

The Insurance Value of Monetary Union: Sovereign Debt and Reserve Pooling

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Abstract

Monetary union pools the foreign reserves that back a shared currency. We show that this pooling insures members against the monetary consequences of national sovereign-debt distress without insuring against default. Monthly central-bank accounts for the eight WAEMU members reveal weak comovement of national foreign claims and divergent national and area-wide reserve coverage during sovereign stress. In a quantitative model of a small member with long-duration defaultable debt, endogenous reserves, a coverage-dependent policy rate and a devaluation hazard, calibrated to Senegal, pooling lowers mean devaluation risk by 82 percent and attenuates the coverage loss from a national shock sevenfold, while equilibrium debt and default frequency rise.

JEL codes: E42, F33, F34, F41, H63, O55.

Keywords: Monetary union, international reserves, sovereign default, fixed exchange rate, devaluation risk.

1 Introduction

Why should countries share a currency when they trade relatively little with one another and face different economic shocks? The standard answer emphasizes the gains from exchange-rate stability and lower transaction costs, weighed against the loss of an independent monetary instrument. But monetary integration also changes the balance sheet that backs the currency. When one member experiences a sovereign-debt shock, its external financing and foreign-asset position may deteriorate without an equivalent deterioration in the currency area's aggregate reserve backing. This paper studies a potentially important implication: *the pooling of foreign-exchange reserves can insure member countries against the monetary consequences of national sovereign-debt distress, even when it does not prevent sovereign default.*

The distinction is relevant to ongoing debates about monetary sovereignty. In the euro area, the prospect of restoring a national currency featured in Marine Le Pen's 2017 presidential campaign in France before her party moved away from a proposal to leave the euro (Cottin, 2019). In West Africa, proposals to change the CFA franc arrangements, including the possibility of a national currency, were debated during Senegal's 2024 presidential campaign (Reuters, 2024). These are different institutional settings, and the political controversies themselves do not identify the economic effects of membership. They nevertheless expose a common question: what does a country receive in exchange for giving up control over its nominal exchange rate and national monetary policy? In the West African Economic and Monetary Union (WAEMU), intra-union merchandise trade accounted for only 15.0 percent of the area's total merchandise-trade flows in

2024 (BCEAO, 2026). That statistic neither measures the trade gains from monetary integration nor establishes that membership is undesirable. It does, however, make it especially important to investigate benefits not captured by conventional trade-based criteria.

We focus on a monetary balance-sheet channel. The eight WAEMU members issue a common currency through the Central Bank of West African States (BCEAO), maintain a fixed parity with the euro, and share the foreign assets supporting the monetary area. Reserve pooling changes how a country-specific loss of foreign assets maps into common reserve coverage, the interest-rate response required to defend the parity, and expectations of a future parity adjustment. The mechanism has two potentially opposing equilibrium effects. Shared backing may attenuate monetary pressure following national debt distress; the resulting insurance may also change sovereign borrowing decisions, debt prices, and default incentives. There is therefore no presumption that lower devaluation risk implies less debt or fewer sovereign defaults.

We first document the quantitative relevance of this mechanism using monthly central-bank balance-sheet accounts for the eight members. From February 2007 to August 2026, the average pairwise correlation of changes in constructed national foreign claims is 0.067. At their observed marginal volatilities, the variance of the aggregate change is only 23.7 percent of the variance under perfectly correlated national movements. A constructed regional foreign-claims-to-monetary-base ratio fluctuates by 4.01 percentage points per month, compared with a weighted average of 8.36 points for the corresponding national ratios. These comparisons indicate substantial *diversification potential*; they are not estimates of a causal treatment effect of the union. We also examine dated episodes of country-specific stress. Following the beginning of Mali’s sanctions in January 2022, its constructed national coverage declined by 9.81 percentage points between December 2021 and July 2022, whereas the aggregate coverage of the eight national accounts increased by 4.62 points. In Senegal, the sovereign option-adjusted spread rose by approximately 934 basis points between August 2024 and December 2025, while constructed national coverage declined 4.42 points and the eight-country aggregate coverage increased 1.67 points. These episodes illustrate how national and aggregate balance-sheet developments can diverge. They do not show that the union caused other countries to accumulate offsetting reserves or that devaluation was imminent in a counterfactual Senegalese currency.

To quantify the implications, we develop a model of a small member economy that borrows externally through long-duration defaultable debt and operates under a fixed external parity. Sovereign borrowing and repayment decisions affect private consumption, external financing, and reserve accumulation. A common monetary authority responds to the coverage of its monetary liabilities, while a state-contingent devaluation hazard captures the risk of an adjustment of the fixed parity. Under pooled backing, the member’s monetary coverage incorporates an exogenous stochastic contribution from the rest of the union. Under national backing, the same member relies on its own reserve position, with reference monetary coverage normalized to be comparable across arrangements. Bond prices, default choices, savings, reserve accumulation, and policy responses are jointly determined in equilibrium. The comparison isolates the *reserve-backing margin under a fixed parity*; it is not a model of an actual exit, redenomination, or a freely floating national currency.

The model yields four results. *First, reserve pooling substantially reduces equilibrium exposure to devaluation.* The mean quarterly devaluation probability is 0.292 percent with pooled reserves and 1.602 percent with national backing, a reduction of approximately 82 percent. Mean monetary coverage is 73.8 rather than 51.6 percent, and the corresponding annualized policy rate averages 3.17 rather than 4.88 percent. The reported probabilities are model outcomes

based on a specified coverage-dependent hazard, not estimates of realized historical devaluations in WAEMU.

Second, pooled reserves attenuate the monetary consequences of a national shock even when the shock still depletes national reserves. In matched simulations of an adverse tradable-income disturbance, national reserves at horizon $h = 23$ fall by 2.77 percentage points of reference annual GDP with pooling and by 3.06 points with national backing. Yet the decline in monetary coverage is only 1.64 percentage points with pooling, versus 11.84 points nationally. The annualized interest-rate increase is approximately 9 rather than 78 basis points, and the quarterly devaluation hazard increases by 0.028 rather than 0.493 percentage point. Thus the quantitative insurance operates principally through a weaker mapping from a national reserve loss into common currency backing, rather than through the elimination of that loss.

Third, this monetary protection changes the sovereign-debt equilibrium rather than uniformly improving all dimensions of financial stability. Mean external debt reaches 53.5 percent of annual GDP under pooled backing, compared with 45.7 percent under national backing. Default events are also more frequent in the baseline pooled equilibrium, and selected market-access spreads are higher. The model therefore separates protection against devaluation from protection against sovereign default. The borrowing response is consistent with altered sovereign incentives, but it should not be labeled a moral-hazard effect without a further decomposition. A comparison in which the devaluation channel is switched off changes the ordering of borrowing across regimes, underscoring the interaction between external debt and monetary backing.

Fourth, insurance depends on the size and condition of the common reserve pool. Larger reserve contributions from the other members mitigate the monetary consequences of national shocks; adverse reserve shocks elsewhere are transmitted through the same common balance sheet. This is insurance against member-specific disturbances, not a guarantee against region-wide external losses. Consumption-equivalent calculations, which we report as a supplementary rather than a defining criterion, likewise do not deliver an unconditional ranking: the population-weighted equivalent is +0.263 percent when both arrangements are evaluated from common admissible initial states drawn from the pooled equilibrium, but -0.353 percent when each regime starts from its own stationary distribution. We consequently interpret the *insurance value* in the title as the stabilization of monetary coverage and devaluation exposure, not as a claim that union membership always increases welfare.

The contribution is to isolate a monetary-balance-sheet mechanism connecting national sovereign risk to the credibility of a shared exchange-rate parity. Three distinctions are central. The first separates reserve diversification from an international fiscal-transfer scheme: an aggregate can be less sensitive to an individual component without any observed compensating transfer. The second separates reduced currency-wide devaluation exposure from sovereign solvency: the two risks need not move together when borrowing adjusts endogenously. The third separates the benefits of sharing reserves from the broader and more difficult question of whether a country should leave a monetary union. These distinctions are useful beyond WAEMU wherever national fiscal liabilities coexist with a common monetary authority and a shared external buffer.

Related literature. The paper relates first to the literature on optimum currency areas and the monetary-policy costs of integration. Mundell (1961) emphasizes the role of factor mobility in the adjustment to asymmetric shocks when nominal exchange rates cannot move. The open-economy trilemma implies that a fixed exchange rate and international capital mobility

constrain independent monetary policy (Obstfeld et al., 2005). At the same time, the benefits and prerequisites of a currency union are potentially endogenous: Frankel and Rose (1998) study how trade integration and business-cycle synchronization may reinforce one another, and Glick and Rose (2002) investigate trade effects of currency-union membership. Our mechanism is distinct from these margins. We ask whether common reserve backing insures the monetary consequences of country-specific sovereign shocks even in an area where intra-union merchandise trade is modest. The observed trade share is used to motivate the question, not to establish that the union is or is not an optimum currency area.

A related literature studies risk sharing and policy incentives inside monetary unions. Farhi and Werning (2017) examine fiscal unions as a response to stabilization and risk-sharing problems, while Aguiar et al. (2015) analyze coordination and crises under common monetary policy and decentralized sovereign borrowing. These studies make clear that membership can affect national incentives as well as the transmission of shocks. Our analysis highlights an additional balance-sheet channel: the central bank’s pooled foreign assets weaken the link between a member’s sovereign financing shock and monetary backing, while national governments still choose debt and default. The channel operates without an explicit fiscal transfer, and its implications for borrowing need not coincide with its implications for currency risk.

The sovereign-debt component builds on quantitative models in which income fluctuations, limited commitment, default, and debt prices are jointly determined (Aguiar and Gopinath, 2006; Arellano, 2008). Long-duration bonds alter default and borrowing incentives (Chatterjee and Eyigungor, 2012), and debt restructuring modifies creditors’ recovery and subsequent market access (Dvorkin et al., 2021). In our model, these choices also change the path of national foreign assets, and hence the exposure of monetary coverage to fiscal stress. This extension allows sovereign debt to generate consequences for a fixed exchange rate that differ across pooled and nationally backed regimes.

The closest connection is to work on international reserves and sovereign risk. Bianchi et al. (2018) study reserves alongside defaultable debt and rollover risk, and Bianchi and Sosa-Padilla (2024) analyze reserve accumulation, macroeconomic stabilization, and sovereign risk with nominal rigidities. Schmitt-Grohé and Uribe (2016) show why nominal rigidities can make adjustment under a peg costly. The difference we emphasize is that a member of a monetary union does not rely exclusively on its own external buffer: monetary backing depends also on other members’ positions. We study how that shared backing changes coverage, policy-rate responses, and an explicit devaluation hazard, allowing borrowing and repayment to adjust in equilibrium. We do not claim that reserves as insurance, or international risk sharing as such, are new ideas.

Finally, studies of West African monetary integration emphasize heterogeneous shocks and fiscal incentives. Masson and Pattillo (2002); Debrun et al. (2005) examine the distribution of potential gains and losses and the fiscal-policy implications of monetary integration in the region. Coulibaly and Ndiaye (2026) provide a sovereign-default analysis directly motivated by Senegal’s hidden-debt crisis. We complement this literature with a quantitative comparison of national and pooled reserve backing that preserves a common fixed-parity environment. The institutional data document both imperfect synchronization and the difference between country-level and regional monetary balance sheets; the equilibrium model evaluates what those features imply for sovereign borrowing and devaluation exposure.

The remainder of the paper is organized as follows. Section 2 presents the institutional setting and stylized facts. Section 3 describes the model, and Section 4 the quantitative strategy.

Section 5 studies debt pricing, default decisions, and the monetary mechanism. Section 6 evaluates reserve-pooling counterfactuals, policy functions, national income and rest-of-union reserve shocks, and supplementary consumption equivalents. Section 7 examines sensitivity, and Section 8 concludes.

2 Institutional Background and Stylized Facts

This section documents three features of the West African monetary arrangement relevant to the quantitative mechanism: a common monetary balance sheet under a fixed external parity, imperfect comovement of members' external positions, and the heterogeneous transmission of country-specific financial stress to area-wide reserve coverage. The analysis is descriptive. In particular, country-level balance-sheet ratios constructed from IMF data are *not* observed stand-alone currency regimes, and a difference between national and regional aggregates is not, by itself, an estimate of the causal impact of reserve pooling.

2.1 Monetary institutions, external parity, and regional integration

The West African Monetary Union consists of Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, and Togo. The BCEAO issues a common currency and sets a policy rate for the monetary area. The CFA franc has been pegged to the euro at CFAF 655.957 per euro since the introduction of the euro in 1999 (BCEAO, nd). National governments retain responsibility for sovereign borrowing, fiscal adjustment, and debt repayment, even though the monetary instrument and external backing are shared. The resulting allocation of responsibilities allows national fiscal financing needs to coexist with a common monetary-policy response.

The external anchor is supported by a distinct institutional arrangement with France. The reform agreed in December 2019 ended the requirement to deposit part of the BCEAO's foreign-exchange reserves in an operations account at the French Treasury and removed French representation from the Union's monetary governance bodies. The fixed euro parity and the French convertibility guarantee were maintained (BCEAO, 2019; Direction générale du Trésor, 2021). These changes should not be confused with an end to *regional* reserve pooling: the BCEAO continues to manage a common monetary balance sheet. They also highlight a boundary of the model developed below. The model isolates reserve backing and a specified risk of parity adjustment; it does not separately quantify the value of the external convertibility guarantee.

Regional integration is economically relevant but incomplete. According to the BCEAO, intra-WAEMU merchandise trade represented 15.0 percent of the area's total merchandise-trade flows in 2024, compared with 15.5 percent in 2023 (BCEAO, 2026). The fixed euro parity may also lower exchange-rate uncertainty in transactions with euro-denominated partners outside the Union. Neither the intra-regional trade statistic nor the nominal anchor alone identifies the net gain from membership: the former is an observed trade share, not a causal trade effect, while the latter necessarily limits national monetary adjustment. The analysis below examines a separate benefit arising from the aggregation of external backing.

2.2 Measuring national and common monetary coverage

We assemble monthly country-level central-bank positions for the eight members from the IMF's *Central Bank Survey*, from January 2007 through August 2026. Let F_{it} denote the survey's

gross claims on nonresidents for member i , and let M_{it} denote its reported monetary base. We construct national and area-wide coverage ratios,

$$c_{it} \equiv \frac{F_{it}}{M_{it}}, \quad c_t^U \equiv \frac{\sum_{i=1}^8 F_{it}}{\sum_{i=1}^8 M_{it}} = \sum_{i=1}^8 w_{it} c_{it}, \quad w_{it} \equiv \frac{M_{it}}{\sum_{j=1}^8 M_{jt}}. \quad (1)$$

This equality is an exact accounting identity for the eight country-level IMF series. It does not imply that c_t^U is identical to the BCEAO's officially reported consolidated coverage ratio. The survey's foreign claims on nonresidents include positions that need not satisfy the definition of freely usable official reserves; the monetary base differs from the statutory concept of liabilities payable on demand. In particular, the 20 percent historical statutory coverage reference is not applied to c_{it} or treated as an automatic devaluation trigger. We use the constructed national ratios to describe *virtual* country-level coverage within the existing union, not the reserves a government would hold after leaving it. Currency exit would alter portfolios, liabilities, monetary policy, and possibly the external guarantee.

The use of a country-level survey rather than the BCEAO's consolidated reserve series is dictated by the decomposition. It makes it possible to compute each country's mechanical contribution to fluctuations in the eight-country aggregate. It also introduces a reconciliation issue: the sum of national survey accounts does not exactly match every item in the official consolidated BCEAO balance sheet. The source archive identifies, for example, a CFAF 489.0 billion difference in the monetary-base comparison for May 2026, despite close agreement among national monetary-base extracts. Accordingly, we label the constructed common series *eight-country aggregate coverage* throughout, rather than claiming it is a direct observation of the BCEAO's statutory ratio. Alternative broader liabilities are examined in the data archive and affect some event-window signs.

2.3 Diversification of external positions and the origin of shocks

Figure 1 presents the cross-country comovement of monthly changes in foreign claims and the volatility of the constructed coverage ratios. Across the 235 common monthly first differences observed from February 2007 to August 2026, the average pairwise correlation of ΔF_{it} is 0.067. Comovement is not uniformly negligible: some pairs are positively correlated, others negatively so, and the quarterly average is higher than the monthly counterpart. The low average correlation therefore supports the presence of diversification opportunities, not independence of all eight series.

A useful variance comparison is

$$\frac{\text{Var}(\sum_i \Delta F_{it})}{(\sum_i \text{SD}(\Delta F_{it}))^2} = 0.237, \quad \frac{\text{Var}(\sum_i \Delta F_{it})}{\sum_i \text{Var}(\Delta F_{it})} = 1.234. \quad (2)$$

The first denominator is the variance that would result if the same national marginal standard deviations were perfectly positively correlated. The observed aggregate variance is 76.3 percent below that benchmark. The second denominator corresponds to a zero-covariance benchmark; its ratio above one indicates that the sum of cross-country covariances is positive. It would thus be incorrect to describe the data as displaying less variability than the independent-shocks benchmark. Because monetary liabilities also change over time, these variance decompositions for F do not mechanically translate into identical variance reductions for the coverage ratios c .

For coverage itself, the standard deviation of monthly changes in $100c_t^U$ is 4.01 percentage points, versus a 8.36-point weighted average of national standard deviations using average

monetary-base weights. A portfolio with fixed weights fluctuates by 4.20 points. The level of the regional coverage series is, by construction, a weighted mean of national levels; the relevant volatility comparison is with the *average volatility of its components*, not with the realized weighted mean itself. This distinction is central to the interpretation of Figure 1.

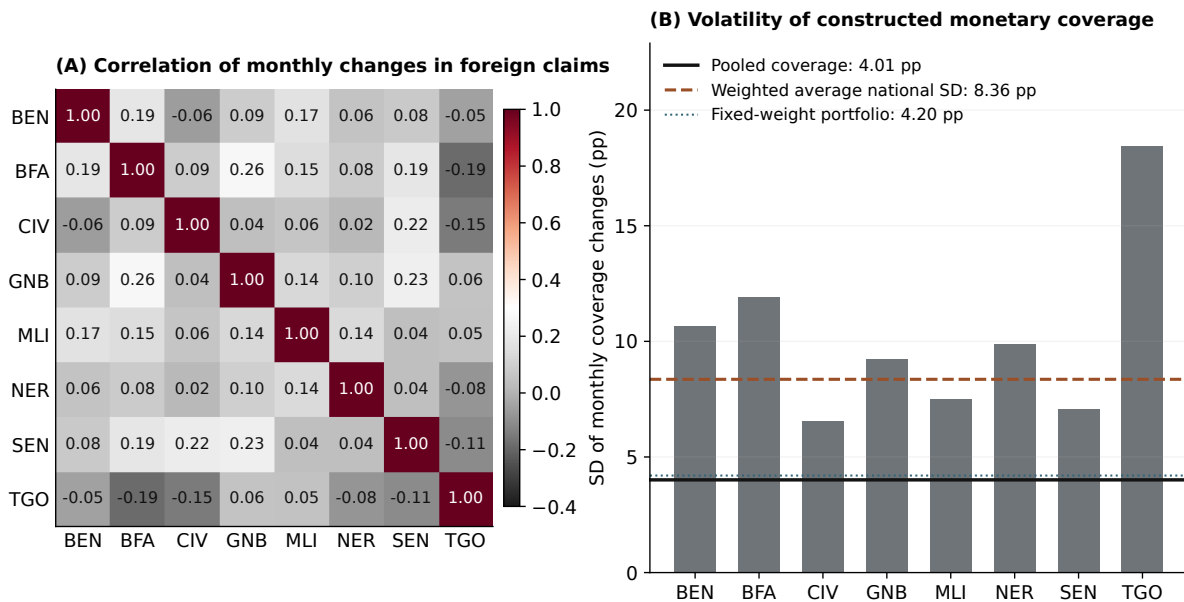


Figure 1: Diversification of external positions across WAEMU members

Notes: Panel A shows pairwise correlations of month-to-month changes in claims on nonresidents from the IMF Central Bank Survey, based on 235 common changes, February 2007–August 2026. Panel B shows standard deviations of monthly changes in constructed foreign-claims-to-monetary-base ratios, in percentage points (pp). The pooled series is the ratio of sums across the eight national IMF accounts, not the official consolidated BCEAO ratio. The dashed comparator is the average of national standard deviations weighted by average monetary-base shares; the dotted comparator holds the coverage weights fixed. BEN, BFA, CIV, GNB, MLI, NER, SEN and TGO denote the eight member countries. *Source:* Authors' calculations using the IMF Central Bank Survey; source data and reproducible code supplied with the paper.

Diversification is plausible because members have different export structures and exposure to commodity prices. To document this heterogeneity, we construct indicative commodity-price terms-of-trade indices using product weights from UN Comtrade (2015–2019) and prices from the World Bank's Pink Sheet. After detrending quarterly log indices and fitting country-specific AR(1) processes, the average pairwise correlation of the terms-of-trade innovations is 0.322 over 1980Q2–2026Q3. Correlation is much higher for import-price innovations (0.839) than for export-price innovations (0.440), and some country pairs have closely synchronized commodity baskets. Thus country shocks are only *partly* diversified. The average correlation between each country's constructed terms-of-trade innovations and those of an equally weighted aggregate of the other seven members is 0.533; this is a different statistic from the average of pairwise correlations. Moreover, these indices omit some products and services, use proxy prices for others, and rely on historical fixed trade weights. They are not official measures of national terms of trade and do not directly estimate the correlation between national output shocks and rest-of-union reserve shocks in the model.

2.4 Sovereign stress and the transmission to common coverage

We next compare national and aggregate coverage around four pre-dated stress episodes: the post-election crisis in Côte d'Ivoire beginning in December 2010, sanctions on Mali beginning in January 2022, sanctions on Niger beginning in July 2023, and the disclosure of previously unreported sovereign debt in Senegal in September 2024. For Senegal we also record February 2025, when the audit of the public finances was published, as an *alternative dating of the same episode*, not an independent observation (International Monetary Fund, 2025). The exercises are event descriptions rather than causal local projections. They have neither randomly assigned crises nor an untreated monetary regime in the data.

Let event month t be fixed by the chronology, and normalize both coverage series at the same end-of-month $t - 1$. At horizon h , the change in national coverage is $\Delta_h c_i = c_{i,t+h} - c_{i,t-1}$, and similarly $\Delta_h c^U = c_{t+h}^U - c_{t-1}^U$. Horizon $h = 6$ therefore corresponds to seven month-end intervals from the common baseline. With subscript 0 denoting month $t - 1$ and 1 month $t + h$, the accounting identity in equation (1) implies an exact decomposition,

$$\begin{aligned} \Delta_h c^U = & \underbrace{w_{i0} \Delta_h c_i}_{\text{affected member}} + \underbrace{\sum_{j \neq i} w_{j0} \Delta_h c_j}_{\text{other members}} \\ & + \underbrace{\sum_j c_{j0} \Delta_h w_j}_{\text{changing monetary shares}} + \underbrace{\sum_j \Delta_h w_j \Delta_h c_j}_{\text{interaction}}. \end{aligned} \quad (3)$$

The first term captures the mechanical effect of the affected member's coverage movement at its initial monetary-base weight. The next term captures observed movements in other members' coverage. Changes in weights and their interactions complete the identity. These terms cannot by themselves tell whether the other countries' foreign claims moved *because of* the shock to the affected country or because of unrelated developments.

Table 1 reports the decomposition at six- and twelve-month event horizons. The heterogeneity is informative. Between December 2021 and July 2022, Mali's coverage fell by 9.81 percentage points; with an initial monetary-base share of approximately 11.2 percent, its direct contribution to the eight-country ratio was -1.10 point. Contemporaneous changes in the other seven members contributed $+6.39$ points; the regional series rose by 4.62 points after allowing for changing weights and interactions. But July 2022 was *after* the July 3 lifting of sanctions, and at the twelve-month horizon Mali and the regional aggregate both declined. The regional offset is therefore episodic, not a general result. The Ivorian and Nigerien episodes, in which constructed national coverage does not fall at the horizons reported, provide further reasons not to select events solely for conformity with a proposed mechanism.

Table 1: Changes in national and eight-country aggregate coverage around stress episodes

Episode	h	Coverage change		Exact contribution to aggregate change			
		National	Aggregate	Member	Others	Weights	Interaction
Côte d'Ivoire, Dec. 2010	6	10.53	1.76	4.19	-2.14	0.09	-0.38
	12	5.55	-6.21	2.21	-8.46	-0.03	0.07
Mali, Jan. 2022	6	-9.81	4.62	-1.10	6.39	-0.01	-0.66
	12	-19.00	-9.17	-2.14	-8.52	0.76	0.73
Niger, July 2023	6	14.82	11.24	0.88	8.81	1.13	0.42
	12	8.83	8.33	0.53	6.40	0.93	0.48
Senegal, Sep. 2024	6	-2.10	-0.41	-0.47	-0.97	0.49	0.54
	12	1.58	6.44	0.35	3.92	1.74	0.43

Notes: All entries are percentage-point changes from the *same* month-end $t - 1$ to month-end $t + h$ and are rounded to two decimals. Country-level foreign claims divided by the monetary base define national coverage; coverage for the eight-country aggregate is the ratio of summed claims to summed bases. The four contribution columns sum to the change in aggregate coverage, up to rounding, by equation (3). $h = 6$ is seven monthly transitions after the initial baseline. The February 2025 audit date is an alternative reference for the Senegalese episode and is reported in the data archive, not treated here as a fifth independent crisis. The terms are accounting contributions, not estimates of causal cross-country transfers. *Source:* Authors' calculations using IMF Central Bank Survey monthly data and documented event chronologies; full horizon and alternative-denominator results supplied in the source archive.

Senegal provides a particularly close link to the paper's sovereign-financing mechanism. Figure 2 plots its US-dollar sovereign option-adjusted spread alongside the two constructed coverages from August 2024 to December 2025. The OAS increases by 933.9 basis points between the initial and final month, while Senegal's constructed coverage declines by 4.42 percentage points and the eight-country coverage rises by 1.67 points. The spread measures compensation for several risks of the dollar-denominated instrument, including credit and liquidity; it is *not* a pure CFA-franc devaluation premium. Moreover, the bond price is observed at the last available trading day of the month whereas the monetary variables are end-month accounting stocks. What the figure establishes is a contrast between pronounced national sovereign market stress and comparatively stable aggregate monetary backing, not a causal rescue by the union.

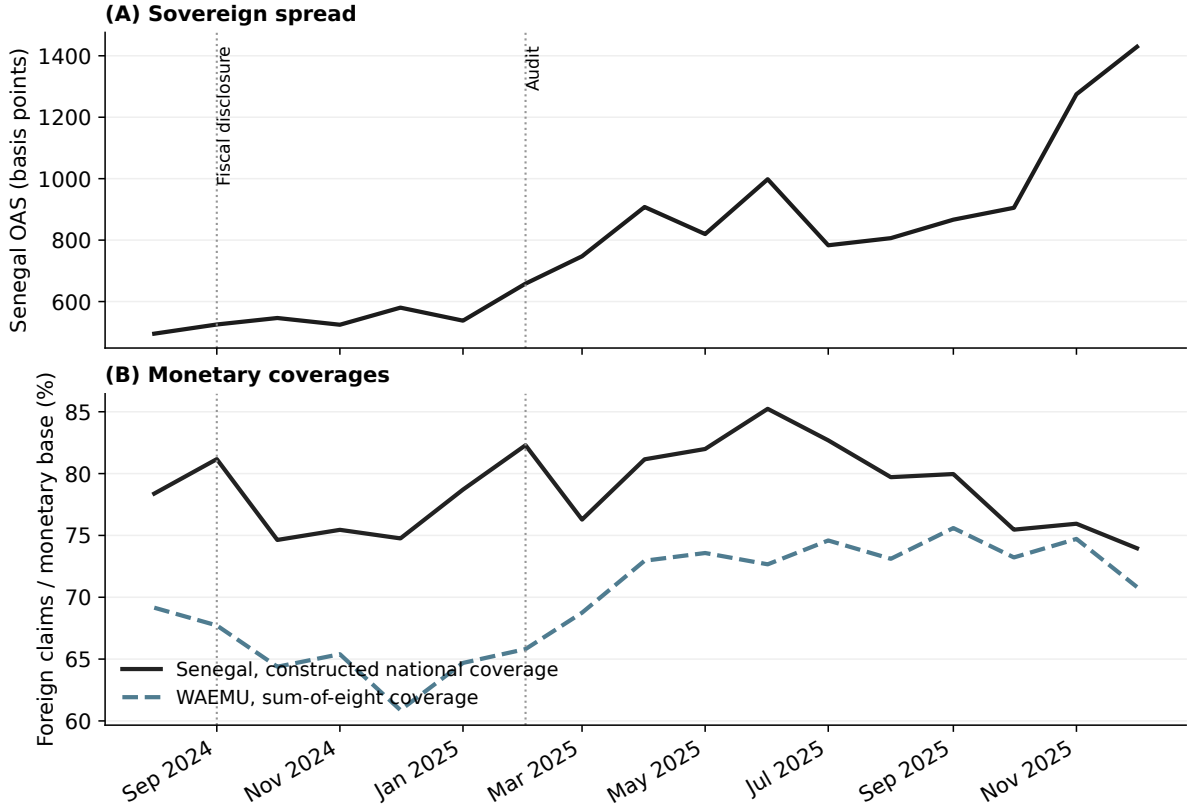


Figure 2: Senegalese sovereign risk and constructed monetary coverage, 2024–2025

Notes: Panel A shows the last available monthly value of Bloomberg series I28798US (INDEX_OAS_TSY), expressed in basis points. Panel B shows country-level IMF foreign claims divided by the monetary base for Senegal and the ratio of the sums over all eight WAEMU members. Vertical markers denote September 2024 (first public disclosure of the fiscal reporting problem) and February 2025 (publication of the public audit); they are two dates within the same episode. The two data sources use different within-month observation conventions. The regional series is an eight-country IMF aggregate, not the official BCEAO consolidated coverage measure; the spread is not a devaluation premium. No interpolation is used. *Sources:* Bloomberg export supplied by the author; IMF Central Bank Survey; International Monetary Fund (2025).

Several qualifications discipline the interpretation. First, neither the Senegalese divergence nor the Mali episode demonstrates what national reserve holdings, interest rates, or exchange rates *would have been* outside the union. Second, the indicative regional auction-derived spreads available for Mali and Niger are not directly comparable with Senegal’s dollar OAS and are missing or stale during sanctions; we do not pool them into a common event-study regression. Third, alternate monetary-liability denominators change some country-level responses, although the basic need to distinguish national and aggregate positions remains. Finally, the observed covariance of foreign claims or commodity prices does not identify a structural shock process for the model’s rest-of-union reserve state. Those parameters are disciplined separately by the quantitative strategy in Section 4.

2.5 Implications for the model counterfactual

Together, the descriptive facts motivate a sharp counterfactual. Countries’ external positions are not perfectly synchronized, so the reserve backing of a currency area can respond differently from the foreign-asset position associated with an individual member. Under an adverse sovereign financing shock, the policy rate needed to defend the fixed parity and the expected risk of

devaluation can consequently differ between a shared and a national reserve balance sheet. The model evaluates this channel while allowing sovereign debt and private allocations to respond endogenously.

It is important not to read more into this experiment than it contains. The BCEAO's observed peg is supported by both regional monetary arrangements and an external convertibility guarantee. The national-backing regime in the model maintains a fixed parity and holds reference monetary coverage comparable; it does not implement an actual separation from WAEMU or determine whether a floating national currency would be preferable. Likewise, the coverage-dependent devaluation probability is a modeling device, not an empirical rule of the BCEAO. The institutional data establish the scope for diversification and document national–regional divergence. The equilibrium results that follow quantify how much these properties matter for sovereign stress, reserve coverage, and model-implied devaluation exposure.

3 Model

The economy is a small member of a monetary union whose government borrows abroad and may default on its external obligations. National saving determines its contribution to foreign reserves, while monetary conditions depend on the backing supplied by the Union as a whole. This distinction connects sovereign financing to a common interest-rate rule and to devaluation exposure. The sovereign-debt structure follows the recursive approach of Arellano (2008) and Chatterjee and Eyigungor (2012). The combination of tradable resources, nontradable production, and nominal wage rigidity relates to the fixed-parity environments studied by Bianchi and Sosa-Padilla (2024) and Coulibaly and Ndiaye (2026). The common-reserve block and the saving condition specified below complete the environment used in the quantitative exercises.

3.1 Environment, shocks, and timing

Time is quarterly. The tradable good is the numeraire, and p_t^N is the relative price of the nontradable good. National quantities are measured per unit of the domestic population, normalized to one; rest-of-Union reserve stocks are expressed in the same units. The country's economic weight is s_i , which scales the response of the rest of the Union but need not equal its share of the common reserve stock. The quantitative economy is Senegal.

The beginning-of-period state is $S_t = (b_t, R_t, z_t, \xi_t, e_t)$, where b_t is inherited external public debt, R_t is national foreign reserves, and $e_t \in \{\mathbf{a}, \mathbf{e}\}$ indicates market access or exclusion. Tradable productivity z_t and the rest-of-Union reserve shifter ξ_t follow

$$\begin{aligned} \log z_{t+1} &= \rho_z \log z_t + \varepsilon_{t+1}, & \varepsilon_{t+1} &\sim N(0, \sigma_\varepsilon^2), \\ \log \xi_{t+1} &= \rho_\xi \log \xi_t + \eta_{t+1}, & \eta_{t+1} &\sim N(0, \sigma_\eta^2). \end{aligned} \tag{4}$$

The innovations are independent in the reported specification. Sovereign exclusion does not directly shift the rest-of-Union process. Denote their joint state by $\Omega = (z, \xi)$ and its transition kernel by $\mathcal{P}(d\Omega' | \Omega)$. The reference values are $z = \xi = 1$; centering the processes in logs does not impose unit unconditional means in levels.

At the start of a quarter, inherited debt and reserves are predetermined. Current shocks determine monetary coverage, the policy rate, and devaluation exposure. A government with market access decides whether to repay and, if repaying, selects next-period debt. Households' reserve-linked saving and the intratemporal allocation respond to that choice. An excluded

government cannot issue debt. At the end of a default or exclusion quarter, market access is restored with probability ϕ , and inherited debt is then restructured to κb_t . Otherwise debt remains frozen. There is no accumulation of contractual interest arrears during exclusion.

The reported economy uses an expected-devaluation formulation. The peg is maintained along the simulated paths, while its model-implied risk affects expected resource losses and the saving margin. Discrete devaluation events are not drawn, and a floating exchange rate is not an alternative policy in this environment. Write $D_t = 1$ in a default-entry or continuing-exclusion quarter and $D_t = 0$ under repayment. Available tradable income is

$$y_t^T = z_t[1 - \psi_\zeta \pi_t] - D_t \Phi(z_t), \quad \Phi(z) = \max\{0, \phi_0 z + \phi_1 z^2\}, \quad (5)$$

where π_t is determined below. Default therefore reduces domestic resources but does not remove the country from the monetary union.

3.2 Households, production, and public provision

A fraction λ of households consumes its current disposable income (type h), while a fraction $1 - \lambda$ holds monetary saving and owns the nontradable firms (type o). Both types supply the same amount of labor when employed and receive the same tradable endowment and transfers. Their consumption baskets and the associated price index satisfy

$$c^j = \left[\alpha_C (c_T^j)^{(\gamma-1)/\gamma} + (1 - \alpha_C) (c_N^j)^{(\gamma-1)/\gamma} \right]^{\gamma/(\gamma-1)}, \quad (6)$$

$$P(p^N) = \left[\alpha_C^\gamma + (1 - \alpha_C)^\gamma (p^N)^{1-\gamma} \right]^{1/(1-\gamma)}, \quad j \in \{h, o\}.$$

The elasticity of substitution is γ . Common homothetic preferences imply the same expenditure composition for both types and hence

$$\frac{C_N}{C_T} = \left(\frac{1 - \alpha_C}{\alpha_C} \right)^\gamma (p^N)^{-\gamma}, \quad C_k = \lambda c_k^h + (1 - \lambda) c_k^o. \quad (7)$$

Private utility is $u(c) = (c^{1-\sigma} - 1)/(1 - \sigma)$, with the logarithmic limit at $\sigma = 1$. Public provision delivers $v(g) = \chi_g(g^{1-\sigma_g} - 1)/(1 - \sigma_g)$. The household discount factor is β_o ; the government may discount future allocations differently.

Competitive nontradable firms hire labor to produce $y^N = A_N n^{\alpha_N}$, with $0 < \alpha_N < 1$. Aggregate labor supply is one. A fixed nominal wage floor, expressed in tradable units under the peg, permits involuntary unemployment:

$$w = \alpha_N p^N A_N n^{\alpha_N - 1}, \quad w \geq \bar{w}, \quad n \leq 1, \quad (w - \bar{w})(1 - n) = 0,$$

$$n = \min \left\{ 1, \left(\frac{\alpha_N p^N A_N}{\bar{w}} \right)^{1/(1-\alpha_N)} \right\}, \quad \Pi^N = p^N y^N - w n. \quad (8)$$

The wage floor adds no lagged wage to the state. Profits Π^N accrue only to type- o households, so profits per owner are $\Pi^N/(1 - \lambda)$.

Public provision uses ωg units of tradables and $(1 - \omega)g$ units of nontradables. Its unit cost is $P_g = \omega + (1 - \omega)p^N$. A proportional revenue rate τ applies to income, and transfers $\bar{T}$ are fixed. Public spending is the residual of the government flow budget:

$$P_g g + \bar{T} = \tau(y^T + p^N y^N) + X + F, \quad g \geq g_{\min}. \quad (9)$$

Here X is the net external-debt cash flow and $F = r_R R - r_L \bar{L}$ is net foreign-asset income. The benchmark sets $\bar{T} = g_{\min} = r_R = r_L = \bar{L} = 0$. Public provision is therefore endogenous to revenue, borrowing, and prices; there is no separate public-capital accumulation equation or independent public-spending choice.

3.3 Consolidated saving and goods-market clearing

Let A denote aggregate reserve-linked monetary saving, and let $\mathcal{N}$ be the constant net domestic-asset component of its counterpart. The consolidated monetary identity is

$$A = R + \mathcal{N}, \quad A' - A = R' - R, \quad R \geq 0. \quad (10)$$

With $\mathcal{N} > 0$, the nonnegativity of national reserves entails an aggregate floor $A \geq \mathcal{N}$. The quantity $A/(1 - \lambda)$ is saving per owner. This accounting closure consolidates domestic intermediaries: there are no separate bank portfolios, refinancing choices, or bank-default states. National saving A is also distinct from the Union's monetary liabilities in the coverage denominator.

The consolidated spending equations used to determine private consumption are

$$\begin{aligned} Pc^h &= (1 - \tau)(y^T + wn) + \bar{T}, \\ Pc^o &= (1 - \tau) \left(y^T + wn + \frac{\Pi^N}{1 - \lambda} \right) + \bar{T} - \frac{R' - R}{1 - \lambda}. \end{aligned} \quad (11)$$

Together with the fiscal budget and nontradable market clearing, these expressions imply

$$\begin{aligned} C_N + (1 - \omega)g &= y^N, \\ R' - R &= y^T + F + X - \omega g - C_T. \end{aligned} \quad (12)$$

The second equality is the external-resource identity. Debt proceeds and payments to foreign creditors affect reserves through X , whereas domestic income redistribution does not create an additional external flow. Given (b', R') and the current state, equations (7)–(12) determine the relative price and the intratemporal allocation. Admissible choices must support positive private consumption and feasible public provision.

Intertemporal reserve choice is closed by a reduced-form saving condition. Define the marginal utility of tradable expenditure for an owner as $\mu = (c^o)^{-\sigma}/P$. The policy rate is transmitted to the saving return according to $i^d = \bar{i} + \varkappa(i - \bar{i})$; in the benchmark, $\varkappa = 1$. Let $\mu^a(b, R, \Omega)$ be next-period marginal utility averaged over the default decision and conditional debt choices, and let μ^e be its counterpart during exclusion. The relevant continuation terms for a current repayment choice and for current exclusion are, respectively,

$$\begin{aligned} \mathcal{E}^r(b', R'; \Omega) &= E_\Omega[(1 - \theta_\zeta \pi(R', \xi')) \mu^a(b', R', \Omega')], \\ \mathcal{E}^e(b, R'; \Omega) &= E_\Omega[(1 - \theta_\zeta \pi(R', \xi')) \{(1 - \phi) \mu^e(b, R', \Omega') + \phi \mu^a(\kappa b, R', \Omega')\}]. \end{aligned} \quad (13)$$

For an interior reserve choice, the condition is

$$\mu_t = \beta_o(1 + i_t^d) \mathcal{E}_t^k, \quad k \in \{r, e\}. \quad (14)$$

At the lower reserve bound the left-hand side is weakly greater than the right-hand side. In the numerical problem, an upper reserve or feasibility bound allows the reverse inequality. Thus the return fixed by the current policy rate multiplies next-period marginal utility, adjusted for next-period devaluation exposure. The parameter θ_ζ affects this expected-return margin, while ψ_ζ governs current expected tradable losses in equation (5).

Equation (14) is imposed as the saving closure alongside the consolidated spending identities. Those identities do not separately record gross interest payments or deposit-valuation transfers. Accordingly, the specification treats the monetary return as a reduced-form intertemporal wedge rather than deriving it from an explicit intermediary balance sheet. For every feasible sovereign choice, the condition defines a reserve response $R' = \mathcal{R}^r(S, b')$ or $R' = \mathcal{R}^e(S)$. If multiple interior roots are found, the reported numerical specification selects the largest feasible reserve root.

3.4 Common reserve backing, the policy rule, and devaluation risk

In the pooled regime the contribution supplied by the rest of the Union is

$$R^U(R, \xi, i) = \bar{R}^U \xi + \frac{1 - s_i}{s_i} \varepsilon_U \bar{c}^U (i - \bar{i}), \quad \mathcal{R} = R + R^U. \quad (15)$$

The independent stock parameter $\bar{R}^U$ need not equal $[(1 - s_i)/s_i] \bar{R}$. The second term is a reduced-form response of external resources to the common interest rate: tighter policy increases the rest-of-Union reserve contribution when $\varepsilon_U > 0$. The national government takes both the shifter and this response as given; it does not choose another member's reserves.

Let $\bar{\mathcal{R}} = \bar{R} + \bar{R}^U$. The coverage of monetary liabilities is

$$\mathcal{M} = \bar{\mathcal{M}} + \varphi_M(\mathcal{R} - \bar{\mathcal{R}}), \quad \text{ccr} = \frac{\mathcal{R}}{\mathcal{M}}, \quad \bar{\mathcal{M}} = \frac{\bar{\mathcal{R}}}{\text{ccr}^*}. \quad (16)$$

The parameter φ_M allows monetary liabilities to respond with reserve backing. This is a model coverage measure whose empirical counterpart and normalization are set out in the quantitative strategy. It is not identified with the national deposit stock A .

The central bank reacts to current coverage using an asymmetric rule with an inaction band of half-width Δ :

$$i = \max \{0, \bar{i} + \gamma_- \max(\text{ccr}^* - \Delta - \text{ccr}, 0) - \gamma_+ \max(\text{ccr} - \text{ccr}^* - \Delta, 0)\}. \quad (17)$$

Because the interest rate also enters R^U , equations (15)–(17) form a within-period fixed point. Monetary objects are functions of predetermined national reserves and the current external shifter, $i = \iota(R, \xi)$ and $\text{ccr} = \mathcal{C}(R, \xi)$. A domestic income shock therefore affects coverage through subsequent reserve adjustment, whereas an external reserve shock can affect it immediately.

Devaluation exposure is governed by

$$\pi(R, \xi) = \frac{\bar{\pi}}{1 + \exp\{[\mathcal{C}(R, \xi) - \text{ccr}_\zeta]/\varsigma_\zeta\}}. \quad (18)$$

The cap $\bar{\pi}$ scales quarterly exposure, ccr_ζ locates the schedule, and $\varsigma_\zeta > 0$ controls its slope. This probabilistic schedule introduces neither a discrete policy decision to abandon the peg nor a mechanical devaluation at a statutory threshold. In the expected-loss implementation, equation (18) enters resources and the saving margin directly. Nominal-wage relief following an actual devaluation is inactive.

The national-backing counterfactual replaces $\mathcal{R}$ by R , removes the external contribution, and sets $\bar{\mathcal{R}} = \bar{R}$ and $\bar{\mathcal{M}} = \bar{R}/\text{ccr}^*$. It preserves the same reference coverage and the same policy and risk schedules. Removing devaluation risk instead sets $\bar{\pi} = 0$, eliminating both expected-loss terms while retaining the relevant reserve arrangement. All these regimes are solved with their own equilibrium policies.

The source of local monetary protection can be seen at the reference allocation, inside the policy-rule band. Holding the external shifter fixed,

$$\left. \frac{\partial \text{ccr}}{\partial R} \right|_{\text{ref}} = \frac{\text{ccr}^*(1 - \varphi_M \text{ccr}^*)}{\mathcal{R}}, \quad \frac{(\partial \text{ccr} / \partial R)_{\text{pooled}}}{(\partial \text{ccr} / \partial R)_{\text{national}}} = \frac{\bar{R}}{\bar{R} + \bar{R}^U}. \quad (19)$$

A given national reserve loss consequently has a smaller local effect on common coverage when backing is pooled. This comparison holds reserves and reference conditions fixed; equilibrium borrowing and saving can reinforce or offset it in the quantitative exercises.

3.5 External debt, default, and sovereign choices

The government issues a long-duration bond to nonresident lenders. One unit of inherited debt pays c_B under repayment and leaves δ_B units of continuing claims. The total next-period debt stock is b' , so the net external cash flow is

$$X^r(S, b', R') = q(b', R'; \Omega)(b' - \delta_B b) - c_B b, \quad X^e = 0. \quad (20)$$

Default suspends both current payments and issuance. Recovery is represented by future claims on κb after re-entry, not by an immediate transfer of κb out of national reserves.

The government's flow objective is

$$U = \lambda u(c^h) + (1 - \lambda)u(c^o) + v(g). \quad (21)$$

Its discount factor is β_G . It anticipates the household reserve response to a current debt choice, but cannot commit future governments. Let $V^a(S)$ be the access value before sovereign taste shocks and $V^e(S)$ the exclusion value. For each debt-grid point b'_j that supports a feasible allocation, define

$$\begin{aligned} v_j^r(S) &= U^r(S, b'_j, \mathcal{R}^r(S, b'_j)) + \beta_G E_\Omega V^a(b'_j, \mathcal{R}^r(S, b'_j), \Omega'), \\ V^e(S) &= U^e(S, \mathcal{R}^e(S)) + \beta_G E_\Omega [(1 - \phi)V^e(b, \mathcal{R}^e(S), \Omega') + \phi V^a(\kappa b, \mathcal{R}^e(S), \Omega')]. \end{aligned} \quad (22)$$

The same exclusion value applies when an access-state government defaults in the current quarter.

The numerical economy incorporates smooth probabilistic sovereign choices. For a debt grid containing N_b points, the repayment value is

$$V^r(S) = \rho_b \log \left[\frac{1}{N_b} \sum_{j \in \mathcal{J}(S)} \exp\{v_j^r(S)/\rho_b\} \right], \quad p_j(S) = \frac{\exp\{v_j^r(S)/\rho_b\}}{\sum_{\ell \in \mathcal{J}(S)} \exp\{v_\ell^r(S)/\rho_b\}}, \quad (23)$$

where $\mathcal{J}(S)$ contains feasible debt choices. The uniform reference weights are $1/N_b$ on the full grid; the value is not renormalized by the number of currently feasible choices. Infeasible choices receive zero probability. If repayment has no feasible choice, default is selected.

The default probability and the value of access are

$$\begin{aligned} P^D(S) &= \frac{\exp\{V^e(S)/\rho_d\}}{\exp\{V^r(S)/\rho_d\} + \exp\{V^e(S)/\rho_d\}}, \\ V^a(S) &= \rho_d \log [\exp\{V^r(S)/\rho_d\} + \exp\{V^e(S)/\rho_d\}]. \end{aligned} \quad (24)$$

The binary log-sum has no additional division by two. Both normalizations are held fixed across regimes, as are ρ_b and ρ_d . As these scales approach zero, the expressions approach the

corresponding maximum-value choices. With positive scales, they are part of the quantitative specification and do not imply a deterministic debt threshold for default. The marginal-utility continuation used in (13) averages actual consumption allocations:

$$\mu^a(S) = (1 - P^D(S)) \sum_{j \in \mathcal{J}(S)} p_j(S) \mu_j^r(S) + P^D(S) \mu^e(S). \quad (25)$$

3.6 Bond pricing and recursive equilibrium

External lenders are risk neutral at the quarterly rate r^* in the reported calibration. Define the expected price of continuing claims conditional on repayment as $\bar{q}(S) = \sum_j p_j(S) q(b'_j, \mathcal{R}^r(S, b'_j); \Omega)$, and let $Q^e(S)$ be the value per old unit of debt following current default or during exclusion. The current payoff associated with one inherited claim, averaged over the sovereign decision, is

$$\mathcal{P}(S) = [1 - P^D(S)] [c_B + \delta_B \bar{q}(S)] + P^D(S) Q^e(S). \quad (26)$$

Bond prices satisfy

$$\begin{aligned} q(b', R'; \Omega) &= \frac{1}{1 + r^*} E_\Omega \mathcal{P}(b', R', \Omega'), \\ Q^e(S) &= \frac{1}{1 + r^*} E_\Omega [(1 - \phi) Q^e(b, \mathcal{R}^e(S), \Omega') + \phi \kappa \mathcal{P}(\kappa b, \mathcal{R}^e(S), \Omega')]. \end{aligned} \quad (27)$$

Thus recovery depends on the duration of exclusion, the haircut, and the possibility of another default after readmission. The pricing kernel in the reported exercises coincides with the physical transition kernel; an additional lender-risk-premium tilt is inactive.

For this geometric bond, the constant risk-free price and the quoted annual spread obey

$$q^{\text{rf}} = \frac{c_B}{1 + r^* - \delta_B}, \quad r^b = \frac{c_B}{q} + \delta_B - 1, \quad s^b = (1 + r^b)^4 - (1 + r^*)^4. \quad (28)$$

The implementation uses $c_B = (1 - \delta_B) + \delta_B r^*$, giving $q^{\text{rf}} = 0.996$ at the reported parameters; it is close to, but not exactly, one. The quantity b and its market value qb remain distinct. Stock ratios use an explicitly stated annual-output normalizer, while rates inside the flow budgets and pricing equations are quarterly.

A recursive equilibrium for the specified saving closure consists of relative prices, employment and consumption allocations, public provision, reserve responses, sovereign values and choice probabilities, and bond prices satisfying all the equations above. Intratemporal allocations clear both goods markets; reserve responses satisfy the saving condition and its boundary inequalities; sovereign choices satisfy the normalized value and probability equations; and lenders price the resulting repayment and restructuring payoffs. The transition combines these policies with the exogenous shock kernel and the re-entry lottery. The numerical solution iterates the associated values, marginal utilities, and prices jointly. The counterfactuals change the stated monetary arrangement or devaluation parameter while retaining this equilibrium definition.

4 Quantitative strategy

The model is solved for Senegal at a quarterly frequency. Section 4.1 fixes parameters using empirical calibration inputs, values from Coulibaly and Ndiaye (2026), and maintained assumptions. Section 4.2 estimates the remaining five parameters by simulated moment matching. Section 4.3 reports the fit and local identification diagnostics, including indicative local parameter-uncertainty scales.

4.1 Externally set parameters

Table 2 lists the externally set parameters. Units are those of the reference allocation: tradable income is $z = 1$, and reference annual GDP equals $4/s_T$, where $s_T = 0.39$ is the reference tradable share. Ratios to GDP are converted to model units with this factor. The stochastic income process is centered in logs, so this reference value is not its unconditional mean in levels; simulated mean output need not equal reference output.

Risk aversion, the tradable preference weight, the elasticity of substitution between tradables and nontradables, the recovery rate, and the re-entry probability are taken from Coulibaly and Ndiaye (2026). The tradable income process $(\rho_z, \sigma_\varepsilon) = (0.957, 0.025)$ also follows that paper. The hand-to-mouth share $\lambda = 0.56$, the tradable content of public spending $\omega = 0.43$, and the debt-persistence parameter $\delta_B = 0.98$ are maintained calibration assumptions in the present specification. In particular, $\delta_B = 0.98$ is the fraction of debt carried into the next quarter, implying geometric average maturity of 50 quarters.

The BCEAO block is parameterized using balance-sheet and policy-record inputs. The reference coverage ratio $\text{ccr}^* = 0.733$ is the 2015–2026 average of an approximate balance-sheet coverage measure; the reference rest-of-Union reserve stock equals 4.467 times Senegal’s. The reserve pass-through to the monetary base is $\varphi_M = 0.57$, and the policy-rule coefficients are $(\gamma_-, \gamma_+) = (0.0202, 0.00996)$, based on the tightening and easing episode calculations used for calibration. The external reserve persistence is $\rho_\xi = 0.955$. Its innovation scale, $\sigma_\eta = 0.113$, is disciplined by the coverage-volatility target, measured over 32-quarter windows, of 0.072. These external calibration inputs are distinct from the five moments matched jointly below. The empirical coverage proxy and the model’s monetary-liability measure are not assumed to reproduce every item in the statutory accounting ratio exactly.

The devaluation specification retains $\text{ccr}_\zeta = 0.20$ as an institutional reference point. Article 76 of the BCEAO’s 2010 statutes requires an extraordinary Monetary Policy Committee meeting when average foreign assets relative to average sight liabilities remain at or below 20% for three consecutive months (BCEAO, 2010). It does not prescribe an automatic parity change. Placing the model’s hazard midpoint at this level is a calibration assumption. The deposit-payoff loss $\theta_\zeta = 1/2$ is motivated by the January 1994 nominal parity change, which halved the CFA franc’s value in French francs (BCEAO, nd); applying that magnitude to a real deposit payoff is an additional modeling assumption, not a measurement of the realized loss in household purchasing power. The hazard width $\varsigma_\zeta = 0.16$ and tradable income cost $\psi_\zeta = 0.03$ are maintained reference scenarios. Section 7 varies θ_ζ , ψ_ζ , and the probability cap $\bar{\pi}$; the hazard width is held fixed in the reported exercises.

Several remaining scales follow from the reference allocation. The reserve and deposit inputs imply $\mathcal{N} = (0.3385 - 0.1167) 4/0.39 = 2.274872$. The nontradable productivity scale, $A_N = 1.509484$, reproduces the reference tradable output share at $z = 1$, zero debt, unchanged reserves, and an inactive wage floor. The public-good weight, $\chi_g = 0.124635$, equates reference marginal private utility per unit of expenditure with marginal public-good utility; this is a preference normalization, not an additional government first-order condition. Reference coverage gives $\bar{\mathcal{M}} = 8.927119$ in the pooled regime. The reference wage is $w^{\text{ref}} = 1.173077$, so the estimated wage fraction implies $\bar{w} = 1.049787$.

Table 2: Externally set parameters

Parameter	Description	Value	Source
<i>Preferences and technology</i>			
σ	Risk aversion	2.000	Coulibaly–Ndiaye (2026)
α_C	Tradable preference weight	0.260	Coulibaly–Ndiaye (2026)
γ	Elasticity of substitution T/N	0.440	Coulibaly–Ndiaye (2026)
λ	Share of hand-to-mouth households	0.560	Maintained calibration assumption
σ_g	Curvature of public-good utility	2.000	Set equal to σ
α_N	Nontradable output elasticity to labour	0.750	Assumption
s_T	Tradable share of GDP	0.390	National-accounts calibration input
<i>Fiscal block</i>			
ω	Import content of public spending	0.430	Maintained calibration assumption
τ	Revenue and grants / GDP	0.199	Data, 2015–2024
<i>Debt and default</i>			
δ_B	Debt persistence (50-quarter mean maturity)	0.980	Maintained calibration assumption
r^*	Risk-free rate (quarterly)	0.0050	Maintained reference rate
κ	Recovery rate	0.500	Coulibaly–Ndiaye (2026)
ϕ_{re}	Re-entry probability	0.100	Coulibaly–Ndiaye (2026)
$\rho_z, \sigma_\varepsilon$	Tradable income process	0.957, 0.025	Coulibaly–Ndiaye (2026)
<i>BCEAO and the rest of the Union</i>			
s_i	Senegal’s share of WAEMU GDP	0.149	WDI calibration input, 2015–2024
$\bar{R}^U / \bar{R}$	Rest-of-Union to Senegal reference reserves	4.467	BCEAO balance-sheet input
$\bar{A}$	Deposits / GDP (sets $\mathcal{N}$)	0.339	BCEAO/WDI calibration input
φ_M	Reserve pass-through to monetary base	0.570	BCEAO balance-sheet input
ccr^*	Reference coverage ratio (proxy)	0.733	BCEAO coverage proxy, 2015–2026
$\bar{i}$	Reference policy rate (annual)	0.0300	BCEAO calibration input, 2015–2024
γ_-, γ_+	Rule coefficients (tightening, easing)	0.0202, 0.00996	BCEAO policy-episode inputs
Δ	Inaction band	0.0200	Assumption
ε_U	Rest-of-Union absorption semi-elasticity	2.000	Maintained calibration input
ρ_ξ, σ_η	Rest-of-Union reserve process	0.955, 0.113	Calibration; coverage volatility
<i>Devaluation</i>			
ccr_ζ	Coverage reference in $\pi(ccr)$	0.200	BCEAO statutes, Article 76
ς_ζ	Width of $\pi(ccr)$	0.160	Maintained assumption; not varied
θ_ζ	Deposit-payoff loss at devaluation	0.500	Assumption inspired by nominal 1994 change
ψ_ζ	Tradable income cost of devaluation	0.0300	Reference scenario (sensitivity)
<i>Numerical</i>			
ρ_d, ρ_b	Taste-shock scales (default, issuance)	0.01, 0.002	Retained numerical scales

4.2 Simulated method of moments

Five parameters remain: the household discount factor β_o , the wage floor $\bar{w}$ expressed as a share of the reference full-employment wage, the government discount factor β_G , default-cost curvature ϕ_1 , and the devaluation-probability cap $\bar{\pi}$. The ratio $\phi_0/\phi_1 \simeq -0.766$ is held fixed under the adopted Chatterjee and Eyigungor (2012) cost specification. The five targets are the ratio of Senegal’s foreign assets at the BCEAO to GDP (0.1167, the 2015–2025 calibration input), employment (0.956, the retained employment target), external public debt to GDP (0.557), the mean sovereign spread (4.72%, the Bloomberg option-adjusted spread average used for calibration), and mean model-implied devaluation probability (0.3% per quarter). The debt and spread targets use the 2015–2024 calibration window. The devaluation target is a historical reference scenario, approximately consistent with one episode over 80 years since the creation of the CFA franc; it is not a moment of a 2015–2024 devaluation-probability series. The BCEAO chronology supplies the historical context for this scenario (BCEAO, nd). There are five moments for five parameters. Each has a main calibration role— β_o for reserves, $\bar{w}$ for employment, β_G for debt, ϕ_1 for spreads, and $\bar{\pi}$ for the hazard level—but the joint solution and the Jacobian allow substantial cross-effects.

Model moments are computed on a simulation of 60,000 quarters, of which the first 5,000 are discarded, with a fixed seed. Debt is measured conditional on beginning-of-quarter market access. Spreads exclude default and exclusion observations and the four quarters preceding each default, selecting financing conditions outside the immediate default build-up. The reserve ratio and employment are unconditional, and devaluation probability is the mean of $\pi(\text{ccr}_t)$ along the simulated path. The diagonal distance criterion uses the inverse squared comparison scales (0.0057, 0.0045, 0.065, 0.0024, 0.003) in the order of the five targets. These comparison scales are not an estimated sampling covariance matrix. In particular, 0.0024 is the scale for the spread *mean*, whereas the calibration standard deviation of the spread series is 0.0099; the devaluation scale accompanies the historical scenario. A quasi-Newton (Broyden) search updates $(\beta_o, \bar{w}, \beta_G, \phi_1)$ using a finite-difference initial Jacobian, with $\bar{\pi}$ adjusted toward its target. The archived search evaluates 26 parameter points and stops after its final attempted updates do not improve the best point. The selected point also has the lowest comparison-scale-weighted quadratic distance among those evaluated: 1.18, against 1.52 for the next best. This comparison does not establish a global minimum over the continuous parameter space.

For descriptive assessment, we report whether each moment lies within one comparison scale of its target. This criterion was adopted after inspecting the results and is not a formal goodness-of-fit test. The model is solved on a grid of 61 debt nodes, 25 reserve nodes, 7 income nodes and 9 rest-of-Union reserve nodes (Appendix A). Appendix A.2 retains the earlier coarser-grid estimates alongside the fine-grid point. Because both the grid and calibrated parameters differ, this is a comparison of two calibrated exercises, not a fixed-parameter grid-convergence test.

4.3 Fit and identification

Table 3 reports the estimates and indicative local uncertainty scales, and Table 4 the targeted and additional moments. All five target discrepancies are smaller than one comparison scale. Employment has the largest normalized gap, 0.97 below its target; the remaining gaps are at most 0.34 in absolute value. The debt ratio is 0.535 against 0.557, a discrepancy of 0.34 times its comparison scale. The model counterpart is a stationary average conditional on market access, so this fit does not identify an end-of-sample debt position.

Table 3: Estimated parameters and indicative local uncertainty scales

Parameter	Description	Estimate	Local scale	Centered scale	Main target
β_o	Household discount factor	0.9916	(0.0015)	(0.0016)	Reserves / GDP
$\bar{w}/w^{\text{ref}}$	Wage floor (share of reference wage)	0.8949	(0.0525)	(0.0586)	Employment
β_G	Government discount factor	0.9528	(0.0119)	(0.0158)	Debt / GDP
ϕ_1	Default cost curvature ($\phi_0 = -0.766 \phi_1$)	1.0496	(0.4212)	(0.9212)	Mean spread
$\bar{\pi}$	Devaluation hazard scale	0.0637	(0.0589)	(0.0592)	Devaluation probability

The two scale columns reproduce $\sqrt{\text{diag}[(1 + 1/\tau)(J'WJ)^{-1}]}$ from the archived calculation, with $\tau = 55,000/40$ and W based on the diagonal comparison scales. The first uses a weighted local linear regression over 35 converged parameter points (bandwidth 3 in normalized step units); the second uses centered finite differences. Neither column is a validated sampling standard error: the calculation does not establish the covariance of estimated moments, including cross-moment and serial dependence, or a corresponding empirical sample-size normalization. The numerical values are retained as indicative local scales. The wage floor is a share of the reference full-employment wage.

Under the local-regression calculation, the reported relative uncertainty scales are approximately 0.15% for β_o , 1.2% for β_G , 6% for the wage fraction, 40% for ϕ_1 , and 92% for $\bar{\pi}$. These contrasts describe the selected Jacobian and diagonal scaling; they do not demonstrate precise sampling estimation of the first three parameters. The relatively large scales for default-cost

Table 4: Targeted and additional moments

<i>Targeted moments</i>				
Moment	Target	Comparison scale	Model	Gap (scale)
Reserves / GDP	0.1167	0.0057	0.1160	-0.12
Employment	0.9560	0.0045	0.9516	-0.97
External public debt / GDP	0.5570	0.0650	0.5346	-0.34
Mean spread (access window)	0.0472	0.0024	0.0480	+0.33
Devaluation probability (quarterly)	0.0030	0.0030	0.0029	-0.03
<i>Additional moments</i>				
Moment	Data		Model	
Spread, s.d. (access window)	0.0099		0.0515	
Spread, median	–		0.0331	
Defaults (per 100 market-access years)	–		12.0	
Share of quarters in exclusion	–		0.2068	
Coverage ratio	0.7330		0.7376	
Coverage ratio, s.d. (32-quarter windows)	0.0720		0.0724	
Policy rate (annual)	0.0300		0.0317	
Reserves / GDP, s.d. (32-quarter windows)	–		0.0214	

Targets and comparison scales are the calibration inputs. The reserve target uses the 2015–2025 calculation; the coverage input uses 2015–2026; debt and spread use 2015–2024. Employment is the retained target and devaluation probability a historical reference scenario. The gap divides the model–target difference by the comparison scale, not by an estimated standard error. Model moments retain 55,000 quarters after burn-in. Debt is conditional on beginning-of-quarter market access; the spread window additionally omits default observations and the four predefault quarters. Default intensity is events per 100 market-access years. Window standard deviations average consecutive valid 32-quarter windows without default or exclusion.

curvature and the hazard cap motivate sensitivity analysis. Spread volatility is a potential additional source of information, but it is not targeted here, and the available calculations do not show that adding it would by itself identify ϕ_1 . Likewise, the scale assigned to the historical devaluation scenario is not the empirical standard deviation of an observed probability series. Results in Section 6 are conditional on these choices. Halving and doubling $\bar{\pi}$ in Section 7 provide parameter scenarios, not endpoints of a confidence interval.

The Jacobian in Appendix Table B.1 is most usefully read at the estimation-step scales: 3×10^{-4} for β_o , 0.03 for the wage fraction, 0.005 for β_G , 0.05 for ϕ_1 , and 0.006 for $\bar{\pi}$. In the local-regression approximation, the reserve ratio changes by approximately +0.010, –0.013, and –0.008 per step in β_o , the wage fraction, and β_G , respectively. The debt-ratio changes for the wage fraction and β_G are –0.026 and –0.022, while the ϕ_1 step gives +0.012. Employment changes by about +0.005 per β_G step and +0.0015 per β_o step. The hazard cap moves mean devaluation probability by about +0.0004 per step; reserve adjustments also make that probability sensitive to other parameters. The spread changes by –0.009, –0.008, and –0.003 per step in the wage fraction, β_G , and β_o , while the ϕ_1 step gives about +0.0006. These cross-effects preclude treating the main-target assignments as five independent calibration equations.

The derivative approximation itself is sensitive to method. For example, the debt derivative with respect to β_o is +12.25 in the bandwidth-three local regression and –9.27 in centered differences; the corresponding spread derivatives are –8.52 and +2.87. Discrete simulated default and issuance choices can make fixed-seed moments irregular at the chosen step sizes. Fitting a local plane to 35 converged points reduces reliance on any single pair, but does not establish that its slopes are the unique or population derivatives. The uncertainty scales differ

particularly for ϕ_1 , at 0.42 versus 0.92 across the two methods. The general asymptotic literature on simulation-based estimators (Pakes and Pollard, 1989; McFadden, 1989) does not, by itself, verify the covariance specification and regularity conditions needed for conventional inference in this application.

The additional moments in Table 4 describe what the model captures beyond the joint five-moment fit. Mean coverage and its 32-quarter-window volatility are 0.738 and 0.072, close to the 0.733 and 0.072 calibration inputs. Both quantities inform external monetary calibration, so this agreement is not an independent validation exercise. The annualized policy rate averages 3.2%, compared with the 3.0% reference. Default intensity is approximately twelve events per 100 market-access years, and the model spends about a fifth of its quarters in exclusion. These outcomes are model implications, without an empirical default-frequency target in the calibration. The principal reported dispersion mismatch is the spread standard deviation: 5.15 percentage points in the selected model window against the 0.99 percentage-point data value. Matching the mean spread does not resolve this discrepancy. Both model spread moments use the predefault-filtered access window, so the gap cannot be attributed simply to including exclusion observations in the model’s spread distribution.

5 Model mechanics

The estimated model connects sovereign financing conditions to the monetary environment through national reserve decisions and common reserve coverage. This section examines that connection within the pooled equilibrium. The policy schedules describe how prices, default incentives, and reserve choices vary across selected states. The default-event study then shows how these objects move together along endogenous crisis episodes. These two exercises serve different purposes: the schedules hold specified state variables fixed, whereas the event averages incorporate the joint evolution of income, debt, reserves, and market access. Their interpretation therefore rests on the conditioning of each figure.

5.1 Debt prices and default risk

Figure 3 displays the bond-price schedule at a common level of next-period national reserves. The horizontal axis measures the chosen debt stock, b' , relative to mean simulated annual output. The left panel varies domestic tradable income while holding the external reserve state at its median. The right panel varies the rest-of-Union reserve state at median domestic income. Neither panel allows the reserve choice to adjust with the debt position. They isolate slices of the equilibrium pricing function in equation (27), rather than the combinations of debt and reserves that the government and households select along a simulated path.

Domestic income has a pronounced effect on borrowing conditions. Lower income shifts the price schedule downward over the displayed debt range, and prices generally fall as the chosen debt stock rises. At the grid point corresponding to debt of approximately 53.75% of mean annual output, the price is 0.339 at the low-income node, 0.660 at the median, and 0.808 at the high-income node. The implied annual yield spreads at these same points are approximately 21.13, 5.26, and 2.37 percentage points. Thus a given future debt position can command very different financing terms depending on the income state from which it is issued. The lower prices in adverse income states increase the amount of debt needed to raise a given quantity of external resources.

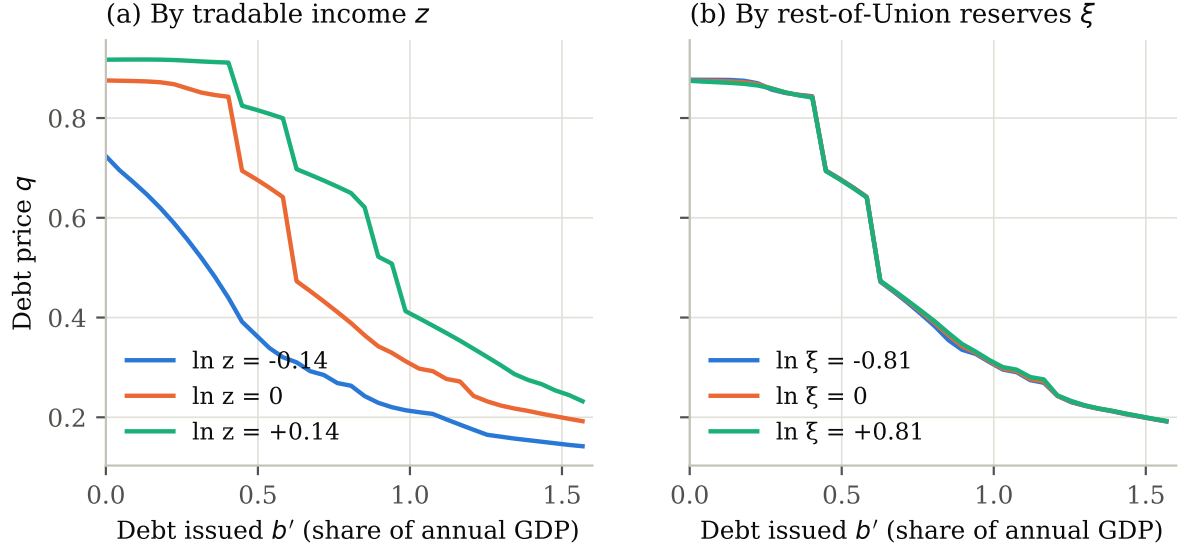


Figure 3: Debt price schedule $q(b', R'; z, \xi)$ in the estimated model

(a) Domestic tradable income varies at median ξ ; (b) the rest-of-Union reserve state varies at median z . Next-period national reserves R' are fixed at the mean simulated stock, 1.155226. Debt is divided by mean simulated annual output, 9.565736. The income nodes are two grid steps around the median, $\log z = \pm 0.140733$; the external-state nodes are three grid steps around the median, $\log \xi = \pm 0.808174$. The middle node is zero in logs. Source: author's equilibrium price schedules.

Changes in the external reserve state have much smaller effects on the particular price slices shown in the right panel. At the same debt point, prices across the three external states range only from about 0.6596 to 0.6609. Moreover, the ordering does not support a general assertion that stronger external reserve backing raises the sovereign bond price at every debt position. Common backing affects the monetary environment, while bond prices also incorporate future borrowing and repayment decisions. The small separation between these price curves consequently cannot be used as a measure of the overall protection supplied by pooling. It establishes a narrower finding: conditional on the reserves and income held fixed here, the displayed domestic-income shifts have much larger pricing effects than the displayed external-state shifts.

Figure 4 describes the contemporaneous default decision. Here the horizontal axis is inherited debt, b , and current reserves are fixed. The probability is obtained from the government's repayment and default values through equation (24). At low income, appreciable default probabilities occur at substantially smaller debt positions than at median income. For example, at inherited debt of 76.15% of mean annual output, the low-income probability is approximately 80.72%, while the median- and high-income probabilities remain close to zero. At high income, default is negligible throughout the displayed range, which ends just below 160% of mean annual output.

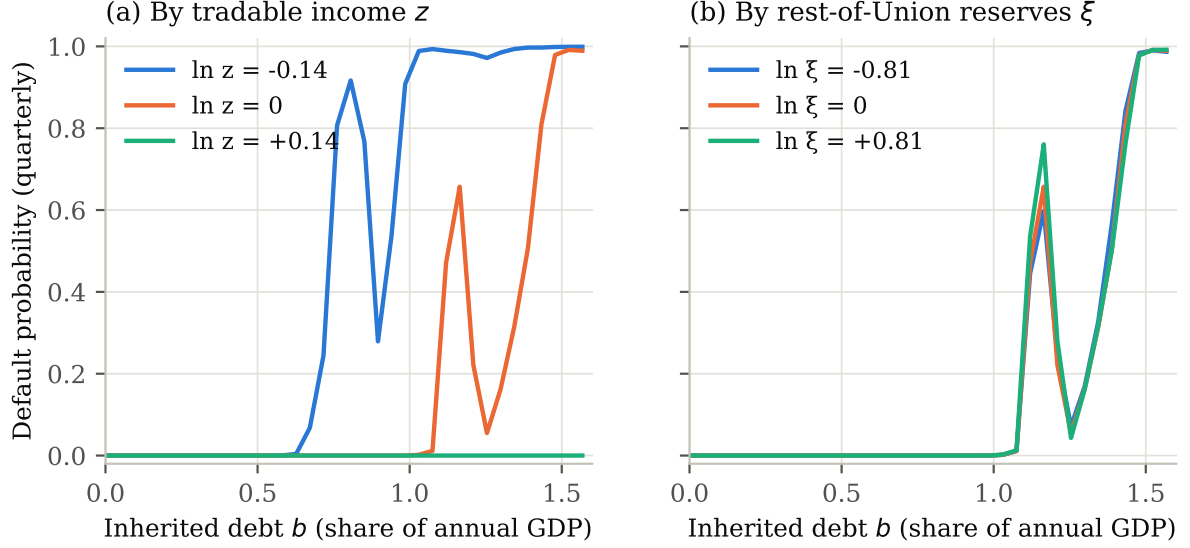


Figure 4: Default probability $P^D(b, R; z, \xi)$ by inherited debt

Quarterly default probabilities in the estimated pooled model. Current national reserves R are fixed at their mean simulated stock. The income and external-state nodes are those in Figure 3; the other exogenous state is held at its median. Inherited debt is divided by mean simulated annual output. The curves retain the nonmonotone segments of the supplied equilibrium schedules. Source: author's default policies.

The default schedules also contain marked nonmonotone segments. At median income and median external reserves, the probability is about 65.70% at a debt ratio of 116.46%, falls to 5.50% at 125.42%, and subsequently rises again. These schedules therefore do not imply a single debt threshold above which default becomes certain. The economically useful comparison is the strong dependence of repayment incentives on the income state, together with the nonlinear response to inherited obligations. The figure alone does not identify the source of every local reversal.

Current default probabilities and bond prices are related but measure different objects. Default concerns the inherited position in the present quarter, whereas the bond price values the future payment stream associated with the newly chosen position. Low current default probability can therefore coexist with an appreciable yield spread. This distinction is especially relevant for long-duration debt: future income, subsequent financing choices, and the possibility of later default enter its valuation even in a state where immediate repayment is strongly preferred.

5.2 Reserves, coverage and the policy rate

Figure 5 shows the monetary relationships that accompany these sovereign policies. For a given external reserve state, greater national reserves raise the coverage of monetary liabilities. The coverage mapping in equation (16) allows the monetary-liability denominator to respond to common reserve backing, so the ratio need not move proportionally with the national reserve stock. Nevertheless, its direction is clear on each displayed slice. At any given level of national reserves, a stronger contribution from the rest of the Union shifts coverage upward.

The magnitude of this external contribution is substantial. Around the mean national reserve stock, the three curves imply coverage of approximately 49.5%, 73.0%, and 103.5%, moving from the low to the high external state. These are conditional coverage levels, not averages

over separate equilibria. Coverage above one means that reserve backing exceeds the monetary-liability measure used in the ratio. Conversely, even when national reserves are zero, common coverage remains positive in all three slices because external reserves continue to contribute to the numerator. The national reserve position therefore does not by itself determine the strength of monetary backing in the pooled regime.

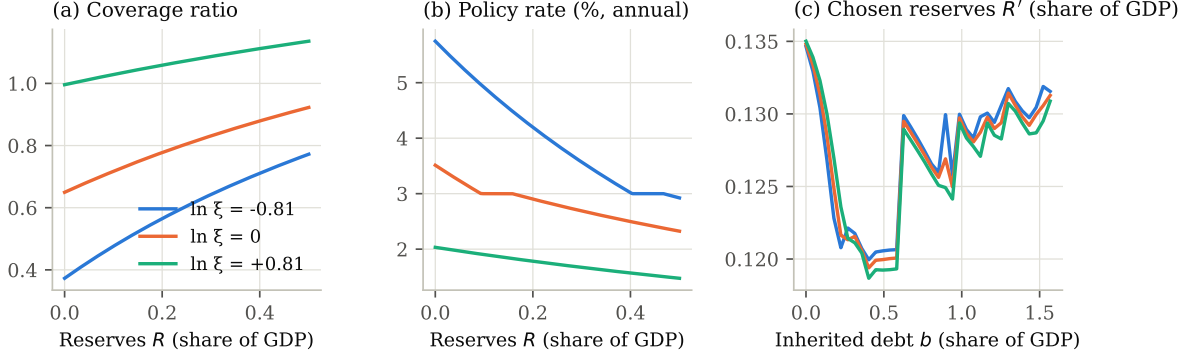


Figure 5: The BCEAO block: coverage ratio, policy rate and reserve choice

(a) Coverage as a function of current national reserves, for the three external-state nodes $\log \xi \in \{-0.808174, 0, 0.808174\}$; (b) the corresponding policy-rate fixed point, multiplied by four and expressed in annual percentage terms; (c) expected next-period national reserves conditional on repayment, at median domestic income and current reserves fixed at their mean simulated stock. The expectation in panel (c) is over the debt-issuance choice and excludes the default branch. All stock ratios use fixed mean simulated annual output, 9.565736. Source: author's monetary mappings and reserve policies.

The policy rate translates coverage conditions into the return relevant to domestic monetary saving. As equation (17) implies, the rate rises when coverage becomes sufficiently weak and falls when coverage is sufficiently strong. The flat portions of the curves correspond to the inaction band around reference coverage. At the mean national reserve stock, the annualized rate is approximately 4.76% in the low external state, 3.00% in the median state, and 1.88% in the high state. The figure therefore reveals a large monetary effect of external reserves even though their effect on the selected bond-price slices is small. Through the devaluation schedule in equation (18), the same coverage differences also imply different exposures to a parity adjustment.

Panel (c) completes the mechanism by allowing the next reserve stock to be chosen. It reports the reserve policy conditional on repayment, averaging over the issuance choices available at each inherited debt position. At median external reserves, expected next-period reserves initially decline from about 13.48% of fixed annual output at zero debt to 11.94% around a debt ratio of 40.31%. Beyond this region, the schedule rises and fluctuates; it does not exhibit a uniform decline with inherited debt. Borrowing conditions and reserve accumulation must consequently be read together rather than summarized by a constant reserve response to an additional unit of debt.

The differences between the three reserve-choice curves are much smaller than their differences in coverage. Around the 40.31% debt position, chosen reserve ratios range from about 11.87% to 11.99% across the external states. The low external state is associated with slightly greater national reserves at this point, consistent with some domestic adjustment to weaker common backing. Such adjustments do not eliminate the monetary separation visible in the first two panels. Pooling changes the coverage consequences of a national balance sheet even when its endogenous reserve position moves by comparatively little.

5.3 Anatomy of a default

Figure 6 organizes the benchmark simulation around 651 endogenous default events. Each retained event has a complete window and beginning-of-quarter market access in each of the preceding twelve quarters. The curves are event averages, while the shaded regions describe dispersion between events. This selection follows episodes in which the government’s own policies eventually lead to default; it does not impose a default on otherwise identical states. It is therefore informative about the sequence of conditions accompanying crises in the pooled equilibrium.

The predefault sequence is characterized by declining domestic income and worsening sovereign financing terms. Twelve quarters before default, mean log tradable income is approximately 0.52% below its full-simulation mean. The shortfall reaches 5.66% in the preceding quarter and 6.50% at the event. Over the predefault window, the annual spread rises from about 8.24 to 31.61 percentage points, while the debt ratio rises from 55.88% to 92.80% of annualized contemporaneous output. These paths connect the adverse income states in the pricing schedules to an endogenous build-up of sovereign stress.

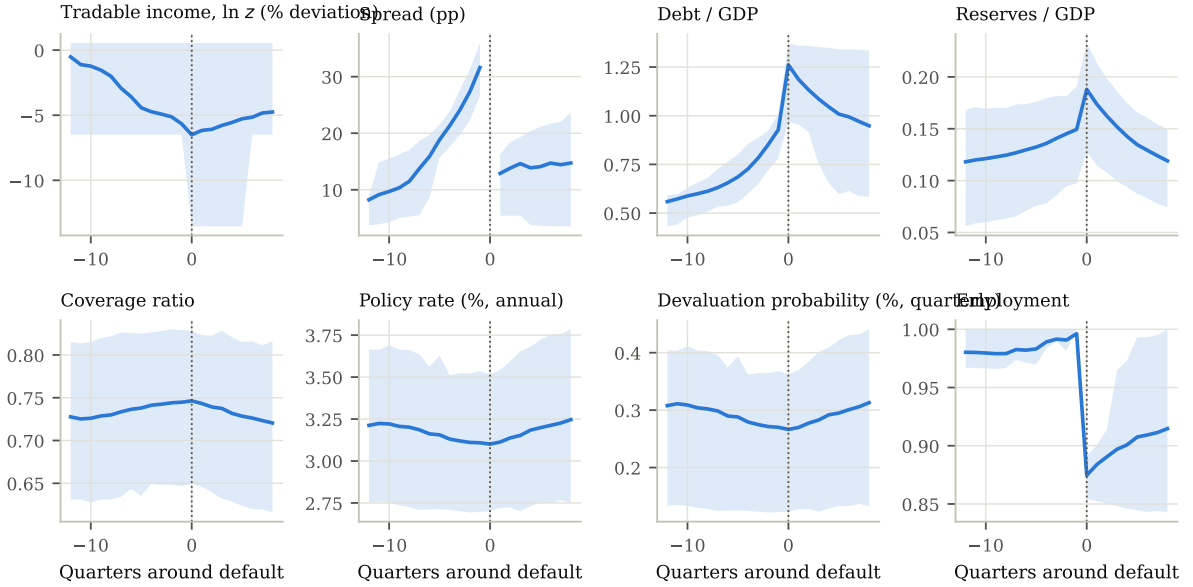


Figure 6: Event study around simulated defaults, $t = -12$ to $+8$ quarters

Means over 651 default events with a complete window and market access at the beginning of each of the twelve preceding quarters. Shading shows the 25th–75th event percentiles, not confidence intervals. Tradable income is $100(\log z_t - \log \bar{z})$. Debt and reserve ratios use four times contemporaneous quarterly output. Spreads are annual percentage points and exclude default and exclusion observations; postdefault means use only the available repayment observations following reentry. The policy rate is annualized, and the devaluation probability is a quarterly model-implied percentage. Employment is a share of normalized labor supply. Source: author’s benchmark simulation.

Common monetary coverage holds up during this deterioration. Its mean rises from 72.76% twelve quarters before default to 74.48% in the preceding quarter. The annualized policy rate correspondingly edges down from 3.21% to 3.11%, and quarterly devaluation probability declines from approximately 0.308% to 0.270%. Increasing sovereign distress is thus compatible with relatively stable common backing. These conditional event paths show why a measure of sovereign repayment risk cannot be treated as interchangeable with a measure of exchange-rate exposure in this model.

At default, the largest immediate real adjustment is in employment. Mean employment falls from 99.62% of normalized labor supply to 87.46%, a decline of about 12.16 percentage points. The debt ratio rises to 126.16% and the reserve ratio to 18.80%. Because inherited debt and beginning-of-quarter reserves are predetermined while output falls within the quarter, these jumps partly reflect the contemporaneous output denominator. They cannot be interpreted as equally sized increases in the underlying stocks. At the same event date, coverage rises slightly to 74.63% and devaluation probability falls to 0.266%; the sharp employment contraction therefore occurs without an immediate collapse of common reserve coverage.

The subsequent recovery remains incomplete over the displayed eight quarters. Employment reaches approximately 91.47% at the end of the window, while tradable income is still 4.75% below its simulation mean in logs. Mean coverage declines to 72.05%, the annualized policy rate rises to 3.25%, and quarterly devaluation probability reaches 0.313%. These later monetary movements accompany the postdefault adjustment. The postdefault spread curve requires a separate interpretation: it averages only the events with an available repayment observation after reentry, so it is not a financing cost faced by the full event sample during exclusion.

Taken together, the schedules and event paths establish the mechanism to be examined across monetary arrangements. Domestic income and inherited debt shape sovereign stress; reserve choices transmit part of that adjustment to monetary backing; and the external reserve contribution changes how strongly national conditions affect coverage. Section 6 evaluates the size of that protection by comparing separately solved pooled and national regimes.

6 The insurance value of reserve pooling

Reserve pooling changes the monetary consequences of a national external imbalance. A member's reserve losses affect the backing of a common currency alongside the resources supplied by the other members. National borrowing and saving decisions respond to this protection, so its quantitative implications require an equilibrium comparison. We first compare the distributions generated by pooled and national coverage, then examine policies at common states and the propagation of national and regional disturbances. Household consumption equivalents provide a supplementary assessment of the resulting allocations.

6.1 Pooled and national regimes

Regime A is the benchmark economy with pooled reserves and devaluation risk. Regime B retains a fixed parity but restricts monetary backing to national reserves. Its reference monetary base is adjusted to preserve the same reference coverage ratio, $ccr^* = 0.733$. Consequently, the experiment holds reference adequacy constant while changing the reserve resources that back the parity. The national regime has no rest-of-Union reserve shock. Regimes C and D repeat the pooled and national arrangements with the devaluation hazard set to zero. All four equilibria are solved separately at otherwise common structural parameters.

Table 5 shows a substantial difference in monetary exposure. Mean quarterly devaluation risk is 0.292% under pooled coverage and 1.602% under national coverage, a reduction of approximately 82%. Average coverage is 73.8% in A and 51.6% in B, while the average annual policy rate is 3.17% and 4.88%, respectively. Pooling also supports a higher ratio of national reserves to GDP, 11.6% against 8.7%. These comparisons concern the conditional hazard

Table 5: Pooled and national reserve coverage: equilibrium moments

Regime	Debt/GDP	Spread	Res./GDP	Coverage	Rate	π	Empl.	Def./100y	Excl.
A: pooled, devaluation risk	0.535	0.0480	0.116	0.738	0.0317	0.0029	0.9516	12.0	0.207
B: national, devaluation risk	0.457	0.0419	0.087	0.516	0.0488	0.0160	0.9530	10.4	0.184
C: pooled, no devaluation	0.432	0.0360	0.169	0.774	0.0298	0.0000	0.9605	8.6	0.164
D: national, no devaluation	0.522	0.0553	0.164	0.815	0.0290	0.0000	0.9499	12.7	0.222
M ₀ : pooled, $\xi = 1$	0.551	0.0476	0.119	0.729	0.0305	0.0024	0.9540	11.1	0.192
M ₀ C: pooled, $\xi \equiv 1$, no devaluation	0.496	0.0410	0.165	0.757	0.0295	0.0000	0.9567	10.0	0.183

A: pooled coverage with devaluation risk; B: national coverage with devaluation risk; C and D: the corresponding arrangements with $\bar{\pi} = 0$. M₀ and M₀C fix $\xi = 1$ under pooled coverage. Each equilibrium is simulated for 60,000 quarters, with 5,000 discarded. Ratios and rates are reported as fractions; the policy rate and spread are annual, and π is quarterly. Debt is measured in market-access quarters. The spread additionally excludes the four quarters preceding default. Defaults are events per 100 market-access years; exclusion is a share of all retained quarters. National reference monetary backing is $\mathcal{M} = \bar{R}/\text{ccr}^*$.

evaluated along equilibrium paths; the simulations incorporate expected devaluation losses rather than draws of realized parity changes.

The sovereign-risk ranking differs from the monetary-risk ranking. External debt averages 53.5% of annual GDP under pooled coverage and 45.7% under national coverage. The corresponding selected-window spreads are 4.80% and 4.19%, and default intensities are 12.0 and 10.4 events per 100 market-access years. The equilibrium therefore combines better monetary protection with greater borrowing and more sovereign defaults in the benchmark comparison. The reduction in devaluation exposure does not impose an ordering on debt sustainability: borrowers adjust their policies to the environment in which they operate. Establishing a separate moral-hazard mechanism would require an additional intervention that holds the relevant borrowing incentives fixed.

The no-devaluation comparison illustrates this interaction. In C, debt and the spread are below their values in D, reversing their ranking in A versus B. National reserve ratios also rise markedly in both arrangements when devaluation risk is removed. The saving condition links this change to the expected return on reserve-backed wealth, but equilibrium consumption, public spending and debt policies adjust jointly. The four regimes are therefore complementary experiments in the interaction between monetary backing and sovereign choices.

6.2 Policy functions under pooled and national coverage

Figure 7 compares decisions at common inherited debt, reference national reserves and the median regional state. At this reference point the monetary normalization makes current coverage, the policy rate and the devaluation hazard equal across A and B. Differences in policy functions consequently reflect the continuation environment and its implications for financing and saving, even when current monetary conditions coincide.

The comparison is state dependent. At median income and an inherited debt ratio of 54.3%, a plotted grid point near the calibration target, the repayment-conditional annual spread is approximately 5.70% in A and 5.98% in B. At the lower plotted debt ratio of 20.9%, the ordering reverses: the corresponding spreads are 1.52% and 0.94%. Thus, differences in average spreads in Table 5 combine differences in conditional pricing with differences in the states visited by the two economies.

The allocation panels make the same distinction useful for reserve accumulation and public spending. At median income, the two economies build reserves at low debt and reduce them at the grid points around 42% and 54% of GDP. Their adjustment becomes less regular in regions

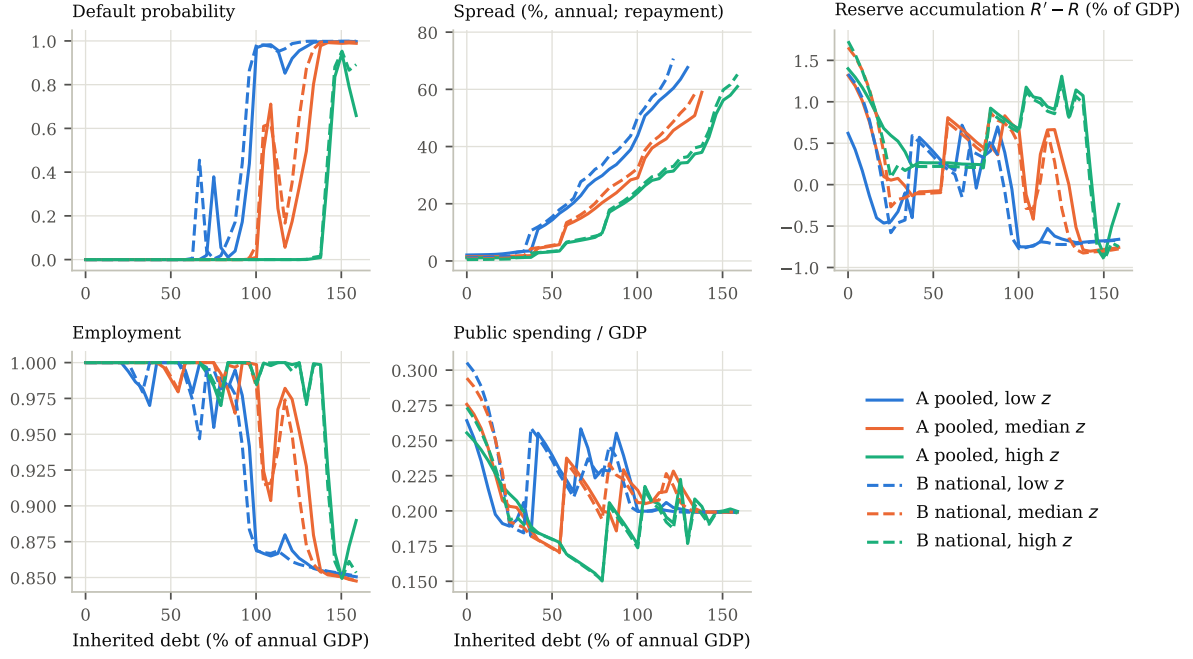


Figure 7: Policy functions under pooled and national coverage

Solid lines: A, pooled coverage. Dashed lines: B, national coverage. Policies are evaluated at $R = \bar{R}$, the median ξ , and market access. The three income states are one grid step, 0.07037 in $\ln z$, below and above the median. Outcomes average over issuance probabilities and, except for the repayment-conditional spread, over the default decision. The spread is an annual percentage and is omitted where $P^D > 0.99$; employment and public spending/GDP are fractions. Reserve accumulation is expressed as a percentage of fixed reference annual GDP, 4/0.39. The public-spending ratio uses contemporaneous output.

where the preferred issuance choice or repayment decision changes. The policy schedules display these transitions directly. They do not establish a single debt threshold separating repayment from default, nor a uniform ranking of employment or spending across all states.

6.3 Responses to a Senegalese income shock

We next lower national tradable income by one grid node at impact, a fall of 0.07037 in $\ln z$, or approximately 6.8% in levels. The disturbance changes national resources and induces endogenous sovereign stress. Shocked and reference paths share subsequent random draws within each experiment.

Figure 8 first fixes initial debt at 20%, 40% or 55.7% of reference annual GDP, with national reserves at their reference level and both shocks initially at their medians. This design separates the role of the initial debt position from differences in the long-run distributions. Pooling attenuates the deterioration in coverage and the rise in devaluation risk at all three initial debt levels. At the last reported quarter, $h = 19$, the increase in the quarterly hazard is about 0.050, 0.028 and 0.043 percentage point in A, compared with 0.737, 0.460 and 0.818 point in B, respectively. The protection is substantial in every comparison, although its magnitude is not monotone in initial debt.

The responses of consumption, employment, public spending and default need not share the ranking of the monetary variables. These quantities depend on the fiscal adjustment, the terms of new borrowing and the distribution of households' resources. The initial-debt experiment

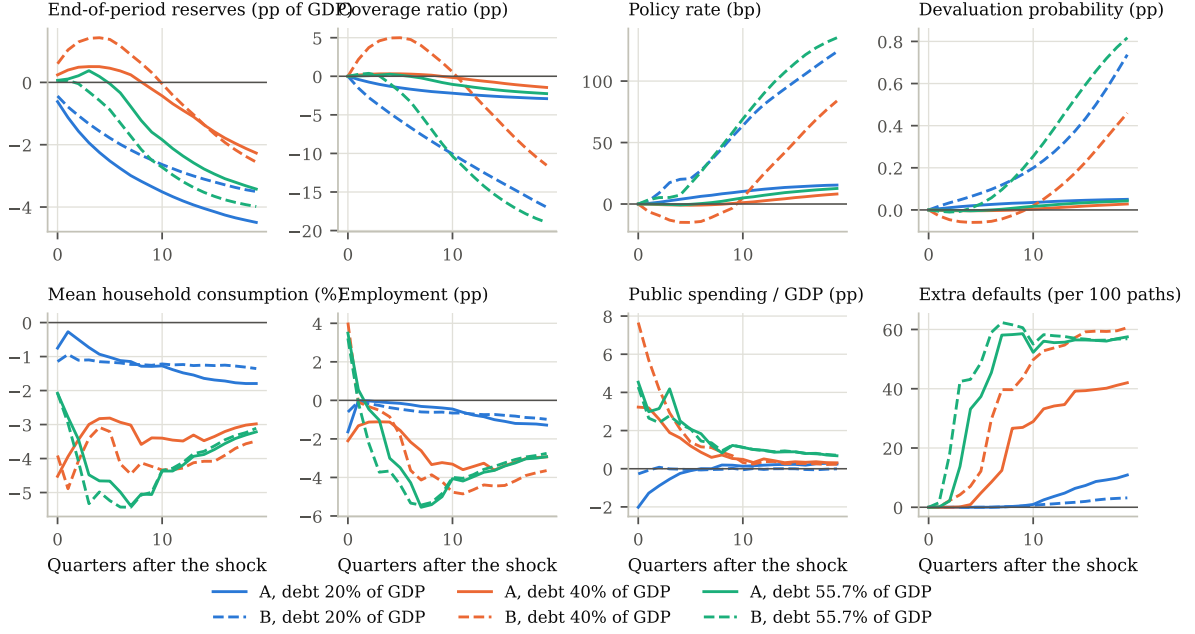


Figure 8: Income-shock responses by initial debt: pooled versus national coverage

Shocked minus reference means from 4,000 paired paths, over $h = 0, \dots, 19$. Initial debt is 20%, 40% or 55.7% of reference annual GDP, $4/0.39 = 10.25641$; $R = \bar{R}$, and z and ξ are initially at their medians. Solid lines denote A and dashed lines B. Reserves are end-of-period stocks divided by fixed reference GDP. Coverage, the annual policy rate and the quarterly hazard are determined from beginning-of-period states. Consumption is the population-weighted mean of the two household consumption composites, expressed relative to its reference-path mean; public spending/GDP uses contemporaneous output. Extra defaults are additional cumulative events per 100 paths and may include repeated defaults.

therefore identifies a stable monetary benefit within a broader adjustment whose real and sovereign-risk consequences remain state dependent.

Figure 9 compares A–D using common national starting states drawn from the benchmark simulation, restricted to market access and shock states at which the perturbations are feasible. At $h = 23$, reserves fall by 2.77 percentage points of reference GDP in A and 3.06 points in B. The associated coverage declines are 1.64 and 11.84 percentage points. The annual policy rate rises by approximately 9 basis points under pooling and 78 basis points under national coverage; the quarterly devaluation hazard rises by 0.028 and 0.493 percentage point. Similar national reserve losses thus have very different consequences for the currency’s backing and the response of monetary policy.

The amplification also differs across C and D, although both have zero effective devaluation risk. Their coverage falls by 1.92 and 7.53 percentage points at $h = 23$, respectively. The latent hazard shown in the figure evaluates the benchmark schedule at these coverage ratios, providing a common index of monetary exposure; it is not a probability applied to households in C or D. This comparison separates the backing mechanism from the equilibrium response to an active devaluation hazard.

The monetary attenuation in A versus B coexists with a larger spread response in A at the terminal horizon, 1.73 against 1.02 percentage points. Additional cumulative defaults are similar, 37.1 and 37.9 events per 100 paths. Pooling therefore protects monetary coverage more clearly than it protects against the sovereign default events generated by this disturbance. Several

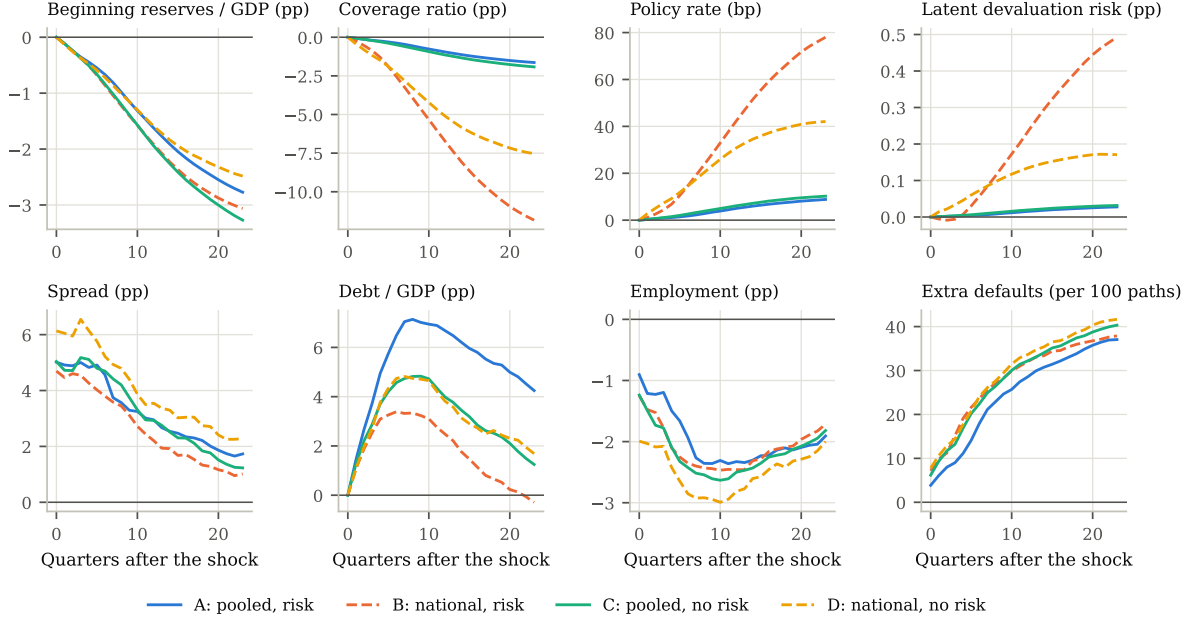


Figure 9: Income-shock responses across the four monetary arrangements

Shocked minus reference means from 10,000 paired paths, over $h = 0, \dots, 23$. National starting states are common across regimes and are drawn from A conditional on market access, z above its lowest node and interior ξ . Income and regional transitions use separate marginal draws, preserving comparable national income histories across regimes. Reserves and debt are beginning-of-period stocks divided by fixed benchmark annual GDP, 9.56574. The latent hazard applies A's devaluation schedule to each regime's coverage; the effective hazard in C and D is zero. The policy rate and spread are annual. Spread means are conditional on repayment and therefore also reflect changes in the composition of surviving access paths. Extra defaults count additional cumulative events per 100 paths.

responses continue to develop at the end of the plotted horizon, so the experiment does not determine their full persistence or a return date to the reference path.

6.4 Responses to a rest-of-Union reserve shock

The common reserve pool is itself exposed to regional disturbances. Figure 10 changes $\ln \xi$ by one grid node, holding the national starting state and subsequent random draws common to the perturbed and reference paths. The negative and positive changes are symmetric in logs, ± 0.26939 , and correspond to a fall of approximately 23.6% or a rise of 30.9% in the regional reserve shifter.

National reserves are predetermined at impact, but the external shock immediately changes common coverage. A fall in ξ reduces coverage by 8.70 percentage points, raises the annual policy rate by 48 basis points and increases the quarterly devaluation hazard by 0.161 percentage point. A rise in ξ raises coverage by 9.43 points, lowers the policy rate by 44 basis points and reduces the hazard by 0.111 point. The asymmetry reflects the monetary rule and the nonlinear mapping from coverage to devaluation exposure, together with the different level changes implied by symmetric log shocks.

These responses establish the regional counterpart of national insurance. A member benefits from access to a larger backing stock while inheriting exposure to movements in the rest of that stock. The effect operates before national reserves adjust and can persist as the regional

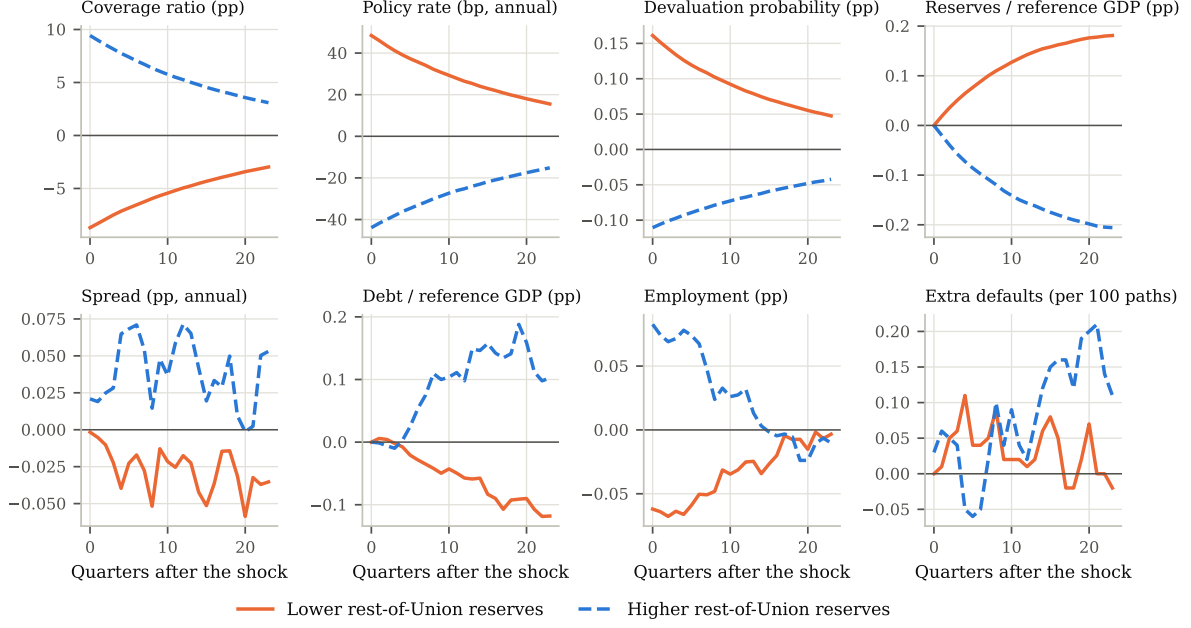


Figure 10: Transmission of a rest-of-Union reserve shock

Regime A, lower or higher ξ minus the reference path. The experiment uses 10,000 paired paths and the same admissible common starting states as Figure 9. Only the initial regional shock is changed. The plotted series come from the expected-devaluation simulator used for the national-shock comparison. National reserves and debt are beginning-of-period stocks divided by fixed reference annual GDP, 9.56574. Policy rates and spreads are annual; devaluation risk is quarterly. Extra defaults are additional events per 100 paths.

process evolves. The monetary advantage of pooling must therefore be evaluated jointly with the conditions of the rest of the Union.

6.5 Household consumption equivalents

Table 6 evaluates the household consumption paths implied by the equilibria. For household type $j \in \{h, o\}$ and a common initial distribution μ_0 , define $\Lambda_j^{A/B}$ by

$$\begin{aligned} \mathbb{E}_{\mu_0} \sum_{t \geq 0} \beta_o^t \left[u \left((1 + \Lambda_j^{A/B}) c_{j,t}^B \right) + v(g_t^B) \right] \\ = \mathbb{E}_{\mu_0} \sum_{t \geq 0} \beta_o^t \left[u(c_{j,t}^A) + v(g_t^A) \right]. \end{aligned} \quad (29)$$

A positive CEV is the permanent increase in comparator-regime private consumption needed to match utility in the pooled regime, keeping comparator public spending unchanged. The national index applies the same calculation to population-weighted household utility, with the public good counted once. The utility aggregation precedes the nonlinear conversion to a consumption equivalent.

From common admissible A states, the national CEV is +0.263%, with a larger gain for hand-to-mouth households, +0.353%, than for savers, +0.101%. The initial debt position changes the comparison: the national measure is -0.346% at 20% debt, +0.597% at 40%, and -0.057% at 55.7%. When each regime starts in its own invariant distribution, the national CEV is -0.353%. This last comparison incorporates differences in the initial distributions of debt, reserves and market exclusion, and answers a different question from a transition evaluated at common states.

Table 6: Household consumption equivalents of pooled coverage

Comparison	Initial state	Hand-to-mouth	Savers	National
Pooled vs national (A vs B)	Common A access states	+0.353 (0.027)	+0.101 (0.029)	+0.263 (0.027)
	Debt 20% of GDP	-0.204 (0.019)	-0.600 (0.021)	-0.346 (0.019)
	Debt 40% of GDP	+0.665 (0.027)	+0.474 (0.029)	+0.597 (0.027)
	Debt 55.7% of GDP	+0.023 (0.022)	-0.201 (0.023)	-0.057 (0.022)
	Own invariant distribution	-0.305 (0.056)	-0.440 (0.065)	-0.353 (0.059)
Pooled vs national, no devaluation (C vs D)	Common A access states	+1.343 (0.026)	+1.333 (0.027)	+1.340 (0.026)
	Debt 20% of GDP	+0.367 (0.022)	+0.202 (0.023)	+0.307 (0.022)
	Debt 40% of GDP	+1.213 (0.024)	+1.191 (0.025)	+1.205 (0.024)
	Debt 55.7% of GDP	+1.363 (0.025)	+1.372 (0.026)	+1.366 (0.025)
	Own invariant distribution	+1.940 (0.057)	+2.055 (0.064)	+1.981 (0.059)

Entries are CEVs in percent; a positive value favors the first, pooled regime. Private consumption in the second regime is scaled as in equation (29). Public-good utility is included and β_o discounts both household types. The national measure weights household utilities by λ and $1 - \lambda$ before calculating the CEV. Common A starts are restricted to admissible market-access states. Fixed-debt starts use mean benchmark national reserves, 1.15523, median shocks, and benchmark mean annual GDP, 9.56574, to set debt; these normalizers differ from those in Figure 8. Own-distribution starts allow each regime its own invariant distribution, including exclusion. Estimates use 5,000 paths of 2,000 quarters; parentheses report Monte Carlo standard errors from 400 paired bootstrap draws over paths, conditional on the maintained parameters.

The consumption results qualify the scope of monetary insurance. Lower exposure to devaluation risk is compatible with different household rankings because consumption also reflects borrowing, fiscal policy and default. These supplementary measures therefore do not support an unconditional household-utility ranking of the monetary arrangements.

6.6 The devaluation channel

The A/B and C/D comparisons measure how the presence of devaluation risk changes the equilibrium consequences of pooling. Table 7 reports the difference between their consumption equivalents. At the common A start, the national CEV in C versus D is +1.340%, compared with +0.263% in A versus B, giving a difference of -1.077 percentage points. The corresponding differences are negative at the other reported starts as well.

Table 7: Interaction between devaluation risk and the consumption-equivalent comparison

Initial state	Hand-to-mouth	Savers	National
Common A access states	-0.990 (0.040)	-1.232 (0.042)	-1.077 (0.040)
Debt 20% of GDP	-0.570 (0.028)	-0.802 (0.030)	-0.653 (0.029)
Debt 40% of GDP	-0.548 (0.040)	-0.717 (0.042)	-0.608 (0.040)
Debt 55.7% of GDP	-1.340 (0.037)	-1.573 (0.039)	-1.424 (0.038)
Own invariant distribution	-2.245 (0.079)	-2.495 (0.091)	-2.335 (0.083)

Percentage-point difference, $100(\Lambda_j^{A/B} - \Lambda_j^{C/D})$, between the two separately solved equilibrium comparisons. Initial-state conventions and bootstrap procedure are those of Table 6. Parentheses measure Monte Carlo uncertainty. The contrast includes the responses of borrowing, default, saving and public spending, as well as the nonlinear conversion from utility to consumption equivalents.

This difference is an equilibrium interaction rather than an additive utility contribution attributable exclusively to devaluation insurance. Setting $\bar{\pi} = 0$ changes both the perceived return to saving and the government's financing environment, inducing the policy changes evident in Table 5. In the benchmark national comparison, introducing devaluation risk lowers debt and default intensity relative to D. Those adjustments help explain why the household comparison

can move differently from the direct reduction in monetary exposure. A separate decomposition of these adjustments would require holding specified policies or prices fixed.

6.7 Pool size

Finally, Table 8 varies rest-of-Union reference reserves while fixing $\xi = 1$. The three values of $\bar{R}^U/\bar{R}$ are 0.75, 2 and 4.467; the last matches the benchmark pool scale. Reference monetary liabilities are renormalized in each economy to keep $\text{ccr}^* = 0.733$. This exercise changes the relative backing available to absorb national reserve movements while preserving reference coverage.

Table 8: Pool size and monetary insurance

Pool size ($\xi \equiv 1$)	Debt/GDP	Spread	Res./GDP	Coverage	Rate	π	Empl.	Def./100y	Excl.
$\bar{R}^U = 0.75 \bar{R}$	0.531	0.0473	0.118	0.709	0.0335	0.0036	0.9516	11.4	0.205
$\bar{R}^U = 2 \bar{R}$	0.526	0.0458	0.122	0.727	0.0315	0.0026	0.9554	10.7	0.189
$\bar{R}^U = 4.467 \bar{R}$ (benchmark scale)	0.551	0.0476	0.119	0.729	0.0305	0.0024	0.9540	11.1	0.192

All rows fix $\xi = 1$ and solve the equilibrium separately at the reported rest-of-Union reserve scale. The 4.467 $\bar{R}$ row is the fixed-regional-state economy M_0 , not the stochastic benchmark A. Reference monetary liabilities are adjusted to preserve coverage of 0.733. Units and moment-selection conventions are those of Table 5. Fixing the log-centered regional process at $\xi = 1$ changes both its variability and its mean in levels relative to A.

Mean quarterly devaluation risk declines from 0.358% at the smallest pool to 0.263% at the intermediate pool and 0.236% at the benchmark scale. The associated annual policy rates fall from 3.35% to 3.15% and 3.05%. The monetary consequences of a national income disturbance also become smaller. At $h = 23$ in the common-state shock experiment, coverage falls by 4.62, 2.87 and 1.70 percentage points across these three pool sizes; the quarterly hazard rises by 0.076, 0.038 and 0.021 percentage point. National reserve losses remain comparable and are slightly larger at the largest pool. The backing stock therefore changes the propagation of a national reserve loss even when it does not eliminate that loss.

Debt and default do not vary monotonically with pool size. Their response depends on the financing and saving choices supported by each arrangement. Within the configurations examined, the clearest common result is the reduced sensitivity of monetary coverage and devaluation exposure to the member's own reserve position.

7 Sensitivity

The monetary-insurance results and supplementary welfare comparisons of Section 6 are conditional on the devaluation specification. The reported experiments vary the deposit-payoff loss θ_ζ , the tradable income cost ψ_ζ , and the probability cap $\bar{\pi}$ one at a time. The hazard width ς_ζ remains at 0.16. These are comparative statics at the remaining baseline parameters, without re-estimation. Regimes A (pooled) and B (national) are solved anew for each change. Because regimes C and D impose $\bar{\pi} = 0$, changes in these three devaluation parameters do not affect their solutions, which are reused throughout. Welfare follows the paired-path procedure of Section 6.5, with the same restricted common sample of baseline-A starting states: market access, productivity above its lowest grid node, and interior rest-of-Union reserve nodes. This choice holds the starting-state distribution fixed across variants.

7.1 Devaluation parameters

Table 9: Sensitivity of moments and welfare to the devaluation parameters

Variant	Regime B (national)			National welfare comparisons		
	Debt/GDP	Def./100 access y.	π	A vs B (%)	C vs D (%)	Interaction (pp)
Baseline	0.457	10.4	0.0160	+0.263 (0.027)	+1.340 (0.026)	-1.077 (0.040)
$\psi_\zeta = 0$	0.478	10.4	0.0163	+0.110 (0.022)	+1.340 (0.026)	-1.230 (0.035)
$\psi_\zeta = 0.06$	0.463	10.1	0.0155	+0.358 (0.028)	+1.340 (0.026)	-0.981 (0.040)
$\theta_\zeta = 1/3$	0.566	13.3	0.0074	+1.218 (0.027)	+1.340 (0.026)	-0.122 (0.035)
$\theta_\zeta = 2/3$	0.748	19.4	0.0223	+1.321 (0.027)	+1.340 (0.026)	-0.018 (0.031)
$\bar{\pi} \times 0.5$	0.360	5.8	0.0033	+0.065 (0.024)	+1.340 (0.026)	-1.274 (0.034)
$\bar{\pi} \times 2$	0.723	20.9	0.0773	+0.849 (0.031)	+1.340 (0.026)	-0.491 (0.044)

Comparative statics at the remaining baseline parameters; A and B solved anew for each change, C and D at baseline. Baseline: $\psi_\zeta = 0.03$, $\theta_\zeta = 1/2$, $\bar{\pi} = 0.0637$; $\zeta_\zeta = 0.16$ in every row. Regime-B debt is conditional on beginning-of-quarter market access; default intensity is events per 100 market-access years; π is mean quarterly devaluation probability. CEVs are percentages for the national index including $v(g)$, from the restricted common baseline-A starts. Parentheses contain paired-bootstrap Monte Carlo standard errors, not parameter-estimation uncertainty. The interaction is $\text{CEV}(\text{A vs B}) - \text{CEV}(\text{C vs D})$ in percentage points; it is not an additive causal decomposition.

Three results emerge. First, pooling attenuates monetary risk in all seven reported specifications, including the baseline. In each case, regime A has higher mean coverage, lower mean devaluation probability, and a lower mean policy rate than regime B. The reduction in mean devaluation probability ranges from approximately 60% when $\bar{\pi}$ is halved to 91% when it is doubled, relative to each variant’s national regime. At the baseline it is approximately 82%. These comparisons support the reserve-insurance mechanism over the scenarios actually computed. They do not establish invariance to the hazard width, which is not varied, or to parameters outside this set.

Second, fiscal and reserve responses differ across the experiments. Raising the deposit loss to $\theta_\zeta = 2/3$ increases national debt from 45.7% to 74.8% of GDP and default intensity from 10.4 to 19.4 events per 100 market-access years. National coverage falls from 0.516 to 0.398, and mean quarterly devaluation probability rises from 1.60% to 2.23%. Reducing the loss to $1/3$ also raises national borrowing and default intensity, to 56.6% of GDP and 13.3 events, but its monetary outcomes move in the opposite direction: coverage increases to 0.690, while devaluation probability falls to 0.74%. A smaller loss is less costly for depositors, and the associated equilibrium response cannot be described as a uniform deterioration in reserve backing. The pooled regime’s debt ratio falls to approximately 48% under either loss change, from 53.5% at the baseline. Thus, the fiscal ranking of the two reserve arrangements changes with this parameter even though their monetary-risk ranking does not.

The probability-cap experiments produce larger changes in national coverage. Doubling $\bar{\pi}$ leaves national coverage at 0.140, with mean devaluation probability of 7.73% per quarter, debt of 72.3% of GDP, and 20.9 defaults per 100 market-access years. The corresponding pooled coverage and devaluation probability are 0.714 and 0.68%. Halving the cap gives national coverage of 0.689, a 0.33% mean devaluation probability, debt of 36.0%, and default intensity of 5.8; the pooled mean probability falls to 0.13%. These are changes in endogenous stationary allocations as well as direct changes to the hazard schedule. Varying ψ_ζ from zero to 0.06 produces smaller changes around the baseline: national debt lies between 46% and 48%, and its mean devaluation probability remains close to 1.6% per quarter.

Third, the national CEV index from the common starting sample remains positive in all seven specifications, but its magnitude is sensitive. It ranges from +0.065% when $\bar{\pi}$ is halved to +1.321% at $\theta_\zeta = 2/3$, compared with +0.263% at the baseline. Setting ψ_ζ to zero or doubling it gives +0.110% and +0.358%. The comparison without devaluation risk is +1.340% throughout because C and D are unchanged by construction. Its constancy across rows is therefore not a separate robustness result. The reported range is a scenario range, not a confidence interval; the bootstrap errors describe simulation precision conditional on each solved specification.

The CEV interaction is negative in every reported row: -1.077 percentage points at the baseline, close to zero at the two alternative deposit losses (-0.122 and -0.018), and -0.491 when the probability cap is doubled. It measures how the welfare comparison between reserve arrangements changes when devaluation risk is permitted. Because all four regimes involve equilibrium changes and the CEV transformation is nonlinear, this difference does not isolate a causal devaluation contribution. In particular, the nonmonotonic response of the national CEV to θ_ζ is consistent with the joint movements in debt, reserves, default, and consumption, but the reported experiments do not assign these movements separate welfare weights.

These positive national indices apply to the stated aggregation and starting sample. They need not imply gains for every household type. With the cap halved, for example, the common-start CEV is approximately +0.130% for hand-to-mouth households and -0.051% for savers. Nor do the common-start results establish positive welfare effects at every initial debt level or under each regime’s own stationary distribution. Section 6.5 documents that distinction at the baseline. Monetary risk attenuation and a positive common-start national CEV are therefore separate findings, with different scopes.

8 Conclusion

This paper asks what a country obtains from a monetary union when it surrenders its nominal exchange rate and national monetary policy, and answers that part of the return is insurance. The pooling of foreign-exchange reserves weakens the link between a member’s sovereign financing shocks and the backing of the common currency. The answer is deliberately narrower than the question of whether membership is desirable. It isolates one balance-sheet channel, quantifies it, and separates it from the other margins—trade, factor mobility, fiscal transfers, and the external convertibility guarantee—that a complete assessment would have to weigh.

The monthly central-bank accounts of the eight WAEMU members show why the channel is quantitatively relevant. National foreign claims comove weakly, so the constructed area-wide coverage ratio fluctuates by roughly half as much as the typical national ratio. During the Malian sanctions of 2022 and the Senegalese hidden-debt episode of 2024–2025, national and aggregate coverage moved in opposite directions. These are accounting facts about diversification rather than estimates of a treatment effect, and they do not reveal what reserves or interest rates would have been under a national currency. They do establish that a member’s reserve position and the backing of the currency it uses are distinct objects.

The quantitative model makes that distinction operational. Under pooled backing, the mean quarterly devaluation probability is 0.29 percent rather than 1.60 percent, mean coverage is 73.8 rather than 51.6 percent, and the policy rate is about 170 basis points lower. After an adverse income shock, national reserves fall by similar amounts under both arrangements, but coverage declines by 1.6 rather than 11.8 percentage points and the policy rate rises by 9 rather than 78 basis points. The insurance therefore operates through a weaker mapping from a national

reserve loss into common backing, not through the elimination of that loss. These magnitudes are outcomes of a specified coverage-dependent hazard and a calibrated policy rule; they are not estimates of realized devaluation risk in WAEMU.

Protection against devaluation is not protection against default. In the benchmark comparison, pooled backing is associated with higher external debt, 53.5 against 45.7 percent of GDP, more frequent defaults, and higher selected spreads, and removing the devaluation hazard reverses this ordering. Consumption-equivalent comparisons are correspondingly conditional: the national index is +0.26 percent from common initial states and -0.35 percent when each regime starts from its own stationary distribution, and it ranges from +0.07 to +1.32 percent across the devaluation parameters examined. We therefore read the insurance value of monetary union as the stabilization of monetary coverage and devaluation exposure. Attributing the borrowing response to moral hazard would require a decomposition that holds sovereign incentives fixed, which the present exercises do not perform.

The insurance is also conditional on the pool itself. A member gains access to a larger backing stock and inherits exposure to its movements: an adverse rest-of-Union reserve shock raises the member's policy rate and devaluation hazard immediately, before its own reserves adjust, and a larger pool strengthens the attenuation of national shocks. The mechanism insures against member-specific disturbances, not against region-wide external losses. For policy, this means that the value of pooling to any one member depends on the reserve positions and fiscal choices of the others, and that assessments of the arrangement cannot be made country by country.

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A Numerical solution

A.1 Grids, shocks and convergence

The state is (b, R, z, ξ, e) : external public debt, national reserves, tradable income, the regional reserve shifter and the market-access status. The baseline uses equally spaced grids with $n_b = 61$ debt nodes and $n_R = 25$ reserve nodes. The debt grid extends from zero to 4.5 times the targeted debt stock, and the reserve grid from zero to four times reference national reserves. The independent log-income and log-regional-reserve processes are discretized by the Rouwenhorst method with seven and nine nodes, respectively. National-coverage and fixed-regional-state economies use $n_\xi = 1$.

The solver iterates backward on sovereign values, debt prices and expected marginal utilities until the recursion stabilizes. Default and issuance are represented by the smooth choice probabilities in equations (23) and (24). Dynamic discrete-choice formulations can facilitate the numerical treatment of sovereign decisions; see Dvorkin et al. (2021). Here the taste-shock scales are fixed at $\rho_d = 0.01$ and $\rho_b = 0.002$, and their normalizations are common across experiments. These choices facilitate iteration but do not establish convergence or uniqueness as a theoretical property.

The saving condition is solved by searching over the reserve grid, selecting the highest feasible root when several roots exist and applying the boundary conditions otherwise. The static relative-price problem uses a Newton iteration with a bisection fallback. Convergence requires the maximum price change and the relative marginal-utility change to be below 10^{-5} , and the maximum value-function change below 10^{-4} . Every one of the 31 distinct fine-grid solutions used in the reported regime, sensitivity and local-perturbation exercises satisfies these criteria, with 336–760 iterations. The earlier parameter search contains one nonconverged evaluation, which is excluded from the local regression described below.

Table A.1: Convergence of the fine-grid model solutions

Block	Solutions	Converged	Median iterations	Median time (min)
Regimes	9	9	416	1
Jacobian ($\pm h$)	10	10	518	42
Sensitivity	12	12	489	27

The summary covers 31 distinct solutions. Three repeated checks in the underlying campaign summary are not counted as additional equilibria. Convergence refers to the stated tolerances on the specified grid.

The stationary simulations retain 55,000 quarters after discarding 5,000 initial observations. Policies are interpolated over debt and reserves, with a common seed across parameter evaluations. None of the nine regime simulations reaches the upper debt node; upper-reserve hits in the benchmark account for approximately 0.007% of retained observations. Small simulated boundary frequencies are useful diagnostics, but neither they nor convergence on a fixed grid establish invariance to grid refinement.

The paired experiments use common uniform draws across shocked and reference paths and, where applicable, across regimes. The transitions of z and ξ are drawn separately from their marginals, so changing the number of regional states does not change the national-income history associated with a given draw. The accelerated welfare simulator reproduces the checked reference paths for rates, debt, reserves, exclusion and employment to numerical precision. This is a check

on simulated allocations and transitions; it does not by itself validate the utility calculation or a welfare interpretation.

All unshocked baseline CEV comparisons reported in the paper have zero recorded static failures and zero forced defaults. Some additional, unreported shocked C/D calculations at low initial debt contain failed static evaluations and are excluded. The reported common-start CEV sensitivity comparisons also have no recorded static failures. The deterministic figures retain the computed policy schedules without smoothing across debt-grid irregularities.

A.2 Comparison with the calibration grid

The earlier calibration-grid results use $n_R = 11$ and $n_\xi = 7$, compared with 25 and nine in the fine-grid baseline; both use 61 debt and seven income nodes. Table A.2 reports the earlier estimates and moments. Each column reflects a separate parameter search. The differences consequently combine discretization changes and parameter adjustment; they are not a refinement test that holds the parameter vector fixed.

Table A.2: Calibration-grid and fine-grid results

	Earlier reported calibration (n_b, n_R, n_z, n_ξ) = (61, 11, 7, 7)	Fine-grid calibration (61, 25, 7, 9)
<i>Estimates</i>		
β_o	0.9910	0.9916
$\bar{w}/w^{\text{ref}}$	0.9007	0.8949
β_G	0.9536	0.9528
ϕ_1	0.9994	1.0496
$\bar{\pi}$	0.0647	0.0637
<i>Targeted moments</i>		
Reserves / GDP	0.1166	0.1160
Employment	0.9561	0.9516
External public debt / GDP	0.5697	0.5346
Mean spread (access window)	0.0473	0.0480
Devaluation probability (quarterly)	0.0031	0.0029
<i>Welfare, common A starts, national measure (%)</i>		
A vs B	+0.030	+0.263 (0.027)
C vs D	−0.009	+1.340 (0.026)

Calibration-grid entries reproduce an earlier calibration summary; fine-grid entries come from the current numerical exercises. Both grids use the same taste-shock scales. Each column has its own calibrated parameter vector. CEV values use population-weighted household utility and the public good. The calibration-grid CEV values are reported from the earlier calibration summary.

The targeted moments remain close under the two calibrations, whereas the CEV comparison changes appreciably. The national common-start A/B CEV rises from approximately 0.03% on the calibration grid to 0.26% on the fine grid; C/D changes from approximately −0.01% to +1.34%. These changes motivate caution about small consumption-equivalent magnitudes and further refinement checks. They do not establish that the fine grid has eliminated discretization error. The main monetary comparisons refer throughout to the fine-grid specification.

B Local uncertainty and identification diagnostics

The quantities reported as standard errors in the estimation files are constructed from

$$V_{\text{diag}} = (1 + 1/\tau) (J'WJ)^{-1}, \quad \tau = 55,000/40, \quad W = \text{diag}(s_1^{-2}, \dots, s_5^{-2}), \quad (30)$$

where the five scales are (0.0057, 0.0045, 0.065, 0.0024, 0.003). The reported numbers are the square roots of its diagonal. We retain both the local-regression and centered-difference versions as measures of local sensitivity under this diagonal construction. The scales used for the targets are not a documented covariance matrix of estimated empirical moments. In particular, the devaluation target is a historical scenario, and its scale is not the estimated sampling variation of a quarterly probability series.

Accordingly, equation (30) is an indicative uncertainty calculation, not a validated sampling variance for the parameter estimator. Formal inference would require the covariance of the empirical moment estimates, including their cross-correlation, serial dependence and sample-length normalization, together with the appropriate variance expression and regularity conditions. The methodological results in Pakes and Pollard (1989) and McFadden (1989) accommodate classes of simulation estimators with nonsmooth sample criteria under stated assumptions; citing them does not establish those assumptions for the present calibration.

The second issue is the derivative matrix J . Centered finite differences use the parameter steps $(3 \times 10^{-4}, 0.03, 0.005, 0.05, 0.006)$ for $(\beta_o, \bar{w}/w^{\text{ref}}, \beta_G, \phi_1, \bar{\pi})$. Several one-sided and centered derivatives differ substantially. For example, the centered derivative of the mean debt ratio with respect to β_o is negative, whereas the local-regression derivative is positive. These differences are relevant to any interpretation of a parameter as affecting one target independently of the others.

The alternative Jacobian comes from weighted local linear regressions over 35 converged fine-grid evaluations: 25 from the parameter search and ten symmetric perturbations of its best point. Gaussian weights use distance from that point measured in units of the parameter steps. The principal specification has bandwidth three. Wider bandwidths provide a sensitivity check on the fitted local slopes, but cannot establish differentiability or identification on their own. The regression residual is especially large for the spread, with a root-mean-square error of roughly twice its comparison scale.

Table B.1: Local-regression and centered-difference Jacobians

Moment	Local regression					Centered differences				
	β_o	$\bar{w}/w^{\text{ref}}$	β_G	ϕ_1	$\bar{\pi}$	β_o	$\bar{w}/w^{\text{ref}}$	β_G	ϕ_1	$\bar{\pi}$
Reserves / GDP	32	-0.439	-1.66	0.0198	-0.611	37.9	-0.388	-2.06	-0.013	-1.51
Employment	5.07	-0.0394	0.989	-0.0244	-0.075	-2.74	-0.103	1.18	0.0208	-0.0182
External public debt / GDP	12.3	-0.876	-4.42	0.24	0.732	-9.27	0.266	-10.3	-0.265	1.06
Mean spread (access window)	-8.52	-0.301	-1.66	0.0126	0.251	2.87	-0.153	-2.03	-0.0287	-0.253
Devaluation probability (quarterly)	-0.412	0.00395	0.0171	0.000161	0.0612	-0.4	0.00457	0.0158	-0.000464	0.0707

Entries are moment derivatives per unit of the parameter. Local regression uses the 35 converged points and bandwidth three parameter steps. Centered differences use $[m(\theta + he_k) - m(\theta - he_k)]/(2h)$ with the steps stated in the text. Differences in sign or magnitude are reported without selecting them according to an expected economic sign.

The local-regression and centered calculations give similar scales for some parameters, but the implied uncertainty for default-cost curvature differs by more than a factor of two, approximately 0.42 versus 0.92. The current results therefore motivate parameter-sensitivity exercises and a transparent account of the diagonal weighting construction. They do not support significance stars or confidence-interval interpretations of the comparative-statics ranges.

Table B.2: Indicative local uncertainty scales: derivative method and grid

Parameter	Fine grid, $\bar{\pi}$ estimated		Fine grid, $\bar{\pi}$ fixed		Calibration grid	
	Local regression	Centered diff.	Local regression		$\bar{\pi}$ estimated	$\bar{\pi}$ fixed
β_o	0.0015	0.0016	0.0002		0.0011	0.0001
$\bar{w}/w^{\text{ref}}$	0.0525	0.0586	0.0334		0.0440	0.0220
β_G	0.0119	0.0158	0.0090		0.0110	0.0051
ϕ_1	0.4212	0.9212	0.3308		0.1020	0.0980
$\bar{\pi}$	0.0589	0.0592	–		0.0630	–

Diagonal sensitivity measures constructed as in equation (30), rather than validated econometric standard errors. “ $\bar{\pi}$ fixed” uses four moments and four parameters. Calibration-grid values reproduce the earlier summary; its β_G derivative is one-sided.

C Additional results

C.1 Consumption-equivalent conventions

Table C.1 retains the supplementary CEV calculations under alternative discounting and utility conventions. Replacing β_o by β_G changes the weighting of the transition and can change the sign of a small comparison. Removing public-good utility changes the object being evaluated. These are alternative evaluations of the simulated allocation paths, rather than additional equilibrium solutions.

Table C.1: Consumption equivalents under alternative conventions

Comparison	Initial state	Baseline	β_G	Without $v(g)$	$T = 1000$	Half samples
A vs B	Common A access states	+0.263	+0.417	+0.273	+0.263	+0.242 / +0.283
	Debt 20% of GDP	-0.346	-0.380	-0.250	-0.346	-0.325 / -0.366
	Debt 40% of GDP	+0.597	+0.739	+0.554	+0.597	+0.583 / +0.611
	Debt 55.7% of GDP	-0.057	+0.147	-0.045	-0.057	-0.016 / -0.099
	Own invariant distribution	-0.353	-0.470	-0.190	-0.353	-0.335 / -0.372
C vs D	Common A access states	+1.340	+0.525	+1.041	+1.339	+1.359 / +1.321
	Debt 20% of GDP	+0.307	+0.200	+0.189	+0.307	+0.305 / +0.310
	Debt 40% of GDP	+1.205	+0.150	+0.943	+1.205	+1.172 / +1.238
	Debt 55.7% of GDP	+1.366	+0.419	+1.059	+1.366	+1.332 / +1.401
	Own invariant distribution	+1.981	+1.669	+1.480	+1.981	+2.028 / +1.935

Percent, national household index. Baseline: β_o , public-good utility included, 2,000 quarters and all 5,000 paths. Each column changes one convention; the half-sample column divides the same paths into two groups. Initial states are defined in Table 6.

Truncating the discounted sums at 1,000 instead of 2,000 quarters changes the baseline national comparisons by less than 0.0005 percentage point. Finite-horizon truncation is consequently small relative to the reported CEV differences. This calculation addresses truncation of the discounted path sums; it does not address parameter or grid uncertainty. The paired-bootstrap errors in the main table likewise measure Monte Carlo precision conditional on the estimated policies and maintained parameters.

C.2 Model without the BCEAO rule

Table C.2 compares the benchmark with a separately solved economy that fixes the policy rate at $\bar{r}$. In this comparison debt, spreads and default intensity are lower without the coverage

reaction, while mean coverage changes little. The result illustrates the equilibrium effects of the rule on borrowing and reserve-linked saving. It is a stationary comparison; the regional-shock figure in the main text reports the benchmark rule and does not identify its effect against a fixed-rate alternative.

Table C.2: Equilibrium moments with and without the BCEAO rule

Model	Debt/GDP	Spread	Res./GDP	Coverage	Rate	π	Empl.	Def./100y	Excl.
Estimated model (A)	0.535	0.0480	0.116	0.738	0.0317	0.0029	0.9516	12.0	0.207
No BCEAO rule ($i \equiv \bar{i}$)	0.468	0.0426	0.120	0.739	0.0300	0.0030	0.9564	10.0	0.185

Each row is a separate equilibrium at otherwise common parameters. Ratios and rates are fractions; the rate and spread are annual and devaluation risk is quarterly. Default intensity is measured per 100 market-access years. Other selection conventions are those of Table 5.