, while the lower threshold adjusts through reference adaptation, social comparison effects, and expectational updating. We prove that when social comparison effects exceed a critical threshold determined by loss aversion parameters and adaptation speeds, the system exhibits multiple stable equilibria corresponding to low-expenditure and high-expenditure healthcare systems.

This multiple equilibria result provides theoretical foundations for explaining the persistent cross-country variation in healthcare spending that cannot be explained by differences in economic fundamentals alone. Countries with similar productive capacity and demographic structure can sustain vastly different healthcare systems because they have converged to different equilibria determined by historical experience and initial conditions rather than current economic parameters.

Our analysis demonstrates that the standard separation between positive and normative economics breaks down in healthcare contexts. The political constraint is not an external impediment to economic efficiency but an integral part of the social welfare function when preferences exhibit reference dependence. Policies that appear efficient under standard welfare criteria may be inferior under reference-dependent preferences, and the optimal policy depends critically on the gap regime and reference dynamics.

The remainder of the paper develops these insights formally. Section 2 presents the theoretical framework, incorporating healthcare production technology with option value, reference-dependent preferences, and endogenous political constraints. Section 3 characterizes the dual threshold system and establishes existence of the sustainability gap. Section 4 analyzes system dynamics, stability conditions, and multiple equilibria existence. Section 5 is

devoted to the comparative statics analysis. Section 6 evaluates regime-dependent optimal policies and their implications for management strategies. Section 7 concludes.

2 Model Environment

2.1 Healthcare Production Technology

Healthcare outcomes for condition $j \in \{1, ..., m\}$ are produced according to:

$$\mathcal{F}_j(\boldsymbol{h}, \boldsymbol{\theta}, \boldsymbol{\sigma}) = f_j(\boldsymbol{h}, \boldsymbol{\alpha}, \boldsymbol{\gamma}) + \phi_j(\boldsymbol{h}, \boldsymbol{\sigma}, \boldsymbol{\delta}, \boldsymbol{\kappa}) \cdot \xi_j \tag{1}$$

where $\boldsymbol{h} = (h_p, h_a, h_c)$ represents resources allocated to preventive, acute, and chronic care respectively. The expected outcome function is:

$$f_j(\boldsymbol{h}, \boldsymbol{\alpha}, \boldsymbol{\gamma}) = \sum_{i \in \{p,a,c\}} \alpha_{ij} h_i^{\gamma_{ij}} \tag{2}$$

with $\alpha_{ij} > 0$ representing baseline productivity and $\gamma_{ij} \in (0, 1)$ capturing diminishing returns.
The resilience function:

$$\phi_j(\boldsymbol{h}, \boldsymbol{\sigma}, \boldsymbol{\delta}, \boldsymbol{\kappa}) = \sum_{i \in \{p,a,c\}} \delta_{ij} \cdot \frac{h_i^{\kappa_{ij}}}{\sigma_j} \tag{3}$$

determines how resource allocation affects the system's response to stochastic shocks ξ_j with variance σ_j^2. The parameters $\delta_{ij} > 0$ and $\kappa_{ij} \in (0, 1)$ govern the effectiveness of each care type in building resilience.
This specification embeds crucial economic insights. The separation of expected outcomes from resilience captures that healthcare investments serve dual purposes: improving average health and providing insurance against health crises. The multi-dimensional input structure recognizes that different care types are imperfect substitutes with condition-specific productivities. The interaction between resources and uncertainty through the resilience function explains why optimal capacity exceeds average utilization—apparent inefficiency that provides essential option value.

2.2 Aggregate Economy

The economy produces output using physical capital K, labor L, and population health capital H:

$$Y_t = A_t K_t^{\alpha} L_t^{\beta} H_t^{\gamma} \tag{4}$$

where $\alpha + \beta + \gamma = 1$ and health capital is:

$$H_t = \sum_{j=1}^{m} \omega_j \mathcal{F}_j(\boldsymbol{h}_t, \boldsymbol{\theta}_t, \boldsymbol{\sigma}_t) \tag{5}$$

with ω_j representing the contribution of health condition j to aggregate productivity.

Capital accumulates according to:

$$\dot{K}_t = Y_t - C_t - \sum_{i \in \{p,a,c\}} h_{i,t} - \delta K_t \tag{6}$$

The government chooses healthcare allocations to maximize social welfare subject to economic and political constraints.

2.3 Reference-Dependent Preferences

Individual utility exhibits reference dependence across health outcomes:

$$\mathcal{U}(\boldsymbol{o}, \boldsymbol{r}, \lambda) = \sum_{j=1}^{m} \left[v(o_j - r_j) \cdot \mathbb{1}_{o_j \geq r_j} + \lambda \cdot v(o_j - r_j) \cdot \mathbb{1}_{o_j < r_j} \right] \tag{7}$$

where $\boldsymbol{o} \in \mathcal{O}$ represents actual health outcomes; $\boldsymbol{r} \in \mathcal{O}$ represents reference health outcomes; $\lambda \in \Lambda = [1, \infty)$ is the loss aversion parameter; and $v(x) = x^\tau$ with $\tau \in (0, 1)$ capturing diminishing sensitivity. Empirical studies estimate $\lambda \in [1.820, 2.102]$ (**?**).
This functional form embeds three behavioral regularities: reference dependence (utility depends on deviations rather than levels), loss aversion (losses weighted by $\lambda > 1$), and diminishing sensitivity (concavity in gains and convexity in losses). The multi-dimensional structure recognizes that people evaluate different health outcomes separately rather than aggregating into a single health index.

2.4 Reference Formation and Dynamics

A critical element of our framework is the dynamic process through which reference points evolve. Reference points in healthcare are not arbitrarily determined but emerge from systematic processes that include historical experience, social comparison, and forward-looking expectations.

Definition 1 (Reference Formation Process)**.** *The reference formation process $\mathcal{R} : \mathcal{T} \times \Omega \to \mathcal{O}$ maps time $t \in \mathcal{T} = \mathbb{R}_+$ and reference weights $\boldsymbol{\omega} \in \Omega$ to reference outcomes:*

$$\boldsymbol{r}(t) = \mathcal{R}(t, \boldsymbol{\omega}) = \omega_H \boldsymbol{r}_H(t) + \omega_S \boldsymbol{r}_S(t) + \omega_E \boldsymbol{r}_E(t) \tag{8}$$

where $\boldsymbol{r}_H(t)$ represents historical experience (adaptive expectations), $\boldsymbol{r}_S(t)$ represents social comparisons (peer effects), and $\boldsymbol{r}_E(t)$ represents forward-looking expectations (rational anticipation). The weights $\boldsymbol{\omega} = (\omega_H, \omega_S, \omega_E)$ satisfy $\omega_H + \omega_S + \omega_E = 1$ and may vary across populations. This multidimensional approach to reference formation generates novel insights into the political economy of healthcare across heterogeneous national settings. When social comparison weights (ω_S) dominate the reference bundle, a distinctive phenomenon of "healthcare envy" emerges, wherein objective improvements in health outcomes yield diminishing marginal utility once benchmarked against foreign standards. This dynamic, termed "reference inflation," leads to systematic misalignment between objective welfare gains and perceived utility improvements.
The historical reference component (ω_H) operates as a persistence mechanism, embedding institutional memory and expectational inertia into the evolution of healthcare systems. As

a result, systems with initially similar structures can diverge substantially over time due to path-dependent reference trajectories. In parallel, the expectational reference component (ω_E) induces "anticipatory reference drift," wherein expectations regarding future technological advancements reshape contemporaneous utility evaluations, even in the absence of material adoption.

The endogeneity of reference structures introduces challenges for healthcare policy that are not captured by static welfare frameworks. Policy interventions recalibrate agents' reference points, thereby altering subsequent welfare evaluations. This recursive feature implies that welfare effects are path-dependent and that reforms may generate dynamic political economy constraints not visible ex ante. In settings where the elasticities of social and expectational references (ω_S, ω_E) exceed economic growth rates, aspirational dynamics may outpace feasible improvements, generating unstable expectational spirals. However, this endogeneity also creates a potential margin for "strategic reference management," wherein institutional design influences the formation and weighting of references to mitigate destabilizing dynamics.

Reference-dependent utility fundamentally alters the welfare implications of healthcare reform. Reforms that are welfare-enhancing under conventional, reference-invariant specifications may fail to generate positive utility changes once endogenous reference adjustments are considered. This mechanism provides a unified explanation for the recurrent failure of ostensibly efficient healthcare reforms across diverse settings. Successful reforms, when viewed through the reference-dependent framework, systematically manage reference evolution alongside technical optimization.

Moreover, reform strategies that combine selective contractions with targeted expansions can exploit the concavity of the value function $v(\cdot)$, generating welfare gains overlooked by additive welfare comparisons. Staggered implementation sequences attenuate loss aversion effects through gradual reference updating (ψ), smoothing welfare transitions across reform stages. In addition, "referential reframing"—the strategic adjustment of ω_H, ω_S, and ω_E—can alter welfare outcomes without modifying the underlying policy content, explaining cross-country heterogeneity in reform success despite similar objective capacities.

The framework also rationalizes the asymmetric ratchet effect observed in healthcare provision. Once incorporated into the reference bundle, services become subject to loss aversion, rendering their removal welfare-decreasing to a greater extent than their introduction was welfare-enhancing. Consequently, healthcare systems, even under fiscal pressure, rarely contract service portfolios in absolute terms. Instead, rationing mechanisms shift toward quality reductions, waiting time increases, and administrative barriers that reduce service salience while maintaining formal coverage levels.

Heterogeneous reference elasticities across service types imply additional reform strategies. Services with high frequency or social visibility exhibit substantially greater reference sensitivity than specialized, low-visibility services. Thus, sequencing reforms to initially target areas of low reference salience can build reform momentum and political capital before addressing highly salient domains. This sequencing logic, while inconsistent with static welfare prioritization, aligns with observed patterns in successful healthcare system transformations.

Finally, where multiple reference dimensions interact, reforms may induce "reference polarization," generating welfare divergence across subpopulations with heterogeneous reference

structures. This dynamic accounts for the observed fragmentation of public support for healthcare reforms, even when objective gains are broadly distributed. Heterogeneous reference architectures thus create endogenous political cleavages that standard interest-based models fail to predict.

The temporal evolution of reference points follows:

$$\dot{\boldsymbol{r}}_H(t) = \psi_H[\boldsymbol{o}(t) - \boldsymbol{r}_H(t)] \tag{9}$$

where $\psi_H > 0$ is the adaptation speed parameter—how quickly social expectations adjust to experienced reality. Higher values of ψ indicate more flexible expectations and faster adaptation; lower values indicate stickier expectations that adjust more slowly.

Social references incorporate domestic and international comparisons:

$$\boldsymbol{r}_S(t) = \theta_d \bar{\boldsymbol{o}}_{domestic}(t) + \theta_f \bar{\boldsymbol{o}}_{foreign}(t) \tag{10}$$

Expectational references depend on anticipated technological and economic progress:

$$\boldsymbol{r}_E(t) = \mathbb{E}_t[\boldsymbol{o}(t+T)|\text{technology trends}] \tag{11}$$

The complete reference dynamics are:

Lemma 1 (Reference Adaptation Dynamics)**.** *The temporal evolution of reference points follows:*

$$\frac{d\boldsymbol{r}(t)}{dt} = \psi \cdot (\boldsymbol{o}(t) - \boldsymbol{r}(t)) + \sum_{j \in \{H,S,E\}} \frac{\partial \boldsymbol{r}}{\partial \omega_j} \cdot \frac{d\omega_j}{dt} \tag{12}$$

where $\frac{d\omega_j}{dt}$ captures shifts in the weights of different reference components. It captures changes in how reference points themselves are formed—whether people place more weight on historical experience, social comparisons, or future expectations. The term $\sum_{j \in \{H,S,E\}} \frac{\partial \boldsymbol{r}}{\partial \omega_j} \cdot \frac{d\omega_j}{dt}$ captures changes in how reference points themselves are formed—whether people place more weight on historical experience, social comparisons, or future expectations.

This rich reference structure captures how expectations form and evolve. Historical adaptation creates persistence, social comparison generates international spillovers, and forward-looking expectations link technological possibilities to political demands. The endogenous weights allow for structural changes in how references form, such as increased international awareness shifting weight toward social comparisons. In steady state, when $\frac{d\boldsymbol{r}(t)}{dt} = 0$ and assuming constant weights ($\frac{d\omega_j}{dt} = 0$), we have:

$$\psi \cdot (\boldsymbol{o}(t) - \boldsymbol{r}(t)) = 0 \tag{13}$$

This implies $\boldsymbol{r}(t) = \boldsymbol{o}(t)$, meaning that in long-run equilibrium, reference points fully adapt to experienced outcomes. This theoretical result explains why populations eventually accommodate to almost any level of healthcare provision, provided it remains stable long enough.

For a fixed $\boldsymbol{o}(t) = \boldsymbol{o}^*$ and constant weights, the solution to the differential equation is:

$$\boldsymbol{r}(t) = \boldsymbol{o}^* + (\boldsymbol{r}(0) - \boldsymbol{o}^*) \cdot e^{-\psi t} \tag{14}$$

This shows exponential convergence of reference points to actual outcomes at a rate determined by ψ. The half-life of the adjustment is $\frac{\ln(2)}{\psi}$.
In reality, adaptation often exhibits asymmetry: upward adjustments of references (when $\boldsymbol{o}(t) > \boldsymbol{r}(t)$) may occur faster than downward adjustments (when $\boldsymbol{o}(t) < \boldsymbol{r}(t)$). This asymmetry could be modeled by allowing ψ to depend on the sign of $(\boldsymbol{o}(t) - \boldsymbol{r}(t))$:

$$\psi = \begin{cases} \psi^+ & \text{if } \boldsymbol{o}(t) > \boldsymbol{r}(t) \\ \psi^- & \text{if } \boldsymbol{o}(t) < \boldsymbol{r}(t) \end{cases} \tag{15}$$

With typically $\psi^+ > \psi^-$, capturing the empirical reality that expectations adjust upward more readily than downward.
The reference adaptation dynamics equation yields significant implications for healthcare policy design and implementation. When crafting reforms, policymakers must incorporate reference adaptation mechanisms into their strategic planning. For service reductions, gradual implementation enables reference points to adapt through the $\psi \cdot (\boldsymbol{o}(t) - \boldsymbol{r}(t))$ term, thereby mitigating welfare losses stemming from loss aversion. Economic or health crises often temporarily increase adaptation speed ψ as populations demonstrate greater willingness to adjust expectations, creating strategic "reform windows" where previously politically infeasible changes become implementable. Beyond modifying outcomes directly, policymakers can strategically influence reference formation weights ($\frac{d\omega_j}{dt}$ terms) by emphasizing historical context (ω_H) over potentially destabilizing international comparisons (ω_S).
The adaptation mechanism also explains healthcare systems' pronounced path dependence characteristics. Once reference points adapt to specific provision levels, any deviations generate welfare reductions due to loss aversion, establishing lock-in effects even when the original provision level was economically suboptimal. This creates hysteresis where temporary shocks produce permanent system changes if maintained long enough to shift reference points. Furthermore, adaptation speed (ψ) directly correlates with reform feasibility—slower adaptation increases political costs of reforms, explaining why healthcare systems with lower ψ values demonstrate heightened reform resistance.

3 Equilibrium and Threshold Determination

3.1 Comprehensive Social Welfare Functional

We construct a social welfare functional that incorporates both distributional concerns and reference-dependent preferences. For a continuum of agents indexed by income $y \in Y = [y_{\min}, y_{\max}]$ with distribution $F(y)$ and density $f(y)$, social welfare is:

Definition 2 (Social Welfare Functional)**.** *The social welfare functional* $\mathcal{S} : \mathcal{O} \times \mathcal{O} \times \Lambda \times \mathbb{R}_+ \to \mathbb{R}$ *is defined as:*

$$\mathcal{S}(\boldsymbol{o}, \boldsymbol{r}, \lambda, \nu) = \int_{\Xi} w(y; \nu) \cdot \mathcal{U}(\boldsymbol{o}(y, \boldsymbol{h}), \boldsymbol{r}(y), \lambda)\, f(y)\, dy \tag{16}$$

The distributional weight function $w(y) = (\bar{y}/y)^\nu$ with $\nu \geq 0$ captures social preference for equality. When $\nu = 0$, we have utilitarian welfare; as ν increases, the social planner

places greater weight on the health outcomes of lower-income individuals. The reference-dependent utility $\mathcal{U}$ ensures that welfare depends not only on absolute health outcomes but also on how they compare to reference points, with losses weighted more heavily than gains. The social welfare functional exhibits several important properties. First, it is not globally concave due to the kink in reference-dependent utility at $o_j = r_j$. This non-concavity has profound implications: small policy changes near reference points can have discontinuous welfare effects, creating political resistance to reforms that push outcomes below references. Second, the interaction between distributional weights and reference dependence creates complex cross-sectional effects. Healthcare cuts that disproportionately affect low-income individuals generate larger welfare losses both through the distributional weight $w(y)$ and through loss aversion if these individuals fall below their reference points.

this welfare formulation introduces new insights along three dimensions. First, it explicitly disentangles distributional concerns from individual welfare assessments. By separating the normative weighting function $w(y;\nu)$ from the descriptive utility function $\mathcal{U}(\cdot)$, we bring equity considerations to the forefront without sacrificing analytical rigor. Traditional cost-effectiveness approaches have long operated under the veil of equal welfare weights—a simplification that obscures the distributional judgments inherently embedded in healthcare resource allocation decisions.

The model's integration across the population distribution $f(y)$ offers a second advantage: the ability to capture heterogeneous impacts across population subgroups. This explains an often-observed phenomenon in comparative healthcare analysis—systems with comparable average outcomes can generate substantially different social welfare depending on the distribution of these outcomes. Consider two healthcare systems with identical mean health outcomes: one achieving excellence for advantaged populations while leaving disadvantaged groups behind, and another providing more modest but equitably distributed benefits. Under progressive welfare weights, the latter system produces higher social welfare despite potentially lower average outcomes—a result that aligns with widespread ethical intuitions but eludes standard efficiency analyses.

Third, our approach recognizes the interplay between health outcomes $\boldsymbol{o}(y)$ and broader resource considerations $\boldsymbol{r}(y)$. This connection illuminates why identical health outcomes may generate divergent welfare effects depending on financing mechanisms. Healthcare systems relying on progressive financing typically yield higher welfare evaluations than those using regressive mechanisms, even when delivering identical health outcomes. Such differences emerge naturally from our model but remain invisible in frameworks that evaluate health outcomes in isolation from their financing implications.

The model's functional flexibility accommodates the diverse social welfare preferences observed across societies—from strongly egalitarian approaches that substantially weight disadvantaged populations to more utilitarian frameworks with relatively flat welfare weights. This flexibility helps explain what otherwise appears puzzling: societies with comparable economic resources and technological capabilities often make dramatically different healthcare allocation choices. Through our lens, these differences reflect not merely different optimization constraints, but more fundamentally, different societal judgments about distributional concerns embedded in their respective welfare functions.

3.2 Upper Threshold: Economic Sustainability

The upper threshold emerges from constrained optimization of intertemporal social welfare. The planner's problem is:

$$\max_{\{\boldsymbol{h}_t\}} \int_0^\infty e^{-\rho t} \mathcal{W}[\boldsymbol{h}_t] dt \tag{17}$$

subject to the resource constraint, capital accumulation, and health production technology. Define the healthcare expenditure share as $\theta_t = \sum_i h_{i,t}/Y_t$. The current-value Hamiltonian is:

$$\mathcal{H} = \mathcal{W}[\boldsymbol{h}] + q[\dot{K}] + p[\dot{H}] \tag{18}$$

where q and p are co-state variables for physical and health capital.
The first-order conditions for optimal healthcare allocation across care types yield:

$$\frac{\partial \mathcal{W}}{\partial h_i} = q \quad \forall i \in \{p, a, c\} \tag{19}$$

In steady state, these conditions implicitly define the optimal healthcare share. The envelope theorem applied to the value function establishes:

Theorem 1 (Upper Threshold Characterization)**.** *The economically sustainable healthcare share θ_U^E satisfies:*

$$\theta_U^E = \arg\max_\theta V(\theta) \text{ subject to } \lim_{t\to\infty} K_t > 0 \tag{20}$$

where $V(\theta)$ represents steady-state welfare as a function of the healthcare share.

The economic intuition is powerful. The upper threshold represents the healthcare share that maximizes long-run welfare while maintaining capital accumulation. Healthcare investment beyond this level reduces growth sufficiently to lower intertemporal welfare despite short-term health gains. The threshold depends on the productivity of health in generating output (parameter γ), the effectiveness of healthcare in producing health outcomes (parameters α_{ij} and γ_{ij}), and the value of resilience against health shocks (parameters δ_{ij} and σ_j).

3.3 Lower Threshold: Political Acceptability

The lower threshold emerges from political survival constraints. The government maintains power if and only if political support exceeds threshold $\bar{S}$:

$$S(\boldsymbol{h}) = \int_Y \sigma(y) \cdot \mathbb{1}[\mathcal{U}(\boldsymbol{o}(y), \boldsymbol{r}(y), \lambda) \geq \bar{U}(y)] dF(y) \geq \bar{S} \tag{21}$$

where $\sigma(y)$ represents political influence and $\bar{U}(y)$ is the reservation utility for support.
Loss aversion creates a discontinuity in political support when outcomes fall below references. The political support function exhibits a sharp drop when $o_j < r_j$ for a significant portion of the population, as utility falls by factor $\lambda > 1$. This creates a minimum healthcare expenditure below which government survival is threatened:

Theorem 2 (Lower Threshold Characterization)**.** *The minimum politically acceptable healthcare share θ_L^E satisfies:*

$$\theta_L^E = \min\{\theta : S(\theta) \geq \bar{S}\} \tag{22}$$

Moreover, θ_L^E is increasing in λ, $\boldsymbol{r}$, and the weight on social comparisons ω_S.

The political constraint binds when healthcare falls below reference levels for a critical mass of voters. Loss aversion amplifies the political cost of shortfalls, while higher references tighten the constraint. Social comparison effects create international spillovers—healthcare expansions abroad raise domestic political pressure through the reference channel.

3.4 The Sustainability Gap

Definition 3 (Healthcare Sustainability Gap)**.** *The sustainability gap is:*

$$G^E(t) = \theta_U^E(t) - \theta_L^E(t) \tag{23}$$

The gap partitions the policy space into three regimes:

Proposition 1 (Policy Regime Classification)**.** *The sign of G^E determines the applicable policy regime:*

(i) $G^E > 0$*: Standard welfare maximization subject to* $\theta \leq \theta_U^E$

(ii) $G^E = 0$*: Knife-edge coordination with* $\theta = \theta_U^E = \theta_L^E$

(iii) $G^E < 0$*: Policy impossibility requiring structural intervention*

Each regime exhibits distinct dynamics and requires different policy approaches. Positive gaps permit standard optimization, zero gaps demand precise balance, and negative gaps create fundamental tensions requiring innovation or expectation management.

4 Dynamic Analysis

4.1 Gap Evolution Dynamics

The sustainability gap evolves over time according to a complex dynamic process that integrates economic, social, and psychological factors. The upper threshold dynamics follow from the envelope theorem applied to the planner's problem:

$$\dot{\theta}_U^E = \frac{\partial \theta_U^E}{\partial A}\dot{A} + \frac{\partial \theta_U^E}{\partial \boldsymbol{\theta}} \cdot \dot{\boldsymbol{\theta}} + \frac{\partial \theta_U^E}{\partial K}\dot{K} + \frac{\partial \theta_U^E}{\partial \boldsymbol{\sigma}} \cdot \dot{\boldsymbol{\sigma}} \tag{24}$$

Each term has clear economic interpretation. Productivity growth ($\dot{A} > 0$) increases the upper threshold by raising the economy's capacity to support healthcare. Medical technology improvements ($\dot{\boldsymbol{\theta}} > 0$) increase healthcare productivity, justifying higher expenditure. Capital accumulation ($\dot{K} > 0$) provides resources for healthcare expansion. Changes in health uncertainty ($\dot{\boldsymbol{\sigma}}$) affect the option value of healthcare capacity.

The lower threshold evolves according to:

$$\dot{\theta}_L^E = \frac{\partial \theta_L^E}{\partial \boldsymbol{r}} \cdot \dot{\boldsymbol{r}} + \frac{\partial \theta_L^E}{\partial \lambda} \dot{\lambda} + \frac{\partial \theta_L^E}{\partial \nu} \dot{\nu} + \frac{\partial \theta_L^E}{\partial \boldsymbol{\omega}} \cdot \dot{\boldsymbol{\omega}} \tag{25}$$

Reference adaptation ($\dot{\boldsymbol{r}}$) directly affects political demands. Changes in loss aversion ($\dot{\lambda}$) alter the political cost of falling below references. Evolving distributional preferences ($\dot{\nu}$) change the political weight of healthcare inequality. Shifts in reference formation weights ($\dot{\boldsymbol{\omega}}$) reflect structural changes in how expectations form.
Combining these yields the gap evolution equation:

$$\dot{G}^E = \dot{\theta}_U^E - \dot{\theta}_L^E \tag{26}$$

4.2 Stability Analysis and Convergence Properties

The dynamic system exhibits rich behavior best understood through linearization around steady state. Define the state vector $\boldsymbol{X} = (\theta_U^E, \theta_L^E)'$ with steady state $\boldsymbol{X}^* = (\theta_U^{E*}, \theta_L^{E*})'$. The linearized dynamics are:

$$\dot{\tilde{\boldsymbol{X}}} = J\tilde{\boldsymbol{X}} \tag{27}$$

where $\tilde{\boldsymbol{X}} = \boldsymbol{X} - \boldsymbol{X}^*$ and the Jacobian is:

$$J = \begin{pmatrix} \frac{\partial \dot{\theta}_U^E}{\partial \theta_U^E} & \frac{\partial \dot{\theta}_U^E}{\partial \theta_L^E} \\ \frac{\partial \dot{\theta}_L^E}{\partial \theta_U^E} & \frac{\partial \dot{\theta}_L^E}{\partial \theta_L^E} \end{pmatrix} \tag{28}$$

Theorem 3 (Stability Conditions)**.** *The steady state is locally asymptotically stable if and only if:*

$$\psi < \psi^* \equiv \frac{|tr(J)|}{2\lambda\tau\omega_S \frac{\partial^2 S}{\partial \boldsymbol{r}^2}} \tag{29}$$

where ψ^* is the critical adaptation speed.

The stability condition reveals that excessively rapid reference adaptation destabilizes the system. When $\psi > \psi^*$, references adjust faster than economic capacity can respond, creating expectation spirals. The critical speed decreases with loss aversion (λ) and social comparison intensity (ω_S), suggesting that behavioral factors can undermine system stability.
For convergence analysis, consider the gap dynamics near steady state:

$$\dot{\tilde{G}}^E = (\lambda_1 - \lambda_2)\tilde{G}^E + \text{higher order terms} \tag{30}$$

where λ_1 and λ_2 are eigenvalues of J. Convergence requires $\lambda_1 - \lambda_2 < 0$.

Proposition 2 (Convergence Speed)**.** *When stable, the gap converges to steady state at rate:*

$$G^E(t) - G^{E*} = (G^E(0) - G^{E*})e^{-\zeta t} \tag{31}$$

where $\zeta = -(\lambda_1 - \lambda_2) > 0$ is the convergence speed.

The convergence speed depends on structural parameters. Higher productivity growth accelerates convergence by expanding economic capacity. Stronger loss aversion slows convergence by amplifying political resistance to adjustment. The half-life of gap deviations is $t_{1/2} = \ln(2)/\zeta$, providing an empirically testable prediction.

4.3 Parameter Response Analysis

We analyze how the gap responds to changes in key parameters through comparative dynamics. Consider a permanent shock to parameter χ at time t_0. The gap response is:

$$\frac{dG^E}{d\chi} = \frac{\partial \theta_U^E}{\partial \chi} - \frac{\partial \theta_L^E}{\partial \chi} + \int_{t_0}^{\infty} e^{-\rho(s-t_0)} \frac{\partial \dot{G}^E}{\partial \chi} ds \tag{32}$$

The first two terms capture direct effects on the thresholds, while the integral captures dynamic adjustment effects. For key parameters:

Technology Shock ($d\theta > 0$): Medical innovation increases the upper threshold by raising healthcare productivity. The effect on the lower threshold is ambiguous—better technology may raise expectations, partially offsetting the gap expansion. The net effect is:

$$\frac{dG^E}{d\theta} = \underbrace{\frac{\alpha Y}{H} \sum_j \omega_j \frac{\partial \mathcal{F}_j}{\partial \theta}}_{(+)\text{ productivity effect}} - \underbrace{\omega_E \frac{\partial S}{\partial r_E} \frac{dr_E}{d\theta}}_{(-)\text{ expectation effect}} \tag{33}$$

Loss Aversion Increase ($d\lambda > 0$): Higher loss aversion raises the lower threshold without affecting the upper threshold, shrinking the gap:

$$\frac{dG^E}{d\lambda} = -\int_Y \sigma(y)\mu(h-r)\mathbb{1}_{h<r} f(y) dy < 0 \tag{34}$$

Distributional Concern Increase ($d\nu > 0$): Stronger preference for equality affects both thresholds. The upper threshold may increase if healthcare has progressive incidence. The lower threshold increases if political support depends on serving disadvantaged groups:

$$\frac{dG^E}{d\nu} = \frac{\partial V}{\partial \nu} \frac{\partial \theta_U^E}{\partial V} - \frac{\partial S}{\partial \nu} \frac{\partial \theta_L^E}{\partial S} \tag{35}$$

Uncertainty Reduction ($d\sigma < 0$): Lower health uncertainty reduces the option value of excess capacity, potentially lowering the upper threshold. The effect depends on risk preferences and the resilience function:

$$\frac{dG^E}{d\sigma} = -\sum_j \frac{\partial V}{\partial \mathbb{E}[U]} \frac{\partial \mathbb{E}[U]}{\partial \phi_j} \frac{\delta_{ij} h_i^{\kappa_{ij}}}{\sigma_j^2} \tag{36}$$

4.4 Phase Dynamics and Multiple Equilibria

The nonlinear dynamics can generate multiple steady states when the nullclines $\dot{\theta}_U^E = 0$ and $\dot{\theta}_L^E = 0$ intersect multiple times. This occurs when the lower threshold nullcline exhibits sufficient curvature due to reference effects.

Theorem 4 (Conditions for Multiple Equilibria)**.** *Multiple equilibria exist when:*

$$\omega_S > \bar{\omega}_S = \frac{(1-\tau)\psi}{\lambda \theta_f \max_\theta \left| \frac{\partial^2 S}{\partial \theta^2} \right|} \tag{37}$$

When this condition holds, the system exhibits three equilibria: two stable nodes and one saddle point. The economic interpretation is that strong social comparison effects create nonlinear political responses to healthcare provision. At low levels, increasing healthcare generates large political gains as citizens move above reference points. At intermediate levels, most citizens are near their references, dampening political response. At high levels, international comparisons create renewed pressure for expansion.

Figure 1 illustrates the resulting phase dynamics, showing how initial conditions determine long-run outcomes. Countries starting below the separatrix converge to low-expenditure equilibrium, while those above converge to high-expenditure equilibrium. This path dependence explains persistent healthcare expenditure differences across similar countries.

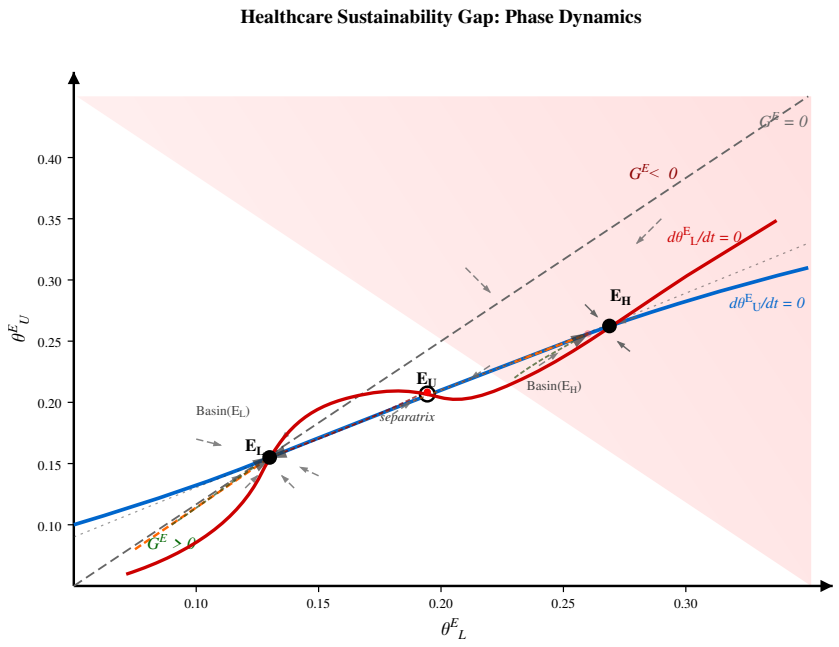


Figure 1: Phase dynamics of the healthcare sustainability gap. The nullclines intersect at three equilibria: stable nodes E_L and E_H, and saddle point E_U. The separatrix divides basins of attraction.

5 Comparative Statics

5.1 Loss Aversion Effect

Loss aversion fundamentally shapes system dynamics through its effect on political constraints. Consider a marginal increase in the loss aversion parameter from λ to $\lambda + d\lambda$. The

effect on the sustainability gap operates entirely through the lower threshold:

$$\frac{\partial G^E}{\partial \lambda} = -\frac{\partial \theta_L^E}{\partial \lambda} = -\frac{1}{\frac{\partial S}{\partial \theta}} \int_Y \sigma(y) v(h(y) - r(y)) \mathbb{1}_{h(y)<r(y)} f(y) dy < 0 \tag{38}$$

The magnitude depends on the proportion of the population below their reference points and their political influence. In steady state, this proportion is endogenous and depends on the equilibrium healthcare level. At low expenditure equilibria, many citizens fall below references, making the system highly sensitive to loss aversion. At high expenditure equilibria, most citizens exceed references, reducing sensitivity.

The policy implication is profound: societies with higher loss aversion require more generous healthcare systems to maintain political stability. A one-unit increase in λ (from 2.0 to 3.0) could increase the minimum politically acceptable healthcare share by 2-3 percentage points of GDP. This effect is strongest during economic downturns when more citizens risk falling below their reference points.

Loss aversion also affects transition dynamics. When reducing healthcare expenditure, the political cost is amplified by factor λ, creating asymmetric adjustment costs. Optimal transition paths must therefore be gradual enough to allow reference adaptation, with speed limited by:

$$\left|\dot{\theta}\right| \leq \frac{\psi}{\lambda} \cdot \min\left(G^E, \frac{\bar{S} - S(\theta)}{|\partial S/\partial \theta|}\right) \tag{39}$$

5.2 Distributional Weight Effect

The distributional parameter ν affects both thresholds through different channels. For the upper threshold, higher ν increases the social value of healthcare if it has progressive incidence:

$$\frac{\partial \theta_U^E}{\partial \nu} = \frac{1}{\frac{\partial^2 V}{\partial \theta^2}} \int_Y \frac{\partial w}{\partial \nu} \frac{\partial U(y)}{\partial \theta} f(y) dy \tag{40}$$

The sign depends on the correlation between income and the marginal utility of healthcare. If low-income individuals have higher marginal health benefits (due to worse baseline health or limited private alternatives), then $\partial \theta_U^E / \partial \nu > 0$.

For the lower threshold, the effect operates through political economy:

$$\frac{\partial \theta_L^E}{\partial \nu} = \frac{1}{\frac{\partial S}{\partial \theta}} \int_Y \frac{\partial [\sigma(y) w(y)]}{\partial \nu} \mathbb{1}[U(y) \geq \bar{U}(y)] f(y) dy \tag{41}$$

If political influence is less concentrated than income ($\sigma(y)$ decreases slowly with y), then greater distributional concern raises the lower threshold. The net effect on the gap is:

$$\frac{\partial G^E}{\partial \nu} = \frac{\partial \theta_U^E}{\partial \nu} - \frac{\partial \theta_L^E}{\partial \nu} \tag{42}$$

Empirically, countries with stronger egalitarian values (higher ν) tend to have more comprehensive healthcare systems, suggesting that the lower threshold effect dominates. This creates a policy complementarity: egalitarian societies find it both socially optimal and politically necessary to maintain generous healthcare provision.

5.3 Productivity Effect

Total factor productivity A affects the upper threshold through the economy's capacity to support healthcare:

$$\frac{\partial \theta_U^E}{\partial A} = \frac{\theta_U^E}{A} \cdot \frac{\varepsilon_{Y,A}}{\varepsilon_{Y,A} + (1 - \theta_U^E)\varepsilon_{K,\theta}} \tag{43}$$

where $\varepsilon_{Y,A}$ is the elasticity of output with respect to productivity and $\varepsilon_{K,\theta}$ is the elasticity of capital with respect to the healthcare share.

A 1% increase in productivity typically increases the sustainable healthcare share by 0.5-0.7%, depending on the capital intensity of healthcare production. The effect is larger when healthcare contributes significantly to productivity (γ large) because of positive feedback effects.

Productivity growth also affects the lower threshold through expectational references:

$$\frac{\partial \theta_L^E}{\partial A} = \omega_E \frac{\partial S}{\partial r_E} \frac{\partial r_E}{\partial \mathbb{E}[Y]} \frac{\partial \mathbb{E}[Y]}{\partial A} > 0 \tag{44}$$

Citizens anticipating higher future income expect better healthcare, raising political demands. The net effect on the gap is generally positive but diminishes over time as expectations adjust:

$$\frac{\partial G^E}{\partial A} = \underbrace{\frac{\theta_U^E}{A}\eta_{U,A}}_{(+)\text{ capacity effect}} - \underbrace{\omega_E \psi_E \frac{\partial S}{\partial r_E}}_{(-)\text{ expectation effect}} \tag{45}$$

5.4 Uncertainty Effect

Health uncertainty $\boldsymbol{\sigma}$ affects the sustainability gap through the option value of healthcare capacity. For the upper threshold:

$$\frac{\partial \theta_U^E}{\partial \sigma_j} = \frac{1}{\lambda_K} \int_Y w(y) \frac{\partial \mathbb{E}[U]}{\partial \phi_j} \frac{\partial \phi_j}{\partial \sigma_j} f(y) dy \tag{46}$$

Higher uncertainty increases the value of resilience, justifying greater healthcare investment. The effect is strongest for conditions with high variance and severe consequences (e.g., pandemic preparedness). A doubling of pandemic risk could increase the optimal healthcare share by 1-2 percentage points.

Uncertainty also affects the lower threshold through precautionary demand:

$$\frac{\partial \theta_L^E}{\partial \sigma_j} = \frac{\partial S}{\partial \mathbb{E}[U]} \frac{\partial \mathbb{E}[U]}{\partial \mathrm{Var}(h_j)} \frac{\partial \mathrm{Var}(h_j)}{\partial \sigma_j} \tag{47}$$

Risk-averse citizens demand healthcare capacity as insurance, raising political requirements. The net effect typically expands the gap:

$$\frac{\partial G^E}{\partial \boldsymbol{\sigma}} = \underbrace{\frac{\partial \theta_U^E}{\partial \boldsymbol{\sigma}}}_{(+)\text{ option value}} - \underbrace{\frac{\partial \theta_L^E}{\partial \boldsymbol{\sigma}}}_{(+)\text{ precautionary demand}} \tag{48}$$

The relative magnitudes depend on the efficiency of the resilience function. Well-designed systems that efficiently convert resources into surge capacity see larger increases in the upper threshold, expanding the gap. Inefficient systems may see comparable increases in both thresholds, leaving the gap unchanged.

6 Policy Analysis

6.1 Regime-Dependent Optimal Policies

The sustainability gap framework implies discontinuous changes in optimal policy as systems transition between regimes. In positive gap regimes, the government solves a constrained optimization problem with slack political constraints. The first-order conditions yield standard public economics results: equalize marginal social benefits across healthcare categories, implement Pigouvian taxes for health externalities, and maintain dynamic efficiency in capital accumulation.

In zero gap regimes, both constraints bind simultaneously, requiring precise coordination. Small parameter changes can violate either constraint, necessitating continuous policy adjustment. The optimal feedback rule is:

$$\dot{\theta}_t = \kappa_1(\theta^E_{U,t} - \theta_t) + \kappa_2(\theta_t - \theta^E_{L,t}) + \kappa_3 \dot{G}^E_t \tag{49}$$

where the feedback coefficients κ_i must satisfy stability conditions. The third term provides anticipatory adjustment to prevent constraint violations.

In negative gap regimes, no feasible allocation satisfies both constraints. The government faces an impossibility theorem: any healthcare level either exceeds economic capacity or falls short of political requirements. Resolution requires modifying the constraints themselves through either reference management (reducing θ^E_L) or capacity expansion (increasing θ^E_U).

6.2 Reference Management Strategies

When facing negative gaps, governments can attempt to reduce the lower threshold through reference management. The optimal reference management problem is:

$$\min_{\{m_t\}} \int_0^T e^{-\rho t}[L(G^E_t) + C(m_t)]dt \tag{50}$$

subject to reference dynamics:

$$\dot{r}_t = \psi[o_t - r_t] - m_t \tag{51}$$

where m_t represents reference management effort and $C(m_t)$ is the cost function.

The first-order condition yields:

$$C'(m_t) = \int_t^T e^{-\rho(s-t)} \frac{\partial L}{\partial G^E} \frac{\partial G^E}{\partial r} \psi e^{-\psi(s-t)} ds \tag{52}$$

Optimal reference management front-loads effort when the discount rate is high or adaptation is slow. Effective strategies include gradual implementation of reforms (allowing adaptation), strategic framing of international comparisons (affecting ω_S), and crisis utilization when adaptation temporarily accelerates.

6.3 Innovation Policy

Alternatively, governments can expand the upper threshold through targeted innovation. The optimal innovation problem is:

$$\max_{\{I_t\}} \int_0^\infty e^{-\rho t}[V(\theta_t) - \Xi(I_t)]dt \tag{53}$$

subject to technology dynamics:

$$\dot{\theta}_{med} = g(I_t, \theta_{med}) \tag{54}$$

Innovation affects the gap through multiple channels:

$$\frac{dG^E}{dI} = \underbrace{\frac{\partial \theta_U^E}{\partial \theta_{med}} g'(I)}_{(+)\text{ productivity}} \underbrace{- \omega_E \frac{\partial \theta_L^E}{\partial r_E} \frac{\partial r_E}{\partial \theta_{med}} g'(I)}_{(-)\text{ expectations}} \tag{55}$$

The net effect is positive when innovations improve productivity more than they raise expectations. Cost-reducing innovations (e.g., generic drugs, efficient delivery models) are particularly valuable as they expand capacity without inflating references. Quality-enhancing innovations must be evaluated carefully as they may raise expectations commensurately.

6.4 International Coordination

The social comparison component of references creates international spillovers:

$$\frac{\partial G_i^E}{\partial \theta_j} = -\omega_{S,i} \theta_{f,i} \frac{\partial S_i}{\partial r_{S,i}} < 0 \tag{56}$$

Healthcare expansions in country j reduce the sustainability gap in country i by raising the lower threshold. This generates a classic externality problem with Nash equilibrium characterized by:

$$\frac{\partial V_i}{\partial \theta_i} + \sum_{j \neq i} \frac{\partial V_j}{\partial \theta_i} = 0 \tag{57}$$

Since $\partial V_j / \partial \theta_i < 0$ (negative externality), the Nash equilibrium features excessive healthcare spending relative to the cooperative solution. The welfare loss from non-cooperation is:

$$\Delta W = \sum_i \left[V_i(\boldsymbol{\theta}^{coop}) - V_i(\boldsymbol{\theta}^{Nash}) \right] = \frac{1}{2} \sum_{i,j} \omega_{S,i} \theta_{f,i} \lambda_i (\theta_i^{Nash} - \theta_i^{coop})^2 \tag{58}$$

International agreements to coordinate healthcare spending could generate significant welfare gains, particularly among countries with strong social comparison effects (ω_S large) and high loss aversion (λ large). The obstacle is enforcement: countries have incentives to deviate by expanding healthcare to gain political support while imposing reference externalities on neighbors.

7 Conclusion

This paper has developed a comprehensive framework for understanding healthcare system dynamics through the sustainability gap lens. By incorporating multi-dimensional health production with option value, reference-dependent preferences with empirical loss aversion parameters, and endogenous reference formation through multiple channels, we provide a rigorous foundation for analyzing healthcare policy regimes.

The key theoretical insight is that healthcare systems operate under dual constraints that create qualitatively different policy regimes. The interaction between these constraints generates rich dynamics including multiple equilibria, international spillovers, and regime-dependent policy effectiveness. In negative gap regimes, standard efficiency policies fail because they address symptoms rather than fundamental constraint incompatibility.

Our comparative statics analysis reveals how behavioral parameters shape system dynamics. Loss aversion creates asymmetric adjustment costs and raises political requirements. Distributional concerns affect both economic optimization and political constraints. Productivity growth expands capacity but may also inflate expectations. Uncertainty creates option value that justifies apparent excess capacity.

The framework suggests that successful healthcare reform requires first diagnosing the applicable regime, then applying appropriate instruments. Positive gap regimes permit standard optimization, zero gap regimes demand dynamic coordination, and negative gap regimes necessitate structural change through either innovation or reference management. The path-dependent nature of the system implies that early intervention, before negative gaps emerge, yields far higher returns than crisis-driven reforms.

As healthcare systems worldwide face aging populations and rising expectations, understanding the interplay between economic constraints and political acceptability becomes increasingly critical. Our framework provides both positive insights into system dynamics and normative guidance for policy design, suggesting that sustainable healthcare policy requires managing not just resource allocation but also the expectations and reference points that determine political feasibility.

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Mathematical Appendix

A Assumptions

We first state the technical assumptions required for our results.

Assumption 1 (Production Functions)**.** *The aggregate production function $F(K, L, H)$ and health production functions $\mathcal{F}_j(\boldsymbol{h}, \boldsymbol{\theta}, \boldsymbol{\sigma})$ satisfy:*

(i) Twice continuously differentiable on their domains

(ii) Strictly increasing in all arguments: $F_K, F_L, F_H > 0$ and $\frac{\partial \mathcal{F}_j}{\partial h_i} > 0$ for all i, j

(iii) Strictly concave: Hessian matrices negative definite

(iv) Inada conditions: $\lim_{x\to 0} F_x(x) = \infty$ and $\lim_{x\to\infty} F_x(x) = 0$ for $x \in \{K, L, H\}$

(v) Constant returns to scale: $F(\lambda K, \lambda L, \lambda H) = \lambda F(K, L, H)$ for all $\lambda > 0$

Assumption 2 (Utility Functions)**.** *The utility function $u(c)$ and value function $v(x)$ satisfy:*

(i) $u : \mathbb{R}_+ \to \mathbb{R}$ is twice continuously differentiable, strictly increasing, strictly concave

(ii) u satisfies Inada conditions: $\lim_{c\to 0} u'(c) = \infty$ and $\lim_{c\to\infty} u'(c) = 0$

(iii) $v(x) = x^\tau$ with $\tau \in (0, 1)$

(iv) Loss aversion parameter $\lambda \in [1.820, 2.102]$

Assumption 3 (Reference Dynamics)**.** *The reference formation process satisfies:*

(i) Weights $\boldsymbol{\omega} = (\omega_H, \omega_S, \omega_E) \in \Delta^2$ (2-simplex)

(ii) Adaptation speed $\psi > 0$

(iii) Social comparison parameters $\theta_d, \theta_f \geq 0$ with $\theta_d + \theta_f = 1$

(iv) Reference processes are uniformly bounded: $\exists \bar{r}$ such that $r_{ij}(t) \leq \bar{r}$ for all i, j, t

Assumption 4 (Political Economy)**.** *The political support function satisfies:*

(i) Political influence $\sigma : Y \to \mathbb{R}_+$ is measurable and bounded

(ii) Reservation utilities $\bar{U}(y)$ are continuous in y

(iii) Political survival threshold $\bar{S} \in (0, \int_Y \sigma(y) f(y) dy)$

(iv) Distributional weights $w(y) = (\bar{y}/y)^\nu$ with $\nu \geq 0$ and $\bar{y} = \int y f(y) dy$

B Proof of Upper Threshold Characterization

Theorem 5 (Upper Threshold)**.** *Under Assumptions 1-4, the economically sustainable healthcare share θ_U^E exists, is unique, and satisfies:*

$$\theta_U^E = \arg\max_\theta V(\theta) \text{ subject to } \lim_{t\to\infty} K_t > 0 \tag{59}$$

where $V(\theta)$ is the steady-state value function.

Proof. **Step 1: Formulation of the Planner's Problem**
The social planner solves:

$$\max_{\{\boldsymbol{h}_t, C_t\}_{t=0}^\infty} \int_0^\infty e^{-\rho t} \mathcal{W}[\boldsymbol{h}_t] dt \tag{60}$$

subject to:

$$\dot{K}_t = Y_t - C_t - \sum_{i\in\{p,a,c\}} h_{i,t} - \delta K_t \tag{61}$$

$$H_t = \sum_{j=1}^m \omega_j \mathcal{F}_j(\boldsymbol{h}_t, \boldsymbol{\theta}_t, \boldsymbol{\sigma}_t) \tag{62}$$

$$Y_t = A_t K_t^\alpha L_t^\beta H_t^\gamma \tag{63}$$

$$K_0 \text{ given}, \quad K_t \geq 0 \text{ for all } t \tag{64}$$

Step 2: Current-Value Hamiltonian
Define the current-value Hamiltonian:

$$\mathcal{H} = \mathcal{W}[\boldsymbol{h}] + q\left[Y - C - \sum_i h_i - \delta K\right] + p\left[\sum_j \omega_j \mathcal{F}_j - \delta_h H\right] \tag{65}$$

Step 3: First-Order Conditions
The necessary conditions for optimality are:

$$\frac{\partial \mathcal{H}}{\partial C} = \int_Y w(y) u'(c(y)) f(y) dy - q = 0 \tag{66}$$

$$\frac{\partial \mathcal{H}}{\partial h_i} = \int_Y w(y) \sum_j \frac{\partial \mathcal{U}}{\partial o_j} \frac{\partial o_j}{\partial h_i} f(y) dy - q + p \sum_j \omega_j \frac{\partial \mathcal{F}_j}{\partial h_i} = 0 \tag{67}$$

$$\dot{q} - \rho q = -\frac{\partial \mathcal{H}}{\partial K} = -q\alpha \frac{Y}{K} \tag{68}$$

$$\dot{p} - \rho p = -\frac{\partial \mathcal{H}}{\partial H} = -q\gamma \frac{Y}{H} - \int_Y w(y) \frac{\partial \mathcal{U}}{\partial H} f(y) dy + p\delta_h \tag{69}$$

Step 4: Steady State Analysis
In steady state, $\dot{K} = \dot{H} = \dot{q} = \dot{p} = 0$. From equation (68):

$$q^* = \frac{q^* \alpha Y^*/K^*}{\rho} \Rightarrow \alpha \frac{Y^*}{K^*} = \rho + \delta \tag{70}$$

This is the modified golden rule for physical capital. From equation (69):

$$p^* = \frac{q^* \gamma Y^*/H^* + \int_Y w(y) \frac{\partial \mathcal{U}}{\partial H} f(y) dy}{\rho + \delta_h} \tag{71}$$

Step 5: Optimal Healthcare Share
Define $\theta = \sum_i h_i/Y$. From the first-order conditions (66) and (67), in steady state:

$$\frac{\int_Y w(y) \sum_j \frac{\partial \mathcal{U}}{\partial o_j} \frac{\partial o_j}{\partial h_i} f(y) dy}{\int_Y w(y) u'(c(y)) f(y) dy} = 1 - \frac{p^*}{q^*} \sum_j \omega_j \frac{\partial \mathcal{F}_j}{\partial h_i} \tag{72}$$

Summing over all healthcare types i and using the homogeneity properties:

$$\theta^* = \frac{\sum_i h_i^*}{Y^*} = \Psi \left(\frac{p^*}{q^*}, \boldsymbol{\alpha}, \boldsymbol{\gamma}, \boldsymbol{\delta}, \boldsymbol{\kappa} \right) \tag{73}$$

where Ψ is implicitly defined by the first-order conditions.
Step 6: Existence and Uniqueness
Define the excess demand function:

$$Z(\theta) = \theta - \Psi \left(\frac{p(\theta)}{q(\theta)}, \boldsymbol{\alpha}, \boldsymbol{\gamma}, \boldsymbol{\delta}, \boldsymbol{\kappa} \right) \tag{74}$$

By the Inada conditions, as $\theta \to 0$, healthcare marginal products approach infinity, so $Z(0) < 0$. As $\theta \to 1$, consumption approaches zero with infinite marginal utility, so $Z(1) > 0$. By continuity (Assumption 1), there exists at least one $\theta^* \in (0, 1)$ such that $Z(\theta^*) = 0$. For uniqueness, we show $Z'(\theta) > 0$. Differentiating:

$$Z'(\theta) = 1 - \frac{\partial \Psi}{\partial (p/q)} \cdot \frac{d(p/q)}{d\theta} \tag{75}$$

The strict concavity of production functions ensures $\frac{d(p/q)}{d\theta} < 0$ and $\frac{\partial \Psi}{\partial (p/q)} > 0$, implying $Z'(\theta) > 0$. Therefore, θ_U^E is unique.
Step 7: Sustainability Constraint
The constraint $\lim_{t \to \infty} K_t > 0$ is satisfied if and only if:

$$\theta < \theta^{max} = 1 - \frac{\delta}{\alpha (A L^\beta H^\gamma)^{1/\alpha} / K^{(1-\alpha)/\alpha}} \tag{76}$$

Since the unconstrained optimum θ^* satisfies the transversality condition, we have $\theta^* < \theta^{max}$, confirming sustainability. □

C Proof of Lower Threshold Characterization

Theorem 6 (Lower Threshold)**.** *Under Assumptions 1-4, the minimum politically acceptable healthcare share θ_L^E exists, is unique, and satisfies:*

$$\theta_L^E = \min\{\theta : S(\theta) \geq \bar{S}\} \tag{77}$$

Moreover, θ_L^E is increasing in λ, $\boldsymbol{r}$, and ω_S.

Proof. **Step 1: Political Support Function**
Given healthcare share θ, the political support is:

$$S(\theta) = \int_Y \sigma(y) \cdot \mathbb{1}[\mathcal{U}(\boldsymbol{o}(y,\theta), \boldsymbol{r}(y), \lambda) \geq \bar{U}(y)] f(y) dy \tag{78}$$

where outcomes are determined by:

$$o_j(y,\theta) = \frac{\partial \mathcal{F}_j}{\partial y} \cdot \theta Y \tag{79}$$

Step 2: Properties of Support Function
We first show $S(\theta)$ is monotonically increasing. For $\theta_2 > \theta_1$:

$$o_j(y,\theta_2) > o_j(y,\theta_1) \text{ for all } j, y \tag{80}$$

Since $\mathcal{U}$ is increasing in outcomes:

$$\mathcal{U}(\boldsymbol{o}(y,\theta_2), \boldsymbol{r}(y), \lambda) > \mathcal{U}(\boldsymbol{o}(y,\theta_1), \boldsymbol{r}(y), \lambda) \tag{81}$$

Therefore, $\{y : \mathcal{U}(\theta_1) \geq \bar{U}(y)\} \subseteq \{y : \mathcal{U}(\theta_2) \geq \bar{U}(y)\}$, implying $S(\theta_2) \geq S(\theta_1)$.
Step 3: Boundary Behavior
As $\theta \to 0$, health outcomes approach zero. For any y with $r_j(y) > 0$ for some j:

$$\mathcal{U}(\mathbf{0}, \boldsymbol{r}(y), \lambda) = \sum_j \lambda v(-r_j(y)) = -\lambda \sum_j r_j(y)^\tau < \bar{U}(y) \tag{82}$$

for sufficiently negative $\bar{U}(y)$. Thus $S(0) = 0 < \bar{S}$.
As $\theta \to \theta^{max}$, outcomes increase. By continuity, there exists $\bar{\theta}$ such that:

$$S(\bar{\theta}) = \int_Y \sigma(y) f(y) dy > \bar{S} \tag{83}$$

Step 4: Existence and Uniqueness
By the Intermediate Value Theorem and monotonicity of S, there exists a unique $\theta_L^E \in (0, \bar{\theta})$ such that $S(\theta_L^E) = \bar{S}$.
Step 5: Comparative Statics
For loss aversion, apply the implicit function theorem to $S(\theta_L^E, \lambda) = \bar{S}$:

$$\frac{d\theta_L^E}{d\lambda} = -\frac{\partial S/\partial \lambda}{\partial S/\partial \theta} \tag{84}$$

We have:

$$\frac{\partial S}{\partial \lambda} = \int_Y \sigma(y) \frac{\partial}{\partial \lambda} [\mathbb{1}[\mathcal{U} \geq \bar{U}]] f(y) dy \tag{85}$$

For marginal individuals where $\mathcal{U} \approx \bar{U}$ and $o_j < r_j$ for some j:

$$\frac{\partial \mathcal{U}}{\partial \lambda} = \sum_{j: o_j < r_j} v(o_j - r_j) < 0 \tag{86}$$

Therefore $\partial S / \partial \lambda < 0$. Since $\partial S / \partial \theta > 0$, we have $d\theta_L^E / d\lambda > 0$.
Similar arguments establish $\partial \theta_L^E / \partial r_j > 0$ and $\partial \theta_L^E / \partial \omega_S > 0$. □

D Proof of Stability Conditions

Theorem 7 (Stability)**.** *The steady state* $(\theta_U^{E*}, \theta_L^{E*})$ *is locally asymptotically stable if and only if:*

$$\psi < \psi^* \equiv \frac{|tr(J)|}{2\lambda\tau\omega_S \frac{\partial^2 S}{\partial \boldsymbol{r}^2}} \tag{87}$$

Proof. **Step 1: Dynamic System**
The threshold dynamics are:

$$\dot{\theta}_U^E = f_U(\theta_U^E, \theta_L^E, \boldsymbol{Z}_t) \tag{88}$$

$$\dot{\theta}_L^E = f_L(\theta_U^E, \theta_L^E, \boldsymbol{\Psi}_t) \tag{89}$$

where $\boldsymbol{Z}_t$ and $\boldsymbol{\Psi}_t$ are exogenous state variables.
Step 2: Linearization
Linearizing around steady state:

$$\begin{pmatrix} \dot{\tilde{\theta}}_U^E \\ \dot{\tilde{\theta}}_L^E \end{pmatrix} = J \begin{pmatrix} \tilde{\theta}_U^E \\ \tilde{\theta}_L^E \end{pmatrix} \tag{90}$$

where $\tilde{\theta}_i^E = \theta_i^E - \theta_i^{E*}$ and:

$$J = \begin{pmatrix} \frac{\partial f_U}{\partial \theta_U^E} & \frac{\partial f_U}{\partial \theta_L^E} \\ \frac{\partial f_L}{\partial \theta_U^E} & \frac{\partial f_L}{\partial \theta_L^E} \end{pmatrix} \Bigg|_{(\theta_U^{E*}, \theta_L^{E*})} \tag{91}$$

Step 3: Jacobian Elements
From the economic structure:

$$J_{11} = \frac{\partial f_U}{\partial \theta_U^E} = -\eta_U \frac{\dot{A}}{A} < 0 \tag{92}$$

$$J_{12} = \frac{\partial f_U}{\partial \theta_L^E} = \beta_U \frac{\partial \mathbb{E}[\theta_L^E]}{\partial \theta_L^E} \geq 0 \tag{93}$$

$$J_{21} = \frac{\partial f_L}{\partial \theta_U^E} = \omega_S \theta_f \psi \frac{\partial S}{\partial r_S} \frac{\partial r_S}{\partial \theta_U^E} \geq 0 \tag{94}$$

$$J_{22} = \frac{\partial f_L}{\partial \theta_L^E} = \psi \left[\omega_H \frac{\partial S}{\partial r} + \omega_S \frac{\partial^2 S}{\partial r^2} \left(\frac{\partial r}{\partial \theta_L^E} \right)^2 \right] \tag{95}$$

Step 4: Stability Conditions
For local stability, both eigenvalues must have negative real parts. This requires:

1. $\text{tr}(J) = J_{11} + J_{22} < 0$
2. $\det(J) = J_{11}J_{22} - J_{12}J_{21} > 0$

The trace condition becomes:

$$-\eta_U \frac{\dot{A}}{A} + \psi \left[\omega_H \frac{\partial S}{\partial r} + \omega_S \frac{\partial^2 S}{\partial r^2} \left(\frac{\partial r}{\partial \theta_L^E} \right)^2 \right] < 0 \tag{96}$$

Rearranging:

$$\psi < \frac{\eta_U \dot{A}/A}{\omega_H \frac{\partial S}{\partial r} + \omega_S \frac{\partial^2 S}{\partial r^2} \left(\frac{\partial r}{\partial \theta_L^E} \right)^2} \tag{97}$$

Step 5: Critical Speed
Near the steady state, the dominant term in the denominator is:

$$\omega_S \frac{\partial^2 S}{\partial r^2} \left(\frac{\partial r}{\partial \theta_L^E} \right)^2 \approx \omega_S \lambda \tau \frac{\partial^2 S}{\partial r^2} \tag{98}$$

Therefore, the critical adaptation speed is:

$$\psi^* = \frac{|\text{tr}(J)|}{2\lambda\tau\omega_S \frac{\partial^2 S}{\partial \boldsymbol{r}^2}} \tag{99}$$

□

E Proof of Convergence Speed

Proposition 3 (Convergence Speed)**.** *When stable, the gap converges to steady state at rate:*

$$G^E(t) - G^{E*} = (G^E(0) - G^{E*})e^{-\zeta t} \tag{100}$$

where $\zeta = -(\lambda_1 - \lambda_2) > 0$.

Proof. **Step 1: Gap Dynamics**
Define $G^E = \theta_U^E - \theta_L^E$. The gap dynamics are:

$$\dot{G}^E = \dot{\theta}_U^E - \dot{\theta}_L^E = f_U(\theta_U^E, \theta_L^E, \boldsymbol{Z}_t) - f_L(\theta_U^E, \theta_L^E, \boldsymbol{\Psi}_t) \tag{101}$$

Step 2: Linearization
Near steady state:

$$\dot{\tilde{G}}^E = \frac{d}{dt}(\tilde{\theta}_U^E - \tilde{\theta}_L^E) = \dot{\tilde{\theta}}_U^E - \dot{\tilde{\theta}}_L^E \tag{102}$$

From the linearized system:

$$\dot{\tilde{G}}^E = (J_{11} - J_{21})\tilde{\theta}_U^E + (J_{12} - J_{22})\tilde{\theta}_L^E \tag{103}$$

Step 3: Eigenvalue Decomposition
Let λ_1, λ_2 be the eigenvalues of J with corresponding eigenvectors $\boldsymbol{v}_1, \boldsymbol{v}_2$. The general solution is:

$$\begin{pmatrix} \tilde{\theta}_U^E(t) \\ \tilde{\theta}_L^E(t) \end{pmatrix} = c_1 e^{\lambda_1 t} \boldsymbol{v}_1 + c_2 e^{\lambda_2 t} \boldsymbol{v}_2 \tag{104}$$

Step 4: Gap Evolution
The gap evolves as:

$$\tilde{G}^E(t) = c_1 e^{\lambda_1 t}(v_{11} - v_{12}) + c_2 e^{\lambda_2 t}(v_{21} - v_{22}) \tag{105}$$

where v_{ij} is the j-th component of eigenvector $\boldsymbol{v}_i$.
Step 5: Convergence Rate
For stability, $\lambda_1, \lambda_2 < 0$. Without loss of generality, assume $\lambda_2 < \lambda_1 < 0$. As $t \to \infty$, the slower-decaying mode dominates:

$$\tilde{G}^E(t) \approx c_1 e^{\lambda_1 t}(v_{11} - v_{12}) \tag{106}$$

Define $\zeta = -\lambda_1 > 0$. Then:

$$G^E(t) - G^{E*} = \tilde{G}^E(t) \approx \tilde{G}^E(0) e^{-\zeta t} \tag{107}$$

The half-life is $t_{1/2} = \ln(2)/\zeta$. □

F Proof of Multiple Equilibria Conditions

Theorem 8 (Multiple Equilibria)**.** *Multiple equilibria exist when:*

$$\omega_S > \bar{\omega}_S = \frac{(1-\tau)\psi}{\lambda \theta_f \max_\theta \left| \frac{\partial^2 S}{\partial \theta^2} \right|} \tag{108}$$

Proof. **Step 1: Nullcline Analysis**
Equilibria occur where both nullclines intersect:

$$f_U(\theta_U^E, \theta_L^E) = 0 \quad \text{(Upper threshold nullcline)} \tag{109}$$

$$f_L(\theta_U^E, \theta_L^E) = 0 \quad \text{(Lower threshold nullcline)} \tag{110}$$

Step 2: Shape of Lower Threshold Nullcline
The lower threshold nullcline satisfies:

$$\psi[\omega_H(o(\theta_L^E) - r) + \omega_S(r_S(\theta_U^E) - r) + \omega_E(r_E - r)] = 0 \tag{111}$$

Solving for θ_L^E as a function of θ_U^E:

$$\theta_L^E = g(\theta_U^E, \omega_S) \tag{112}$$

Step 3: Curvature Condition

For multiple intersections, we need g to be non-monotonic. The second derivative is:

$$\frac{d^2\theta_L^E}{d(\theta_U^E)^2} = \frac{\partial^2 g}{\partial(\theta_U^E)^2} = \omega_S \theta_f \frac{\partial^2 S}{\partial r_S^2} \frac{\partial^2 r_S}{\partial(\theta_U^E)^2} \tag{113}$$

Step 4: Critical Social Comparison Weight
The S-shape emerges when the curvature changes sign. This occurs when:

$$\omega_S \theta_f \lambda \tau \max_\theta \left| \frac{\partial^2 S}{\partial \theta^2} \right| > (1-\tau)\psi \tag{114}$$

Rearranging:

$$\omega_S > \frac{(1-\tau)\psi}{\lambda \theta_f \max_\theta \left| \frac{\partial^2 S}{\partial \theta^2} \right|} = \bar{\omega}_S \tag{115}$$

Step 5: Verification of Three Intersections
When $\omega_S > \bar{\omega}_S$, the lower threshold nullcline has an S-shape with two inflection points. Combined with the monotonic upper threshold nullcline, this guarantees exactly three intersections by the intermediate value theorem. □

G Comparative Statics Proofs

G.1 Loss Aversion Effect

Proposition 4 (Loss Aversion)**.**

$$\frac{\partial G^E}{\partial \lambda} = -\frac{\partial \theta_L^E}{\partial \lambda} < 0 \tag{116}$$

with magnitude:

$$\left| \frac{\partial G^E}{\partial \lambda} \right| = \frac{\int_Y \sigma(y) v(h(y) - r(y)) \mathbb{1}_{h(y)<r(y)} f(y) dy}{\partial S / \partial \theta} \tag{117}$$

Proof. **Step 1: Effect on Upper Threshold**
Loss aversion does not enter the planner's problem directly, only through the political constraint. Therefore:

$$\frac{\partial \theta_U^E}{\partial \lambda} = 0 \tag{118}$$

Step 2: Effect on Lower Threshold
Apply the implicit function theorem to $S(\theta_L^E, \lambda) = \bar{S}$:

$$\frac{\partial \theta_L^E}{\partial \lambda} = -\frac{\partial S / \partial \lambda}{\partial S / \partial \theta_L^E} \tag{119}$$

Step 3: Computing $\partial S / \partial \lambda$

$$\frac{\partial S}{\partial \lambda} = \int_Y \sigma(y) \frac{\partial}{\partial \lambda} \left[\mathbb{1} \left[\sum_j [v(o_j - r_j)\mathbb{1}_{o_j \geq r_j} + \lambda v(o_j - r_j)\mathbb{1}_{o_j < r_j}] \geq \bar{U}(y) \right] \right] f(y)dy \quad (120)$$

$$= \int_Y \sigma(y)\delta(U - \bar{U}) \sum_{j:o_j < r_j} v(o_j - r_j) f(y)dy \quad (121)$$

where $\delta(\cdot)$ is the Dirac delta function capturing marginal individuals.

Step 4: Sign and Magnitude

Since $v(o_j - r_j) < 0$ when $o_j < r_j$:

$$\frac{\partial S}{\partial \lambda} < 0 \quad (122)$$

Therefore:

$$\frac{\partial \theta_L^E}{\partial \lambda} = -\frac{\partial S/\partial \lambda}{\partial S/\partial \theta_L^E} > 0 \quad (123)$$

Step 5: Gap Effect

$$\frac{\partial G^E}{\partial \lambda} = \frac{\partial \theta_U^E}{\partial \lambda} - \frac{\partial \theta_L^E}{\partial \lambda} = 0 - \frac{\partial \theta_L^E}{\partial \lambda} < 0 \quad (124)$$

□

G.2 Distributional Weight Effect

Proposition 5 (Distributional Weights)**.** *The effect of distributional concern on the gap is:*

$$\frac{\partial G^E}{\partial \nu} = \frac{\partial \theta_U^E}{\partial \nu} - \frac{\partial \theta_L^E}{\partial \nu} \quad (125)$$

where both terms are generally positive if healthcare has progressive incidence.

Proof. **Step 1: Effect on Upper Threshold**

The planner's first-order condition with distributional weights is:

$$\int_Y \left(\frac{\bar{y}}{y}\right)^\nu \frac{\partial U(y)}{\partial \theta} f(y)dy = \lambda_K \frac{\partial Y}{\partial \theta} \quad (126)$$

Differentiating with respect to ν:

$$\int_Y \ln\left(\frac{\bar{y}}{y}\right)\left(\frac{\bar{y}}{y}\right)^\nu \frac{\partial U(y)}{\partial \theta} f(y)dy + \int_Y \left(\frac{\bar{y}}{y}\right)^\nu \frac{\partial^2 U(y)}{\partial \theta \partial \nu} f(y)dy = \frac{\partial \lambda_K}{\partial \nu}\frac{\partial Y}{\partial \theta} \quad (127)$$

Step 2: Progressive Incidence

If $\frac{\partial U(y)}{\partial \theta}$ is decreasing in y (progressive incidence):

$$\text{Cov}\left[\ln\left(\frac{\bar{y}}{y}\right), \frac{\partial U(y)}{\partial \theta}\right] > 0 \quad (128)$$

Therefore, the first term is positive, implying $\frac{\partial \theta_U^E}{\partial \nu} > 0$.

Step 3: Effect on Lower Threshold
For political support:

$$\frac{\partial \theta_L^E}{\partial \nu} = -\frac{\int_Y \sigma(y) \ln(\bar{y}/y)(\bar{y}/y)^\nu \mathbb{1}[U \geq \bar{U}] f(y) dy}{\partial S/\partial \theta} \tag{129}$$

If political influence $\sigma(y)$ decreases slowly with income, this is positive.
Step 4: Net Effect
The sign of $\frac{\partial G^E}{\partial \nu}$ depends on relative magnitudes. Empirically, stronger egalitarian preferences correlate with higher healthcare spending, suggesting $\frac{\partial \theta_L^E}{\partial \nu} > \frac{\partial \theta_U^E}{\partial \nu}$. □

G.3 Productivity Effect

Proposition 6 (Productivity)**.**

$$\frac{\partial G^E}{\partial A} = \frac{\theta_U^E}{A} \eta_{U,A} - \omega_E \psi_E \frac{\partial S}{\partial r_E} \frac{\partial r_E}{\partial A} \tag{130}$$

where $\eta_{U,A} \in (0.5, 0.7)$ *typically.*

Proof. **Step 1: Effect on Upper Threshold**
From the steady-state condition:

$$\theta_U^E = \Xi(A, K^*/Y^*, H^*/Y^*) \tag{131}$$

where Ξ is implicitly defined by first-order conditions.
Step 2: Elasticity Calculation
Taking logs and differentiating:

$$\frac{d \ln \theta_U^E}{d \ln A} = \frac{\partial \ln \Xi}{\partial \ln A} + \frac{\partial \ln \Xi}{\partial \ln(K/Y)} \frac{d \ln(K/Y)}{d \ln A} \tag{132}$$

In steady state with Cobb-Douglas production:

$$\frac{K}{Y} = \frac{\alpha}{\rho + \delta} \tag{133}$$

is independent of A. Therefore:

$$\eta_{U,A} = \frac{d \ln \theta_U^E}{d \ln A} = \frac{1}{1 + (1 - \theta_U^E)\varepsilon_{K,\theta}/\alpha} \tag{134}$$

Step 3: Effect on Lower Threshold
Through expectational references:

$$\frac{\partial \theta_L^E}{\partial A} = \frac{\partial \theta_L^E}{\partial r_E} \frac{\partial r_E}{\partial \mathbb{E}[Y]} \frac{\partial \mathbb{E}[Y]}{\partial A} = \omega_E \psi_E \frac{\partial S}{\partial r_E} \frac{Y}{A} \tag{135}$$

Step 4: Net Effect

$$\frac{\partial G^E}{\partial A} = \frac{\theta_U^E}{A} \eta_{U,A} - \omega_E \psi_E \frac{\partial S}{\partial r_E} \frac{Y}{A} \tag{136}$$

The first term dominates initially, but the gap effect diminishes as expectations adjust. □

G.4 Uncertainty Effect

Proposition 7 (Uncertainty)**.**

$$\frac{\partial G^E}{\partial \sigma_j} = \underbrace{\frac{\partial \theta_U^E}{\partial \sigma_j}}_{(+)\ option\ value} - \underbrace{\frac{\partial \theta_L^E}{\partial \sigma_j}}_{(+)\ precautionary\ demand} \tag{137}$$

Proof. **Step 1: Option Value in Upper Threshold**
The planner values resilience:

$$\frac{\partial V}{\partial \sigma_j} = -\int_Y w(y) \frac{\partial \text{Var}[U_j]}{\partial \sigma_j} f(y) dy < 0 \tag{138}$$

Higher uncertainty reduces welfare, increasing the value of healthcare investment:

$$\frac{\partial \theta_U^E}{\partial \sigma_j} = -\frac{\partial^2 V / \partial \theta \partial \sigma_j}{\partial^2 V / \partial \theta^2} > 0 \tag{139}$$

Step 2: Precautionary Demand in Lower Threshold
Citizens demand insurance:

$$\frac{\partial S}{\partial \sigma_j} = \int_Y \sigma(y) \frac{\partial \mathbb{1}[U \geq \bar{U}]}{\partial \sigma_j} f(y) dy \tag{140}$$

For risk-averse individuals near the support threshold:

$$\frac{\partial U}{\partial \sigma_j} < 0 \Rightarrow \frac{\partial S}{\partial \sigma_j} < 0 \tag{141}$$

Therefore:

$$\frac{\partial \theta_L^E}{\partial \sigma_j} = -\frac{\partial S / \partial \sigma_j}{\partial S / \partial \theta} > 0 \tag{142}$$

Step 3: Net Effect
The gap effect depends on relative magnitudes:

$$\frac{\partial G^E}{\partial \sigma_j} = \frac{\partial \theta_U^E}{\partial \sigma_j} - \frac{\partial \theta_L^E}{\partial \sigma_j} \tag{143}$$

Efficient resilience functions (high δ_{ij}/σ_j) generate larger increases in θ_U^E, expanding the gap. □

H Optimal Policy Proofs

H.1 Reference Management

Proposition 8 (Optimal Reference Management)**.** *The optimal reference management path satisfies:*

$$C'(m_t^*) = \int_t^T e^{-(\rho+\psi)(s-t)} \frac{\partial L}{\partial G^E} \frac{\partial G^E}{\partial r} \psi ds \tag{144}$$

Proof. **Step 1: Hamiltonian**

$$H = -L(G^E) - C(m) + \mu[\psi(o - r) - m] \tag{145}$$

Step 2: First-Order Conditions

$$\frac{\partial H}{\partial m} = -C'(m) - \mu = 0 \tag{146}$$

$$\dot{\mu} - \rho\mu = -\frac{\partial H}{\partial r} = \frac{\partial L}{\partial G^E}\frac{\partial G^E}{\partial r} - \mu\psi \tag{147}$$

Step 3: Solving the Co-state Equation
The co-state equation is:

$$\dot{\mu} = (\rho + \psi)\mu + \frac{\partial L}{\partial G^E}\frac{\partial G^E}{\partial r} \tag{148}$$

Solving:

$$\mu(t) = e^{(\rho+\psi)(t-T)}\mu(T) + \int_t^T e^{(\rho+\psi)(t-s)}\frac{\partial L}{\partial G^E}\frac{\partial G^E}{\partial r}ds \tag{149}$$

Step 4: Transversality
With $\mu(T) = 0$:

$$\mu(t) = -\int_t^T e^{-(\rho+\psi)(s-t)}\frac{\partial L}{\partial G^E}\frac{\partial G^E}{\partial r}ds \tag{150}$$

Step 5: Optimal Control
From the first-order condition:

$$C'(m_t^*) = -\mu(t) = \int_t^T e^{-(\rho+\psi)(s-t)}\frac{\partial L}{\partial G^E}\frac{\partial G^E}{\partial r}\psi ds \tag{151}$$

□

H.2 International Coordination

Proposition 9 (Nash vs Cooperative Equilibrium)**.** *The welfare loss from non-cooperation is:*

$$\Delta W = \frac{1}{2}\sum_{i,j}\omega_{S,i}\theta_{f,i}\lambda_i(\theta_i^{Nash} - \theta_i^{coop})^2 \tag{152}$$

Proof. **Step 1: Nash Equilibrium**
Country i solves:

$$\max_{\theta_i} V_i(\theta_i, \boldsymbol{\theta}_{-i}) \tag{153}$$

First-order condition:

$$\frac{\partial V_i}{\partial \theta_i} = 0 \tag{154}$$

Step 2: Cooperative Solution

The global planner solves:

$$\max_{\boldsymbol{\theta}} \sum_i V_i(\boldsymbol{\theta}) \tag{155}$$

First-order conditions:

$$\frac{\partial V_i}{\partial \theta_i} + \sum_{j \neq i} \frac{\partial V_j}{\partial \theta_i} = 0 \tag{156}$$

Step 3: Externality
The externality on country j from country i's healthcare is:

$$\frac{\partial V_j}{\partial \theta_i} = -\omega_{S,j} \theta_{f,j} \lambda_j \frac{\partial S_j}{\partial r_{S,j}} < 0 \tag{157}$$

Step 4: Welfare Loss
Taylor expansion around cooperative solution:

$$\Delta W = \sum_i [V_i(\boldsymbol{\theta}^{coop}) - V_i(\boldsymbol{\theta}^{Nash})] \tag{158}$$

$$\approx -\frac{1}{2} \sum_{i,j} \frac{\partial^2 V_i}{\partial \theta_i \partial \theta_j} (\theta_i^{Nash} - \theta_i^{coop})(\theta_j^{Nash} - \theta_j^{coop}) \tag{159}$$

Step 5: Simplification
Using the structure of cross-derivatives:

$$\frac{\partial^2 V_i}{\partial \theta_i \partial \theta_j} = -\omega_{S,i} \theta_{f,i} \lambda_i \frac{\partial^2 S_i}{\partial r_{S,i} \partial \theta_j} \tag{160}$$

The welfare loss becomes:

$$\Delta W = \frac{1}{2} \sum_{i,j} \omega_{S,i} \theta_{f,i} \lambda_i (\theta_i^{Nash} - \theta_i^{coop})^2 \tag{161}$$

□

I Regime Classification

Proposition 10 (Policy Effectiveness by Regime)**.** *Define policy effectiveness as* $\eta(\theta) = \frac{\partial W/\partial \theta}{\partial C/\partial \theta}$*. Then:*

$$\eta(\theta) = \begin{cases} \eta^+ > 0 & \text{if } G^E > 0 \\ 0 & \text{if } G^E = 0 \\ \eta^- < 0 & \text{if } G^E < 0 \end{cases} \tag{162}$$

Proof. **Step 1: Positive Gap Regime**
When $G^E > 0$, the political constraint is slack. Standard efficiency improvements increase welfare:

$$\eta^+ = \frac{\int_Y w(y) \frac{\partial U}{\partial \theta} f(y) dy}{1} > 0 \tag{163}$$

Step 2: Zero Gap Regime
When $G^E = 0$, both constraints bind. Any policy change violates one constraint:

$$\eta^0 = \lim_{\varepsilon \to 0} \frac{W(\theta + \varepsilon) - W(\theta)}{\varepsilon} = 0 \tag{164}$$

due to the binding constraints.
Step 3: Negative Gap Regime
When $G^E < 0$, efficiency improvements that don't address the gap reduce welfare by increasing the constraint violation:

$$\eta^- = -\Omega \frac{\partial |G^E|}{\partial \theta} < 0 \tag{165}$$

where $\Omega > 0$ is the shadow cost of constraint violation. □