# Macroeconomic Reforms and Civic Cohesion

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August 2025

**Abstract**

We develop a model to study how major macroeconomic reforms, mainly Structural Adjustment Programs (SAPs), affect civic cohesion in developing economies. A benevolent planner chooses SAP intensity to balance productivity gains against the erosion of civic nationalism, an identity-based stock variable that enters utility and evolves endogenously. SAPs raise productivity but weaken nationalism and may also ease the resource constraint through externally financed transfers, depending on their absorption. We characterize the model's steady states, prove existence and uniqueness (under a mild curvature condition) of optimal SAP intensity, and derive comparative statics—including a closed-form sign condition for how SAP-linked transfers affect reform intensity under partial absorption. The contribution is theoretical: a tractable framework in which external conditionality prices a political-identity variable through its interaction with technology and fiscal dynamics. The model generates testable predictions for how international reform programs influence civic cohesion through economic channels. .

## 1 Introduction

Since their introduction in the late twentieth century, IMF Structural Adjustment Programs (SAPs) have been central policy tools in many developing economies (Dreher, 2006; Easterly, 2003). SAPs typically involve fiscal consolidation, structural reforms, and liberalization policies, with the aim of restoring macroeconomic stability and promoting growth. Although some countries have seen improved productivity, economic revival, and improved fiscal outcomes, others have experienced more varied results (Kentikelenis et al., 2016; Reinsberg et al., 2020).

A less studied dimension is the impact of SAPs on civic nationalism—the sense of inclusive identity, institutional trust, and legitimacy grounded in citizenship rather than ethnicity or sectarian lines (Wimmer, 2018; Yack, 1996). Civic nationalism plays a crucial role in sustaining policy stability, reform coalitions, and governance capacity. It is closely related to broader concepts of social cohesion and generalized trust, which have been shown to affect institutional quality and long-term economic development (Tabellini, 2010). External interventions may impact this form of nationalism.

This paper formalizes the interaction between the economic gains from SAP participation and the perceived political-identity costs. Drawing on identity economics (Akerlof and Kranton, 2000), the political economy of conditionality (Vreeland, 2003; Besley and Persson, 2011) and theories of endogenous institutional development (Acemoglu and Robinson, 2006), we present a model in which a benevolent social planner chooses consumption and SAP intensity to minimize domestic outcomes. Productivity depends positively on and is enhanced by SAPs, nationalism is eroded by economic-enhancing SAPs but recovers over time, and government finance includes tax revenue and SAP-linked transfers that may be fully or partially absorbed into government current purchases. When it is not fully absorbed, the unabsorved transfers free up resources for investment in the purchase of new capital stock.

The model yields several predictions: greater concern for nationalism or faster erosion of nationalism reduces optimal SAP intensity, while stronger productivity gains increase it. We also characterize the effects of SAPs on steady-state capital, consumption, and nationalism, and provide a precise condition under which larger SAP-linked transfers raise optimal SAP intensity even when transfers are not fully absorbed by government. The contribution is theoretical; we discuss testable implications for future work.

## 2 Related Literature

This paper connects three theoretical strands. First, we build on identity economics by treating civic nationalism as a utility-relevant state variable that evolves endogenously (Akerlof and Kranton, 2000) and on political theory that conceptualizes civic nationhood as an integrative, institutional form of solidarity (Yack, 1996; Wimmer, 2018). Second, we relate to political-economy models of external conditionality and state capacity, where policy concessions trade off with domestic legitimacy and institutional development (Vreeland, 2003; Nelson, 1990; Besley and Persson, 2011; Acemoglu and Robinson, 2006). Our contribution is to embed this political-identity stock into a tractable intertemporal planner problem so that external financing and reforms jointly determine both technology and legitimacy. Third, we align with dynamic macro frameworks where preferences, technology, and fiscal capacity are jointly chosen objects. Relative to existing work, we (i) make the nationalism erosion channel explicit and testable, (ii) allow SAP-linked resources to enter the feasibility constraint through an absorption parameter, and (iii) deliver closed-form comparative statics—including a sharp condition for when larger program transfers increase optimal program intensity. The analysis is purely theoretical; empirical implications are outlined but deferred.

## 3 Environment

For quantitative tractability and mathematical exposition, we work in continuous time. We consider a continuous-time small open economy. Time is $t \in [0, \infty)$. The social planner chooses aggregate consumption $C_t > 0$ and SAP intensity $S_t \in [0, 1]$ (we write $S_t \equiv SAP_t$) to maximize intertemporal welfare.

## 3.1 Preferences

We consider a benevolent social planner who chooses aggregate consumption $C_t$ and SAP intensity $S_t$ over time to maximize lifetime utility. The planner derives utility from material wellbeing and civic nationalism, both of which enter the objective function in logarithmic form. The intertemporal utility function is:

$$\max_{\{C_t, S_t\}_{t\geq 0}} \int_0^\infty e^{-\rho t} \left[(1-\mu)\log C_t + \mu \log N_t\right] dt, \quad \rho > 0, \quad \mu \in (0,1). \tag{1}$$

Here, $\rho$ is the subjective discount rate, and $\mu \in (0,1)$ is the planner's weight on civic nationalism, which is the importance the planner assigns to nationalism.

Our formulation draws inspiration from log-additive utility structures used in models with durable goods and public capital (Barro, 1990), as well as in models of health and environmental capital (Grossman, 1972; Brock & Taylor, 2010). We extend this framework to civic cohesion, treating nationalism as a stock variable that enters utility alongside consumption.

## 3.2 Nationalism Dynamics

Civic nationalism $N_t$ is modeled as a utility-relevant stock variable that evolves over time. It tends to revert toward a long-run societal benchmark $\bar{N}$, but is eroded by participation in structural adjustment programs (SAPs). The law of motion is:

$$\dot{N}_t = \phi(\bar{N} - N_t) - \chi S_t, \qquad \phi > 0, \ \chi > 0. \tag{2}$$

where $N_t$ denotes the stock of civic nationalism at time $t$, $\bar{N}$ is the long-run societal benchmark or potential level of nationalism in the absence of SAPs, $\phi > 0$ is the rate at which nationalism converges back toward $\bar{N}$, $\chi > 0$ measures the extent to which SAP intensity $S_t \in [0,1]$ erodes civic nationalism, $S_t$ is the intensity of structural adjustment policy at time $t$.

This specification is inspired by mean-reverting dynamics commonly used in models with durable goods and stock variables, such as public capital (Barro, 1990), health capital (Grossman, 1972), and environmental capital (Brock and Taylor, 2010). We extend this framework to civic cohesion, treating nationalism as a socially relevant state variable affected by both long-run convergence and policy erosion.

### 3.3 Technology

We abstract from labor by normalizing it to one. This allows us to focus on the dynamic interaction between capital accumulation, reform intensity, and civic nationalism, with SAPs modeled as augmenting total factor productivity. Output is produced according to a Cobb–Douglas production function:

$$Y_t = A(S_t)\, K_t^{\alpha}, \qquad 0 < \alpha < 1, \tag{3}$$

where $Y_t$ denotes total output at time $t$, $K_t$ is the capital stock at time $t$, $A(S_t)$ is total factor productivity, which depends on SAP intensity $S_t \in [0,1]$, $\alpha \in (0,1)$ is the capital elasticity of output.

We assume that the function $A : [0,1] \to \mathbb{R}_+$ is twice continuously differentiable, strictly increasing ($A'(S) > 0$), and concave ($A''(S) < 0$), reflecting diminishing returns to reform intensity.

### 3.4 Government Purchases and Absorption

Government spending consists of two components: a share of domestic output financed by taxation and an externally financed transfer linked to SAP intensity. Only a portion of the external transfer is absorbed as government purchases; the rest is effectively released into the private sector, relaxing the resource constraint. The public spending function is:

$$G_t = \tau Y_t + \theta \, \psi \, S_t, \qquad \tau \in [0,1), \quad \psi \geq 0, \quad \theta \in [0,1]. \tag{4}$$

Here, $G_t$ is total government spending at time $t$, $\tau$ is the tax rate on output $Y_t$, $\psi \geq 0$ is the total size of SAP-linked external transfers per unit of intensity, $\theta \in [0,1]$ is the fraction of transfers that is absorbed into public purchases, $S_t \in [0,1]$ is the SAP intensity at time $t$.

The remaining share $(1-\theta)\psi S_t$ of the transfer is not spent by the government but instead relaxes the private resource constraint contemporaneously.[1]

## 3.5 Goods Market and Capital Law

The economy's resource constraint equates total available resources to their uses in private consumption, government purchases, and investment. Inflow of external transfers from SAPs enters the right-hand side of the feasibility condition. The capital stock accumulates through net investment, which accounts for both gross investment and depreciation. The feasibility condition and capital accumulation law are given by:

$$C_t + G_t + I_t = Y_t + \psi S_t, \quad \text{with} \quad I_t = \dot{K}_t + \delta K_t, \quad \delta > 0.$$

Combining this with the expression for government purchases in equation (4), we obtain the law of motion for capital:

$$\dot{K}_t = (1-\tau)A(S_t)K_t^{\alpha} + (1-\theta)\psi S_t - C_t - \delta K_t. \tag{5}$$

where $C_t$: private consumption, $G_t$: government purchases, $I_t$: total investment, $Y_t$: total output, $\psi S_t$: external transfers linked to SAP intensity, $\delta > 0$: capital depreciation rate, $\dot{K}_t$: net change in capital stock.

The equation shows that capital accumulation is driven by the portion of output retained

[1] One can equivalently introduce a public asset/reserve account to track $(1-\theta)\psi S_t$. We use this reduced-form closure for tractability.

after taxation, the unabsorbed portion of external transfers, and is reduced by consumption and depreciation.

# 4 Assumptions and Equilibrium

We now formalize the planner's problem and characterize the dynamic equilibrium. This requires specifying parameter restrictions, admissible policies, and a key curvature condition that ensures uniqueness of the optimal SAP intensity. We then derive the Hamilton–Jacobi–Bellman (HJB) equation and the associated first-order conditions. An equilibrium is defined as a solution to this dynamic program that respects feasibility and the transversality condition.

**Model Assumptions.**

We begin by detailing the primitives of the model.

[Primitives] Parameters satisfy $\rho > 0$, $\mu \in (0, 1)$, $\phi > 0$, $\chi > 0$, $\delta > 0$, $\tau \in [0, 1)$, $\psi \geq 0$, and $\theta \in [0, 1]$. The productivity function $A$ is twice continuously differentiable on $[0, 1]$, strictly increasing, and concave: $A'(S) > 0$, $A''(S) < 0$.

Table 1: Model Primitives

| **Symbol** | **Description** | **Type** |
|---|---|---|
| $\rho > 0$ | Subjective discount rate of the planner | Scalar |
| $\mu \in (0, 1)$ | Utility weight on nationalism vs. consumption | Scalar |
| $\bar{N} > 0$ | Long-run benchmark level of nationalism | Constant |
| $\phi > 0$ | Speed of mean reversion in nationalism | Scalar |
| $\chi > 0$ | Rate at which SAPs erode nationalism | Scalar |
| $\tau \in [0, 1)$ | Tax rate on output | Scalar |
| $\psi \geq 0$ | Transfer received per unit of SAP intensity | Scalar |
| $\theta \in [0, 1]$ | Share of transfers used for public goods | Scalar |
| $\delta > 0$ | Depreciation rate of capital | Scalar |
| $\alpha \in (0, 1)$ | Capital share in production | Scalar |
| $A(S)$ | Productivity function, increasing in $S$ | $C^2$ function |
| $A'(S) > 0$ | Marginal effect of SAPs on productivity | Assumption |
| $A''(S) \leq 0$ | Concavity of productivity function | Assumption |
| $S_t \in [0, 1]$ | SAP intensity (policy variable) | Control variable |

Next, we define the set of admissible policy functions.

[Admissible policies] Policies $(C_t, S_t)$ are measurable with $S_t \in [0,1]$ and $C_t > 0$, and satisfy the law of motion for capital (5), the nationalism dynamics $\dot{N}_t = \phi(\bar{N} - N_t) - \chi S_t$ given $(K_0, N_0)$, and the goods market identity.

Table 2: Endogenous Variables

| **Symbol** | **Description** | **Type** |
|---|---|---|
| $C_t$ | Consumption at time $t$ | Endogenous variable |
| $K_t$ | Capital stock at time $t$ | State variable |
| $N_t$ | Stock of civic nationalism at time $t$ | State variable |
| $S_t$ | SAP intensity at time $t$ | Control variable (policy) |
| $Y_t$ | Output at time $t$ | Derived from production |
| $I_t$ | Investment at time $t$ | Derived from capital law |
| $G_t$ | Public spending at time $t$ | Determined by transfers ($\theta$) |
| $V(K_t, N_t)$ | Value function of the planner | Bellman object |

We impose a curvature condition to guarantee monotonicity of the marginal benefit from SAP intensity.

[Monotone marginal benefit (sufficient curvature)] For all $S \in [0,1]$,

$$A''(S) \leq -\frac{\alpha}{1-\alpha} \cdot \frac{(A'(S))^2}{A(S)}.$$

Equivalently, $A$ is sufficiently log-concave such that the marginal-benefit term in (15) is weakly decreasing in $S$, even accounting for the feedback through $K^*(S)$.

**Value Function and HJB.**

Let $V(K_t, N_t)$ denote the value function for the planner. The associated Hamilton–Jacobi–Bellman (HJB) equation is:

$$\rho V(K,N) = \max_{C,S} \Big\{ (1-\mu)\log C + \mu \log N$$
$$+ V_K\big[(1-\tau)A(S)K^{\alpha} + (1-\theta)\psi\, S - C - \delta K\big]$$
$$+ V_N\big[\phi(\bar{N} - N) - \chi\, S\big]\Big\}. \tag{6}$$

Table 3: Control and State Variables

| **Symbol** | **Description** | **Role** |
|---|---|---|
| $K_t$ | Capital stock | State variable |
| $N_t$ | Nationalism stock | State variable |
| $C_t$ | Consumption | Control variable |
| $S_t$ | SAP intensity | Control variable (policy instrument) |

The corresponding first-order and envelope conditions are:

$$V_K = \frac{1-\mu}{C}, \tag{7}$$

$$V_K\left[(1-\tau)A'(S)K^{\alpha} + (1-\theta)\psi\right] = \chi\, V_N, \tag{8}$$

$$\rho V_N = \frac{\mu}{N} - \phi V_N \quad \Rightarrow \quad V_N = \frac{\mu}{(\rho+\phi)N}, \tag{9}$$

$$\rho V_K = V_K\left[\alpha(1-\tau)A(S)K^{\alpha-1} - \delta\right]$$
$$\Rightarrow \quad \alpha(1-\tau)A(S)K^{\alpha-1} = \rho + \delta \quad \text{(Euler condition)}. \tag{10}$$

**Equilibrium Definition.**

[Planner's equilibrium] An equilibrium consists of admissible policy functions $(C_t, S_t)$ and associated state trajectories $(K_t, N_t)$ that solve the planner's optimization problem and satisfy the transversality condition:

$$\lim_{t\to\infty} e^{-\rho t} V_K(K_t, N_t) K_t = 0.$$

# 5 Characterization

We now solve for the steady state of the system, where all variables are constant and time derivatives vanish. The key conditions are derived block by block. We characterize the steady state $(C^*, K^*, N^*, S^*)$ that satisfies all equilibrium and feasibility conditions, including optimality and stationarity. The steady-state system consists of the following blocks:

## Steady-state blocks

**Nationalism.** At $\dot{N} = 0$:

$$N^* = \bar{N} - \frac{\chi}{\phi} S^*. \tag{11}$$

**Capital.** From (10):

$$K^* = \left[\frac{\rho + \delta}{\alpha(1-\tau)A(S^*)}\right]^{\frac{1}{\alpha-1}}, \qquad \frac{\partial K^*}{\partial S^*} = \frac{-1}{\alpha - 1}\frac{A'(S^*)}{A(S^*)}K^* > 0. \tag{12}$$

**Consumption.** From $\dot{K} = 0$ in (5):

$$C^* = (1-\tau)A(S^*)(K^*)^\alpha + (1-\theta)\psi\, S^* - \delta K^*, \tag{13}$$

and

$$\frac{\partial C^*}{\partial S^*} = (1-\tau)A'(S^*)(K^*)^\alpha + (1-\theta)\psi + \rho\,\frac{\partial K^*}{\partial S^*}. \tag{14}$$

**SAP FOC.** Using (7)–(9), the steady-state FOC is

$$\frac{1-\mu}{C^*}\Big[(1-\tau)A'(S^*)(K^*)^\alpha + (1-\theta)\psi\Big] = \frac{\chi\mu}{(\rho+\phi)N^*}. \tag{15}$$

This condition equates the marginal utility-weighted productivity and transfer gains from SAP intensity to the marginal utility loss from reduced civic nationalism.

## 5.1 Reduction to a scalar equation and corner checks

Define the steady-state feasibility set for program intensity as

$$\mathcal{S} \equiv \left\{ S \in [0,1] \ : \ N^*(S) > 0 \right\} = \Big[0,\ \min\{1,\ \tfrac{\phi \bar{N}}{\chi}\}\Big),$$

where $N^*(S) = \bar{N} - \frac{\chi}{\phi} S$ comes from $\dot{N} = 0$ and the $\log N$ preference requires $N^*(S) > 0$.

Using the steady-state blocks, the steady-state FOC (15) can be written as the zero of a single function

$$F(S) \ \equiv \ \underbrace{\frac{1-\mu}{C^*(S)}\Big[(1-\tau)A'(S)(K^*(S))^{\alpha} + (1-\theta)\psi\Big]}_{\text{marginal benefit of } S} - \underbrace{\frac{\chi\mu}{(\rho+\phi)N^*(S)}}_{\text{marginal cost via nationalism}} \ = \ 0. \quad (16)$$

**Properties.** Under Assumptions 4–4, $F$ is continuous on $\mathcal{S}$ and strictly decreasing: $F'(S) < 0$ (see Appendix Lemma 6 for a formal derivation).[2]

**Corner checks.** Because $S \in \mathcal{S}$ is bounded, the optimum can be at a boundary. Evaluate (16) at the edges:

$$\text{If } F(0) \le 0 \quad \Rightarrow \quad \text{MB} \le \text{MC at the start, hence } S^* = 0.$$

$$\text{If } F(\bar{S}) \ge 0 \quad \Rightarrow \quad \text{MB} \ge \text{MC at the cap, hence } S^* = \bar{S},$$

where $\bar{S} \equiv \sup \mathcal{S} = \min\{1, \phi\bar{N}/\chi\}$. Otherwise, by continuity and strict monotonicity, there exists a *unique* interior $S^* \in (0, \bar{S})$ such that $F(S^*) = 0$.

[2] Intuition: concavity/log-concavity of $A$ ensures the marginal-benefit term is weakly decreasing in $S$ after accounting for $K^*(S)$; meanwhile $N^*(S)$ falls in $S$, raising marginal cost.

## 5.2 Main results

[Existence, uniqueness, and corners] Under Assumptions 4–4, a steady state exists and the steady-state SAP intensity $S^* \in \mathcal{S}$ is unique. Moreover, if

$$\frac{1-\mu}{C^*(0)}\Big[(1-\tau)A'(0)(K^*(0))^{\alpha} + (1-\theta)\psi\Big] \leq \frac{\chi\mu}{(\rho+\phi)N^*(0)},$$

then $S^* = 0$. If the reverse strict inequality holds at $S = \bar{S}$, then $S^* = \bar{S}$. Otherwise $S^* \in (0, \bar{S})$ is interior and satisfies (15).

[Transversality] With $\alpha \in (0,1)$ and bounded $A(S)$, any optimal path satisfying the Euler equation and feasibility also satisfies $\lim_{t\to\infty} e^{-\rho t} V_K K_t = 0$.

[Nationalism erosion] If $\chi$ rises, $S^*$ falls. In particular, an increase in $\chi$ shifts the RHS of (15) up and (by strict monotonicity of $F$) reduces $S^*$, potentially to the corner $S^* = 0$.

[Comparative statics (signs)] At an interior $S^*$, the following hold:

$$\frac{\partial S^*}{\partial \mu} < 0, \qquad \frac{\partial S^*}{\partial \chi} < 0, \qquad \frac{\partial S^*}{\partial A'} > 0,$$

and under partial absorption $(0 < \theta < 1)$ the sign of $\frac{\partial S^*}{\partial \psi}$ is given in Corollary 5.2; under full absorption $(\theta = 1)$, $\frac{\partial S^*}{\partial \psi} = 0$.

[Transfers under partial absorption] If $0 < \theta < 1$, then

$$\operatorname{sign}\left(\frac{\partial S^*}{\partial \psi}\right) = \operatorname{sign}\left[\left(\tfrac{\rho+\delta}{\alpha}\right)\left(1 - \tfrac{S^* A'(S^*)}{A(S^*)}\right) - \delta\right].$$

Equivalently, $\frac{\partial S^*}{\partial \psi} > 0$ whenever $\frac{S^* A'(S^*)}{A(S^*)} < \frac{\rho+\delta(1-\alpha)}{\rho+\delta}$, and $\frac{\partial S^*}{\partial \psi} = 0$ when $\theta = 1$.

## 5.3 Robustness: $\theta = 1$ vs. $0 < \theta < 1$

To test the sensitivity of our results to the treatment of fiscal absorption, we compare two specifications of the government transfer mechanism. In the baseline model, a share $\theta \in (0,1)$ of the external transfer $\psi S_t$ is absorbed into government purchases, while the remainder

$(1-\theta)\psi S_t$ relaxes the private resource constraint. This reduced-form closure captures partial absorption typical in low-capacity states. For robustness, we also consider the extreme case of full absorption ($\theta = 1$), in which transfers do not directly affect the private sector's resource envelope. The key distinctions are summarized below.

(i) Transfer comparative static. With $0 < \theta < 1$, $\psi$ enters (15) positively and (under the sufficient condition in Corollary 5.2) increases $S$. With $\theta = 1$, $\psi$ drops out and $\frac{\partial S}{\partial \psi} = 0$.

(ii) Consumption. Only when $\theta < 1$ does $C$ contain the direct term $(1-\theta)\psi S$ in (13).

(iii) Capital/Euler. The Euler condition (10) and the $K^*$ block (12) are identical across closures.

These distinctions advance a key policy insight: the structure of fiscal absorption critically affects the incentive compatibility of external support. When transfers are fully absorbed into government spending ($\theta = 1$), they fail to incentivize reforms because they provide no direct utility-enhancing effect for households. In contrast, when a share reaches the private sector ($\theta < 1$), households internalize the benefit of reform-linked transfers, raising the marginal value of SAPs and thus supporting higher optimal intensity. This suggests that effective transfer design and absorption capacity are crucial levers in the success of externally-supported reform programs.

# 6 proof of lemma 5.2

This paper presents a tractable model in which external conditionality, implemented through Structural Adjustment Programs, simultaneously raises productivity and erodes civic cohesion. A benevolent planner internalizes this tradeoff by jointly optimizing consumption and SAP intensity, with civic nationalism modeled as a stock variable that evolves endogenously in response to policy.

We establish existence and (under a mild curvature condition) uniqueness of the optimal SAP path, and derive closed-form comparative statics that demonstrate how institutional features—such as absorption and transfer mechanisms—influence policy outcomes. In particular, we show that partial fiscal absorption of SAP-linked transfers increases optimal reform intensity, while full absorption sterilizes their effect. Capital deepening rises with SAP intensity via the Euler channel, but this economic gain comes at the cost of diminished civic cohesion.

The model offers clear, testable predictions for how international conditionality programs affect both macroeconomic outcomes and political identity. It provides a flexible theoretical foundation for future empirical work linking externally induced reforms to nationalism, macroeconomic dynamics, political economy stability, and state legitimacy.

Future studies could test this by examining whether participation in Structural Adjustment Programs systematically reduces civic nationalist sentiment, using cross-country panel data on IMF programs and nationally representative survey measures of civic cohesion. Empirical designs could exploit variation in program timing, intensity, or absorptive capacity to identify causal effects.

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# Appendix: Proofs

[Monotonicity of $F$] Under Assumptions 4–4, $F'(S) < 0$ for all $S \in \mathcal{S}$.

**Proof.** Define $F(S) = \mathrm{MB}(S) - \mathrm{MC}(S)$ with

$$\mathrm{MB}(S) = \frac{1-\mu}{C^*(S)}\Big[(1-\tau)A'(S)(K^*(S))^\alpha + (1-\theta)\psi\Big], \quad \mathrm{MC}(S) = \frac{\chi\mu}{(\rho+\phi)N^*(S)}.$$

**(i) MC is increasing in $S$.** From $N^*(S) = \bar{N} - \frac{\chi}{\phi}S$, we have

$$\frac{d\,\mathrm{MC}}{dS} = \frac{d}{dS}\left(\frac{\chi\mu}{(\rho+\phi)N^*(S)}\right) = \frac{\chi\mu}{(\rho+\phi)} \cdot \frac{1}{(N^*(S))^2} \cdot \left(\frac{\chi}{\phi}\right) > 0.$$

So, $\mathrm{MC}'(S) > 0$.

**(ii) MB is decreasing in $S$.** Let $B(S) \equiv (1-\tau)A'(S)(K^*)^\alpha + (1-\theta)\psi$, so

$$\mathrm{MB}(S) = \frac{1-\mu}{C^*(S)}B(S).$$

Differentiating:

$$\frac{d\,\mathrm{MB}}{dS} = (1-\mu)\left[-\frac{C^*_S}{(C^*)^2}B(S) + \frac{1}{C^*}B_S(S)\right].$$

From equation (14), we know $C^*_S > 0$ under standard parameters, so the first term is $\leq 0$.

Now compute:

$$B_S(S) = (1-\tau)\left[A''(S)(K^*)^\alpha + A'(S)\alpha(K^*)^{\alpha-1}K^*_S\right].$$

From (12), we have

$$K^*_S = \frac{-1}{\alpha-1} \cdot \frac{A'(S)}{A(S)}K^* > 0.$$

Therefore:

$$B_S(S) = (1-\tau)(K^*)^\alpha \left[A''(S) + \frac{\alpha}{1-\alpha} \cdot \frac{(A'(S))^2}{A(S)}\right] \leq 0$$

by Assumption 4, which imposes sufficient log-concavity on $A(S)$. So the second term is also $\leq 0$.

Thus:

$$\frac{d\,\mathrm{MB}}{dS} \leq 0.$$

**Thus** since $\mathrm{MB}'(S) \leq 0$ and $\mathrm{MC}'(S) > 0$, it follows that

$$F'(S) = \mathrm{MB}'(S) - \mathrm{MC}'(S) < 0 \quad \text{for all } S \in \mathcal{S}.$$

, showing F(S) is monotone decreasing. □

## Proof of Proposition 5.2

Continuity of $F$ follows from continuity of $A, A', K^*, C^*, N^*$ in $S$. By Lemma 6, $F'(S) < 0$ on $\mathcal{S}$, so $F$ is strictly decreasing. Existence then follows by the intermediate value theorem; strict monotonicity implies uniqueness. Corner cases follow from sign checks of $F(0)$ and $F(\bar{S})$. $\square$

## Proof of Lemma 5.2 (Transversality Condition)

Log utility ensures $C_t$ stays bounded away from zero along optimal paths. With $\alpha \in (0,1)$, (10) prevents explosive accumulation. Since $\rho > 0$, standard arguments imply $\lim_{t\to\infty} e^{-\rho t} V_K K_t = 0$. $\square$. *With $\alpha \in (0,1)$ and bounded $A(S)$, any optimal path satisfying the Euler equation and feasibility also satisfies the transversality condition:*

$$\lim_{t\to\infty} e^{-\rho t} V_K(K_t, N_t) K_t = 0.$$

We begin by recalling the transversality condition in dynamic optimization, which ensures that the planner does not leave unutilized value in capital stock asymptotically:

$$\lim_{t\to\infty} e^{-\rho t} V_K(K_t, N_t) K_t = 0.$$

We proceed in three steps:

**Boundedness of Consumption**

From the HJB first-order condition with log utility:

$$V_K = \frac{1-\mu}{C_t}.$$

Since $C_t > 0$ for all $t$ by admissibility and log utility would assign infinite negative utility to zero consumption, optimal paths must keep $C_t$ bounded away from zero. Moreover, since resources are finite (due to the feasibility constraint), $C_t$ is also bounded above. Therefore, we conclude:

$$0 < \underline{C} \le C_t \le \overline{C} < \infty.$$

Hence, $V_K = \frac{1-\mu}{C_t}$ is also uniformly bounded for all $t$:

$$0 < \underline{V_K} \leq V_K \leq \overline{V_K} < \infty.$$

**Boundedness of $K_t$ and Prevention of Explosion**

The Euler condition in steady state is:

$$\rho V_K = V_K \left[\alpha(1-\tau)A(S)K^{\alpha-1} - \delta\right].$$

Solving for the implied steady-state relationship:

$$\alpha(1-\tau)A(S)K^{\alpha-1} = \rho + \delta.$$

Since $\alpha \in (0,1)$ and $A(S)$ is bounded above by assumption (i.e., $A(S) \leq A_{\max}$), this equation pins down $K$ to a finite steady-state level:

$$K^{\alpha-1} = \frac{\rho+\delta}{\alpha(1-\tau)A(S)} \quad \Rightarrow \quad K = \left(\frac{\rho+\delta}{\alpha(1-\tau)A(S)}\right)^{\frac{1}{\alpha-1}}.$$

Note that because $\alpha - 1 < 0$, the function $x^{1/(\alpha-1)}$ is decreasing. So a bounded positive $A(S)$ implies a finite, positive steady-state capital stock $K^*$. Moreover, feasibility and the capital law of motion:

$$\dot{K}_t = (1-\tau)A(S_t)K_t^{\alpha} + (1-\theta)\psi S_t - C_t - \delta K_t$$

prevent unbounded accumulation since net investment is bounded above due to the concavity of $K^{\alpha}$ and bounded $A(S)$ and $C_t$.

Thus, we conclude $K_t$ is uniformly bounded over time: there exists $K_{\max} < \infty$ such that

$$0 < K_t \leq K_{\max} < \infty.$$

**Verifying the Transversality Condition**

We now consider the product:

$$e^{-\rho t}V_K(K_t,N_t)K_t = e^{-\rho t}\cdot\frac{1-\mu}{C_t}\cdot K_t.$$

From Step 1, $C_t \geq \underline{C} > 0$ and from Step 2, $K_t \leq K_{\max}$. Thus:

$$e^{-\rho t}V_K K_t \leq e^{-\rho t}\cdot\frac{1-\mu}{\underline{C}}\cdot K_{\max} \to 0 \quad \text{as } t\to\infty.$$

Therefore,

$$\lim_{t\to\infty} e^{-\rho t}V_K(K_t,N_t)K_t = 0.$$

■

## Proof of Proposition 5.2

Let the optimal SAP intensity $S^*$ solve the equation:

$$F(S;\mu,\chi,A',\psi) = \mathrm{MB}(S) - \mathrm{MC}(S) = 0,$$

where

$$\mathrm{MB}(S) = \frac{1-\mu}{C^*(S)}\left[(1-\tau)A'(S)(K^*(S))^\alpha + (1-\theta)\psi\right], \qquad \mathrm{MC}(S) = \frac{\chi\mu}{(\rho+\phi)N^*(S)}.$$

Differentiating both sides with respect to the parameter $\eta \in \{\mu,\chi,A',\psi\}$ and applying the Implicit Function Theorem yields

$$\frac{\partial S^*}{\partial \eta} = -\frac{\partial F/\partial\eta}{\partial F/\partial S},$$

where the denominator satisfies $F_S < 0$ by Lemma 6. The sign of each comparative static is therefore the **opposite** of the sign of $F_\eta$.

**For $\eta = \mu$:**

$$\frac{\partial \mathrm{MB}}{\partial\mu} = -\frac{1}{C^*(S)}\left[(1-\tau)A'(S)(K^*(S))^\alpha + (1-\theta)\psi\right] < 0, \quad \frac{\partial \mathrm{MC}}{\partial\mu} = \frac{\chi}{(\rho+\phi)N^*(S)} > 0,$$

$$\Rightarrow \quad F_\mu < 0, \quad \Rightarrow \quad \frac{\partial S^*}{\partial \mu} > 0.$$

**For** $\eta = \chi$**:**

$$\frac{\partial \text{MB}}{\partial \chi} = 0, \quad \frac{\partial \text{MC}}{\partial \chi} = \frac{\mu}{(\rho+\phi)N^*(S)} > 0, \quad \Rightarrow \quad F_\chi < 0, \quad \Rightarrow \quad \frac{\partial S^*}{\partial \chi} > 0.$$

**For** $\eta = A'(S)$**:**

$$\frac{\partial \text{MB}}{\partial A'} = \frac{1-\mu}{C^*(S)}(1-\tau)(K^*(S))^\alpha > 0, \quad \frac{\partial \text{MC}}{\partial A'} = 0, \quad \Rightarrow \quad F_{A'} > 0, \quad \Rightarrow \quad \frac{\partial S^*}{\partial A'} < 0.$$

**For** $\eta = \psi$**:**

When $\theta < 1$:

$$\frac{\partial \text{MB}}{\partial \psi} = \frac{1-\mu}{C^*(S)}(1-\theta) > 0, \quad \frac{\partial \text{MC}}{\partial \psi} = 0, \quad \Rightarrow \quad F_\psi > 0, \quad \Rightarrow \quad \frac{\partial S^*}{\partial \psi} < 0.$$

When $\theta = 1$, the transfer $\psi$ drops out of MB($S$), so $\partial S^*/\partial \psi = 0$.

■

Table 4: *

**Comparative Statics Summary for $S^*$**

| **Parameter $\eta$** | **Sign of $F_\eta$** | **Effect on $S^*$ (Sign of $\frac{\partial S^*}{\partial \eta}$)** |
|---|---|---|
| $\mu$ | $F_\mu < 0$ | $\frac{\partial S^*}{\partial \mu} > 0$ |
| $\chi$ | $F_\chi < 0$ | $\frac{\partial S^*}{\partial \chi} > 0$ |
| $A'$ | $F_{A'} > 0$ | $\frac{\partial S^*}{\partial A'} < 0$ |
| $\psi$ ($\theta < 1$) | $F_\psi > 0$ | $\frac{\partial S^*}{\partial \psi} < 0$ |
| $\psi$ ($\theta = 1$) | $F_\psi = 0$ | $\frac{\partial S^*}{\partial \psi} = 0$ |

## Proof of Corollary 5.2

Differentiate $F(S,\psi)=0$ at an interior solution with $0<\theta<1$. Using the steady-state blocks and (10), one obtains

$$\frac{\partial S^*}{\partial \psi}=\frac{(1-\theta)\,C^*}{(1-\mu)\,|F_S|}\left[\left(\tfrac{\rho+\delta}{\alpha}\right)\left(1-\tfrac{S^*A'(S^*)}{A(S^*)}\right)-\delta\right],$$

so the sign is as stated. For $\theta=1$, the prefactor $(1-\theta)$ is zero and therefore $\partial S^*/\partial\psi=0$. □

## A.2 Proof of Existence of Optimal SAP Intensity

We prove that there exists an interior policy level $S^*\in(0,1)$ such that $F(S^*)=0$, where $F(S)$ is the steady-state first-order condition defined in the main text. The proof proceeds in three steps.

**1. Continuity of $F(S)$.**

Recall that

$$F(S)=\frac{1-\mu}{C^*(S)}\left[(1-\tau)A'(S)(K^*(S))^\alpha+(1-\theta)\psi\right]-\frac{\chi\mu}{(\rho+\phi)N^*(S)}.$$

We verify that $F(S)$ is continuous on $[0,\bar{S}]$, where $\bar{S}=\min\left\{1,\frac{\phi\bar{N}}{\chi}\right\}$ ensures $N^*(S)>0$.

- $A(S)$ is twice continuously differentiable by assumption, so both $A(S)$ and $A'(S)$ are continuous.
- $K^*(S)=\left[\frac{\rho+\delta}{\alpha(1-\tau)A(S)}\right]^{\frac{1}{\alpha-1}}$ is continuous in $S$ as a composition of continuous functions.
- $C^*(S)=(1-\tau)A(S)(K^*(S))^\alpha+(1-\theta)\psi S-\delta K^*(S)$ is continuous as a sum of continuous terms.
- $N^*(S)=\bar{N}-\frac{\chi}{\phi}S$ is linear and hence continuous.

Since all components are continuous and $C^*(S)$ and $N^*(S)$ are bounded away from zero on $(0,\bar{S})$, we conclude that $F(S)$ is continuous on $[0,\bar{S}]$.

**2. Sign change on $[0,\bar{S}]$.**

We evaluate $F(S)$ at the boundaries and show that it changes sign.

*At $S = 0$:*

$$N^*(0) = \bar{N}, \quad K^*(0) = \left[\frac{\rho + \delta}{\alpha(1-\tau)A(0)}\right]^{\frac{1}{\alpha-1}},$$

$$C^*(0) = (1-\tau)A(0)(K^*(0))^\alpha - \delta K^*(0), \quad \text{(assuming } \theta = 1 \text{ for simplicity).}$$

$$F(0) = \frac{1-\mu}{C^*(0)}\left[(1-\tau)A'(0)(K^*(0))^\alpha + (1-\theta)\psi\right] - \frac{\chi\mu}{(\rho+\phi)\bar{N}}.$$

The first term is positive, and the second term is a finite negative constant. For sufficiently small $\mu$, large $\psi$, or small $\chi$, this implies $F(0) > 0$.

*At $S = \bar{S}$:*

By definition, $\bar{S} = \frac{\phi\bar{N}}{\chi}$ implies $N^*(\bar{S}) = 0$, and thus

$$\lim_{S \to \bar{S}^-} \frac{\chi\mu}{(\rho+\phi)N^*(S)} = +\infty.$$

Hence,

$$\lim_{S \to \bar{S}^-} F(S) = -\infty.$$

So $F(0) > 0$ and $F(\bar{S}) < 0$, which implies $F(0) \cdot F(\bar{S}) < 0$.

Since $F(S)$ is continuous on $[0, \bar{S}]$ and satisfies $F(0) > 0$, $F(\bar{S}) < 0$, **the Intermediate Value Theorem** guarantees that there exists $S^* \in (0, \bar{S}) \subseteq (0, 1)$ such that:

$$\boxed{F(S^*) = 0}.$$

This completes the existence proof. □