BRICS Trade Coalitions Under Financial Sanctions

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Abstract

This paper studies when financial sanctions induce BRICS countries to coordinate alternative trade settlement regimes. I develop a dynamic quantitative gravity framework in which countries trade under a dominant dollar-based settlement regime and face stochastic financial sanctions that raise the effective cost of dollar-settled transactions through payment-system frictions. Countries may instead coordinate on an alternative trade settlement arrangement that insulates intra-coalition trade from the sanctions wedge but entails scale-dependent network costs together with one-time switching costs and smaller return costs. Equilibrium wages, prices, and welfare are computed in an Eaton–Kortum general equilibrium, and forward-looking regime choice is determined by value iteration in a persistent sanctions environment. The model generates endogenous switching thresholds corresponding to economically meaningful trade-cost shocks, roughly equivalent to 20–25% reductions in trade under dollar settlement, together with coalition formation dynamics under collective and sequential arrangements. Quantitative results show that collective adoption becomes optimal at moderate sanctions intensity, while bilateral initiation typically requires higher sanctions because marginal costs remain elevated in small coalitions. The founding bilateral coalition is China–Russia, whose combined trade scale generates sufficient marginal cost compression to trigger an immediate cascade to the full BRICS bloc. Coordination frictions between the collective benchmark and the self-enforcing full-coalition threshold are small, and redistribution can sustain coordination over a somewhat wider range of sanctions intensities. Evaluated at current country-specific sanctions intensities, the model is consistent with the observed bilateral shift in China–Russia trade settlement while explaining the absence of switching among other BRICS pairs. The framework provides a tractable approach to studying trade coalitions and financial sanctions in a geoeconomic environment.

Keywords: International Trade, Financial Sanctions, Trade Coalitions, BRICS, Geoeconomics

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1 Introduction

Financial sanctions have become a central instrument of economic statecraft (Farrell and Newman 2019; Felbermayr, Kariem, et al. 2025). Because a large share of cross-border trade settlement and financial contracting relies on dollar-based infrastructure (Gopinath and Itskhoki 2022; Gopinath and Stein 2021), the dominant invoicing currency shapes both trade costs and the effectiveness of coercion (Farrell and Newman 2019). Access to SWIFT correspondent banking, dollar clearing systems, and U.S.-jurisdiction payment networks can be restricted as part of a sanctions campaign, raising the effective cost of dollar-settled transactions for the targeted country even when trade flows involve non-sanctioning partners (Farrell and Newman 2019). At the same time, BRICS economies have expanded initiatives to settle trade through alternative currency and payment rails (Liu and Papa 2022; Poenisch 2024), motivated in part by concerns about exposure to this form of dollar weaponization.

In practice, these initiatives combine two related elements. First, trade may be invoiced and settled in non-dollar currencies. Second, transactions may be routed through payment and clearing infrastructures that operate outside the Western-controlled financial network, such as bilateral currency clearing arrangements or alternative messaging systems. In this paper, these dimensions are treated jointly in the model through an alternative settlement regime under which switching removes the sanctions-related frictions associated with dollar clearing infrastructure for intra-coalition trade but introduces network and infrastructure costs reflecting the frictions of operating outside the mature dollar system.

Figure 1 provides the empirical backdrop. Sanctions exposure across BRICS members is highly uneven: Russia and China have experienced sharp increases in recent years, while Brazil, India, and South Africa face comparatively limited direct pressure. Sanctions episodes tend to persist once imposed, reinforcing the importance of forward-looking regime choice. At the same time, the 2022 comprehensive sanctions against Russia—including SWIFT exclusions, the freezing of approximately $300 billion in cen-

tral bank reserves, and broad restrictions on correspondent banking relationships (U.S. Department of the Treasury, Office of Foreign Assets Control 2024)—demonstrated that dollar-based financial infrastructure can be weaponized at scale, prompting Russian reorientation toward yuan-denominated trade arrangements. By 2024, local-currency-settled trade accounted for approximately 90% of Russia–China bilateral flows (Sacks and Palmer 2024), demonstrating that severe financial coercion can accelerate geoeconomic realignment rapidly. In parallel, BRICS summits in 2023 and 2024 explicitly framed alternative payment infrastructure as an instrument of economic sovereignty rather than technical efficiency (Poenisch 2024).

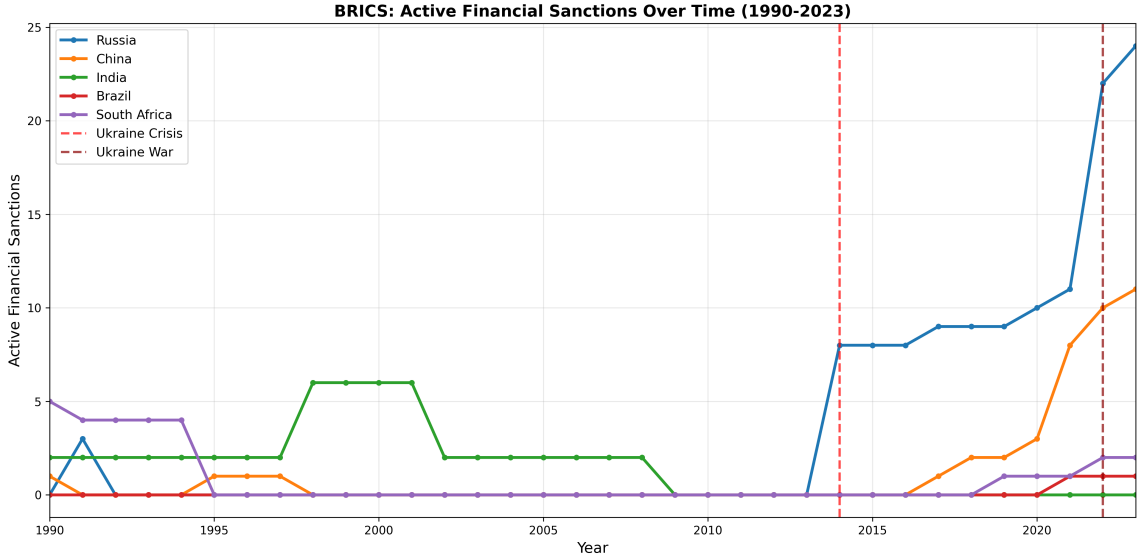


Figure 1: Active financial sanctions affecting BRICS members over time (1990–2023). Source: (Felbermayr, Kariem, et al. 2025)

In this context, this paper addresses three central questions in the intersection of geoeconomics and trade. First, at what sanctions intensity do BRICS countries find switching from dollar-denominated trade to alternative settlement individually optimal, treating regime choice as a rational economic decision rather than purely geopolitical posturing? Second, how do coalition formation dynamics—collective coordination via joint agreement versus sequential adoption through bilateral initiation—affect the threshold and composition of switching coalitions in an environment where network effects create strategic complementarities? Third, what does the model imply about observed settlement pat-

terns at current sanctions intensities, and does it rationalize the China–Russia case while explaining the absence of broader local-currency adoption?

To answer these questions, I develop a dynamic gravity model with regime-switching, combining international trade theory with game-theoretic coalition formation analysis in an explicitly geoeconomic context. Countries choose between two settlement regimes in a forward-looking manner, trading off current welfare against expected future sanctions evolution. Under the dollar regime, financial sanctions operate as an importer-side wedge on trade costs: delivering goods from country i to sanctioned destination j carries an additional iceberg burden $\kappa\gamma_j$ proportional to the destination's sanctions intensity $\gamma_j \in [0, 1]$ and governed by a semi-elasticity parameter κ. This specification reflects that financial sanctions target access to dollar payment infrastructure at the destination country level—SWIFT exclusions, compliance requirements, and correspondent banking restrictions raise costs for any counterparty transacting in dollars with the sanctioned economy—so the wedge falls on bilateral flows through the importer rather than requiring a separate exporter-side vulnerability index.

Under the alternative settlement regime, intra-coalition trade is insulated from the sanctions wedge but incurs network and infrastructure costs that decline with coalition scale. The additional marginal cost function $\mu(K) = \mu_s + \mu_n(1 - \sum_{i \in K} \omega_i^{trade})$ has two components. The structural component μ_s persists even at full coalition scale, reflecting two sources of permanent friction: the maturity gap between the established dollar system and emerging alternative payment infrastructure, and elevated trade finance costs under non-dollar settlement. Chahrour and Valchev (2022) show that in the dollar-dominant equilibrium, non-dollar safe assets must offer an interest rate premium of approximately 1% (107bps) above dollar rates to attract holders, which is a persistent financing cost disadvantage that reflects the structural orientation of global trade credit markets toward dollar collateral and that coalition scale alone cannot resolve. The scale-dependent component μ_n vanishes as the coalition encompasses a larger share of intra-BRICS trade, capturing matching frictions, liquidity depth, and infrastructure-cost sharing that improve with transaction volume routed through the alternative system. Crucially, coali-

tion scale is measured using trade-involvement weights ω_i^{trade} rather than GDP weights, because network liquidity and payment-system interoperability are proportional to actual trade volume routed through the alternative infrastructure rather than to economic size per se. Non-BRICS trade under the alternative regime continues to bear the sanctions wedge because switching escapes dollar-system restrictions only within the coalition, not globally.

Countries solve infinite-horizon dynamic programming problems, comparing continuation values under both regimes while accounting for switching costs scaled by the country's share in BRICS GDP and smaller return costs. Sanctions evolve as a persistent Markov process: with probability π_{USD}, the sanctions state changes and a new intensity is drawn from a distribution fitted to the empirical distribution of sanctions episodes; otherwise, the current intensity persists. Under the alternative regime, the probability of sanctions state changes increases with coalition GDP share, $\pi_{ALT}(K) = \pi_{USD} + \Delta\pi \cdot s^{GDP}(K)$, capturing that larger coalitions challenging dollar dominance face greater geopolitical volatility. This forward-looking structure distinguishes the analysis from static welfare comparisons that would suggest immediate switching whenever current sanctions costs exceed additional marginal costs.

Coalition formation proceeds through two institutional pathways. The collective scenario models a BRICS-wide joint decision that maximizes GDP-weighted welfare, internalizing network externalities and potentially employing transfers to align member incentives, approximating the formal treaty approach discussed at Johannesburg and Kazan summits (Liu and Papa 2022). The sequential scenario allows organic emergence through bilateral agreements that subsequent countries can join incrementally, with cascade checks determining whether network effects trigger simultaneous mass adoption once a founding bilateral establishes critical infrastructure, approximating the market-driven process observed in Russian–Chinese yuan arrangements. The two scenarios generate distinct switching thresholds and formation paths, and comparing them reveals the economic value of formal coordination.

The calibrated model yields four headline results, considering that $\gamma = 1$ represents current Russia's sanction intensity. First, the collective benchmark occurs at $\hat{\gamma}^{Collective} = 0.315$ while the self-enforcing full-BRICS threshold is $\hat{\gamma}^{Full,self\text{-}enforcing} = 0.327$, a gap of only 1.2 percentage points. This tight coordination gap implies that the welfare loss from the inability to implement transfers is small: redistribution becomes feasible just slightly below the self-enforcing threshold, meaning that formal coordination via transfers provides only marginal benefit beyond what decentralized arrangements deliver once the full coalition is close to viable. The collective threshold corresponds to moderate financial coercion, well below comprehensive economic warfare.

Second, sequential formation identifies China–Russia as the founding bilateral coalition, with a Nash threshold of $\hat{\gamma}_{CR}^{Nash} = 0.393$. Interpreted through the model's trade-cost mapping, this threshold corresponds to sanctions levels that reduce trade under the dollar settlement regime by roughly one quarter relative to a frictionless baseline, providing an economically interpretable benchmark for the magnitude of coercion required to trigger bilateral regime switching. China is a systematic participant in the most viable bilateral pairs because it contributes the largest share of intra-BRICS trade, generating the greatest network cost reduction when it joins. Critically, the China–Russia bilateral encompasses sufficient combined trade scale that, once formed, network cost compression immediately triggers a full cascade: India, Brazil, and South Africa all find it optimal to join at $\gamma = 0.393$—the same point at which China–Russia becomes viable—producing a discontinuous expansion from two to five members. This cascade reflects that the founding bilateral already accounts for a substantial share of intra-BRICS trade, generating network cost levels that make entry attractive for all remaining members simultaneously.

Third, the framework produces sharp heterogeneity in bilateral feasibility. Among the ten BRICS pairs, only four are feasible under the balanced-trade closure—China–Russia, China–India, China–ZAF, and China–BRA—and in all cases China's participation constraint frequently binds, because China's intra-BRICS trade share is small relative to its global trade, limiting private gains from insulating a modest share of total flows. Pairs that exclude China face extremely high thresholds or are infeasible entirely, as they cannot

generate sufficient network scale to make switching worthwhile for both partners simultaneously. This pattern is a general equilibrium result: the welfare gain from switching depends not only on the savings from the sanctions wedge on intra-coalition flows, but on how equilibrium wages and price indices adjust throughout the entire economy.

Fourth, evaluation at current country-specific sanctions intensities shows that only China–Russia generates nonnegative welfare gains for both members simultaneously. All other BRICS bilateral pairs exhibit negative net gains for at least one member at current sanctions levels, explaining the absence of widespread local-currency adoption beyond the Russia–China case. China's positive gain in the China–Russia pair reflects that dollar-settled trade with Russia is costly precisely because of Russia's high sanctions intensity: the importer-side wedge makes importing from Russia expensive under USD, and switching removes that burden on intra-coalition flows. Dynamic continuation values further reinforce the China–Russia incentive through the persistence of Russia's extreme sanctions position. This alignment between predicted thresholds and observed settlement choices constitutes an empirical validation of the model's threshold structure.

The analysis contributes to three literatures at the intersection of international economics and the political economy of geoeconomic competition. First, it provides the first quantitative model of BRICS de-dollarization thresholds derived from a structural general equilibrium trade model with coalition formation dynamics, bridging a trade settlement perspective work on currency arrangement with game-theoretic coalition analysis in the context of great power rivalry. While existing work analyzes equilibrium currency selection through strategic complementarities, it does not quantify the sanctions intensity required to overcome dollar network effects in trade or examine coalition formation among heterogeneous countries facing asymmetric coercion. Second, the paper extends gravity trade theory to incorporate dynamic regime-switching with forward-looking sanctions expectations, moving beyond static welfare comparisons to model how anticipation of future sanctions shapes current currency regime decisions. Third, it formalizes the weaponized interdependence argument of Farrell and Newman (2019) in a quantitative framework with testable threshold predictions, demonstrating that using financial infrastructure co-

ercively creates measurable incentives to changes at moderate sanctions intensities and that these incentives operate heterogeneously across BRICS members in ways consistent with observed behavior.

The paper proceeds as follows. Section 2 reviews related literature. Section 3 develops the theoretical framework. Section 4 describes data sources and calibration strategy. Section 5 presents baseline quantitative findings. Section 6 examines sensitivity to the trade-balance closure and to cost parameter specifications. Section 7 concludes.

2 Literature Review

This paper contributes to three strands of literature examining the political economy of international monetary arrangements in an era of intensifying geoeconomic competition: (i) the trade effects of sanctions and the weaponization of financial infrastructure; (ii) currency regime choice and dominant currency persistence under network effects; and (iii) coalition formation in international economics with application to the emerging multipolar order. Each literature provides essential building blocks, but none addresses the specific question of when and how Western financial coercion triggers coordinated de-dollarization among heterogeneous countries with forward-looking expectations about future sanctions in a strategic rivalry context.

2.1 Sanctions and financial weaponization

The empirical literature on sanctions and trade has established that financial sanctions act as effective trade wedges, reducing bilateral flows and generating reallocation toward non-sanctioning partners. Yang et al. (2009) provides early evidence that U.S. sanctions create short-run negative spillovers on EU trade followed by diversion and reorientation, while Haidar (2017) documents that Iran deflected approximately two-thirds of non-oil exports toward non-sanctioning partners following intensification of financial measures. These trade-reallocation patterns are central to understanding BRICS countries' incentives, as

reorientation toward bloc-internal trade reduces the cost of escaping dollar-based payment systems.

Recent structural gravity approaches quantify the magnitude of sanctions effects and their general equilibrium welfare consequences more precisely. Felbermayr, Kirilakha, et al. (2020) document that financial sanctions reduce bilateral trade by 10–19% on average, with effects operating through both direct trade restrictions and financial frictions extending beyond the directly sanctioning country pair—the extraterritorial mechanism that motivates modeling the sanctions wedge as an importer-side cost rather than a bilateral cost between sanctioner and target. Egger, Syropoulos, and Yotov (2024) provide a comprehensive structural gravity synthesis showing that sanctions generate sizable welfare losses and persistent trade diversion effects across both targeted and non-targeted partners. Kwon, Syropoulos, and Yotov (2024) emphasize the extraterritorial dimension of sanctions, demonstrating that third-country trade is significantly affected through global production and financial networks, consistent with the present paper's specification that dollar-settled transactions with sanctioned partners impose costs regardless of whether the trading partner is itself a sanctioner. Using GSDB Release 4, Felbermayr, Kariem, et al. (2025) show that post-2014 sanctions against Russia had larger effects than earlier episodes and accelerated trade reorientation toward China, India, and Turkey, directly motivating the empirical distribution of sanctions intensity used to calibrate the model's stochastic process.

More recent work clarifies the mechanisms through which sanctions propagate. Itskhoki and Ribakova (2024) distinguish trade, financial, and payment-system sanctions and highlight how enforcement frictions and payment disruptions shape economic outcomes at the aggregate level. Ghironi, Kim, and Ozhan (2025) analyze sanctions dynamics in a general equilibrium framework with heterogeneous firms and endogenous entry, documenting short, medium- and long-run welfare effects under trade sanctions and financial sanctions separately. The latter is computed based on how financial sanctions impact foreign agents in participating in international bonds market. While these contributions rigorously quantify sanctions' trade effects, they take the settlement regime as fixed.

My framework takes the established empirical evidence on sanctions as trade wedges as its foundation and asks the subsequent question: when do those wedges become large enough to justify bearing alternative regime costs, and through what coalition formation mechanism?

The weaponized interdependence framework of Farrell and Newman (2019) provides the conceptual foundation for the coercion mechanism. They argue that asymmetric network structures—with the United States at the center of global dollar clearing and SWIFT correspondent banking—enable coercion by denying network access, but using coercive power undermines network appeal by incentivizing targets to build alternative systems that reduce future vulnerability. This creates self-limiting dynamics in economic statecraft as each sanctions episode demonstrates the risks of dollar dependence. Bianchi and Sosa-Padilla (2023) construct a quantitative model showing how comprehensive sanctions and reserve seizures reduce dollar attractiveness as a reserve asset when targets update beliefs about safety, finding that these measures can substantially accelerate reserve diversification—a mechanism complementary to the trade invoicing channel analyzed here. The present paper formalizes the weaponized interdependence intuition in a quantitative model with testable threshold predictions, demonstrating that the mechanism operates at moderate rather than extreme sanctions intensities.

2.2 Dominant currency invoicing and network externalities

The literature on currency choice in international trade has established that dollar dominance creates substantial network externalities with far-reaching implications for monetary power. Krugman (1980) provides the foundational analysis, showing that vehicle currency use generates thick-market externalities where concentration of trading activity in a single currency reduces transaction costs through improved liquidity and matching efficiency, creating first-mover advantages and lock-in effects that help explain dollar persistence despite the U.S. declining share of world trade. Rey (2001) extends this framework to incorporate search frictions, demonstrating that network externalities generate

coordination problems. That is, even if an alternative currency would be socially optimal ex post, coordination failures prevent transition from established equilibria, maintaining incumbent currency dominance through strategic complementarities rather than fundamental efficiency.

Recent work has moved toward quantitative models of currency choice with microfoundations suitable for analyzing regime transitions. Gopinath and Itskhoki (2022) develops the Dominant Currency Paradigm showing that when trade is predominantly dollar-invoiced, bilateral exchange rates matter less than dollar exchange rates for trade elasticities and pass-through, implying that even large economies face limited ability to challenge dollar dominance through pure market size. Mukhin (2022) constructs an equilibrium model where currency choice emerges from strategic complementarities in pricing decisions and input-output linkages, demonstrating that dollar dominance reflects a combination of U.S. economic size, exchange rate pegs, and history dependence rather than purely exogenous preference. Devereux et al. (2025) extends this analysis to multi-country settings, showing that global currency pricing patterns reflect both direct bilateral trade costs and multilateral market access considerations mediated through the dominant currency.

While these papers rigorously model the economic mechanisms sustaining dollar dominance, they take the dollar regime as the given equilibrium and do not analyze the conditions under which coordinated switching to alternative regimes becomes individually and collectively optimal. My contribution is to embed regime choice within a calibrated dynamic general equilibrium model where countries face an explicit trade-off between dollar sanctions costs (reflecting economic coercion in great power competition) and alternative additional marginal costs (reflecting inefficiencies of emerging systems), yielding quantitative thresholds for regime transition that depend on sanctions intensity as a policy variable.

Political economy analyses provide complementary insight into the structural determinants of currency dominance. Kindleberger (1973) argues that stable international

monetary systems require a dominant power providing public goods including liquidity provision and lender-of-last-resort functions. Norrlof (2014) documents how dollar hegemony derives from both economic size and coercive capacity. Carvalho, Monte, and Ornelas (2025) models the shift from rules-based toward power-based international economic order in a forward-looking framework that informs the dynamic programming approach employed here. Mattoo, Ruta, and Staiger (2025) examine how strategic rivalry between major powers has undermined multilateral rules and encouraged preferential arrangements along geopolitical lines. Hassan et al. (2025) analyze how trade wars weaken the dollar's safe-haven properties and create openings for alternative currency emergence. Collectively, this work establishes the broader geoeconomic context within which settlement regime choice occurs, though none models the specific quantitative thresholds at which financial coercion triggers coordinated currency switching.

2.3 Coalition formation in international economics

Coalition formation theory provides the third foundation for this analysis. d'Aspremont et al. (1983) introduce internal and external stability concepts for coalitions, establishing the conditions under which a coalition is self-enforcing: no member wishes to exit (internal stability) and no outsider wishes to join (external stability). Bernheim, Peleg, and Whinston (1987) refine equilibrium notions by ruling out coalition structures vulnerable to coordinated deviations by subgroups, providing the coalition-proof refinement concept. I apply both frameworks to evaluate when the full BRICS coalition is stable, when it survives exit perturbations, and when it requires transfers to satisfy individual participation constraints.

Carraro and Siniscalco (1993) apply coalition stability concepts to international environmental agreements, showing how heterogeneous countries form partial coalitions sustained by transfers that compensate high-cost members—an insight directly applicable to understanding coordinated de-dollarization among asymmetric economies with heterogeneous sanctions exposure. McLaren (1997) highlights how sunk costs and irre-

versibility can delay mutually beneficial agreements, motivating the asymmetric structure of switching costs (higher to enter ALT than to return to USD) in the present model. Bagwell and Staiger (1999) analyzes self-enforcing multilateral trade agreements under free-riding incentives, illustrating why cooperative arrangements may remain limited even when aggregate gains exist.

The broader context of international currency cooperation differs from standard optimal currency area frameworks (Mundell 1961; Bayoumi and Eichengreen 1997) in a fundamental way. Rather than eliminating exchange rate fluctuations through a currency union among cooperative partners, the BRICS context involves coordinating on non-dollar invoicing and settlement while maintaining separate national currencies, in an adversarial relationship with the Western-led monetary order. The motivation is defensive—reducing vulnerability to financial infrastructure weaponization—rather than efficiency-seeking in monetary policy coordination, fundamentally altering the political economy of currency regime choice.

Recent policy-oriented analyses provide valuable institutional context. Liu and Papa (2022) document limited pre-2022 progress on BRICS currency initiatives but note accelerated momentum following Russian sanctions as a demonstration effect. Bastanifar, Khan, and Koch (2024) develop an economic geopolitical framework examining BRICSIZATION through trade and financial integration indices. Arnold (2025) analyzes dedollarization as a sovereignty project. Rediker (2024) and Council on Foreign Relations (2025) provide policy assessments of BRICS expansion and currency initiatives, emphasizing political obstacles. These contributions provide valuable institutional context but lack the formal economic modeling of switching thresholds and coalition formation dynamics needed for quantitative assessment of when economic incentives become strong enough to overcome those obstacles.

3 Model

I develop a dynamic quantitative gravity model where BRICS countries choose between dollar-denominated trade settlement and an alternative settlement regime under evolving Western sanctions pressure. The framework combines an Eaton–Kortum general equilibrium trade structure with regime-dependent trade costs, coalition-specific network effects, and forward-looking switching decisions.

3.1 Environment and timing

The world consists of N countries including BRICS members $\mathcal{B} = \{\text{Brazil, Russia, India, China, South Africa}\}$ and a residual Rest of World (ROW). Time is discrete and infinite, indexed by $t = 0, 1, 2, \ldots$. Each period, countries face a vector of sanctions intensities $\boldsymbol{\gamma}_t = (\gamma_{j,t})_{j=1}^{N}$ with $\gamma_j \in [0, 1]$, normalized such that the most sanctioned economy equals one, and choose currency regime $R_t \in \{\text{USD}, \text{ALT}\}$ for trade settlement.

Within-period timing proceeds as follows. Countries observe current sanctions state $\boldsymbol{\gamma}_t$ and recall previous regime choice R_{t-1}. Countries simultaneously choose current regime R_t, paying switching cost $\tau_i^s(R_{t-1}, R_t)$ if $R_t \neq R_{t-1}$. Current-period welfare $W_i(R_t, \boldsymbol{\gamma}_t)$ is realized based on regime choice and sanctions state. The period ends, sanctions evolve to $\boldsymbol{\gamma}_{t+1}$ according to a regime-dependent Markov process, and countries enter period $t + 1$ with state $(\boldsymbol{\gamma}_{t+1}, R_t)$.

The payoff-relevant state is $\mathbf{s}_t = (\gamma_t, R_{t-1})$ where γ_t is the scalar sanctions intensity and R_{t-1} is the previous regime choice. Countries maximize expected discounted welfare with discount factor $\beta = 0.96$.

3.2 Gravity trade structure

Following Eaton and Kortum (2002), each country i produces a continuum of varieties with efficiency drawn independently from a Fréchet distribution:

$$F_i(z) = \Pr[Z_i(\omega) \leq z] = \exp(-T_i z^{-\theta}) \tag{1}$$

where scale parameter $T_i > 0$ captures absolute advantage and shape parameter $\theta > 1$ governs comparative advantage strength. Following the meta-analysis of Head and Mayer (2014), I set $\theta = 5$ as the baseline trade elasticity.

Goods face iceberg trade costs: delivering one unit from country i to country j requires shipping $\tau_{ij} \geq 1$ units. Country j sources each variety from the lowest-cost supplier. With Fréchet productivity and iceberg costs, the bilateral expenditure share in country j's imports from country i is:

$$\pi_{ij} = \frac{T_i(w_i \tau_{ij})^{-\theta}}{\sum_{k=1}^{N} T_k(w_k \tau_{kj})^{-\theta}} \tag{2}$$

where w_i is country i's wage. The aggregate price index satisfies:

$$P_j = \Gamma_\theta \left(\sum_{k=1}^{N} T_k(w_k \tau_{kj})^{-\theta} \right)^{-1/\theta} \tag{3}$$

where Γ_θ is a constant depending on θ and the elasticity of substitution. Real welfare is:

$$W_j = \frac{w_j}{P_j} \tag{4}$$

Higher market access—lower trade costs from all sources—increases $\sum_k T_k(w_k \tau_{kj})^{-\theta}$, lowers P_j, and raises real welfare monotonically.

3.3 Sanctions as trade costs

Financial sanctions in state γ_j increase the cost of dollar-settled transactions into destination j through payment-system restrictions, SWIFT exclusions, correspondent banking limitations, and legal compliance requirements on any counterparty processing dollar transactions with a sanctioned economy. I model this as an importer-side iceberg wedge on dollar-settled trade:

$$\tau_{ij}^{USD}(\gamma_j) = \begin{cases} 1, & i = j, \\ 1 + \kappa\gamma_j, & i \neq j. \end{cases} \tag{5}$$

Here $\kappa = 0.15$ is the sanctions semi-elasticity governing how sanctions intensity γ_j translates into additional iceberg trade costs. The importer-side incidence reflects that financial sanctions targeting a country's access to dollar payment infrastructure raise costs for any counterparty routing dollar transactions through sanctioned correspondent networks, regardless of the exporter's own sanctions status. Critically, this wedge applies to all of j's trade partners simultaneously, so a highly sanctioned country faces elevated import costs even from non-sanctioning partners when transactions are dollar-denominated. At full sanctions intensity ($\gamma_j = 1$), the trade-cost multiplier $(1 + \kappa)^{-\theta} = (1.15)^{-5} \approx 0.50$ implies approximately a 50% reduction in trade relative to a world with no sanctions, consistent with the large effects documented for comprehensive financial sanctions episodes (Felbermayr, Kirilakha, et al. 2020).

3.4 Alternative settlement and additional marginal costs

Under the alternative settlement regime, intra-coalition trade is routed through non-dollar payment infrastructure, insulating it from the sanctions wedge. Let $K \subseteq \mathcal{B}$ denote the coalition of countries adopting alternative settlement. Trade costs under ALT are:

$$\tau_{ij}^{ALT}(\gamma_j; K) = \begin{cases} 1 + \mu(K), & i \in K,\ j \in K,\ i \neq j, \\ \tau_{ij}^{USD}(\gamma_j), & \text{otherwise.} \end{cases} \tag{6}$$

For intra-coalition trade, the sanctions wedge is replaced by an additional marginal cost $\mu(K) \geq 0$ that reflects the frictions of transacting through alternative settlement infrastructure. Conceptually, the switching cost τ_i^{out} captures the fixed investment required to adopt the alternative settlement system—including banking integration, regulatory adaptation, and liquidity provision for new clearing arrangements—while the additional marginal cost $\mu(K)$ captures the ongoing transaction frictions associated with operating within that system. Trade with non-coalition partners, and all trade of non-coalition countries, continues to bear the dollar sanctions wedge.

Additional marginal costs decline with coalition scale in trade. I parameterize:

$$\mu(K) = \mu_s + \mu_n \left(1 - \sum_{i \in K} \omega_i^{trade}\right) \tag{7}$$

where ω_i^{trade} measures country i's share in total intra-BRICS trade volume (exports plus imports within the bloc), normalized so that $\sum_{i \in \mathcal{B}} \omega_i^{trade} = 1$. The structural component $\mu_s = 0.03$ persists even at full coalition scale, representing inherent inefficiency from the maturity gap between the established dollar system (with 50-year development, universal banking participation, and deep liquidity) and emerging alternatives such as CIPS, SPFS, or bilateral currency arrangements. The network component $\mu_n = 0.05$ vanishes linearly as the coalition's share in intra-BRICS trade approaches one, capturing the scale economies in matching, liquidity depth, and infrastructure cost-sharing that arise when more trade volume flows through the alternative system.

Critically, coalition scale is measured using trade-based weights ω_i^{trade} rather than GDP weights. This reflects that network liquidity and payment-system interoperability depend on the volume of transactions routed through the system rather than on economic size per se. A country that participates in a large share of intra-BRICS bilateral trade provides more liquidity and generates more matching opportunities for the alternative payment network, reducing transaction costs for all members. The calibrated weights (China: 0.448, India: 0.171, Russia: 0.172, Brazil: 0.159, South Africa: 0.050) reflect China's dominant role in BRICS bilateral trade flows and imply that China's participation is

highly valuable for network cost compression.

At full coalition scale ($\sum_{i\in\mathcal{B}} \omega_i^{trade} = 1$), additional marginal costs collapse to $\mu(\mathcal{B}) = \mu_s = 0.03$, so the alternative iceberg cost for intra-BRICS trade equals $1 + 0.03 = 1.03$. For small bilateral coalitions, the scale-dependent component adds up to $\mu_n = 0.05$, raising total additional marginal costs to as high as 1.08 in the limit. This creates strategic complementarity in coalition formation: each country that joins reduces $\mu(K)$ for all existing members, raising the value of the coalition to incumbents and potentially attracting further entrants.

3.5 Equilibrium computation: hat algebra

For a given sanctions level γ and coalition configuration K, equilibrium prices, wages, and welfare are computed using exact hat algebra (Arkolakis, Costinot, and Rodríguez-Clare 2012; Dekle, Eaton, and Kortum 2007). Let $\hat{x} \equiv x'/x^0$ denote the ratio of a counterfactual variable x' to its baseline value x^0. Given baseline trade shares $\Pi^0 = \{\pi_{ij}^0\}$ and baseline income Y^0, the counterfactual trade shares under a new iceberg matrix τ_{ij} satisfy:

$$\pi'_{ij}(\hat{w}) = \frac{\pi_{ij}^0(\hat{w}_i\tau_{ij})^{-\theta}}{\sum_k \pi_{kj}^0(\hat{w}_k\tau_{kj})^{-\theta}} \tag{8}$$

where τ_{ij} here denotes the ratio of counterfactual to baseline iceberg costs. Expenditure in country j under the two closures is:

$$E_j = \begin{cases} \hat{w}_j Y_j^0, & \textbf{Balanced Trade (BT),} \\ \hat{w}_j Y_j^0 + D_j^0, & \textbf{Fixed Deficits (FD),} \end{cases} \tag{9}$$

where $D_j^0 = -NX_j^0$ is the baseline trade imbalance, and under BT all trade balances are set to zero so the closure corresponds to proportional adjustment of absorption. Under FD, trade imbalances are held fixed at their observed WDI values, allowing absorption

to adjust. The wage vector satisfies the market-clearing condition:

$$\hat{w}_i = \frac{\sum_j \pi'_{ij}(\hat{w}) E_j}{Y_i^0} \tag{10}$$

normalized by $\hat{w}_{ROW} = 1$. This system is solved iteratively until convergence, yielding counterfactual wages $\hat{w}$, price index changes $\hat{P}_j = (\sum_k \pi^0_{kj}(\hat{w}_k \tau_{kj})^{-\theta})^{-1/\theta}$, and welfare changes $\hat{W}_j = \hat{w}_j / \hat{P}_j$.

The hat-algebra approach has two advantages relative to the reduced-form market access measures used in earlier versions of related work. First, it ensures full general equilibrium consistency: wages, prices, and trade shares all adjust simultaneously in response to the sanctions wedge, so the welfare implications reflect economy-wide resource reallocation rather than partial-equilibrium approximations. Second, it requires only observed trade shares and aggregate income data as inputs, avoiding the need for separate structural gravity estimation or the imposition of ad hoc bilateral trade costs. I implement this computation for each point on a 101-point grid $\gamma \in [0, 1]$ and for each coalition mask $K \in \{1, \ldots, 31\}$, generating the static payoff arrays $W_i^{USD}(\gamma)$ and $W_i^{ALT}(\gamma; K)$ that feed into the dynamic programming step.

3.6 Dynamic regime choice

The static payoffs $W_i^{USD}(\gamma)$ and $W_i^{ALT}(\gamma; K)$ enter a dynamic programming problem that accounts for sanctions persistence and switching costs. Switching from USD to ALT entails a one-time cost:

$$\tau_i^{out} = 0.005 \times \omega_i^{GDP} \tag{11}$$

representing 0.5% of BRICS GDP proportional to country i's GDP share ω_i^{GDP}. Reverting back to USD entails a smaller return cost $\tau_i^{ret} = 0.0005 \times \omega_i^{GDP}$ (0.05% of GDP), capturing that exiting ALT requires contract renegotiation but not the full infrastructure investment. The asymmetry creates hysteresis: countries that switch to ALT are reluctant to revert because return is also costly.

Sanctions are persistent. With probability $\pi(R)$, the sanctions state changes and next period's γ' is drawn from the fitted distribution $F(\gamma)$; with probability $1 - \pi(R)$, the current intensity persists. Under the dollar regime, $\pi_{USD} = 0.285$. Under the alternative regime, the probability of state changes increases with coalition GDP share:

$$\pi_{ALT}(K) = \pi_{USD} + \Delta\pi \cdot s^{GDP}(K) \tag{12}$$

where $\Delta\pi = 0.285$ and $s^{GDP}(K) = \sum_{i \in K} \omega_i^{GDP}$ is the coalition's share of BRICS GDP. This specification reflects that larger coalitions challenging dollar dominance invite greater geopolitical volatility in future sanctions environments, creating an option-value motive for delay in switching.

The value function for country i in coalition K starting from regime R_{-1} at sanctions intensity γ is:

$$\begin{aligned} V_i(\gamma, R_{-1}; K) = \max_R \Big\{ & W_i(R, \gamma; K) - \tau_i(R_{-1} \to R) \\ & + \beta \left[\pi(R) \mathbb{E}_{\gamma'}[V_i(\gamma', R; K)] + (1 - \pi(R)) V_i(\gamma, R; K) \right] \Big\} \end{aligned} \tag{13}$$

where $\tau_i(R_{-1} \to R) = \tau_i^{out}$ if switching from USD to ALT, τ_i^{ret} if switching back, and zero otherwise. I solve this system by value iteration on a 101-point grid in γ, using the Beta$(1, 5)$ distribution $F(\gamma)$ for the shock distribution, iterating until convergence (tolerance 10^{-10}). The switching threshold $\hat{\gamma}_i^K$ is defined as the smallest γ at which country i, currently in the dollar regime, strictly prefers to switch to ALT given coalition K:

$$\hat{\gamma}_i^K = \inf \left\{ \gamma : W_i^{ALT}(\gamma; K) - \tau_i^{out} + \beta \mathbb{E}_{\gamma'}[V_i(\gamma', \text{ALT}; K)] \geq W_i^{USD}(\gamma) + \beta \mathbb{E}_{\gamma'}[V_i(\gamma', \text{USD}; K)] \right\} \tag{14}$$

3.7 Bilateral Nash thresholds

For a bilateral coalition $\{i, j\}$, switching requires that both countries simultaneously prefer ALT to USD net of switching costs. The Nash threshold for the bilateral is:

$$\hat{\gamma}_{ij}^{Nash} = \max\{\hat{\gamma}_i^{\{i,j\}}, \hat{\gamma}_j^{\{i,j\}}\} \tag{15}$$

At $\gamma < \hat{\gamma}_{ij}^{Nash}$, at least one country prefers USD, preventing bilateral formation. At $\gamma \geq \hat{\gamma}_{ij}^{Nash}$, both prefer ALT and the bilateral is mutually beneficial. Each country identifies its optimal bilateral partner as the one yielding the lowest Nash threshold:

$$j^*(i) = \arg\min_{j \neq i} \hat{\gamma}_{ij}^{Nash} \tag{16}$$

3.8 Collective coordination

Under collective coordination, BRICS countries make a joint settlement decision that maximizes GDP-weighted welfare. Define collective welfare as:

$$\mathcal{W}^{BRICS}(R, \gamma; K) = \sum_{i=1}^{5} \omega_i^{GDP} W_i(R, \gamma; K) \tag{17}$$

where GDP weights ω_i^{GDP} reflect bargaining power proportional to economic size (China: 0.570, India: 0.242, Russia: 0.103, Brazil: 0.071, South Africa: 0.015). The collective value function satisfies:

$$V^{BRICS}(\gamma, R_{-1}) = \max_{R \in \{\text{USD, ALT}\}} \left\{ \mathcal{W}^{BRICS}(R, \gamma; \mathcal{B}) - \bar{\tau}^{out} \mathbb{1}_{R \neq R_{-1}} + \beta \mathbb{E}_{\gamma'}[V^{BRICS}(\gamma', R) | \gamma, R] \right\} \tag{18}$$

where weighted switching cost $\bar{\tau}^{out} = \sum_i \omega_i^{GDP} \tau_i^{out} = 0.005$ and the coalition is the full bloc. The collective threshold $\hat{\gamma}^{BRICS}$ is where the collective value function crosses from preferring USD to preferring ALT.

This mechanism internalizes network externalities—the full coalition achieves $\mu(\mathcal{B}) =$

$\mu_s = 0.03$—and allows for potential compensatory transfers to align individual incentives. However, the empirical finding that the self-enforcing threshold occurs at $\hat{\gamma}^{Full,self\text{-}enforcing} = 0.327$, only 1.2 percentage points above the collective benchmark $\hat{\gamma}^{BRICS} = 0.315$, suggests that formal transfers provide limited additional value.

3.9 Self-enforcing full coalition threshold

A critical distinction separates the collective planner threshold $\hat{\gamma}^{BRICS} = 0.315$ (where GDP-weighted welfare favors switching) from the self-enforcing threshold where all members individually prefer switching without transfers. The self-enforcing full-BRICS threshold is:

$$\hat{\gamma}^{Full,stable} = \min\{\gamma : \Delta_i(\mathcal{B}, \gamma) \geq 0 \text{ for all } i \in \mathcal{B}\} \tag{19}$$

where $\Delta_i(K, \gamma) = V_i^{ALT}(\gamma; K) - V_i^{USD}(\gamma) - \tau_i^{out}$ is country i's net benefit from joining coalition K. A closely related object is the transfer-feasibility threshold: the smallest γ at which total surplus across countries that gain from switching exceeds the compensation required by countries that do not yet gain, making redistribution feasible in aggregate. The model delivers transfer feasibility at $\gamma \approx 0.315$, (which computing under grid of 0.05, gives us the 0.320 starting point of feasibility) slightly below $\hat{\gamma}^{Full,stable}$.

3.10 Sequential coalition formation

Under sequential formation, coalitions emerge through decentralized bilateral agreements that expand as network costs fall with coalition size. The formation process follows two phases.

In Phase 1, a founding bilateral coalition $\{i^*, j^*\}$ forms when both countries' individual Nash threshold is satisfied:

$$\{i^*, j^*\} = \arg\min_{\{i,j\}} \hat{\gamma}_{ij}^{Nash} \tag{20}$$

Empirically, China–Russia emerges as the founding bilateral with $\hat{\gamma}_{CR}^{Nash} = 0.393$, reflecting Russia's extreme sanctions exposure and China's dominant trade-scale weight, which

together produce the lowest Nash threshold among all feasible pairs.

In Phase 2, sequential expansion proceeds through a cascade check. Given existing coalition $K(t)$ with $|K(t)| \geq 2$, I evaluate whether all remaining countries want to join simultaneously (cascade) or whether individual entry occurs. Country $k \notin K(t)$'s joining value is:

$$\Delta_k(K(t), \gamma) = V_k^{ALT}(\gamma; K(t) \cup \{k\}) - V_k^{USD}(\gamma) - \tau_k^{out} \tag{21}$$

Cascade occurs if $\Delta_k(K(t), \gamma) > 0$ for all $k \notin K(t)$ simultaneously. This happens when network benefits from joining the existing coalition create positive joining values for all remaining outsiders at once. Empirically, the China–Russia bilateral at $\omega^{trade} = 0.620$ immediately triggers a cascade: India, Brazil, and South Africa all exhibit positive joining values at $\gamma = 0.393$, enabling discontinuous expansion from two to five members at the founding bilateral threshold.

If the cascade condition fails, individual entry proceeds sequentially with the country showing the highest positive joining value entering first. The process terminates when no country wants to join, yielding an externally stable coalition.

3.11 Coalition stability

Following d'Aspremont et al. (1983), a coalition K at sanctions level γ is stable if it satisfies both internal and external stability.

Internal stability requires that no subset $S \subseteq K$ collectively prefers to exit to USD:

$$\sum_{i \in S} V_i(\gamma | \text{stay in } K) \geq \sum_{i \in S} V_i(\gamma | \text{exit to USD, coalition becomes } K \setminus S) \tag{22}$$

for all non-empty $S \subseteq K$. This includes individual rationality when $|S| = 1$ (no single member wants to exit) and extends to coordinated deviations by subsets. Exit entails paying the smaller return cost τ_i^{ret}, creating a modest barrier.

External stability requires that no outsider $j \notin K$ wants to join:

$$V_j(\gamma|\text{stay in USD}) \geq V_j(\gamma|\text{join } K) - \tau_j^{out} \tag{23}$$

I evaluate robustness of the full coalition to single- and paired-member exits across the range of sanctions intensities. An "exit" means that one or two members revert to USD (paying return costs), and the remaining coalition is re-evaluated. The model shows that internal stability of the full coalition emerges at $\gamma \approx 0.327$, while robustness to any single exit requires considerably higher sanctions intensities (approximately $\gamma \approx 0.84$), reflecting the stronger requirement that a smaller coalition must also be self-sustaining after the departure.

4 Data and Calibration

This section describes the empirical strategy for calibrating the model. I combine three data sources: the Global Sanctions Database for constructing sanctions intensity measures and the sanctions stochastic process; IMF bilateral trade statistics for the trade matrix, baseline EK shares, and network scale weights; and World Bank data for GDP shares and trade imbalances under the fixed-deficits closure.

4.1 Data sources

4.1.1 Global Sanctions Database (GSDB V4)

The GSDB (Felbermayr, Kariem, et al. 2025) provides comprehensive data on 1,547 sanctions episodes from 1950–2023, including case identifiers, sanctioning and sanctioned states, duration, and sanction type indicators (trade, financial, military, travel). I focus on financial sanctions episodes because these directly affect currency and payment systems through mechanisms including correspondent banking restrictions, SWIFT access limitations, central bank reserve freezes, and cross-border payment disruptions—the

channels most relevant for analyzing currency regime switching decisions.

A critical filtering decision restricts analysis to Western sanctioners only: United States, European Union, United Kingdom, Canada, Japan, Australia, and NATO/G7 collective actions. This filter isolates sanctions relevant to dollar financial infrastructure control, since sanctions imposed by non-Western countries do not affect access to dollar payment systems and thus should not enter the sanctions intensity measure. After filtering, the dataset provides sufficient coverage of Western financial sanctions history across all BRICS members to construct both the country-specific intensity γ_i and the empirical distribution $F(\gamma)$.

For BRICS countries specifically, Western financial sanctions history varies dramatically, generating the heterogeneity in current sanctions intensity that drives differential switching incentives. Russia has accumulated the largest exposure following escalation after the 2014 Crimea annexation and the comprehensive 2022 measures including SWIFT exclusions and the freezing of approximately $300 billion in central bank reserves—the most extensive weaponization of dollar financial infrastructure in modern history. China faces an intermediate level of Western financial sanctions, primarily U.S.-imposed measures related to technology transfer, strategic competition, and human rights. South Africa and Brazil have accumulated minimal exposure. India shows near-zero current financial sanctions, though earlier episodes related to technology proliferation were temporary and resolved.

4.1.2 Country-specific sanctions intensity

From the GSDB financial sanctions counts for Western sanctioners, I construct a normalized intensity measure $\gamma_i \in [0, 1]$ for each BRICS member. Russia is normalized to $\gamma_{RUS} = 1.0$ as the most comprehensively sanctioned country. Other BRICS members are scaled proportionally, yielding: China at $\gamma_{CHN} = 0.344$, Brazil at $\gamma_{BRA} = 0.062$, South Africa at $\gamma_{ZAF} = 0.031$, and India at $\gamma_{IND} = 0$. These current intensities are used in Section 5 to evaluate bilateral switching incentives at observed sanctions levels and validate

the model against the Russia–China settlement pattern.

Figure 2 reports the empirical distribution of sanctions intensity across the broader population of sanctioned countries and the fitted Beta$(1, 5)$ approximation used to draw future sanctions states in the value iteration step. The right-skewed distribution reflects that most countries in the GSDB panel face low-to-moderate financial sanctions, with comprehensive sanctions of the Russian type representing the extreme tail.

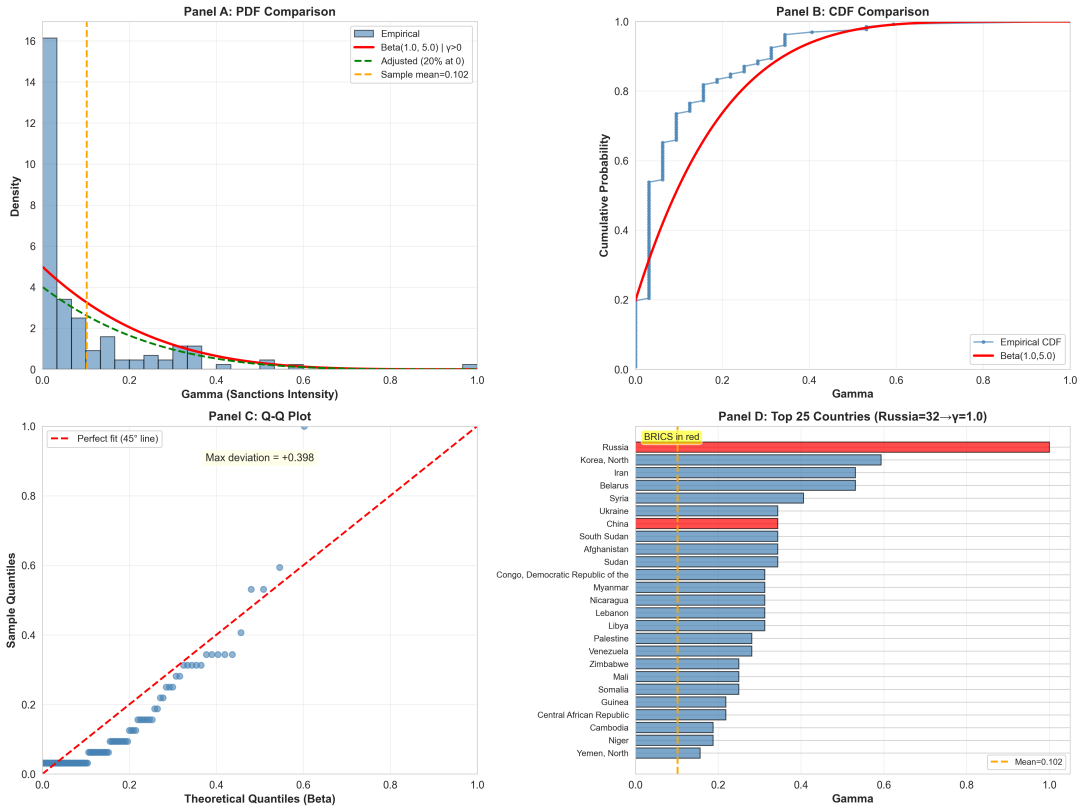


Figure 2: Empirical sanctions intensity distribution and Beta$(1, 5)$ fit used as $F(\gamma)$ in the dynamic programming step. The distribution is estimated from the population of Western financial sanctions episodes in GSDB Release 4 (1990–2023).

4.1.3 IMF trade data

I obtain bilateral annual trade flows from IMF International Trade Statistics, covering BRICS bilateral pairs and BRICS–ROW flows. I use annual averages over 2017–2022, excluding the COVID-disrupted 2020 year when feasible and using five-year averages otherwise, to avoid temporary pandemic-driven distortions. ROW is defined residually as world exports minus BRICS exports.

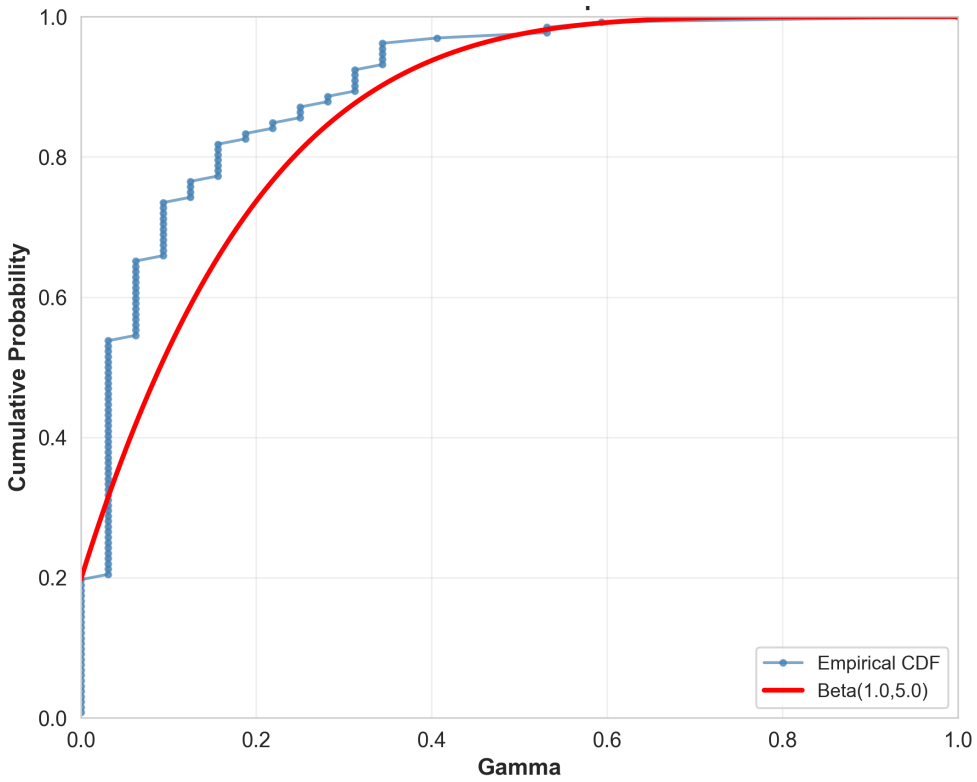


Figure 3: Empirical CDF of sanctions intensity for the most-affected country group and the fitted Beta$(1, 5)$ approximation.

From these flows, I construct two empirical objects. First, the bilateral trade matrix X_{ij} for all six trading units (five BRICS members plus ROW), which together with absorption data allows construction of the baseline EK trade share matrix Π^0. Baseline shares satisfy $\pi^0_{ij} = X_{ij}/X_j$ where $X_j = \sum_i X_{ij}$ is total absorption in country j (expenditure); the domestic share is computed residually as $\pi^0_{jj} = 1 - \sum_{i \neq j} \pi^0_{ij}$. Table 1 reports these domestic shares: all five BRICS members and ROW exhibit high domestic absorption shares (ranging from 0.752 for South Africa to 0.947 for ROW), reflecting that intra-BRICS trade is modest relative to total absorption in each economy.

Table 1: Domestic expenditure shares from baseline trade data

Country	Domestic share π^0_{ii}
China	0.852
India	0.824
Russia	0.851
Brazil	0.888
South Africa	0.752
ROW	0.947

Second, I construct the network scale weights ω_i^{trade} measuring each BRICS member's share in total intra-BRICS bilateral trade (exports plus imports among the five members):

$$\omega_i^{trade} = \frac{\sum_{j \in \mathcal{B}, j \neq i} (X_{ij} + X_{ji})}{\sum_{k \in \mathcal{B}} \sum_{j \in \mathcal{B}, j \neq k} (X_{kj} + X_{jk})} \tag{24}$$

Table 2 reports these weights. China dominates at $\omega_{CHN}^{trade} = 0.448$, reflecting its central role in intra-BRICS bilateral trade flows. Russia and India follow at approximately 0.17 each, with Brazil close behind at 0.159 and South Africa smallest at 0.050. These weights directly determine how much each country's participation reduces network costs for the coalition: China's entry alone reduces the scale-dependent component by 44.8%, so the first-best founding pair for network cost purposes would include China.

Table 2: Trade-based coalition scale weights ω_i^{trade}

Country	ω_i^{trade}
China	0.448
India	0.171
Russia	0.172
Brazil	0.159
South Africa	0.050
Total	1.000

4.1.4 World Bank WDI

GDP and national accounts data are obtained from the World Development Indicators (WDI). GDP levels Y_i^0 (averaged 2017–2022) provide the basis for GDP weights ω_i^{GDP} used in switching costs and collective welfare aggregation. Under the fixed-deficits closure, I additionally use WDI-based net export data NX_i^0 to construct baseline trade imbalances $D_i^0 = -NX_i^0$, enforcing world adding-up $\sum_i D_i^0 = 0$ by adjusting the ROW row. Table 3 reports the baseline macro inputs for each country.

Table 3: Baseline macro inputs from WDI (2017–2022 averages, billions USD)

Country	GDP Y_i^0	Absorption X_j^0	Net exports NX_i^0	Imbalance $D_i^0 = -NX_i^0$
China	15,460	15,154	306	−306
India	2,896	2,975	−79	79
Russia	1,756	1,604	153	−153
Brazil	1,825	1,819	6	−6
South Africa	390	381	10	−10
ROW	68,284	68,000	284	−284

4.2 Parameter calibration

Table 4 reports the full set of calibrated parameters. I discuss the three most consequential choices.

Table 4: Calibration summary

Parameter	Description	Value	Source/notes
Panel A: Core data objects			
γ_i	Sanctions intensity (normalized)	[0,1]	GSDB R4, Russia = 1
X_{ij}	Bilateral exports (BRICS+ROW)	2017–2022 avg	IMF
Π^0	Baseline EK shares	Constructed	From X, absorption
ω_i^{trade}	Network scale weights	Sums to 1	Intra-BRICS trade volume
ω_i^{GDP}	Welfare/cost weights	Sums to 1	WDI GDP shares
Panel B: Structural parameters			
θ	Trade elasticity	5.0	Head and Mayer (2014) benchmark
β	Discount factor	0.96	Standard annual discounting
κ	Sanctions iceberg semi-elasticity	0.15	$(1+\kappa)^{-\theta} \approx 0.50$ at $\gamma = 1$
μ_s	Structural additional marginal cost	0.03	Persistent ALT friction
μ_n	Scale-dependent network cost	0.05	Falls with coalition trade scale
τ_i^{out}	Switching cost	$0.005\,\omega_i^{GDP}$	Bank of England 2001 for EUR
τ_i^{ret}	Return cost	$0.0005\,\omega_i^{GDP}$	0.05% of GDP (one-time)
Panel C: Sanctions process (dynamic programming)			
π_{USD}	Prob. sanctions state changes	0.285	GSDB persistence estimate
$\Delta\pi$	Extra volatility under ALT	0.285	Scales with coalition GDP share
$F(\gamma)$	Future sanctions draw	Beta$(1,5)$	Fitted to GSDB intensity dist.

The *sanctions semi-elasticity* $\kappa = 0.15$ is calibrated to be consistent with the empirical evidence on financial sanctions effects. At $\gamma = 1$ (Russia-level comprehensive sanctions), the trade cost multiplier $(1 + 0.15)^{-5} \approx 0.50$ implies that full financial sanctions reduce trade by approximately 50% relative to a world without sanctions, consistent with the large effects documented by Felbermayr, Kirilakha, et al. (2020) and the post-2022 trade collapse experienced by Russia with Western partners. At intermediate intensities rele-

vant for other BRICS members—China at $\gamma = 0.344$ or Brazil at $\gamma = 0.062$—the implied trade cost increases are modest, generating small welfare losses that explain why these countries maintain dollar settlement without strong de-dollarization incentives absent coordination.

The *additional marginal cost parameters* $\mu_s = 0.03$ and $\mu_n = 0.05$ imply a full-coalition additional marginal cost of 3% and a bilateral-level additional marginal cost of up to 8%, depending on the GDP scale of the founding bilateral. The 3% structural component reflects the persistent efficiency gap between mature dollar-system infrastructure (SWIFT with 11,000+ member institutions, 50 years of development, and global liquidity) and emerging alternatives (CIPS with approximately 1,530 institutions as of 2024, limited global acceptance outside BRICS partners). The 5% maximum scale-dependent component reflects the liquidity and matching friction in thin alternative payment markets, where bid-ask spreads on non-major currency pairs can be 10–50 basis points compared with 1–2 basis points for major currency pairs. Both parameters are at the conservative end of the plausible range; the sensitivity analysis in Section 6 examines a wide grid around these baseline values.

The *sanctions process* parameters $\pi_{USD} = 0.285$ and $\Delta\pi = 0.285$ are derived from the GSDB panel's time-series properties of sanctions episodes. The persistence parameter implies that the sanctions state changes in approximately 28.5% of years under dollar settlement, generating realistic forward-looking incentives for regime switching without making the environment purely transitory. The additional volatility $\Delta\pi$ under the alternative regime, scaling with coalition GDP share, captures the geopolitical risk that a larger coalition challenging dollar dominance invites more aggressive and unpredictable sanctions responses from Western powers. The Beta$(1, 5)$ distribution for future sanctions draws is fitted to the empirical intensity distribution from the GSDB filtered panel of most-affected countries, generating the right-skewed distribution shown in Figure 2 where most realizations are at low-to-moderate intensities.

5 Results

This section presents the quantitative results from the calibrated model. I begin with the price–wage–welfare mechanism implied by the sanctions wedge and alternative settlement costs, then present coalition thresholds, sequential formation dynamics, transfer feasibility, coalition stability, and bilateral incentives at current sanctions intensities.

5.1 Mechanism: prices, wages, and welfare

The model's first prediction is that financial sanctions, modeled as an importer-side trade cost, translate into welfare losses through two compounding channels in general equilibrium. The first channel operates through prices: higher import costs raise the aggregate price index in sanctioned destinations, reducing real purchasing power. The second channel operates through wages: as expensive imports reduce absorption capacity, factor market clearing adjusts wages downward, amplifying the welfare loss. The Alternative regime removes the sanctions wedge on intra-coalition flows but replaces it with additional marginal costs, so the welfare comparison depends on whether the sanctions-cost savings dominate the network-cost burden—a comparison that tips in favour of ALT at higher sanctions intensities.

Figures 4 and 5 illustrate these mechanisms for the China–Russia bilateral pair (the founding coalition) under both closures. Under USD, prices increase with sanctions intensity γ at a rate governed by $\kappa = 0.15$—the wedge grows linearly but its effect on trade shares and prices is nonlinear through the Fréchet structure. Under ALT, intra-coalition prices are dampened by the removal of the sanctions wedge, with the residual additional marginal cost $(1 + \mu)$ providing a floor. The wage response amplifies the price effect: wages adjust to clear the factor market under the new trade cost structure, so that the general equilibrium welfare loss from sanctions exceeds the partial-equilibrium price increase.

Figure 6 shows welfare under each regime, and Figure 7 shows the welfare gain from

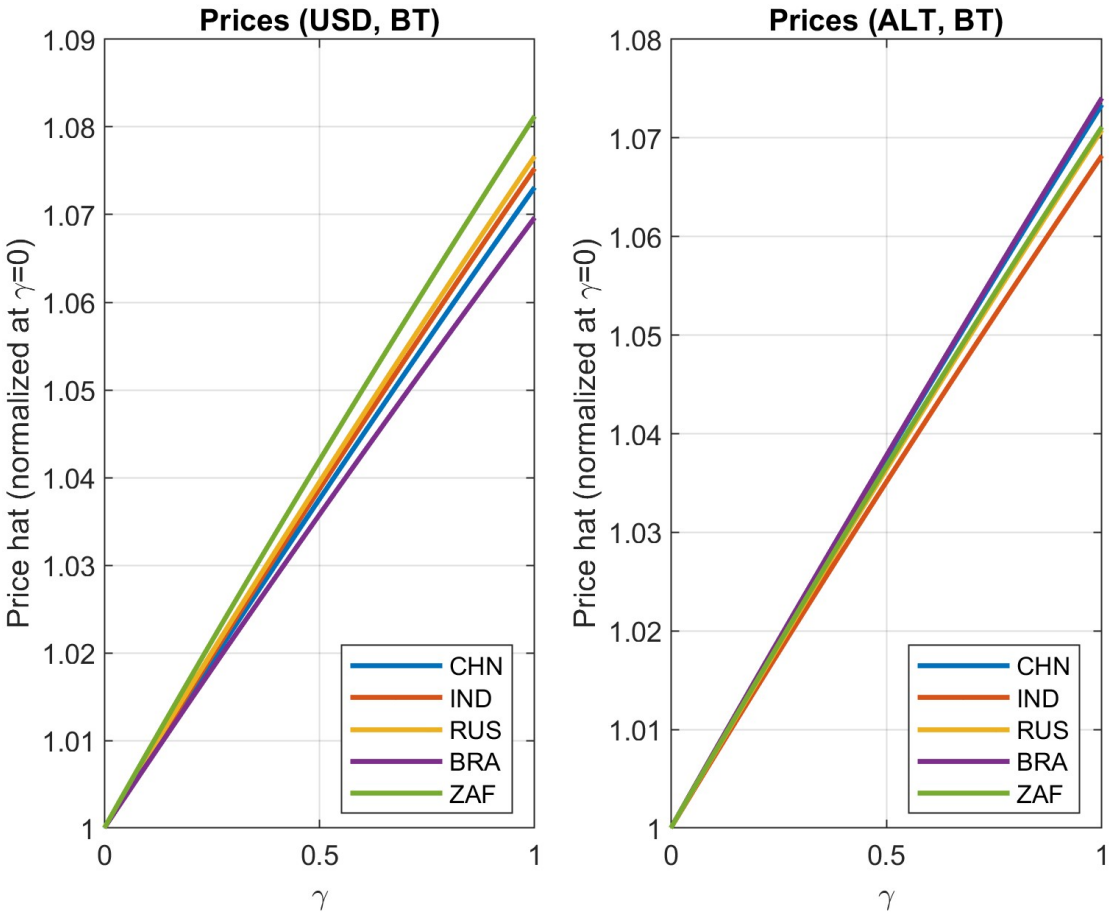


Figure 4: Price indices under USD and ALT settlement across sanctions intensity γ for the China–Russia founding pair (balanced trade closure). Prices increase under USD as the sanctions wedge $(1+\kappa\gamma)$ raises import costs. Under ALT, prices are dampened within the coalition through removal of the wedge, with the additional marginal cost $(1+\mu(K))$ providing a floor.

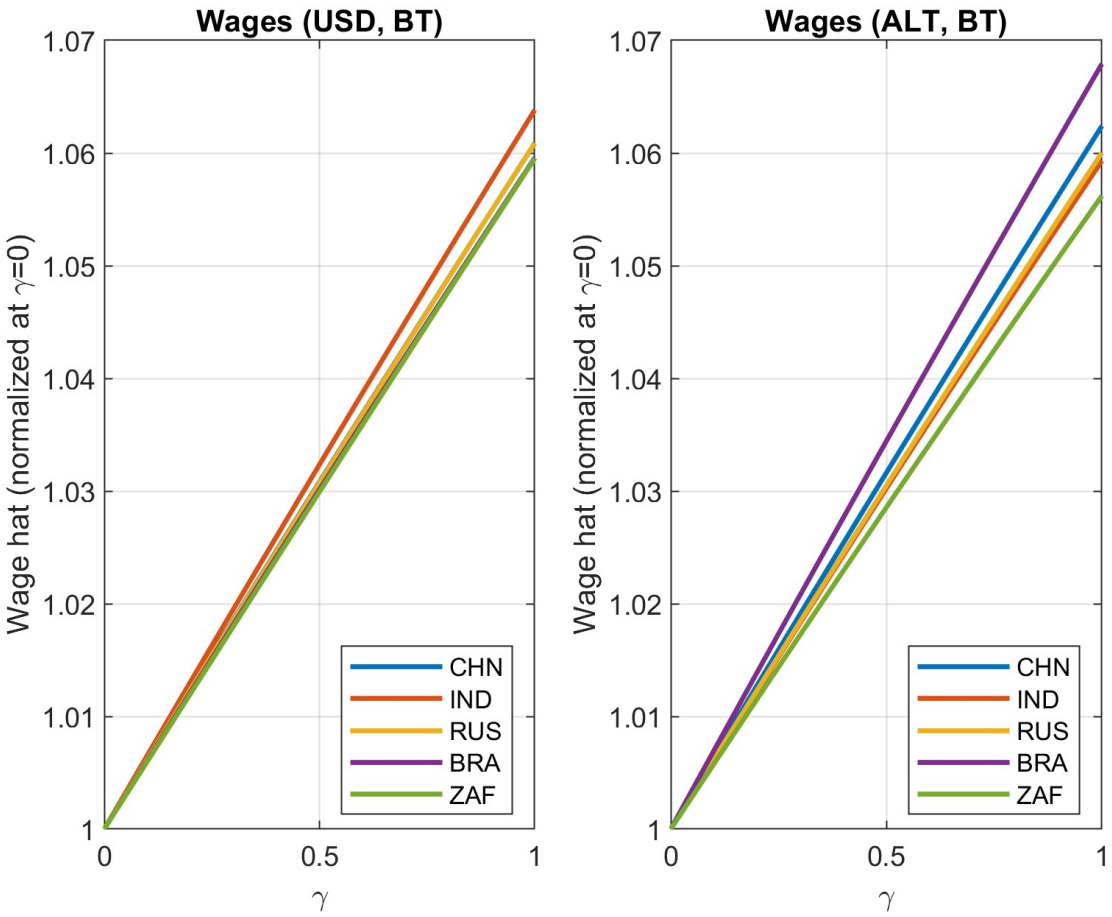


Figure 5: Wages under USD and ALT settlement across sanctions intensity γ for the China–Russia founding pair (balanced trade closure). General equilibrium wage adjustment amplifies the welfare effects of the sanctions wedge, as factor market clearing responds to the changed trade cost structure.

switching to ALT as a function of γ. Welfare under USD declines monotonically in sanctions intensity. Welfare under ALT is initially lower than USD (additional marginal costs dominate at low sanctions) but eventually exceeds USD welfare as the sanctions wedge grows. The crossing point corresponds to the static indifference condition; accounting for switching costs and forward-looking continuation values yields the dynamic switching threshold, which is somewhat higher because the option value of remaining in USD is positive when sanctions intensity may revert.

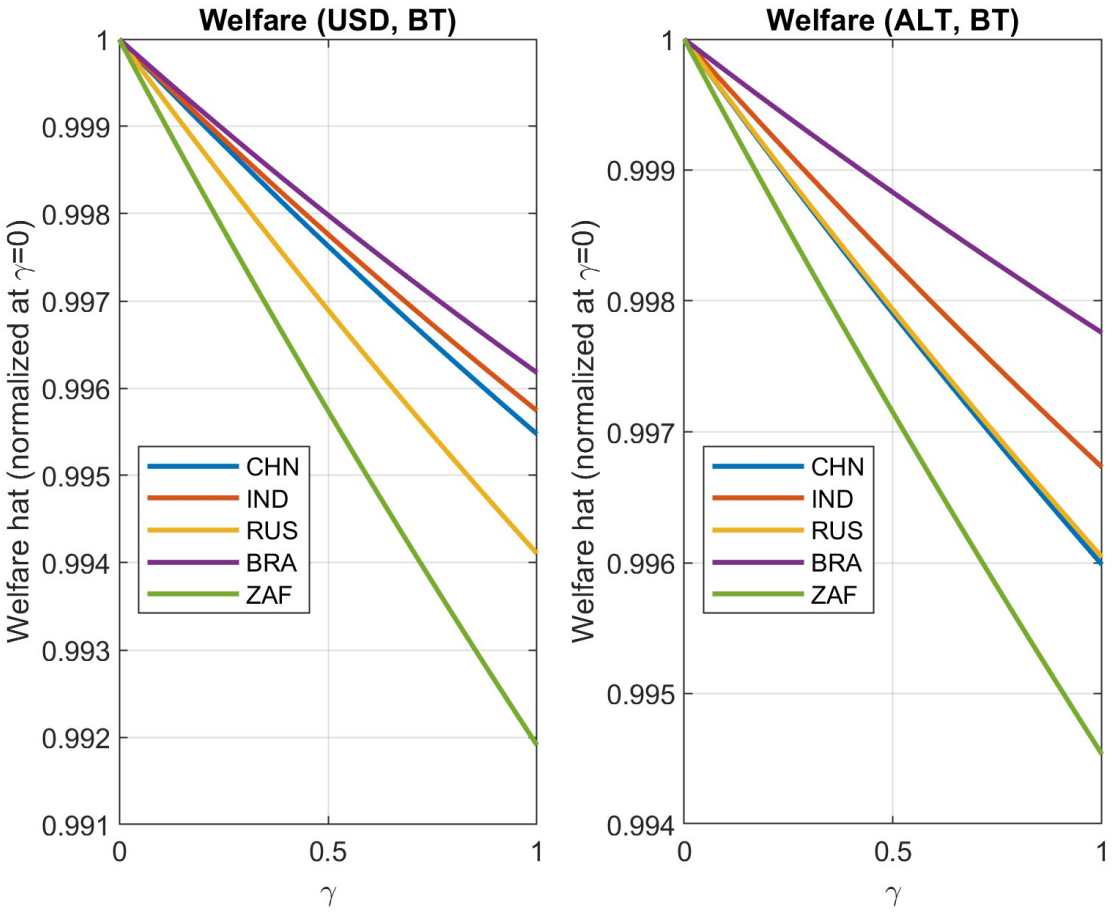


Figure 6: Welfare under USD and ALT settlement across sanctions intensity γ for the founding bilateral pair (balanced trade closure). Welfare under USD declines monotonically; ALT welfare is initially lower due to additional marginal costs but dominates at higher sanctions intensities.

The heterogeneity in welfare gains reflects two forces. Countries with higher current sanctions intensity γ_i experience larger absolute welfare losses under USD, so their static gain from switching is largest. Countries with higher intra-BRICS trade shares gain more from the sanctions-cost removal on intra-coalition flows. Russia dominates on the first

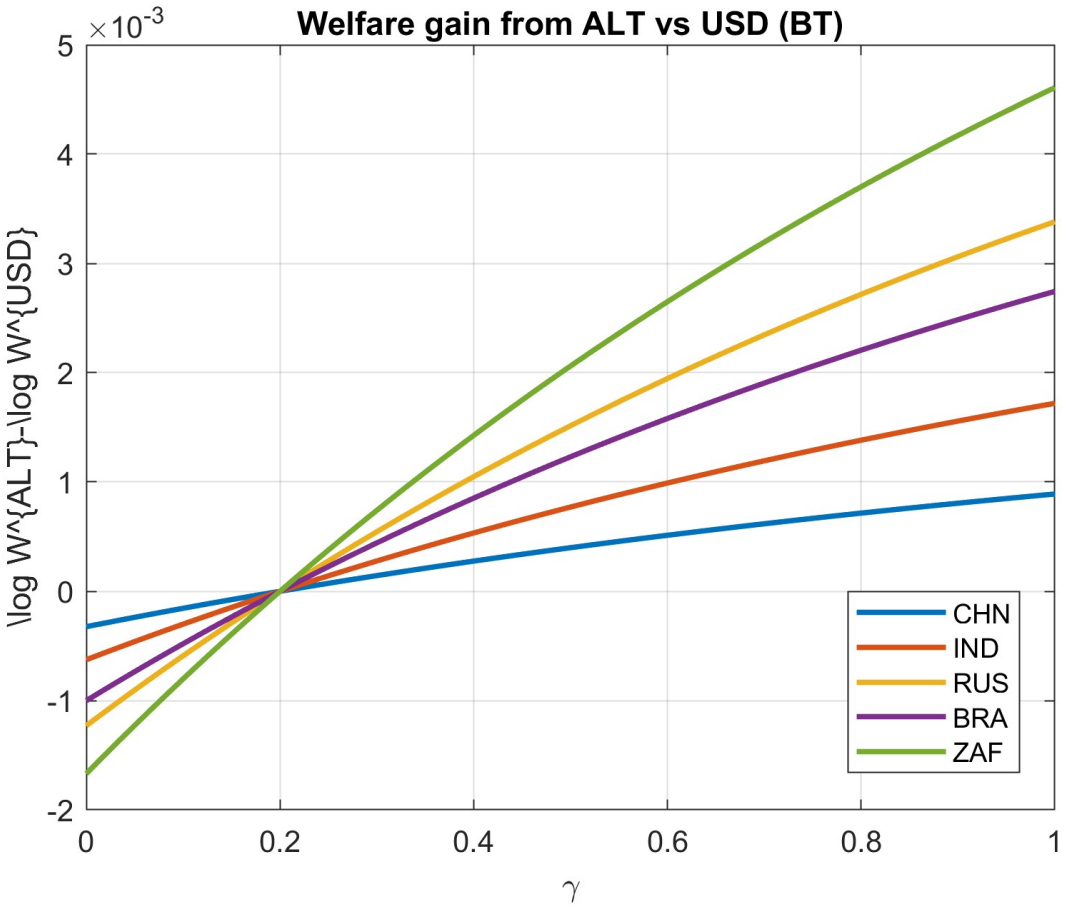


Figure 7: Welfare gain from switching to ALT (log difference from USD) for each BRICS country across sanctions intensity γ. Gains increase with sanctions intensity and turn positive at different thresholds reflecting heterogeneous trade shares and general equilibrium adjustments. Russia benefits most from switching due to its highest sanctions exposure.

dimension; Brazil has the highest intra-BRICS trade share but the lowest effective gain because its current sanctions level is near zero. China's gain, while positive in the Russia–China pair, is modest because its intra-BRICS trade share is small relative to its total global trade.

5.2 Collective switching and coalition thresholds

The model delivers several threshold objects characterizing coalition feasibility and stability. Table 5 reports the headline objects under the baseline balanced-trade closure. The proximity of the collective benchmark to the self-enforcing threshold reflects strong natural alignment of incentives generated by the network effects and the sanctions cost distribution.

Table 5: Key threshold objects (balanced trade, baseline calibration)

Object	$\hat{\gamma}$	Trade relative to no-sanctions baseline
Collective benchmark (GDP-weighted planner)	0.315	0.79
Self-enforcing full coalition	0.327	0.78
Founding bilateral Nash threshold (China–Russia)	0.393	0.75

The magnitude of these thresholds can be interpreted in terms of implied trade cost effects under the dollar settlement regime. In the model, sanctions increase bilateral trade costs according to $\tau_{ij}^{USD} = 1 + \kappa\gamma_j$ with $\kappa = 0.15$. The resulting reduction in trade relative to a world without sanctions is approximately $(1 + \kappa\gamma)^{-\theta}$.

For the founding bilateral threshold $\hat{\gamma}_{CR}^{Nash} = 0.393$, the implied trade multiplier is $(1 + 0.15 \times 0.393)^{-5} \approx 0.75$, corresponding to roughly a 25% reduction in trade under the dollar settlement regime relative to a frictionless baseline. The collective benchmark $\hat{\gamma}^{Collective} = 0.315$ implies a multiplier of $(1 + 0.15 \times 0.315)^{-5} \approx 0.79$, corresponding to a trade reduction of approximately 21%. These magnitudes lie between the moderate trade disruptions observed in targeted financial sanctions episodes and the much larger collapses associated with comprehensive sanctions regimes.

The collective benchmark of 0.315 corresponds to the sanctions intensity at which

GDP-weighted BRICS welfare favors collective adoption of the alternative regime.

Figure 8 summarizes Nash thresholds across all possible BRICS coalition sizes and illustrates the monotone relationship between coalition scale and threshold level. Larger coalitions require lower sanctions intensities to be self-sustaining, reflecting the declining additional marginal cost function $\mu(K)$ with coalition scale. The full five-member coalition achieves the lowest Nash threshold at 0.327, while bilateral coalitions require sanctions intensities ranging from 0.393 (China–Russia) to effectively infeasible for most pairs. Several three-member coalitions containing China fall in the range 0.370–0.425, and four-member coalitions with China fall in the range 0.339–0.379. The systematic pattern—China-inclusive coalitions dominate across all sizes—reflects China's dominant trade-scale weight (0.448), which generates the largest network cost reduction upon joining.

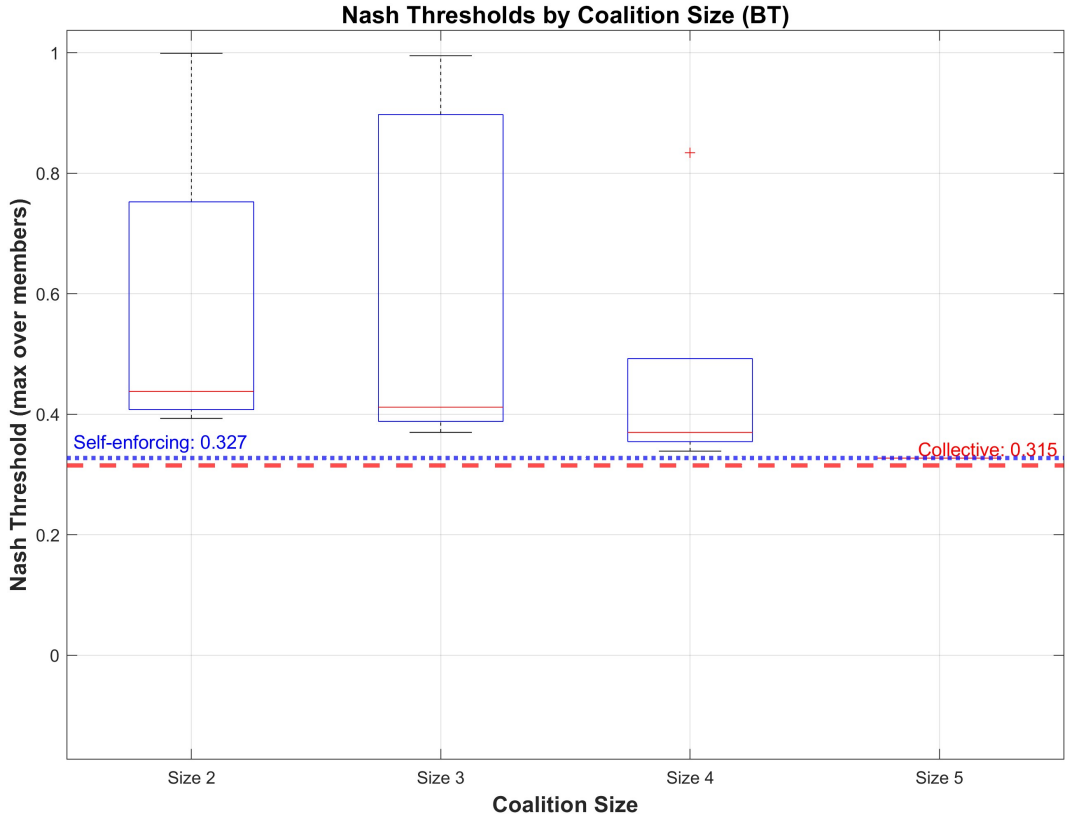


Figure 8: Distribution of Nash thresholds across BRICS coalitions of each size (balanced trade). Each data point represents the Nash threshold for one coalition; boxes summarize the distribution by size. Larger coalitions systematically require lower sanctions intensities, reflecting declining network costs with scale. Reference lines show the collective benchmark ($\gamma = 0.315$) and self-enforcing full-coalition threshold ($\gamma = 0.327$).

To visualize the collective switching condition, Figure 9 plots the aggregate value functions under USD and ALT. The crossing of these value functions corresponds to the collective benchmark in Table 5. The dynamic nature of the value functions—reflecting sanctions persistence, switching costs, and option values—means that the crossing occurs at higher γ than the static welfare indifference point, because countries in USD weigh the possibility of future sanctions reduction against the cost of switching.

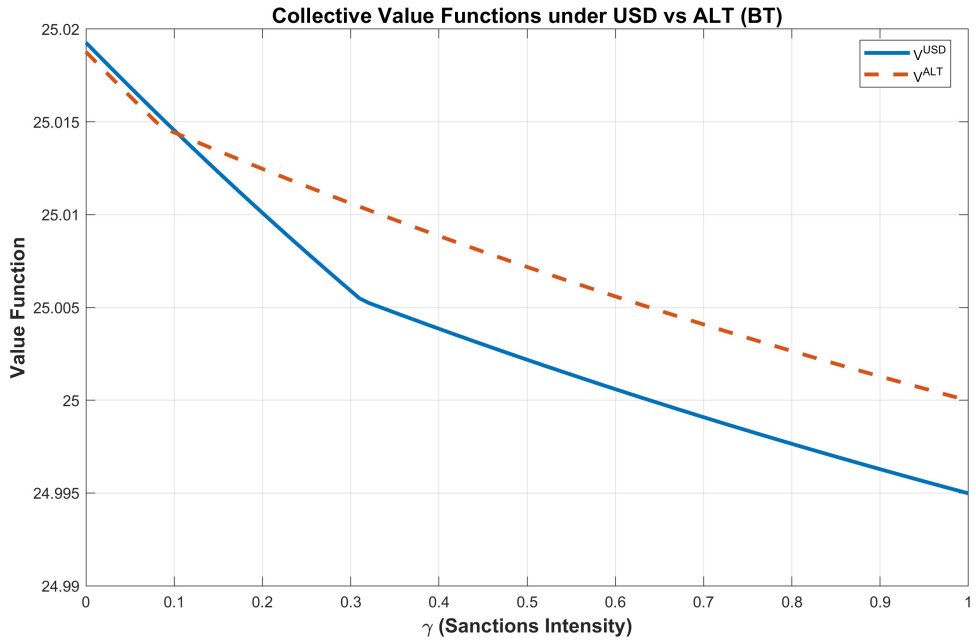


Figure 9: Collective (GDP-weighted) value functions under USD and ALT settlement across sanctions intensity γ. The crossing at $\gamma = 0.315$ defines the collective benchmark threshold. The gap between static and dynamic indifference points reflects the option value of remaining in USD under persistent but uncertain sanctions.

5.3 Bilateral Nash thresholds and partner choice

Bilateral switching requires that both members simultaneously prefer ALT net of switching costs. Table 6 reports bilateral Nash thresholds for all ten BRICS pairs, identifying the binding constraint (the member whose individual threshold determines the bilateral Nash threshold) and the infeasible pairs whose individual thresholds either do not exist in $[0, 1]$ or where the joint condition cannot be satisfied simultaneously.

Two patterns are systematic. First, among feasible pairs, China is a member of all four—consistent with China's dominant trade-scale weight generating the largest network

Table 6: Bilateral Nash thresholds and binding member constraints (balanced trade). Infeasible indicates that at least one member's threshold is not reached within $\gamma \in [0, 1]$.

Pair	Binding member	$\hat{\gamma}_{ij}^{Nash}$	$\hat{\gamma}_i$	$\hat{\gamma}_j$
China–Russia	China	0.393	0.393	0.340
China–India	India	0.408	0.379	0.408
China–ZAF	China	0.407	0.407	0.317
China–Brazil	Brazil	0.438	0.392	0.438
India–Russia	—	Infeasible	∞	0.767
India–ZAF	—	Infeasible	∞	0.708
Russia–Brazil	—	Infeasible	0.999	∞
India–Brazil	—	Infeasible	∞	∞
Russia–ZAF	—	Infeasible	∞	∞
Brazil–ZAF	—	Infeasible	∞	∞

cost reduction and making the alternative regime most attractive for any partner when China participates. Second, China's constraint frequently binds (China–Russia, China–ZAF) or comes close to binding (China–India, China–Brazil). This reflects a fundamental asymmetry in China's incentives: while China contributes substantially to the network by routing a large share of intra-BRICS trade through the alternative system, its private gain is limited because intra-BRICS trade accounts for only 5.2% of China's total trade. The network externality is large and diffuse—China's participation benefits all other members substantially—while China's private gain is concentrated only on the small fraction of its trade with other BRICS members.

For pairs that exclude China, the individual thresholds are either extremely high (Russia–Brazil at 0.999, India–Russia at 0.767, India–ZAF at 0.708) or do not exist within the unit interval. These pairs cannot generate sufficient network scale to make the alternative regime competitive for both members simultaneously. India's threshold is effectively infinite for non-China pairs because its current sanctions exposure is zero ($\gamma_{IND} = 0$) and the additional marginal cost of a small-scale alternative system exceeds any foreseeable sanctions cost savings. Brazil's situation is similar: with $\gamma_{BRA} = 0.062$, the savings from insulating its intra-BRICS trade are insufficient to justify switching unless the coalition is large enough that network costs fall substantially.

This bilateral feasibility pattern has a direct implication for sequential formation dy-

namics: the only viable founding bilaterals are those containing China, and among these, China–Russia offers the lowest Nash threshold because Russia's extreme sanctions exposure creates the strongest unilateral incentive to switch, pulling the bilateral threshold down toward the China-binding constraint.

5.4 Sequential coalition formation

The sequential formation analysis identifies China–Russia as the founding bilateral at $\hat{\gamma}_{CR}^{Nash} = 0.393$ and shows that this founding coalition immediately triggers a cascade to the full BRICS bloc. Figure 10 reports the formation path.

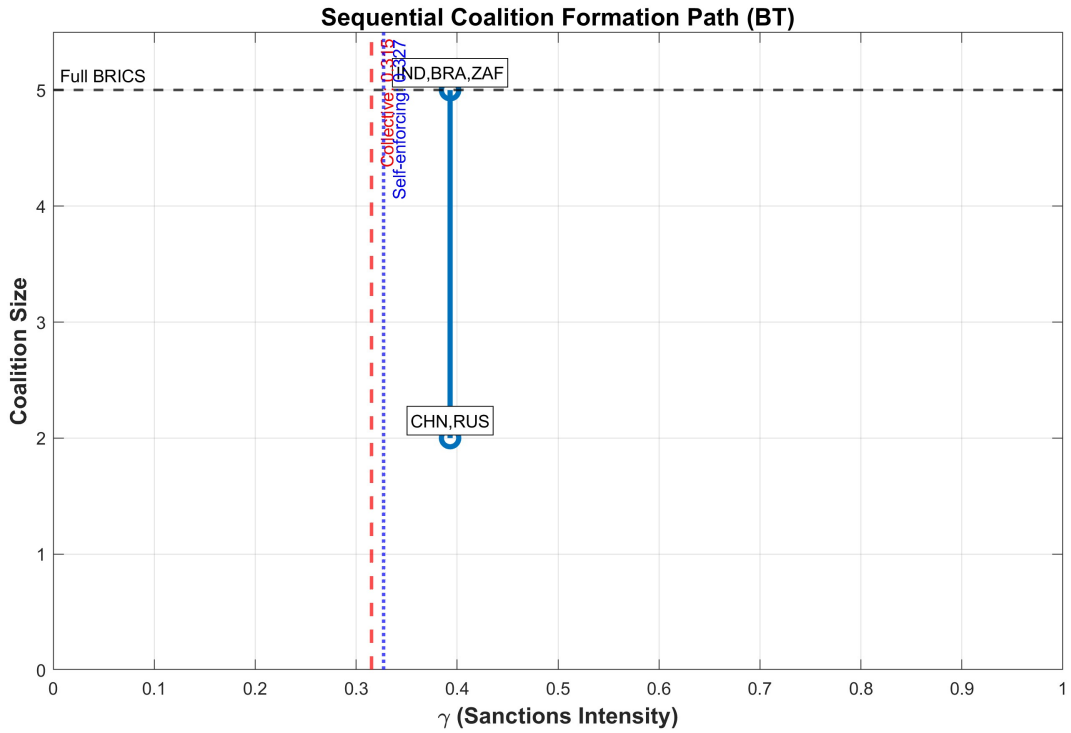


Figure 10: Sequential coalition formation path (balanced trade). The founding bilateral China–Russia forms at $\gamma = 0.393$. At this same sanctions intensity, network cost compression immediately triggers a cascade: India, Brazil, and South Africa all find it optimal to join simultaneously, expanding the coalition from two to five members in a single step.

The cascade mechanism works as follows. The China–Russia bilateral encompasses trade scale weights $\omega_{CHN}^{trade} + \omega_{RUS}^{trade} = 0.448 + 0.172 = 0.620$, implying additional marginal cost $\mu(\{CHN, RUS\}) = 0.03 + 0.05 \times (1 - 0.620) = 0.049$—an alternative iceberg cost of 1.049 for intra-coalition flows. When the remaining three outsiders—India, Brazil, and

South Africa—evaluate whether to join the China–Russia coalition, they compare the value of joining (which uses the full five-member additional marginal cost $\mu = 0.030$ since all three join simultaneously) against remaining in USD. At $\gamma = 0.393$, all three exhibit positive joining values simultaneously, producing the cascade.

This cascade result is economically significant: it implies that sequential and collective switching thresholds are not as far apart as bilateral Nash thresholds alone would suggest. While the collective benchmark occurs at $\gamma = 0.315$ and the founding bilateral occurs at $\gamma = 0.393$, the sequential path reaches the full coalition at $\gamma = 0.393$ through the cascade, compressing the effective gap between collective and decentralized coordination. The sequential full-coalition threshold of 0.393 remains above the collective benchmark of 0.315 by 7.8 percentage points—representing the true coordination cost of decentralized versus centralized formation—but this is substantially smaller than the naive comparison of individual bilateral Nash thresholds (which range up to infeasible) would suggest.

Table 7 reports conditional entry thresholds for outsiders given the China–Russia founding pair. These conditional thresholds—the sanctions intensity at which an outsider would join if the China–Russia coalition already existed—are all lower than the founding bilateral threshold of 0.393, confirming that the cascade condition is satisfied and that the coalition expands immediately.

Table 7: Conditional entry thresholds for outsiders given the China–Russia founding pair. All conditional thresholds are below the founding bilateral threshold, confirming the cascade.

Outsider	Conditional entry threshold	Joining at γ
South Africa	0.286	0.393
India	0.370	0.393
Brazil	0.390	0.393

The ordering of conditional entry thresholds reveals an interesting economic pattern. South Africa enters first (lowest conditional threshold at 0.286) despite having the smallest trade-scale weight, because at $\gamma = 0.393$—the China–Russia founding threshold—the existing coalition already delivers substantial network cost reduction, and South Africa's switching cost is proportionally small given its low GDP weight. India enters second

(0.370), and Brazil last (0.390), reflecting that Brazil has the highest bilateral Nash threshold among feasible China pairs (0.438) and thus requires the most coalition support to make switching individually rational.

5.5 Transfer feasibility

Collective switching can be sustained with transfers even when the full coalition is not yet self-enforcing at all individual thresholds simultaneously. I evaluate transfer feasibility by comparing aggregate present-value gains across members that benefit from switching against the compensation required by members that do not yet benefit.

Figure 11 plots the net slack (aggregate surplus minus aggregate deficit) for the full BRICS coalition across γ. Net slack turns nonnegative after $\gamma = 0.315$ (which computing for 0.05 grids, give us 0.320 as the starting feasibility point),which is below the self-enforcing threshold of 0.327. This implies that redistribution from strong gainers (Russia, and to a lesser extent China) to weak gainers or losers (India, Brazil, South Africa at moderate sanctions) can sustain full-coalition coordination beginning at $\gamma = 0.320$—slightly before all individual participation constraints are satisfied simultaneously. The narrow window of 0.7 percentage points between transfer feasibility and self-enforcement confirms that formal compensation mechanisms provide only marginal value over what decentralized incentives deliver when sanctions reach the relevant range.

5.6 Coalition stability and exit robustness

I evaluate the internal stability of the full BRICS coalition and its robustness to exit perturbations. Internal stability at γ requires that no individual member or subgroup collectively prefers to exit to USD given the remaining coalition. Exit-robustness asks whether, if one or two members revert to USD (paying return costs), the remaining coalition remains internally stable.

Figure 12 reports stability indicators across the full range of γ. The full BRICS coalition

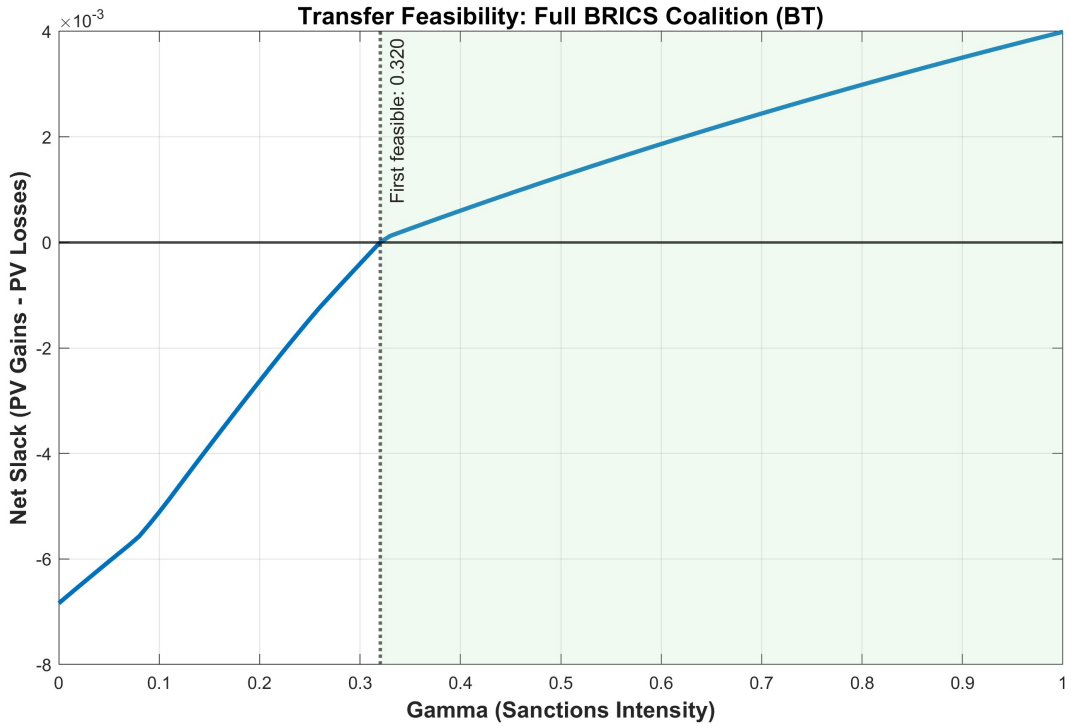


Figure 11: Net slack (aggregate present-value surplus minus deficit) for the full BRICS coalition across sanctions intensity γ. Net slack becomes nonnegative at $\gamma \approx 0.320$, indicating that redistribution can sustain full-coalition coordination 0.7 percentage points before all members are individually rational at $\gamma = 0.327$.

becomes internally stable at $\gamma \approx 0.327$ (the self-enforcing threshold). However, robustness to any single exit requires considerably higher sanctions intensities, becoming satisfied only at approximately $\gamma \approx 0.840$. The full coalition does not survive any two-member exit within the $\gamma \in [0, 1]$ range tested.

This sharp divergence between stability and exit-robustness reflects the role of network scale in sustaining coalition value. When the full five-member coalition is stable at moderate sanctions ($\gamma \approx 0.327$–0.839), it is self-sustaining because all members prefer ALT to USD given the full network. But if a single member exits, the four-member coalition faces higher network costs (μ rises because the coalition's trade scale weight falls), reducing the value of remaining in ALT for all remaining members. At moderate sanctions intensities ($\gamma < 0.84$), this reduction in network value is sufficient to unravel the coalition, as remaining members may prefer USD when the exiting member's trade scale contribution is lost. Only at high sanctions intensities ($\gamma > 0.84$) is the sanctions cost high enough that four-member coalitions remain viable even after a single departure.

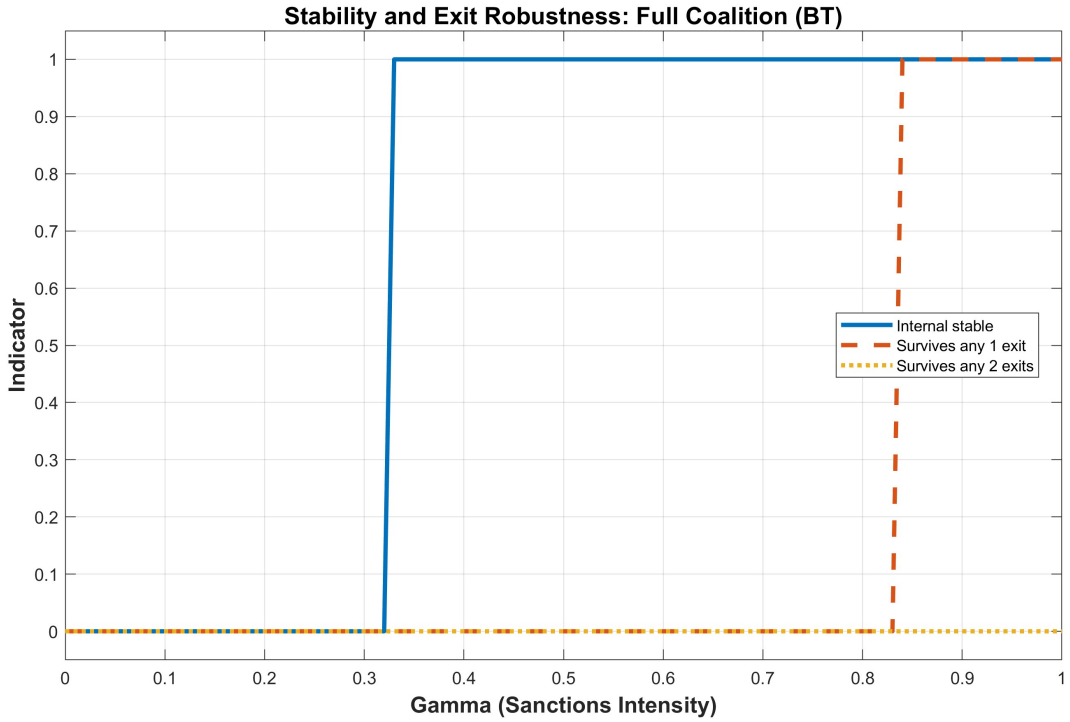


Figure 12: Internal stability and exit robustness of the full BRICS coalition across γ. The full coalition becomes internally stable at $\gamma = 0.327$. Robustness to any single-member exit requires $\gamma \approx 0.840$. The coalition does not survive any two-member exit within the range tested, reflecting the importance of network scale for viability.

The divergence between internal stability and exit-robustness underscores an important policy implication: the full BRICS coalition, once formed at or above $\gamma = 0.327$, is self-sustaining against individual defection precisely because switching back to USD is itself costly (return costs), and at the relevant sanctions intensities the USD welfare loss exceeds the return cost. However, the coalition is vulnerable to coordinated exit by two members if sanctions fall to levels below $\gamma = 0.84$—implying that if Western powers moderated sanctions substantially, the BRICS settlement bloc could become fragile even after formation.

5.7 Bilateral incentives at current sanctions intensities

To connect the model to observed settlement patterns, I evaluate bilateral switching incentives at current country-specific sanctions intensities: $\gamma^{RUS} = 1.0$, $\gamma^{CHN} = 0.344$, $\gamma^{BRA} = 0.062$, $\gamma^{ZAF} = 0.031$, and $\gamma^{IND} = 0$.

Table 8 reports the dynamic welfare gain $\Delta \log V_i$ for each country in each bilateral coalition, evaluated at the current sanctions vector. Bilateral switching is privately feasible only when both entries are nonnegative, requiring that both members gain in dynamic value terms from adopting the alternative settlement arrangement.

Table 8: Bilateral switching incentives at current sanctions intensities. A bilateral deviation is privately feasible only if both $\Delta \log V_i \geq 0$ and $\Delta \log V_j \geq 0$ simultaneously.

Pair	$\Delta \log V_i$	$\Delta \log V_j$
China–India	+0.00304 (China)	–0.00065 (India)
China–Russia	**+0.00289 (China)**	**+0.000393 (Russia)**
China–Brazil	+0.00290 (China)	–0.000041 (Brazil)
China–ZAF	+0.00280 (China)	–0.0000874 (ZAF)
India–Russia	–0.0000649 (India)	+0.000393 (Russia)
India–Brazil	–0.0000649 (India)	–0.0000409 (Brazil)
India–ZAF	–0.0000649 (India)	–0.0000874 (ZAF)
Russia–Brazil	+0.000366 (Russia)	–0.0000409 (Brazil)
Russia–ZAF	+0.000218 (Russia)	–0.0000874 (ZAF)
Brazil–ZAF	–0.0000395 (Brazil)	–0.0000874 (ZAF)

Only China–Russia satisfies the bilateral Nash feasibility condition: both China (+0.00289) and Russia (+0.000393) exhibit nonnegative dynamic value gains from adopting the alternative settlement arrangement bilaterally. All other nine BRICS pairs fail the joint feasibility condition because at least one member exhibits a negative welfare change.

The China–Russia result is consistent once I distinguish the scalar threshold exercise from the heterogeneous "current sanctions" evaluation. The bilateral Nash threshold $\hat{\gamma}_{CR}^{\text{Nash}} = 0.393$ is computed under a uniform sanctions environment in which all BRICS face the same scalar intensity γ. In contrast, the bilateral ΔV table evaluates incentives at the realized heterogeneous vector (γ_{CHN}, γ_{IND}, γ_{RUS}, γ_{BRA},γ_{ZAF}). Under the importer-side sanctions wedge in the model, switching to the alternative arrangement removes the sanctions-related trade wedge on intra-coalition imports and replaces it with additional marginal costs. At current intensities, this substitution can generate positive gains for China even when γ_{CHN} is below the uniform-γ threshold. Moreover, Russia's extreme sanctions intensity affects global equilibrium prices and wages through general equilibrium feedback, reinforcing China's incentives in the forward-looking value function.

All other pairs that include China (China–India, China–Brazil, China–ZAF) show positive gains for China but negative gains for the partner. At current sanctions, India, Brazil, and South Africa face near-zero or zero own-sanctions intensity, so their welfare loss under USD from the sanctions wedge is minimal. Switching to ALT would expose them to additional marginal costs without commensurate sanctions-cost savings, generating a net welfare loss. Russia's high sanctions intensity makes it a beneficial bilateral partner for China through the importer-side mechanism, but Russia's partners excluding China (India, Brazil, South Africa) similarly find that their own-sanctions intensity is too low to justify bearing the additional marginal cost of bilateral alternative settlement.

This pattern—China–Russia as the sole feasible bilateral at current sanctions—provides direct empirical validation of the model. The 90% yuan share in Russia–China bilateral trade by late 2024 (International Monetary Fund 2023) corresponds precisely to the scenario the model predicts: a bilateral deviation that is privately feasible and mutually welfare-improving under current sanctions, while all other BRICS bilateral pairs remain sub-threshold. The model's threshold structure predicts that absent significant escalation of sanctions against other BRICS members—particularly India, Brazil, and South Africa—widespread local-currency adoption beyond the Russia–China case is unlikely to emerge through decentralized bilateral incentives alone.

6 Sensitivity and Robustness

The baseline results above use the balanced-trade (BT) closure and specific values of the switching cost and additional marginal cost parameters. This section examines how results vary across the trade-balance closure and across a grid of cost parameter values, and shows that the qualitative conclusions are robust while the quantitative thresholds vary in predictable ways.

6.1 Fixed-deficits closure

Under the baseline balanced-trade closure, each country's expenditure in the counterfactual equals wage income, eliminating baseline trade imbalances. Under the fixed-deficits (FD) closure, trade imbalances are held fixed at their observed WDI values ($D_i^0 = -NX_i^0$), and expenditure equals $\hat{w}_i Y_i^0 + D_i^0$. The FD closure maintains the observed surplus and deficit positions, so the general equilibrium wage adjustment reflects both the direct sanctions wedge and the constraint that net export positions are unchanged.

Table 9 reports the key threshold objects under FD. Quantitatively, all thresholds shift modestly upward relative to BT: the collective benchmark rises from 0.315 to 0.317, the self-enforcing full-coalition threshold from 0.327 to 0.328, and the founding bilateral from 0.393 to 0.397. These differences are on the order of single basis points to a few percentage points, well within the precision of the empirical calibration. The founding bilateral remains China–Russia, the cascade to the full five-member coalition continues to occur at the founding threshold, and the qualitative pattern of bilateral feasibility is unchanged.

Table 9: Key threshold objects under the fixed-deficits (FD) closure. Differences from BT are modest and do not affect qualitative conclusions.

Object	BT	FD
Collective benchmark	0.315	0.317
Self-enforcing full coalition	0.327	0.328
Founding bilateral (China–Russia)	0.393	0.397

Figures 13 and 14 confirm the robustness visually. The gap between the best bilateral Nash threshold and the collective benchmark is maintained, and the sequential formation path under FD replicates the cascade structure of the BT baseline. These results establish that the model's qualitative architecture—cascade from the China–Russia founding bilateral to the full bloc, tight gap between collective and self-enforcing thresholds, and the feasibility hierarchy across coalition sizes—is not driven by the particular treatment of trade imbalances.

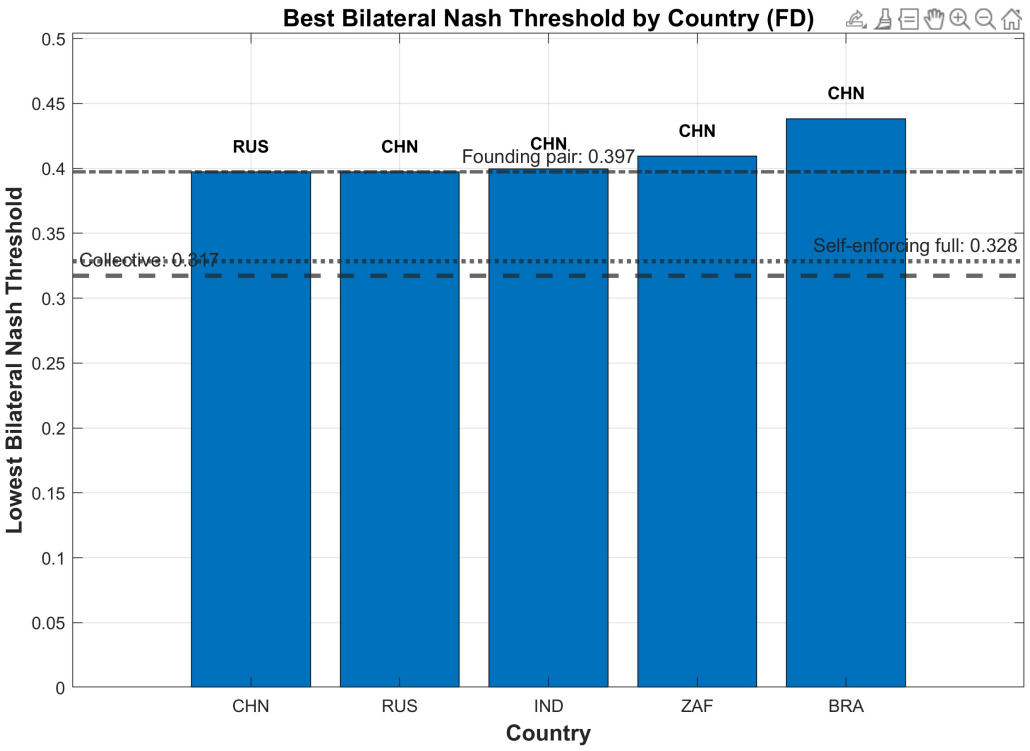


Figure 13: Best bilateral Nash threshold versus collective benchmark under the fixed-deficits closure. The qualitative structure—collective below bilateral, gap of roughly 7–8 percentage points—is maintained from the balanced-trade baseline.

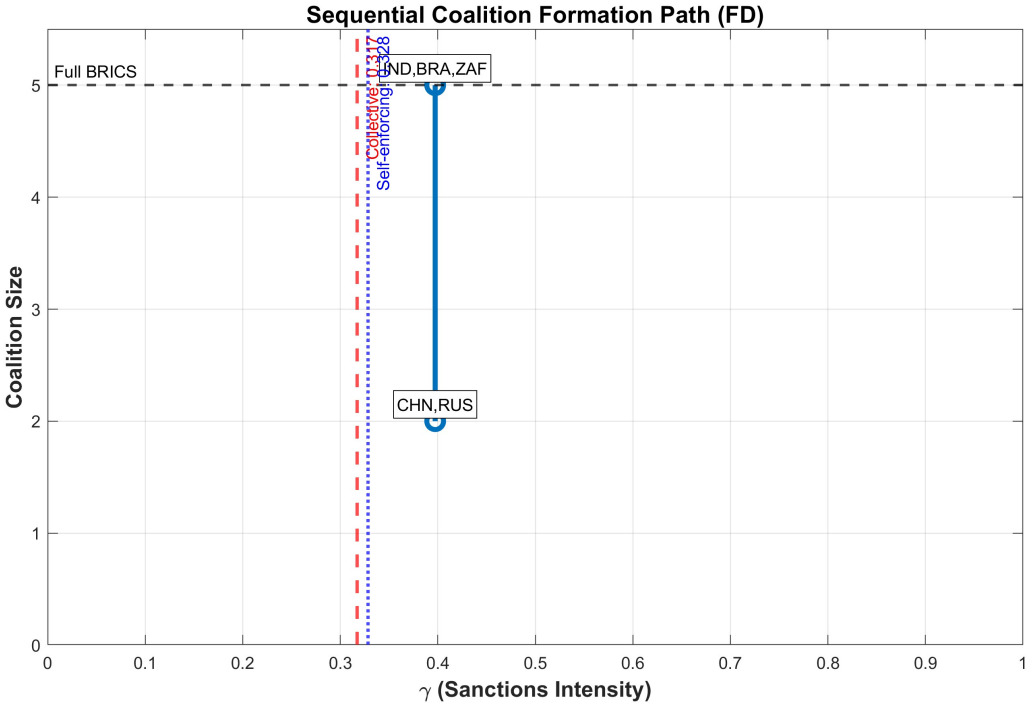


Figure 14: Sequential coalition formation path under the fixed-deficits closure. China–Russia remains the founding bilateral, and the cascade to the full five-member coalition continues to trigger at the founding threshold.

Figures 15 and 16 complete the robustness picture by showing the collective value functions and transfer feasibility under FD. Both are closely aligned with their BT counterparts, confirming the stability of the mechanism across closures.

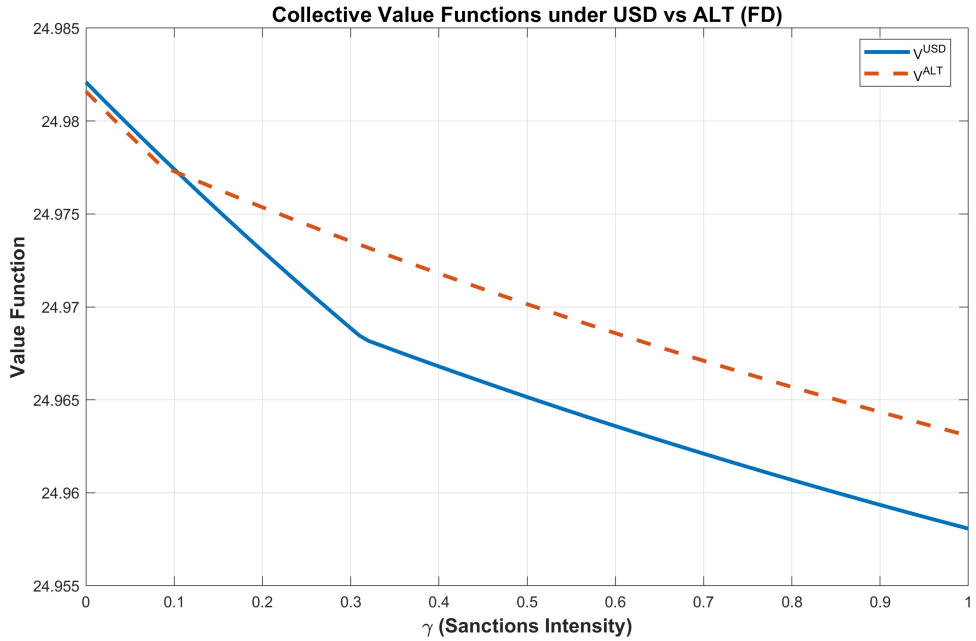


Figure 15: Collective value functions under USD and ALT (fixed-deficits closure). The crossing structure replicates the balanced-trade results with a marginal shift in the threshold level.

6.2 Sensitivity to switching and additional marginal costs

The two key cost parameters governing threshold levels are the switching cost τ_i^{out} (expressed as a share of GDP, τ_{share}) and the additional marginal cost μ_n (the scale-dependent component of the network friction). I vary these parameters over a grid and recompute the best bilateral Nash threshold and the collective benchmark for each grid point, holding all other parameters at their baseline values.

Figure 17 plots the sensitivity of the best bilateral Nash threshold across the switching-cost and network-cost parameter space. Several patterns emerge. First, both cost parameters increase thresholds monotonically: higher switching costs raise thresholds by increasing the benefit required to justify the one-time investment, while higher additional marginal costs raise thresholds by increasing the ongoing friction under ALT. Second, the

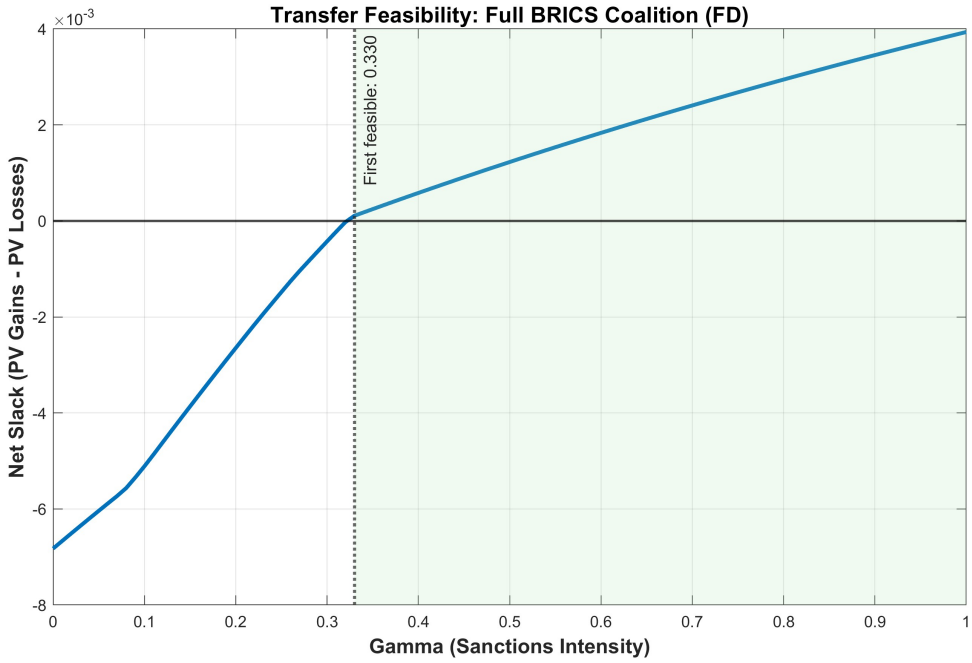


Figure 16: Transfer feasibility (net slack) for the full coalition under the fixed-deficits closure. The qualitative pattern mirrors the balanced-trade closure, with net slack turning nonnegative at a similar sanctions intensity.

two dimensions interact: at low switching costs, even high marginal costs yield thresholds below 0.6, while at high switching costs combined with high additional marginal costs the bilateral threshold approaches 0.9. The baseline calibration sits comfortably in an intermediate region where the bilateral threshold of 0.393 is well-identified relative to the extremes.

Figure 18 plots the corresponding sensitivity for the collective benchmark threshold. Two additional robust patterns emerge from the comparison of these figures. First, the collective threshold is uniformly below the bilateral Nash threshold across the entire parameter grid, reflecting the network externality internalization under collective coordination: the planner can immediately deploy the full-coalition network size, while bilateral formation must start from a two-member network. Second, the gap between bilateral and collective thresholds is largest at high network-cost values, where the scale advantage of full-coalition adoption is most valuable. This confirms that the value of formal coordination is primarily a network-scale benefit rather than a switching-cost benefit.

At zero additional marginal cost ($\mu_n = 0$) and near-zero switching cost, the bilateral

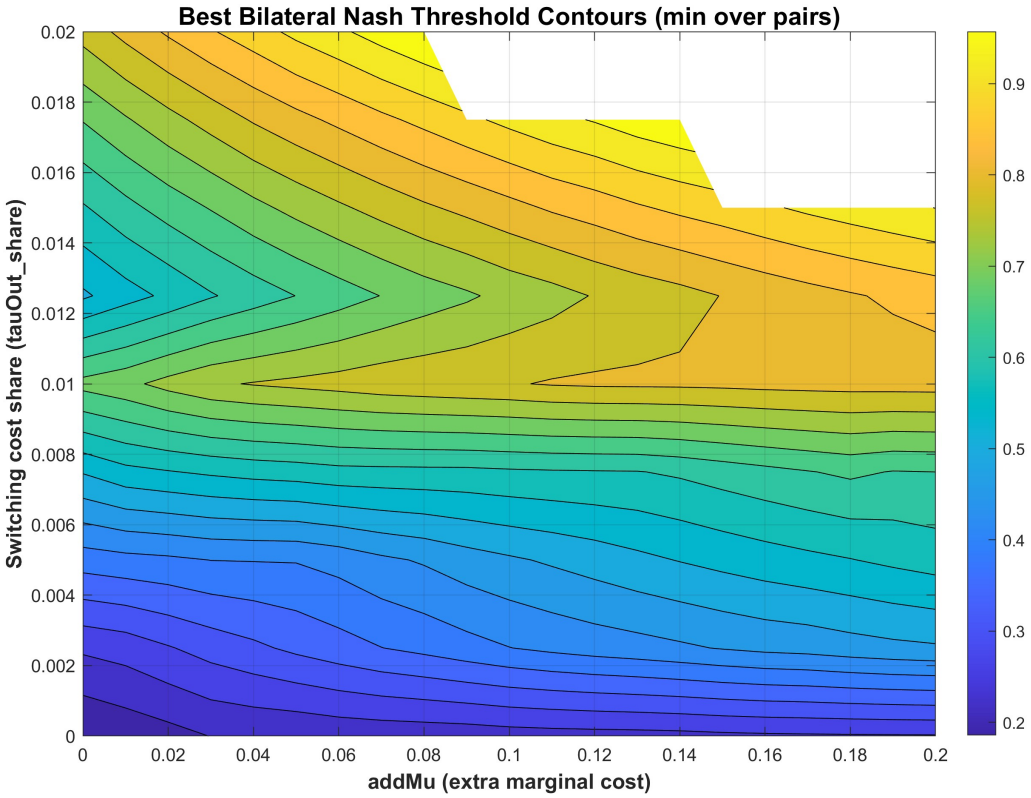


Figure 17: Sensitivity of the best bilateral Nash threshold (China–Russia) to switching-cost share τ_{share} and additional marginal cost μ_n. Contours show threshold levels. The baseline calibration ($\tau_{share} = 0.005$, $\mu_n = 0.05$) is marked. Thresholds increase smoothly in both dimensions and interact multiplicatively at extremes.

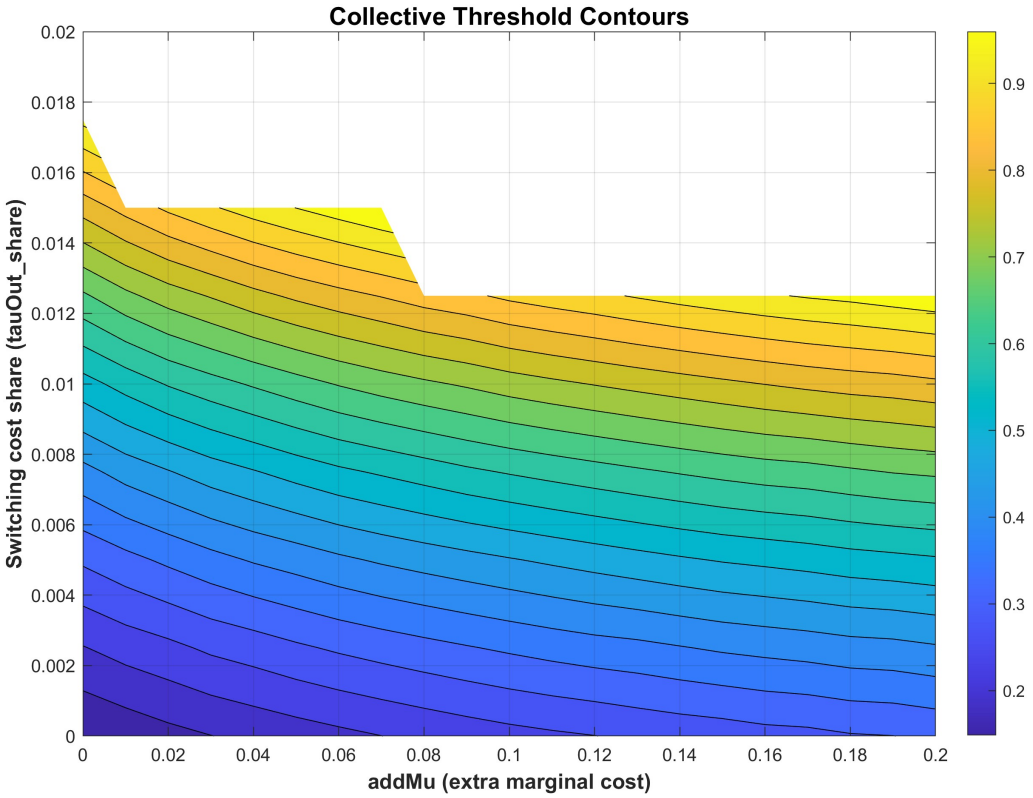


Figure 18: Sensitivity of the collective benchmark threshold to switching-cost share τ_{share} and additional marginal cost μ_n. The collective threshold is uniformly below the bilateral Nash threshold (Figure 17) across all parameter values, with the gap largest at high additional marginal costs.

threshold falls toward $\gamma \approx 0.2$—the sanctions intensity at which the structural additional marginal cost alone ($\mu_s = 0.03$) is insufficient to deter bilateral switching for China and Russia. At the high end, with $\tau_{share} \approx 0.02$ (2% of GDP switching cost) and $\mu_n = 0.10$ (double the baseline marginal cost), the bilateral threshold approaches $\gamma \approx 0.9$—within the extreme comprehensive sanctions range. The baseline calibration at $\tau_{share} = 0.005$ and $\mu_n = 0.05$ yields the intermediate result of 0.393, which aligns with the observed pattern where China–Russia switching has occurred under Russia's maximum sanctions but broader BRICS adoption has not.

Three further observations from the sensitivity analysis deserve emphasis. First, across all specifications tested, China–Russia remains the founding bilateral coalition because the relative ordering of bilateral Nash thresholds is robust to proportional cost scaling: raising or lowering costs affects all pairs' thresholds, but China–Russia's advantage from Russia's extreme sanctions intensity and China's trade-scale weight is preserved. Second, the cascade from China–Russia to the full BRICS bloc occurs across a wide range of parameter values, reflecting that the combined trade-scale weight of China and Russia (0.620 of intra-BRICS trade) is sufficient to make the remaining members' joining values positive under most calibrations. Third, Brazil and South Africa display the greatest threshold sensitivity—their thresholds increase most under adverse cost assumptions—because their low sanctions intensities mean that small changes in network costs can flip their individual participation constraints, making them the marginal members whose entry into the coalition is most uncertain.

These sensitivity results jointly support the paper's main conclusions: the China–Russia founding bilateral is robust, the cascade to full BRICS is robust, the collective threshold is uniformly below the bilateral Nash threshold, and coordination frictions between collective and self-enforcing outcomes are consistently small across the parameter space.

6.3 Robustness: Vectorial Value Function Representation

The baseline dynamic programming solution approximates the continuation value of the alternative settlement regime using a scalar state representation. To verify that the results are not driven by this computational simplification, I solve the Bellman problem using a vectorial representation of the value function over the coalition state space.

In this alternative specification, the value function is evaluated directly over the multidimensional state vector describing coalition participation rather than through a scalar aggregation. The equilibrium switching condition is therefore computed from the vectorial value function $V(s, \gamma)$ by identifying the sanction intensity Γ^* at which the alternative regime weakly dominates the dollar regime along the coalition diagonal.

The results confirm the main mechanism of the model. The sanctions threshold required to sustain the alternative settlement regime declines sharply once a coalition of at least two countries forms, reflecting the presence of network and scale effects in the alternative payment infrastructure. After the initial bilateral coalition forms, additional members have only a limited effect on the threshold.

Although the exact numerical values differ from those obtained under the scalar approximation, the qualitative pattern is identical: bilateral adoption remains difficult at low sanction intensity, but once a small coalition emerges the required sanction intensity stabilizes around a moderate level.

These findings indicate that the equilibrium coalition dynamics are robust to the representation of the value function used in the dynamic programming algorithm. Table 14 in Appendix 7 reports the underlying numerical values.

7 Conclusion

This paper develops and quantifies a dynamic gravity model with regime-switching to study when BRICS countries coordinate to abandon dollar-denominated trade settle-

ment in response to Western financial sanctions. Combining an Eaton–Kortum general equilibrium trade environment with forward-looking regime choice, scale-dependent additional marginal costs for alternative settlement, and coalition formation dynamics, the model delivers a set of threshold objects governing bilateral, collective, and sequential switching decisions that can be matched to observable data and evaluated against observed settlement patterns.

The first central finding is that coordination frictions between collective and self-enforcing outcomes are small. The collective benchmark occurs at $\hat{\gamma}^{Collective} = 0.315$ while the self-enforcing full-BRICS threshold is $\hat{\gamma}^{Full,self\text{-}enforcing} = 0.327$, only 1.2 percentage points higher. The narrow gap implies that network effects and the distribution of sanctions costs create strong natural alignment of incentives among BRICS members: the welfare gain from full-coalition network scale is sufficiently large that decentralized incentives converge rapidly to the collective optimum. Formal BRICS summit mechanisms, while potentially valuable for political signaling and institutional commitment, add limited economic value beyond what decentralized market forces deliver through sequential bilateral arrangements.

Second, sequential coalition formation identifies China–Russia as the founding bilateral at $\hat{\gamma}_{CR}^{Nash} = 0.393$, driven by Russia's extreme sanctions exposure and China's dominant intra-BRICS trade weight. The founding coalition's combined trade scale (0.620 of intra-BRICS trade) immediately triggers a cascade: India, Brazil, and South Africa all exhibit positive joining values at the founding threshold, producing a discontinuous expansion from two to five members in a single step. This cascade mechanism means that the sequential path to full BRICS adoption, while requiring higher sanctions than the collective optimum, reaches the same five-member outcome at a single threshold point rather than through gradual sequential accretion. The scale economies in additional marginal costs dominate the coordination frictions, collapsing what might have been a multi-stage formation process into a two-stage event: bilateral initiation followed by immediate full-bloc expansion.

Third, bilateral feasibility is sharply concentrated among pairs that include China. Only four of ten BRICS bilateral pairs are feasible within the sanctions range $\gamma \in [0, 1]$, all involving China as a member. The remaining six pairs—those excluding China—face either infeasible or near-infeasible thresholds because they cannot generate sufficient combined trade scale to reduce network costs to competitive levels. China's participation constraint frequently binds the bilateral Nash threshold because its private gain from insulating a modest intra-BRICS trade share is limited, even as China's presence substantially benefits all other members. This structural asymmetry implies that any de-dollarization pathway among BRICS members requires China's active participation; without it, additional marginal costs remain too high for smaller members to justify switching.

Fourth, evaluation at current sanctions intensities ($\gamma^{RUS} = 1.0$, $\gamma^{CHN} = 0.344$, $\gamma^{BRA} = 0.062$, $\gamma^{ZAF} = 0.031$, $\gamma^{IND} = 0$) produces a precise validation of the model. Only China–Russia generates nonnegative dynamic welfare gains for both members simultaneously; all other nine BRICS bilateral pairs fail the Nash feasibility condition at current sanctions levels. China's positive gain in the China–Russia pair despite its own-sanctions intensity falling below the bilateral Nash threshold reflects the importer-side wedge mechanism: dollar-settled imports from Russia are costly for China precisely because of Russia's extreme sanctions intensity, so switching removes a cost burden on a meaningful share of China's import basket. The model thus rationalizes the observed 90% yuan share in Russia–China bilateral trade by late 2024 while simultaneously explaining the absence of broader local-currency adoption—a dual prediction that would be difficult to generate without the importer-side sanctions wedge and the full general equilibrium adjustment in the EK framework.

Fifth, coalition stability analysis reveals an important distinction between internal stability and exit-robustness. The full BRICS coalition becomes internally stable at $\gamma = 0.327$, but robustness to any single-member exit requires considerably higher sanctions ($\gamma \approx 0.840$). The coalition does not survive any two-member exit within the $\gamma \in [0, 1]$ range. This divergence has a direct policy implication: while a formed BRICS settlement

coalition would be self-sustaining against individual defection under moderate-to-high sanctions, coordinated exits by two or more members would unravel the coalition at all but the most extreme sanctions environments. Western policy responses that successfully reduce sanctions below threshold levels—or that create conditions under which large BRICS members find switching back to USD attractive—could in principle destabilize a formed coalition by triggering correlated exit.

The sensitivity analysis establishes robustness across the trade-balance closure (balanced trade versus fixed deficits yield nearly identical results) and across the switching-cost and network-cost parameter space (threshold levels vary smoothly and China–Russia remains the founding bilateral throughout). These exercises confirm that the qualitative conclusions are not artifacts of specific parameter choices but emerge from the structural features of the model: the combination of Russia's extreme sanctions exposure, China's dominant trade-scale position in BRICS, and the scale-dependent additional marginal cost function.

Overall, the analysis shows that de-dollarization of trade settlement under geoeconomic competition is governed by measurable thresholds that depend on the full general equilibrium response to sanctions and additional marginal costs, rather than on simple bilateral trade share comparisons. The threshold structure implies that moderate financial sanctions—on the order of 30% of the maximum observed intensity—are sufficient to make coordinated regime switching economically optimal for BRICS as a bloc. In trade-cost terms, these thresholds correspond to sanctions-induced trade reductions on the order of 20–25% under the dollar settlement regime, providing an economically interpretable benchmark for the level of coercion required to trigger regime switching. The model's quantitative predictions align closely with observed behavior, validating the framework as a useful tool for understanding how trade and currency arrangements evolve under intensifying strategic rivalry.

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Appendix

A. Value Functions and Forward-Looking Dynamics

Dynamic value functions incorporate expectations about future sanctions evolution and regime persistence, distinguishing the model's predictions from static welfare comparisons. Figure 19 shows the collective value functions under the fixed-deficits closure for comparison with the baseline:

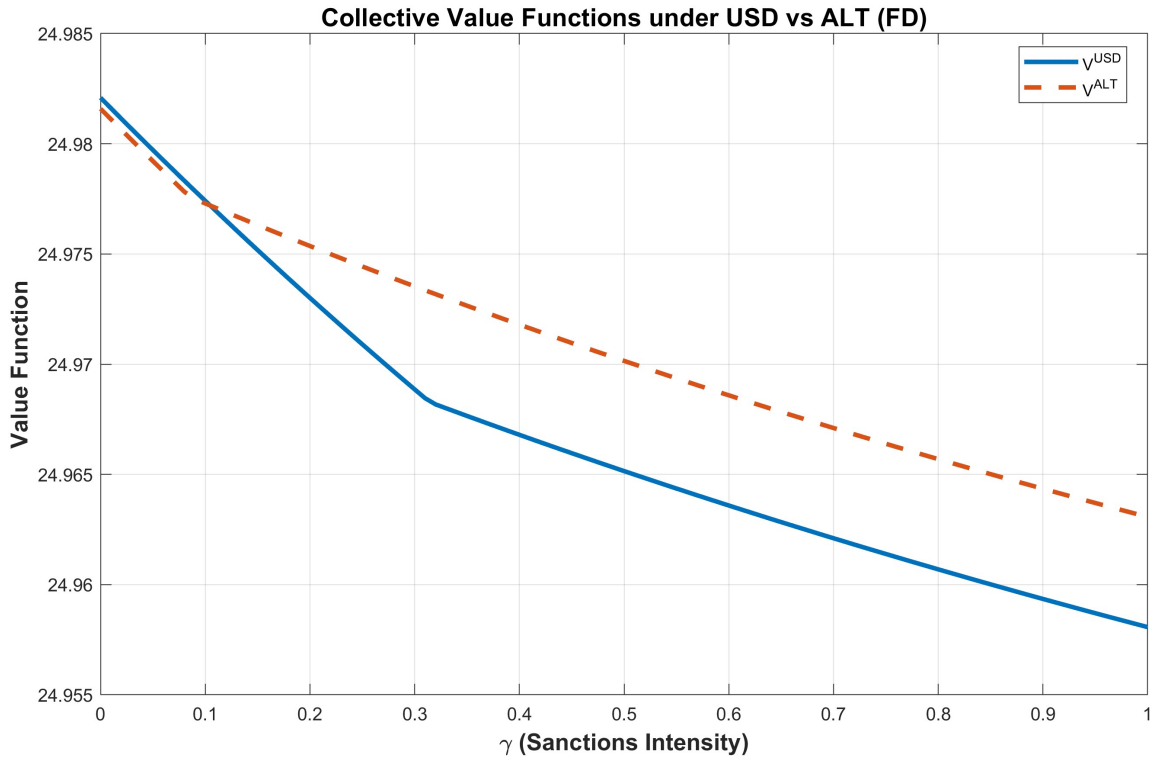


Figure 19: Collective value functions under USD and ALT (fixed-deficits closure). Qualitative structure mirrors the balanced-trade closure with minor threshold shifts.

Dollar values decline monotonically with slopes determined by the importer-side sanctions wedge through the general equilibrium price and wage adjustments. Alternative values are relatively flat at low sanctions intensities (additional marginal costs dominate) but grow slowly as the regime insulates an increasing share of intra-BRICS trade from the sanctions burden. The crossover point at the collective switching threshold reflects where declining Dollar values intersect the stable Alternative value. The dynamic value functions incorporate two forces absent from the static welfare comparison: the option

value of remaining in USD (given that future sanctions may revert to lower levels), which delays switching relative to the static crossing; and the switching-cost barrier, which shifts the threshold further rightward compared with the frictionless regime choice.

For each BRICS member i in coalition K, the individual value function is computed separately from the collective aggregate through the value iteration described in Section 3. Individual thresholds $\hat{\gamma}_i^K$ vary across coalition configurations because the ALT payoff depends on coalition scale (which determines $\mu(K)$) while the USD payoff is coalition-independent. This generates the pattern observed in Table 10 (below): larger coalitions reduce $\mu(K)$ and therefore lower each member's individual threshold, pulling all five individual thresholds downward as coalition size grows.

B. All-coalition Nash thresholds

Table 10 reports Nash thresholds for all 26 non-trivial BRICS subcoalitions (coalitions of size 2 through 5) under the balanced-trade closure, and Table 11 reports the corresponding values under fixed deficits. Together, these tables establish the full landscape of coalition feasibility and the systematic relationship between coalition size and threshold levels discussed in the main text.

Table 10: Nash thresholds for all non-trivial BRICS coalitions (balanced trade).

Coalition	Size	Nash threshold
BRA, ZAF	2	Infeasible
CHN, BRA	2	0.438
CHN, IND	2	0.408
CHN, RUS	2	**0.393**
CHN, ZAF	2	0.407
IND, BRA	2	Infeasible
IND, RUS	2	Infeasible

Continued on next page

Table 10: Nash thresholds for all BRICS coalitions (balanced trade).

Coalition	Size	Nash threshold
IND, ZAF	2	Infeasible
RUS, BRA	2	Infeasible
RUS, ZAF	2	Infeasible
CHN, BRA, ZAF	3	0.425
CHN, IND, BRA	3	0.383
CHN, IND, RUS	3	0.370
CHN, IND, ZAF	3	0.398
CHN, RUS, BRA	3	0.390
CHN, RUS, ZAF	3	0.388
IND, BRA, ZAF	3	0.995
IND, RUS, BRA	3	0.887
IND, RUS, ZAF	3	0.990
RUS, BRA, ZAF	3	0.897
CHN, IND, BRA, ZAF	4	0.370
CHN, IND, RUS, BRA	4	0.339
CHN, IND, RUS, ZAF	4	0.360
CHN, RUS, BRA, ZAF	4	0.379
IND, RUS, BRA, ZAF	4	0.834
CHN, IND, RUS, BRA, ZAF	5	**0.327**

Table 11: Nash thresholds for all non-trivial BRICS coalitions (fixed deficits).

Coalition	Size	Nash threshold
BRA, ZAF	2	Infeasible
CHN, BRA	2	0.438

Continued on next page

Table 11: Nash thresholds for all BRICS coalitions (fixed deficits).

Coalition	Size	Nash threshold
CHN, IND	2	0.399
CHN, RUS	2	**0.397**
CHN, ZAF	2	0.409
IND, BRA	2	Infeasible
IND, RUS	2	0.819
IND, ZAF	2	0.717
RUS, BRA	2	Infeasible
RUS, ZAF	2	Infeasible
CHN, BRA, ZAF	3	0.426
CHN, IND, BRA	3	0.385
CHN, IND, RUS	3	0.366
CHN, IND, ZAF	3	0.390
CHN, RUS, BRA	3	0.390
CHN, RUS, ZAF	3	0.390
IND, BRA, ZAF	3	0.969
IND, RUS, BRA	3	0.889
IND, RUS, ZAF	3	0.959
RUS, BRA, ZAF	3	0.969
CHN, IND, BRA, ZAF	4	0.370
CHN, IND, RUS, BRA	4	0.339
CHN, IND, RUS, ZAF	4	0.356
CHN, RUS, BRA, ZAF	4	0.379
IND, RUS, BRA, ZAF	4	0.836
CHN, IND, RUS, BRA, ZAF	5	**0.328**

C. Transfer feasibility series and stability indicators

Tables 12 and 13 report the full series of transfer feasibility and coalition stability indicators across the γ grid, providing the data underlying Figures 11 and 12 in the main text.

Table 12: Transfer feasibility for the full BRICS coalition across γ (balanced trade). TotalSurplus = aggregate gains; TotalDeficit = aggregate losses; NetSlack = TotalSurplus − TotalDeficit; Feasible = 1 when NetSlack ≥ 0.

γ	TotalSurplus	TotalDeficit	NetSlack	Feasible
0.00	0.000	0.007	–0.007	0
0.05	0.000	0.006	–0.006	0
0.10	0.000	0.005	–0.005	0
0.15	0.000	0.004	–0.004	0
0.20	0.000	0.003	–0.003	0
0.25	0.000	0.001	–0.001	0
0.30	0.000	0.000	–0.000	0
0.32	0.000	0.000	0.000	1
0.35	0.000	0.000	0.000	1
0.40	0.001	0.000	0.001	1
0.50	0.001	0.000	0.001	1
0.60	0.002	0.000	0.002	1
0.70	0.002	0.000	0.002	1
0.80	0.003	0.000	0.003	1
0.90	0.004	0.000	0.004	1
1.00	0.004	0.000	0.004	1

Table 13: Internal stability and exit-robustness indicators for the full BRICS coalition across γ (balanced trade). InternalStable_Full = 1 when full coalition is internally stable; Exit1_Survives = 1 when any single-member exit leaves remaining 4-member coalition stable; Exit2_Survives = 1 when any two-member exit leaves remaining 3-member coalition stable.

γ	InternalStable_Full	Exit1_Survives	Exit2_Survives
0.00	0	0	0
0.10	0	0	0
0.20	0	0	0
0.30	0	0	0
0.33	1	0	0
0.40	1	0	0
0.50	1	0	0
0.60	1	0	0
0.70	1	0	0
0.80	1	0	0
0.84	1	1	0
0.90	1	1	0
1.00	1	1	0

D. Vectorial Value Function Robustness

This appendix reports robustness results obtained from solving the dynamic programming problem using a vectorial representation of the value function.

In the baseline algorithm, the continuation value of the alternative regime is approximated using a scalar state variable summarizing coalition size. While this approach greatly reduces the dimensionality of the state space, it may potentially smooth over heterogeneity across coalition configurations.

To address this concern, I recompute the value function using the full vectorial state

representation. The Bellman equation is solved over the discrete coalition state space using value iteration. The sanction threshold Γ^* is then obtained by identifying the value of the sanction intensity at which the value of the alternative settlement regime equals that of the dollar regime along the coalition diagonal.

Table 14 reports the resulting diagonal thresholds for different coalition sizes.

Table 14: Sanctions Thresholds from Vectorial Value Function

Coalition Size	Γ^*
1	0.00
2	0.30
3	0.20
4	0.20
5	0.20