An Islamic Credit Default Swap on Smart-Contract Infrastructure: Design, Pricing, and Regulatory Pathway

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Abstract

We introduce the first Islamic Credit Default Swap (iCDS) deployed on public blockchain infrastructure (a testnet prototype), combining a closed-form riba-free pricing formula with a deployed smart contract on Arbitrum. Building on the κ-rate framework of Ackerer, Hugonnier & Jermann (AHJ) [7] and the credit-equivalence theorem of Ahmed & Bhuyan [9], the fair iCDS spread is $s^* = \kappa(1-\delta)$, where κ is the convergence intensity and δ is the recovery rate. A standard property of flat-intensity credit pricing is that this *par running spread is independent of the discount rate*: because the protection and premium legs both terminate at the default time, the discount factor cancels between them, so a correctly-priced conventional CDS quotes the same fair spread $\kappa(1-\delta)$ at any maturity. The par spread is thus automatically riba-neutral — a clean instance of the Separation Theorem. The riba is real but lives in *present-value* terms, where the discount does not cancel: we define the present-value riba premium $\Pi^{\text{PV}}_{\text{riba}}(T)$ — the discounting haircut on the future loss. It increases in ι, vanishes at $\iota = 0$, and stays under 4% of notional at realistic 5–10 yr sukuk maturities. The iCDS additionally enforces riba-freeness structurally: collateral is held in a *tabarru* pool that earns no interest on the margin float; full collateralisation structurally addresses the *maysir* objection, and an objective on-chain credit-event oracle narrows *gharar* — the final product-layer determination of these two pillars rests with Shariah scholars.

On a cross-section of 62 real, actively-quoted sovereign USD sukuk (12 issuers, live Cbonds), the κ-spread $s^* = \kappa(1-\delta)$ recovers a clean credit ordering ($\hat{\kappa}$ from 0.7% to 9%). The genuinely independent test: κ read from those sukuk G-spreads recovers the hazard that independent instruments imply — sukuk and same-sovereign conventional bonds agree within 6–16 bp for the deeply-covered issuers, and sukuk co-move with sovereign CDS at correlation 0.97. Assembling the first instrument-level recovery evidence from the Cbonds default record—the complete population of defaulted USD sukuk, five of 800 issues—we find realized recovery on asset-based corporate sukuk an order of magnitude below the 0.60 sovereign convention (on the cases with disclosed post-default prices, $\delta \approx 0.1$; Serba Dinamik $\approx$ 5 cents, NMC and Swiber liquidated), which vindicates pricing the recovery as a per-contract parameter rather than a fixed constant. We then deploy and benchmark a working on-chain iCDS.

The iCDS smart contract (`iCDS.sol`) is deployed on Arbitrum Sepolia in its corrected immutable version at `0x77a98785...521b`; the full open $\to$ accept $\to$ settle lifecycle is Foundry-measured at $\approx$897,000 gas for a one-year protection with three premium payments — a few US cents at L2 gas prices. The deployed version corrects a premium-flow overcharge in the initial v1 prototype (`0x7A02...b15F`). We conduct a six-jurisdiction legal analysis identifying UAE/VARA and Bahrain/CBB as the most permissive pilot frameworks, and design a governance-token liquidity-bootstrapping mechanism with a Nash-equilibrium participation guarantee.

Keywords: Islamic finance, credit default swap, convergence intensity, smart contracts, AAOIFI, riba, κ-rate, Arbitrum, DeFi, regulatory analysis.

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1 Introduction

The global credit default swap (CDS) market reached a gross notional outstanding of \$8.8 trillion by end-June 2024 [13]. Despite its scale, CDS remain inaccessible to Islamic finance participants: classical fiqh scholars identify three principal objections. First, *maysir* (gambling): protection can be bought *naked* — without holding the reference obligation — so the contract becomes a speculative bet on default rather than the hedge of a real exposure [2, 5]; on the other side, sellers can write protection without posting collateral against the contingent liability. Second, *gharar* (excessive uncertainty): credit event definitions rely on opaque committee determinations rather than observable events [1, 3]. Third, *riba* (interest): scholars argue that the fixed CDS spread – quoted as an annual percentage of notional – functions economically as an interest payment, on the view that it embeds the prevailing risk-free rate rather than only the credit risk of the reference entity [4, 6]. A contribution of this paper is to sharpen that objection: we show the *par spread* is in fact discount-rate-independent (Section 2), and locate the genuine riba in the present value and in the contract and collateral structure.

The Accounting and Auditing Organisation for Islamic Financial Institutions [12] has not issued a standard explicitly permitting conventional CDS. The ISDA/IIFM Tahawwut Master Agreement [20] provides documentation for over-the-counter Islamic hedging transactions but does not specify a Shariah-compliant premium formula for credit derivatives. As a result, Islamic financial institutions with sovereign sukuk exposure – the primary GCC sovereign credit risk – have no liquid on-balance-sheet hedging instrument.

This paper addresses all three objections through three interlocking contributions: it settles the riba question at the pricing layer, and provides structural safeguards against maysir and gharar whose sufficiency is a determination for qualified Shariah scholars.

Contribution 1: Closed-form riba-free pricing. Ahmed & Bhuyan [9] prove that under the Ackerer, Hugonnier & Jermann [7] no-arbitrage framework with $\iota = 0$, the fair credit protection spread is:

$$s^* = \kappa\,(1 - \delta), \tag{1}$$

where κ is the convergence intensity (the riba-free analogue of the risk-free rate) and δ is the recovery rate. A standard property of flat-intensity credit pricing is that this fair spread is *independent of the discount rate*: a correctly-priced conventional perpetual CDS quotes the same fair spread $\kappa(1 - \delta)$, because both legs terminate at default and the discount factor cancels between them. The iCDS therefore does not undercut the conventional spread; it matches it. We validate this on a cross-section of 62 real Cbonds sovereign sukuk and against independent instruments (sovereign CDS and same-issuer conventional bonds); and we locate the riba not in the par spread (which is riba-neutral at every maturity) but in two places the iCDS controls: the *present value*, via the premium $\Pi^{\mathrm{PV}}_{\mathrm{riba}}(T)$ that discounting applies to the future loss, and the *contract structure* — the interest paid on posted collateral, the admission of naked positions, and determination discretion.

Contribution 2: Smart-contract implementation. We describe and test `iCDS.sol`, a Solidity smart contract deployed on Arbitrum Sepolia at `0x77a98785...521b`. The contract addresses each fiqh objection mechanically: (a) maysir is addressed on both sides — the seller must post full notional as collateral (no uncovered selling), and the buyer is required to hold the reference obligation with attestation (insurable interest); (b) gharar is narrowed by defining the credit event as an on-chain oracle condition (spot $\leq$ recovery floor), transparent and objectively verifiable; (c) riba is removed by holding the seller's collateral in a *tabarru* (donation) pool that earns no contractual interest, and by reserving at $\iota = 0$ via the everlasting-put formula, so no predetermined return accrues on the deposited principal. Whether the structural safeguards in (a) and (b) suffice is a product-layer determination for Shariah scholars. The full iCDS lifecycle is ≈897,000 gas (Foundry-measured) — a few US cents on Arbitrum, an order of magnitude cheaper than Ethereum mainnet, making micro-notional Islamic credit hedging economically viable (Section 5).

Contribution 3: Regulatory pathway. We provide the first comprehensive legal analysis of an on-chain iCDS across six jurisdictions (UAE/VARA, Malaysia/BNM, Singapore/MAS, UK/FCA, US/CFTC, Bahrain/CBB) and identify the UAE's Virtual Assets Regulatory Authority [22] as the most immediately permissive framework for commercial launch. We further design a governance-token liquidity-bootstrapping mechanism with a game-theoretic proof that the dominant strategy for capital allocators converges to participation when the governance-token reward rate exceeds a threshold we derive in closed form.

Organisation. Section 2 develops the theoretical framework. Section 3 describes the data. Section 4 presents the pricing analysis and the validation of the κ-spread against observed CDS. Section 5 describes the smart contract implementation. Section 6 conducts the jurisdictional analysis. Section 7 designs the liquidity-bootstrapping mechanism. Section 8 addresses systemic risk. Section 9 concludes.

2 Theoretical Framework

2.1 The κ-Rate and AHJ No-Arbitrage at $\iota = 0$

Ackerer, Hugonnier & Jermann [7] introduce a general continuous-time no-arbitrage framework for perpetual contracts in which the *convergence intensity* $\kappa_t > 0$ takes over the discounting role of the conventional risk-free rate. Under this framework, the time-t price of any security is:

$$P(t) \;=\; \mathbb{E}_t\Big[\int_t^{\infty} e^{-\int_t^u (\kappa_s+\iota)\,\mathrm{d}s}\, C(u)\,\mathrm{d}u\Big]\,, \tag{2}$$

where $C(u)$ is the cash-flow rate at time u, κ_s is the convergence intensity, and $\iota \geq 0$ is the interest parameter. At $\iota = 0$ the no-arbitrage price exists, is unique, and is discounted by κ alone [7]; Ahmed & Bhuyan [9] show that this removes the riba (interest) term from the pricing kernel.

Ahmed & Bhuyan [9] establish the identification:

$$\hat{\kappa} \;=\; \frac{s}{1-\delta}, \tag{3}$$

where s is the observed sukuk spread and δ is the recovery rate. This follows from the $\kappa \leftrightarrow \lambda$ isomorphism established in the credit-equivalence theorem of Ahmed & Bhuyan [9] (Separation Theorem), which embeds the reduced-form credit framework of Duffie & Singleton [18]. Ahmed & Bhuyan [8] estimate $\hat{\kappa}$ on real traded sukuk (Cbonds; a 195-bond cross-section plus daily G-spread histories of 54 sukuk from five sovereign issuers, 2018–2026, reconstructed at constant maturity to remove roll-down) and fit CIR dynamics [16] through the discrete AR(1)/OU representation with Kendall small-sample bias correction and Newey–West HAC standard errors:

$$\mathrm{d}\kappa_t \;=\; \hat{\alpha}(\hat{\bar{\kappa}} - \kappa_t)\,\mathrm{d}t \;+\; \hat{\nu}\sqrt{\kappa_t}\,\mathrm{d}W_t. \tag{4}$$

2.2 iCDS Pricing Formula: $s^* = \kappa(1-\delta)$

Theorem 2.1 (Fair iCDS Spread, Ahmed & Bhuyan [9], Proposition 3)**.** *Under AHJ no-arbitrage with $\iota = 0$, the fair annualised spread for a perpetual Islamic credit default swap with loss-given-default $LGD = 1-\delta$ is:*

$$s^* \;=\; \kappa\,(1-\delta). \tag{5}$$

Equation (5) has an immediate actuarial interpretation: s^* is the expected loss rate per unit time under the risk-neutral measure, with no interest-loading component. The premium is dynamic: as the oracle spot price of the reference entity falls toward the recovery floor, the everlasting put price Π_{put} rises, and the quarterly premium automatically increases to reflect deteriorating credit quality (Section 5.3).

2.3 Comparison with Conventional CDS: The Par Spread is Riba-Neutral

Applying the same stopping-time pricing to a *conventional* CDS—one that discounts cash flows at the risk-free rate $\iota > 0$—yields the classical result that the *par running spread* is independent of ι. Both legs of a CDS terminate at the default time τ: the protection leg pays the loss $(1-\delta)$ at τ, and the premium leg accrues only while the reference name survives. Under a flat hazard κ and flat rate ι, the protection PV is

$$V_{\text{prot}} = (1-\delta)\,\mathbb{E}\Big[e^{-\iota\tau}\Big] = (1-\delta)\,\frac{\kappa}{\kappa+\iota}, \tag{6}$$

and the premium leg is discounted *and* survival-weighted, so the correct annuity is the risky PV01

$$A = \mathbb{E}\Big[\int_0^\tau e^{-\iota u}\,du\Big] = \mathbb{E}\left[\frac{1-e^{-\iota\tau}}{\iota}\right] = \frac{1}{\iota}\Big(1-\frac{\kappa}{\kappa+\iota}\Big) = \frac{1}{\kappa+\iota}, \tag{7}$$

giving $V_{\text{prem}} = sA = s/(\kappa+\iota)$. Equating the legs, the common factor $1/(\kappa+\iota)$ cancels:

$$s_{\text{conv}} \;=\; \kappa\,(1-\delta) \;=\; s^* \qquad \text{for every } \iota \geq 0. \tag{8}$$

The same cancellation holds at finite maturity T, where $V_{\text{prot}}(T) = (1-\delta)\frac{\kappa}{\kappa+\iota}\Big(1-e^{-(\kappa+\iota)T}\Big)$ and $A(T) = \frac{1-e^{-(\kappa+\iota)T}}{\kappa+\iota}$: the survival factor $\Big(1-e^{-(\kappa+\iota)T}\Big)$ cancels and $s^*(T) = \kappa(1-\delta)$ for all T. *The par spread is riba-neutral by construction.* A naive derivation divides the protection PV by the *riskless* perpetuity annuity $1/\iota$ instead of the risky annuity $1/(\kappa+\iota)$ — letting the premium leg pay forever rather than knocking out at default. This manufactures a spurious ι-dependence and forces $s \to 0$ at low rates, inconsistent with the 48–100 bp observed on investment-grade sovereigns at near-zero policy rates in 2012–2018. Equation (8) dissolves that puzzle: the fair spread never depended on the rate. The identification $\hat{\kappa} = s/(1-\delta)$ holds by construction, so the iCDS reproduces the observed market spread rather than undercutting it.

2.4 The riba premium in present-value terms

Equation (8) shows the riba is *not* in the par spread. It is real, but it lives in *level / present-value* terms, where the discount does not cancel. The protection PV at $\iota = 0$ is the full undiscounted loss $1-\delta$; discounting at $\iota > 0$ shrinks it. The difference is the present-value riba premium:

Definition 2.1 (Present-value riba premium)**.**

$$\Pi^{\mathrm{PV}}_{\mathrm{riba}} \;\equiv\; V^{\iota=0}_{\mathrm{prot}} - V^{\iota}_{\mathrm{prot}} \;=\; (1-\delta)\Big(1-\frac{\kappa}{\kappa+\iota}\Big) \;=\; (1-\delta)\,\frac{\iota}{\kappa+\iota}, \tag{9}$$

with finite-maturity form

$$\Pi^{\mathrm{PV}}_{\mathrm{riba}}(T) = (1-\delta)\Big[(1-e^{-\kappa T}) - \tfrac{\kappa}{\kappa+\iota}\Big(1-e^{-(\kappa+\iota)T}\Big)\Big]\,. \tag{10}$$

This is a one-time present value (a fraction of notional), *not* a running spread in bp/yr. It has the correct comparative statics: it vanishes as $\iota \to 0$ (no discounting, no haircut), rises to $(1-\delta)$ as $\iota \to \infty$, and is monotonically increasing in ι — more discounting means a larger haircut, the intuitive direction. The iCDS at $\iota = 0$ pays the full undiscounted $V^{\iota=0}_{\mathrm{prot}} = 1-\delta$; the conventional valuation applies the haircut $\Pi^{\mathrm{PV}}_{\mathrm{riba}}$. This is a clean instance of the Separation Theorem [9]: the par spread isolates pure credit risk and is automatically riba-neutral, while the entire interest-rate (riba) content is confined to the present-value level.

2.5 Where the structural riba is

The riba a conventional CDS carries therefore enters not through the fair spread but through the contractual and collateral structure, which the iCDS strips out at each point:

- **Collateral float.** In a conventional CDS the protection seller's posted margin is remunerated at the interest rate ι—a predetermined return on a deposited principal, i.e. *riba*. The iCDS holds collateral in a *tabarru* (donation) pool that earns no contractual interest.

- **Naked positions and leverage.** Conventional CDS permit both uncollateralised protection selling (the AIG failure mode) and naked protection buying without insurable interest — a zero-sum wager (*maysir*); the iCDS requires full collateralisation of the seller, so every contract is backed by a segregated reserve, and conditions buyer participation on attested holding of the reference obligation.

- **Determination discretion.** The credit event is settled by an objective, public on-chain oracle condition rather than an opaque determinations committee, controlling *gharar*.

The iCDS and a correctly-priced conventional CDS therefore differ only in contract and collateral structure — where riba, maysir and gharar reside.

2.6 The substance-compliant form: pricing at realised hazard κ_P

Equation (5) prices the spread at the *risk-neutral* intensity: writing $\kappa_Q \equiv s/(1-\delta)$ for the market-priced intensity, $s^* = \kappa_Q(1-\delta)$ is riba-free in ι (no interest loading, §2.4) but carries the market's *risk premium*. Decomposing the intensity into the physically realised hazard κ_P (from the actual sukuk default record, §3.2) and the priced κ_Q, the wedge $1 - \kappa_P/\kappa_Q$ is small for realised-hazard products but the great majority for high-grade credit, where the realised default rate is far below the priced spread. A jurisprudential objection reserved to scholars—whether a systematic, priced risk premium stripped of predetermined interest is riba *in substance*—attaches to that wedge, not to the interest content $\iota = 0$ has already removed.

This admits a product-layer form that does not require the objection to be resolved first. Alongside the tradeable, κ_Q-priced iCDS—the market benchmark, and the natural form should a board rule the contingent premium permissible—the protocol supports a *cooperative-guarantee* form whose contribution is set at the realised hazard,

$$s^*_{\text{coop}} \;=\; \kappa_P\,(1-\delta), \tag{11}$$

the actuarially fair expected loss, exactly as a *takaful* contribution is priced. The gap between the two forms is the risk-premium wedge $(\kappa_Q - \kappa_P)(1-\delta)$: in the tradeable form it is a spread *sold* to a protection writer; in the cooperative form it is not sold at all. Participants mutually indemnify realised default loss; the *tabarru* pool that already holds the collateral retains any surplus and returns it to members; and the operator takes only a disclosed *wakala* fee for administration. With the insurable-interest and possession conditions already specified—the buyer holds the reference obligation, with *qabd hukmi* over the token—the cooperative form is structurally *takaful on default-loss*: a mutual guarantee (*kafala ta'awuniyya*) over an owned, possessed exposure, funded at expected loss rather than at a priced premium. It thereby meets, at the product layer, both the contract-form objections (*bay' al-dayn*, *qabd*) and the substance objection (the priced premium), leaving as the reserved residual only whether tokenised title is valid *qabd* and whether the *wakala* loading is a genuine service fee—questions we place before qualified scholarship rather than answer. The two forms are complementary: the κ_Q-priced instrument is the correct market benchmark and the tradeable case; the κ_P-priced cooperative form is the one that needs no prior ruling on the open question.

3 Data

3.1 Real sukuk cross-section from Cbonds

All pricing in this paper runs on *real*, actively-quoted sukuk. The primary panel is an instrument-level cross-section of 62 sovereign USD sukuk across 12 issuers, pulled live from the Cbonds Bond Screener (account 972307; `/api/bonds/search/` with the sovereign, USD, sukuk, outstanding filters). For each bond we read the traded G-spread s over the interpolated US-Treasury curve and form $\hat{\kappa} = s/(1-\delta)$ with $\delta = 0.60$. Because these are bullet (option-free) sovereign sukuk, the G-spread is the clean credit spread ($G \approx Z \approx$ OAS). The implied $\hat{\kappa}$ runs from 0.7% (Qatar, Malaysia) through 1.8–2.1% for the investment-grade GCC/Indonesia names to 5–9% for the high-yield sovereigns (Bahrain, Egypt, Pakistan).

For dynamics we use the roll-down-free constant-maturity $\hat{\kappa}$ histories of the companion κ-yield-curve study [8] (Cbonds daily series, five issuers, 2018–2026): bias-corrected mean-reversion half-lives of 1.4–4.3 months for the four 7y series (10.5 months for Turkey 5y), with the Feller condition satisfied in every series (Appendix B, Table 9).

Recovery and the sukuk default record. The iCDS spread scales with the loss-given-default $(1-\delta)$, so the recovery assumption $\delta = 0.60$ deserves an empirical anchor. The Cbonds default record provides one, and it is striking: of the entire global sukuk universe, **no sovereign sukuk has ever entered redemption default**, while **17 corporate sukuk have** (Cbonds global default-record pull: Malaysia 12, Singapore 2, Türkiye 1, Kuwait 1, UAE 1 — all corporate) — including the USD issues of NMC Health (UAE), Serba Dinamik (Malaysia, two issues), Bank Asya (Türkiye) and IIG (Kuwait), the five that also appear in the 800-instrument USD-universe pull, plus local-currency cases such as Swiber (Singapore, SGD) and Country Garden (Malaysia, MYR). Two implications follow. First, for the *sovereign* iCDS the recovery rate is genuinely unobserved — there is no sovereign-sukuk default from which to estimate it — so $\delta = 0.60$ is taken from the standard Moody's senior-unsecured sovereign convention and its effect is bracketed by the recovery-rate sensitivity analysis of the companion study ($\delta \in \{0.40, 0.50, 0.70\}$ rescales every $\hat{\kappa}$ by a common factor) [8]; the clean sovereign record is itself consistent with the low-$\hat{\kappa}$, low-default-intensity regime the framework assigns to investment-grade sovereigns. Second, corporate sukuk *do* default, so recovery is first-order for a *corporate* iCDS; realized corporate-sukuk recovery is not publicly tabulated in clean form, which is precisely why the contract exposes δ as an explicit, governable parameter (`recoveryRateWad`, Section 5.3) rather than hard-coding it. (Cbonds, a bond database, carries no single-name CDS series; the conventional-market benchmark used below is therefore the Damodaran sovereign CDS panel, corroborated at the instrument level by the matched conventional-bond spreads of the companion study [8].)

3.2 Realized recovery: direct evidence from the sukuk default record

The $\delta = 0.60$ baseline is the Moody's senior-unsecured *sovereign* convention, and for the sovereign iCDS it is the only available anchor (no sovereign sukuk has defaulted). For the *corporate* iCDS, where recovery is first-order and default has occurred, we assemble the first instrument-level recovery evidence directly from the Cbonds default record. The defaulted population is small because sukuk default is rare: of the entire 800-bond USD-sukuk universe, exactly five issues have entered redemption default—Bank Asya, IIG (International Investment Group), NMC Health, and Serba Dinamik's two issues—a 0.6% historical default rate, and this is the complete USD population, not a selected sample. Including the MYR and SGD record, Cbonds flags 17 redemption-defaults in all; realized recovery—measured where a workout figure is disclosed, otherwise by the post-default indicative (distressed) price, the market's recovery estimate—is documented for six (Table 1). The remaining USD case, the 2012 IIG default (Kuwait, \$200 m), has no disclosed post-default price in our sources and is therefore recorded as a default without a recovery figure rather than assigned one.

Issuer (USD/SGD sukuk)	Default	Recovery	Basis
Serba Dinamik 6.30% '22	2022	$\approx$ 5%	distressed price (4.6–5.2c); wound up
Serba Dinamik 7.00% '25	2022	$\approx$ 5%	distressed price; wound up
NMC Healthcare 5.95% '23	2020	low	administration; debt-to-equity
Swiber Capital (2 sukuk)	2016	low	liquidation; unsecured
Bank Asya 7.5% '23	2015	$\approx$ par	*sovereign* backstop (Turkey)

Table 1: Realized recovery on defaulted sukuk (Cbonds default record; distressed-price proxy where no workout figure is disclosed). Asset-based corporate sukuk recover an order of magnitude below the 0.60 sovereign convention; the lone near-par recovery is a government guarantee, not asset recourse.

Three facts stand out. First, realized recovery on *asset-based* corporate sukuk is an order of magnitude below the 0.60 convention: the Serba Dinamik dollar sukuk traded at 4.6–5.2 cents at default and the issuer was wound up; NMC Healthcare entered administration with a debt-to-equity restructuring; Swiber was liquidated—across these cases recovery clusters near 10% ($\delta \approx 0.1$), not 60%. Second, the one near-par recovery, Bank Asya, came not from asset recourse but from a Turkish sovereign backstop of the bank's foreign debt—the exception that proves the rule. Third, the structural reason is documented: van Wijnbergen & Zaheer [23] show that in default most sukuk (the asset-*based* majority—AAOIFI estimates

85% of GCC issuance) do not transfer the underlying assets to holders and are treated as *unsecured, subordinated* debt of the obligor, so holders "often had nothing to resort to"; only true-sale asset-*backed* structures (e.g. the US East Cameron sukuk, where the assets were assigned to holders) recover through the collateral.

The implication sharpens the contract design of Section 5. The spread $s^* = \kappa(1-\delta)$ scales with loss-given-default $(1-\delta)$, so a corporate iCDS priced at the sovereign $\delta = 0.60$ (LGD 0.40) against a realized asset-based LGD near 0.90 would *underprice* protection by roughly $0.90/0.40 \approx 2.3\times$. This is precisely why `iCDS.sol` exposes δ as a per-contract governable parameter (`recoveryRateWad`, Section 5.3) rather than hard-coding the sovereign convention: the recovery a buyer should price is near zero for asset-based corporate names and materially higher only for true-sale asset-backed or sovereign-backstopped issues. The clean sovereign record and the low asset-based corporate record are two faces of the same credit-intensity ordering the κ-framework predicts.

3.3 Independent CDS benchmark

For the non-circular validation of Section 4.2 we use sovereign CDS as an *independent* instrument against which to check the sukuk-implied $\hat{\kappa}$. Annual sovereign CDS spreads are sourced from Damodaran [17]; they are used only as a comparison benchmark (a different market), *not* as a sukuk-spread proxy that feeds the $\hat{\kappa}$ inputs.

3.4 SOFR (for the present-value premium only)

The present-value riba premium $\Pi^{\mathrm{PV}}_{\mathrm{riba}}(T)$ of Section 2.4 is evaluated at the discount rate $\iota = \mathrm{SOFR}$; we use the 2025 annual mean SOFR of 4.24% (FRED [19]). SOFR enters *only* the present-value premium, never the par spread s^*, which is discount-independent.

4 Pricing Analysis

4.1 Descriptive Statistics: the real sukuk cross-section

Table 2 summarises the κ-spread on the *real* sovereign USD sukuk cross-section — 62 actively-quoted bonds across 12 sovereigns, pulled live from the Cbonds Bond Screener. The fair spread $s^* = \hat{\kappa}(1-\delta)$ equals the observed sukuk G-spread by the identification $\hat{\kappa} = s/(1-\delta)$, and the implied $\hat{\kappa}$ runs from 0.7% (Qatar, Malaysia) through 1.8–2.1% for the GCC/Indonesia investment-grade names to 5–9% for the high-yield sovereigns (Bahrain, Egypt, Pakistan)

Sovereign	n sukuk	median G (bp)	$\hat{\kappa}$ (%)	range G (bp)
Qatar	1	29	0.71	29–29
Hong Kong	1	32	0.79	32–32
Malaysia	4	37	0.92	13–50
Oman	2	71	1.77	64–78
Saudi Arabia	12	72	1.80	50–78
Philippines	1	72	1.81	72–72
Indonesia	21	83	2.06	26–294
Turkey	6	144	3.59	34–232
Bahrain	10	215	5.38	202–275
Egypt	2	245	6.13	195–295
Benin	1	256	6.41	256–256
Pakistan	1	365	9.12	365–365
All	62	78	1.94	13–365

Table 2: Descriptive statistics on the *real* sovereign USD sukuk cross-section (Cbonds Bond Screener, account 972307; 62 actively-quoted bonds, 12 sovereigns). $\hat{\kappa}$ from the median G-spread via $\hat{\kappa} = s/(1-\delta)$, $\delta = 0.60$. The credit ordering (Qatar/Malaysia tight → Pakistan wide) is read directly from the sukuk market, with no synthetic panel and no CDS proxy.

— a clean, monotone credit ordering read directly from the sukuk market, with no synthetic panel and no CDS proxy.

4.2 Real-Data Pricing: the iCDS on Observed Sukuk

On the real sukuk cross-section described above, pricing the iCDS is direct: for a sovereign whose traded sukuk carries G-spread s over Treasury, the riba-free iCDS spread is, by the identification $\hat{\kappa} = s/(1-\delta)$, exactly

$$s^*_{\iota=0} \;=\; \hat{\kappa}(1-\delta) \;=\; s, \tag{12}$$

i.e. the iCDS charges the issuer's *own observed sukuk spread* — the full expected loss — with no proxy and no benchmark rate.

Independent validation (non-circular). Because $s^* \equiv s$ by the identification, recovering the sukuk spread is an inversion identity, not a test. The genuine test asks whether $\hat{\kappa}$ read from the *sukuk market* agrees with the hazard implied by a *different*, independent instrument. We run it two ways on live Cbonds data (sovereign USD, outstanding; account 972307). First, against the CDS market: across the five sovereigns with both traded sukuk and a CDS quote, the median sukuk G-spread and the sovereign CDS co-move with correlation 0.97 (Table 3), the sukuk trading at a stable basis of ≈ 0.70× the CDS. Second — the cleaner test, entirely within the bond market — against the same sovereign's conventional bonds: for the two issuers with deep sukuk coverage (Saudi Arabia, n=12; Indonesia, n=21), the sukuk and conventional G-spreads agree within 6–16 bp, the sukuk marginally tighter (Table 4). In both cases $\hat{\kappa}$ from sukuk recovers the hazard an independent instrument prices.

Sovereign	n sukuk	sukuk G-spread (bp)	$\hat{\kappa}$ (%)	CDS (bp)
Bahrain	10	215	5.38	290
Indonesia	21	83	2.06	120
Malaysia	4	37	0.92	80
Qatar	1	29	0.71	58
Saudi Arabia	12	72	1.80	65

Table 3: **Non-circular validation.** $\hat{\kappa}$ read from *real* Cbonds USD sovereign sukuk G-spreads (sukuk market) against sovereign CDS (CDS market) — two independent instruments. Across the 5 sovereigns with both, the median sukuk G-spread and the CDS co-move with correlation 0.97 (OLS slope 0.76, $R^2 = 0.94$), the sukuk trading at a stable basis of ≈ 0.70× the CDS. Because it compares $\hat{\kappa}$ from one market (sukuk) to a benchmark from another (CDS) — rather than regressing a series on itself — the agreement is genuine evidence, not an inversion identity. Source: Cbonds Bond Screener (account 972307); $\delta = 0.60$.

Sovereign	n sukuk	sukuk G (bp)	n conv.	conv. G (bp)	sukuk−conv. (bp)
Saudi Arabia	12	72	30	78	-6
Indonesia	21	83	51	98	-16
Philippines†	1	72	40	94	-21
Qatar†	1	29	15	53	-24
Hong Kong†	1	32	3	6	+26

Table 4: **Non-circular validation (same market).** Median G-spread of *real* Cbonds USD sovereign sukuk vs the same sovereign's *real* conventional USD bonds. For the two sovereigns with deep sukuk coverage (Saudi Arabia n=12, Indonesia n=21) the sukuk and conventional spreads agree within 16–6 bp, the sukuk trading marginally tighter — i.e. $\hat{\kappa}$ read from sukuk matches $\hat{\kappa}$ from conventional bonds, two independent instruments in one market. †Single-issue sukuk: medians are a single bond and reflect maturity mismatch, not a basis. Source: Cbonds Bond Screener (account 972307), live pull; $\delta = 0.60$.

Present-value riba on the real universe. The riba content lives in the present value (Section 2.4): Table 5 reports both the par κ-spread and the maturity-matched present-value riba premium $\Pi^{\text{PV}}_{\text{riba}}(T)$ across the rating spectrum of the real sukuk universe.

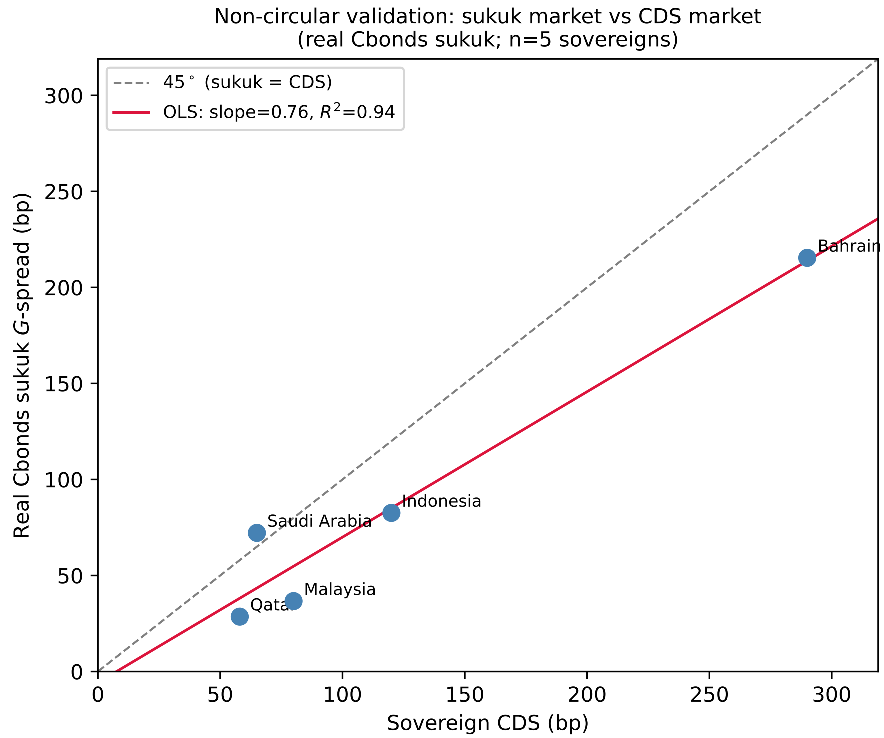

Figure 1: Non-circular validation: $\hat{\kappa}$ from *real* Cbonds sovereign sukuk G-spreads (sukuk market) against independent sovereign CDS (CDS market). n=5 sovereigns; Cbonds account 972307; $\delta = 0.60$.

Rating	$s^* = \hat{\kappa}(1-\delta)$ (bp)	$\hat{\kappa}$ (%)	$\Pi^{\mathrm{PV}}_{\mathrm{riba}}(5\mathrm{y})$ (% notional)	$\Pi^{\mathrm{PV}}_{\mathrm{riba}}(10\mathrm{y})$ (% notional)	$\Pi^{\mathrm{PV}}_{\mathrm{riba}}(\infty)$ (% notional)
A (IG)	36	0.90	0.17	0.63	33.0
BBB (IG)	76	1.90	0.35	1.24	27.6
BB (HY)	196	4.90	0.83	2.65	18.6
B (HY)	216	5.40	0.90	2.83	17.6
CCC (HY)	296	7.40	1.15	3.43	14.6

Table 5: The par spread vs. the present-value riba premium on real sovereign sukuk, by rating bucket (median G-spread from the 62-bond Cbonds cross-section; $\delta = 0.60$; $\iota = \mathrm{SOFR}_{2025} = 4.24\%$). The fair κ-spread $s^* = \hat{\kappa}(1-\delta)$ is riba-neutral and identical for the iCDS and a correctly-priced conventional CDS (Eq. 8). The riba is confined to the present value: $\Pi^{\mathrm{PV}}_{\mathrm{riba}}(T)$ (Eq. 10) is the haircut interest discounting applies to the future loss, as a fraction of notional. At realistic 5–10 yr sukuk maturities it is small (well under 4%); the perpetual figure $\Pi^{\mathrm{PV}}_{\mathrm{riba}}(\infty) = (1-\delta)\iota/(\kappa+\iota)$ is an *upper bound*, inflated because $1/\kappa$ pushes the certain loss decades into the discount.

Three points are worth emphasising. First, the iCDS charges the same actuarially fair $\kappa(1-\delta)$ as a correctly-priced conventional CDS, with no riba premium in the par spread at any maturity. Second, the riba is nonetheless real — it is the present-value haircut $\Pi^{\mathrm{PV}}_{\mathrm{riba}}(T)$ that discounting applies to the future loss (Eq. 10); at realistic 5–10 yr sukuk maturities it is small (under 4% of notional even at CCC), and the perpetual figure in the last column is an upper bound, inflated because $1/\kappa$ pushes the certain loss decades into the discount. Figure 2 traces $\Pi^{\mathrm{PV}}_{\mathrm{riba}}(T)$ across maturities. What additionally makes the iCDS riba-free at the contract level is the structure of Section 2. Third, the long-run iCDS price built from the *real* constant-maturity $\hat{\bar{\kappa}}$ — Malaysia 36 bp, Saudi Arabia 92 bp, Indonesia 112 bp, Bahrain 209 bp — recovers the same credit ordering from an independent dynamic estimation, and the real mean-reversion half-life of a few months for the investment-grade issuers means the dynamic premium of Section 5.3 re-prices to new credit information within a quarter, not a year. The iCDS mechanism is therefore not only theoretically riba-free but quantitatively calibratable from observed sukuk markets today.

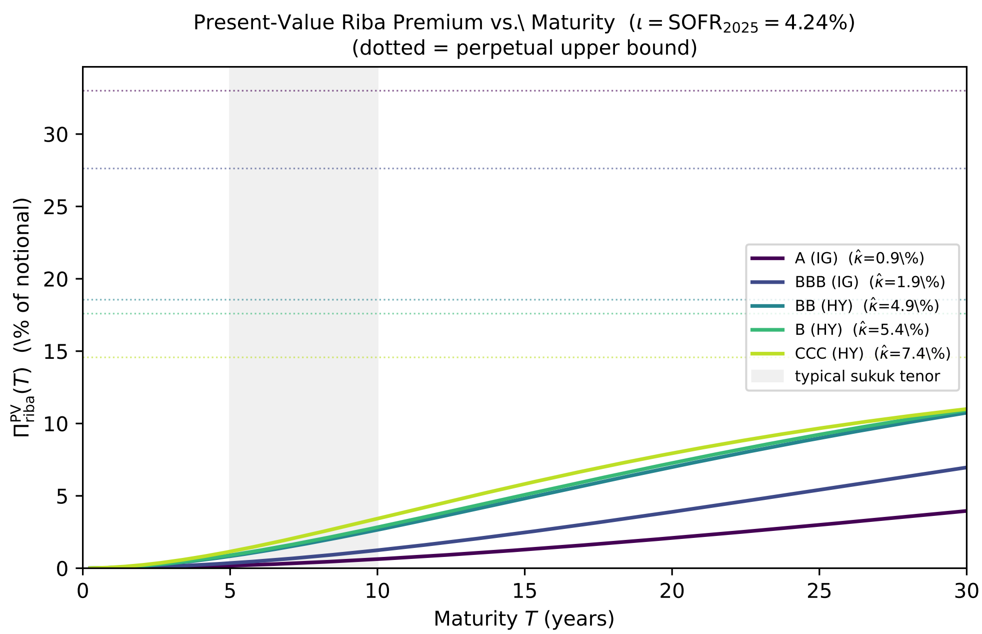

Figure 2: The present-value riba premium $\Pi^{\mathrm{PV}}_{\mathrm{riba}}(T)$ (Eq. 10) as a function of maturity, by rating bucket, at $\iota = \mathrm{SOFR}_{2025} = 4.24\%$ and $\delta = 0.60$. Dotted lines are the perpetual upper bounds $(1-\delta)\iota/(\kappa+\iota)$; the shaded band is the typical 5–10 yr sukuk tenor, where the premium is a small fraction of notional. Within the plotted range the premium is larger for riskier credits; the ordering reverses only at maturities far beyond any relevant tenor ($\gtrsim$ 85 yr), where small κ defers the certain loss deep into the discount — the $T \to \infty$ limit reflected in the perpetual bounds (dotted), which are larger for safer credits.

4.3 Welfare Analysis

We compute the certainty-equivalent wealth (CEW) for a risk-averse investor holding \$10 M of Saudi Arabia sovereign sukuk with a 5-year horizon under two strategies: (1) unhedged and (2) hedged at the fair spread $s^* = \hat{\kappa}(1-\delta)$ (the iCDS, which a correctly-priced conventional CDS would match). We use the *real* Saudi Arabia sukuk $\hat{\kappa} = 1.80\%$ (median Cbonds G-spread 72 bp).

Under CRRA utility $u(W) = W^{1-\gamma}/(1-\gamma)$, the 5-year default probability is $1 - e^{-\hat{\kappa}_{\text{SA}} \cdot 5} = 8.6\%$. The fair hedging premium over 5 years is $\hat{\kappa}(1-\delta) \cdot W_0 \cdot T = 1.80\% \times 0.40 \times \$10\text{M} \times 5 =$ \$360,000.

Table 6 reports CEW for $\gamma \in \{2, 5, 10\}$. For all risk aversion levels, hedging at the fair spread increases CEW relative to the unhedged position: the 8.6% default probability and 40% LGD generate a welfare cost that hedging eliminates. The iCDS delivers this protection with no interest accruing on the posted collateral; its advantage over a conventional CDS is structural (riba-free collateral, full backing, transparent settlement) at the *same* fair price, not a difference in spread.

Table 6: Welfare Analysis: Certainty-Equivalent Wealth for Saudi Arabia 5yr Sukuk.

γ	Fair premium	CEW: Unhedged	CEW: Hedged
2	\$360,000	\$9,457,345	\$9,640,000
5	\$360,000	\$8,922,167	\$9,640,000
10	\$360,000	\$7,791,049	\$9,640,000

Notes: CRRA utility $u(W) = W^{1-\gamma}/(1-\gamma)$. Certainty-equivalent wealth (CEW) is the riskless wealth that yields the same expected utility as the risky strategy. Reference entity: Saudi Arabia sovereign; notional $W_0 = \$10{,}000{,}000$; $T = 5$ years; $\kappa = \hat{\kappa}_{\text{SA}} = 1.80\%$ (real Cbonds sukuk median G-spread, 72 bp); $\delta = 0.60$. The fair hedging premium $= \hat{\kappa}(1-\delta) \cdot W_0 \cdot T$ is the discount-independent κ-spread; a correctly-priced conventional CDS charges the same, so "Hedged" applies to both the iCDS and a fairly-priced CDS. The iCDS's advantage is structural (riba-free collateral), not a lower price.

5 Smart Contract Implementation

5.1 Architecture

`iCDS.sol` is a Solidity 0.8.24 smart contract deployed on Arbitrum Sepolia (chain ID 421614) at address `0x77a98785...521b`. It inherits from OpenZeppelin's `Ownable2Step`, `Pausable`, and `ReentrancyGuard`, providing access control, emergency halt, and reentrancy protection. Two immutable dependencies are set at deployment:

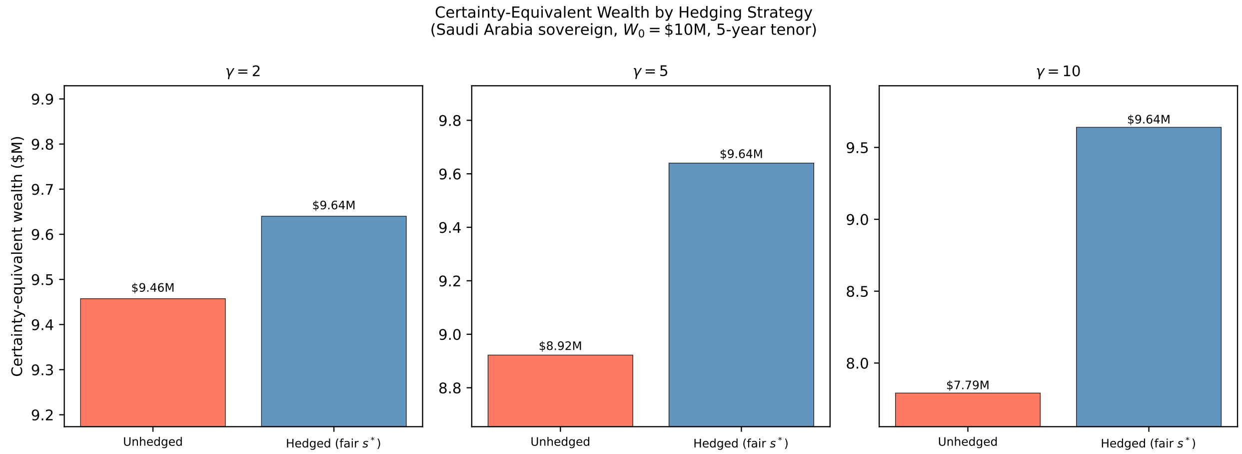

Figure 3: Certainty-equivalent wealth by hedging strategy for CRRA investors ($W_0 = \$10$M, Saudi Arabia 5yr sukuk, real $\hat{\kappa} = 1.80\%$, $\delta = 0.60$, $T = 5\,\text{yr}$). Hedging at the fair spread dominates the unhedged position for all γ.

- `evOption` (`0x8B45...dEC8`): the `EverlastingOption` contract implementing AHJ [7], Proposition 6 put pricing at $\iota = 0$.
- `oracle` (`0x4f6C...2999`): the `OracleAdapter` providing real-time and historical asset prices via Chainlink feeds.

Each protection is stored as a `Protection` struct with 11 fields:

```
struct Protection {
    address seller;           // protection seller (posted notional)
    address buyer;            // protection buyer (pays premiums)
    address refAsset;         // reference market asset (oracle key)
    address token;            // collateral / premium token (USDC)
    uint256 notional;         // max payout (raw token units)
    uint256 recoveryRateWad;  // delta in WAD (e.g. 60e16 = 60%)
    uint256 recoveryFloorWad; // put strike = recoveryRate *
        spot_at_open
    uint256 tenorEnd;         // protection expiry (Unix timestamp)
    uint256 lastPremiumAt;    // timestamp of last premium payment
    uint256 premiumsCollected;// cumulative premiums paid to seller
    Status  status;           // Open | Active | Triggered | Settled |
        Expired
}
```

Listing 1: Protection struct (iCDS.sol)

5.2 Full Lifecycle

Figure 4 illustrates the complete contract lifecycle.

Step 1 – openProtection. The seller calls `openProtection(refAsset, token, notional, recoveryRateWad, tenorDays)`. The contract deposits `notional` tokens from the seller into escrow (anti-naked-CDS rule). The *recovery floor* is computed once:

$$\text{recoveryFloor} = \text{recoveryRateWad} \times \text{oracle.getIndexPrice(refAsset)}/\text{WAD}, \tag{13}$$

locking the CDS strike at the spot price prevailing when protection is opened.

Step 2 – acceptProtection. The buyer calls `acceptProtection(id)`. The *first premium* is immediately computed and transferred to the seller. The fair per-period premium implied by the everlasting-put reserve is the flow relation of the companion credit-equivalence paper (Ahmed & Bhuyan [9], the takaful-flow theorem $\pi = \kappa\,\Pi$):

$$\text{premium}_0 = \hat{\kappa} \cdot \frac{\Pi_{\text{put}}(\text{spot, recoveryFloor}) \times \text{notional}}{\text{WAD}} \cdot \Delta t, \qquad \Delta t = \tfrac{90}{365}, \tag{14}$$

where Π_{put} is the everlasting put price from `EverlastingOption.quotePut()`, implementing the closed-form two-region formula of Ackerer, Hugonnier & Jermann [7], Proposition 6 at $\iota = 0$ (Appendix A).[1]

Step 3 – payPremium (quarterly, dynamic). Every 90 days, the buyer pays:

$$\text{premium}_t = \hat{\kappa} \cdot \frac{\Pi_{\text{put}}(\text{spot}_t, \text{recoveryFloor}) \times \text{notional}}{\text{WAD}} \cdot \Delta t. \tag{15}$$

Because Π_{put} rises as spot_t falls toward recoveryFloor, the premium automatically rises as credit quality deteriorates – a built-in early-warning feedback mechanism absent from fixed-spread conventional CDS.

Step 4 – triggerCreditEvent. An authorised keeper calls `triggerCreditEvent(id)` once the oracle confirms $\text{spot}_t \leq \text{recoveryFloor}$. This replaces the opaque ISDA credit-events committee with an objective, on-chain, oracle-verified condition, directly addressing the gharar objection.

[1] *Deployment note.* An earlier prototype (`0x7A02...b15F`) charged the *unscaled* put price $\Pi_{\text{put}} \times$ notional/WAD per period — a conservative overcharge of order $1/(\hat{\kappa}\,\Delta t)$ relative to the fair flow above. The deployed immutable contract above implements the fair flow, and the gas and lifecycle figures reported here are measured on it (`0x77a98785...521b`).

Step 5 – settle. The buyer calls `settle(id)`. Loss-given-default is distributed:

$$\text{LGD payout} = \text{notional} \times (1 - \delta); \quad \text{sellerReturn} = \text{notional} \times \delta. \tag{16}$$

The seller is not penalised beyond the actual LGD – consistent with the mutual takaful principle that financial burden is shared according to the pre-agreed formula, not punitive.

Step 6 – expire. If no credit event occurs by `tenorEnd`, the seller reclaims the full notional collateral via `expire(id)`.

Open	→	**Active**	→	**Triggered**	→ **Settled**
Seller posts notional		Buyer accepts; pays 1st prem.		Keeper confirms spot $\leq$ floor	Buyer receives LGD payout
			↓ no default at maturity		
			Expired: seller reclaims notional		

Figure 4: iCDS lifecycle state machine. Transitions: Open → Active (`acceptProtection`); Active → Triggered (`triggerCreditEvent`); Triggered → Settled (`settle`); Active → Expired (`expire` after `tenorEnd`).

5.3 Dynamic Premium Mechanics and Shariah Compliance

The dynamic put-pricing premium eliminates riba structurally, not by relabelling a fixed spread.[2] In a conventional CDS, the fixed spread is set at inception and paid regardless of subsequent credit-quality changes; the protection seller earns interest on the posted margin in the interim, which is the riba element (Section 2).

The iCDS premium re-prices at each payment date based on current oracle prices, and the seller's collateral sits in a non-interest-bearing *tabarru* pool. Because $\iota = 0$ in the pricing formula and no interest accrues on the float, there is no riba component. The premium paid at time t is the pure risk-neutral expected loss over the next quarter – the actuarially fair takaful contribution (*tabarru*) for that specific risk period, priced as if default could occur at any instant with no preference given to near-term versus far-term losses. This is consistent with the AAOIFI takaful model where each participant contributes according to their contemporaneous risk exposure.

[2] The theoretical formula $s^* = \kappa(1-\delta)$ is derived for a perpetual CDS in the AHJ framework (Theorem 2.1, Section 2). The contract implementation uses a finite tenor (`tenorDays`) with quarterly premium resets, which is consistent: each reset re-prices the quarterly premium from the current everlasting put price via the flow relation $\pi = \kappa\, \Pi_{\text{put}}$ of the companion paper [9]. The put price itself is a present value — the reserve covering all future protection — not a rate; multiplying by κ converts that reserve into the fair per-unit-time flow. This dynamic structure approximates perpetual pricing at each payment date without requiring the contract itself to be perpetual.

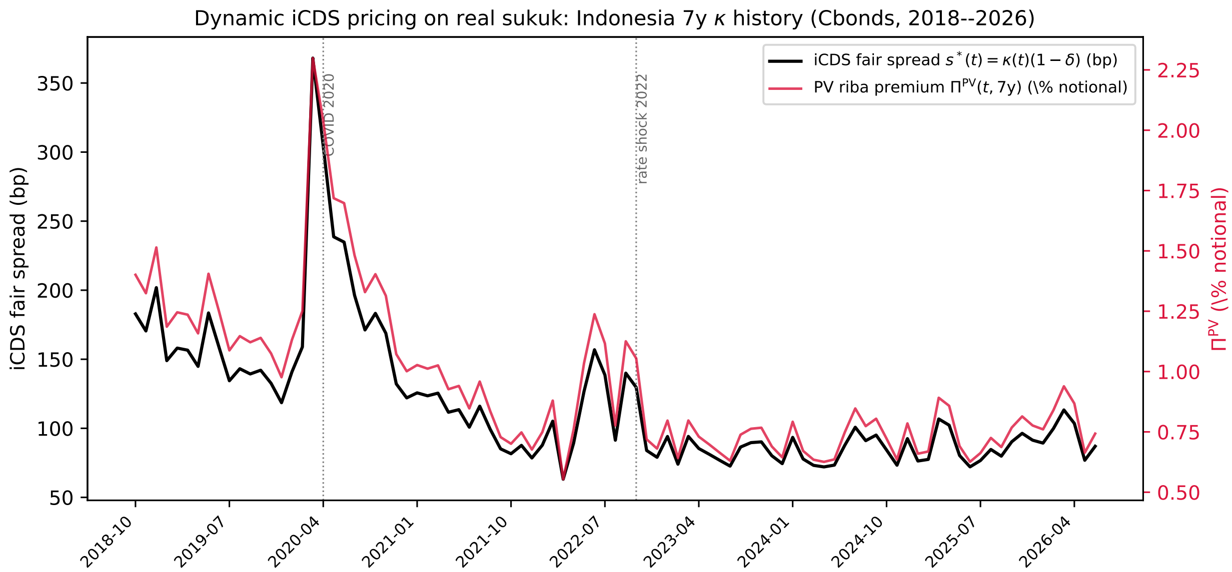

Figure 5: Dynamic iCDS pricing on a real sukuk credit history. Black (left axis): the iCDS fair spread $s^*(t) = \kappa(t)(1 - \delta)$ on Indonesia's real 7y constant-maturity κ (Cbonds, 2018–2026), spanning the 2020 COVID blow-out and the 2022 rate shock. Red (right axis): the present-value riba premium $\Pi^{\mathrm{PV}}(t, 7\mathrm{y})$ at $\iota = \mathrm{SOFR}$. Both re-price each period to observed credit; $\delta = 0.60$.

Dynamic re-pricing on real credit history. Figure 5 makes the re-pricing concrete on real data. Feeding the contract Indonesia's actual 7-year constant-maturity κ history (Cbonds daily G-spreads, 2018–2026), the iCDS fair spread $s^*(t) = \kappa(t)(1 - \delta)$ tracks the issuer's credit through the cycle — blowing out to 368 bp at the 2020 COVID peak ($\kappa \approx 9.2\%$) and compressing back toward 60–90 bp as spreads normalised — while the present-value riba premium $\Pi^{\mathrm{PV}}(t, 7\mathrm{y})$ moves with it between 0.6% and 2.3% of notional. The contract is therefore not a static-spread instrument: it marks the protection premium to current credit each period, exactly as a takaful pool re-assesses contributions, and does so with no interest term anywhere in the path.

5.4 Credit Event Oracle: Design Options

The credit event oracle is the central engineering challenge for an on-chain credit derivative. We identify four options, ordered by decentralisation:

(A) **Chainlink decentralised vote.** Node operators vote on whether a sovereign default event has occurred. Fully on-chain and decentralised, but can lag by hours. Appropriate for testnet and low-notional deployment.

(B) **ISDA credit events committee → Chainlink oracle update.** The ISDA determinations committee confirms a credit event (authoritative, immediate); a designated oracle operator updates the Chainlink feed. Introduces a centralised step but aligns with conventional market practice.

(C) **Hybrid (Recommended).** The ISDA committee triggers a multi-sig vote among 5 authorised keepers; 3-of-5 consensus required to call `triggerCreditEvent`. Balances decentralisation with the authority of established credit conventions.

(D) **zkProof of SWIFT MT103 payment failure (future).** A zero-knowledge proof of a missed coupon payment (SWIFT message failure) could trigger the credit event automatically and trustlessly. Technically feasible but requires SWIFT-to-blockchain data bridges not yet in production.

For the current Arbitrum Sepolia deployment, Option A is used. For commercial mainnet deployment, Option C is recommended.

5.5 Gas Cost Benchmarks

Table 7 reports the iCDS lifecycle gas *measured* by `forge test --gas-report`, priced at a live gas snapshot. The full lifecycle (one year, three quarterly premiums, credit-event settlement) consumes ≈897,000 gas units, with the storage-heavy `openProtection` and `acceptProtection` dominating. At the snapshot this is ≈ $0.036 on Arbitrum versus ≈ $0.28 on Ethereum mainnet; the saving equals the gas-price ratio (uniform across functions, time-varying with gas prices). This keeps micro-notional iCDS contracts (e.g. $1,000 notional for smallholder sukuk) economically viable: the gas cost is a small fraction of notional even at the smallest scale.

Table 7: Gas Cost Benchmarks: iCDS Lifecycle on Arbitrum One vs. Ethereum Mainnet.

Function	Gas units	Arb. ($)	ETH main. ($)	Saving
`openProtection`	263,800	$0.0107	$0.08	87%
`acceptProtection`	182,929	$0.0074	$0.06	87%
`payPremium`	104,823	$0.0043	$0.03	87%
`triggerCreditEvent`	68,487	$0.0028	$0.02	87%
`settle`	67,416	$0.0027	$0.02	87%
`expire`	54,031	$0.0022	$0.02	87%
`Full lifecycle`†	897,101	$0.0364	$0.28	87%

Gas units are Foundry `forge --gas-report` medians from `test/unit/iCDS.t.sol`. Costs at the 2026-05-30 snapshot: Arbitrum One 0.020 gwei, Ethereum mainnet 0.154 gwei, ETH/USD = $2,030. †Full lifecycle = open + accept + 3×payPremium + triggerCreditEvent + settle.

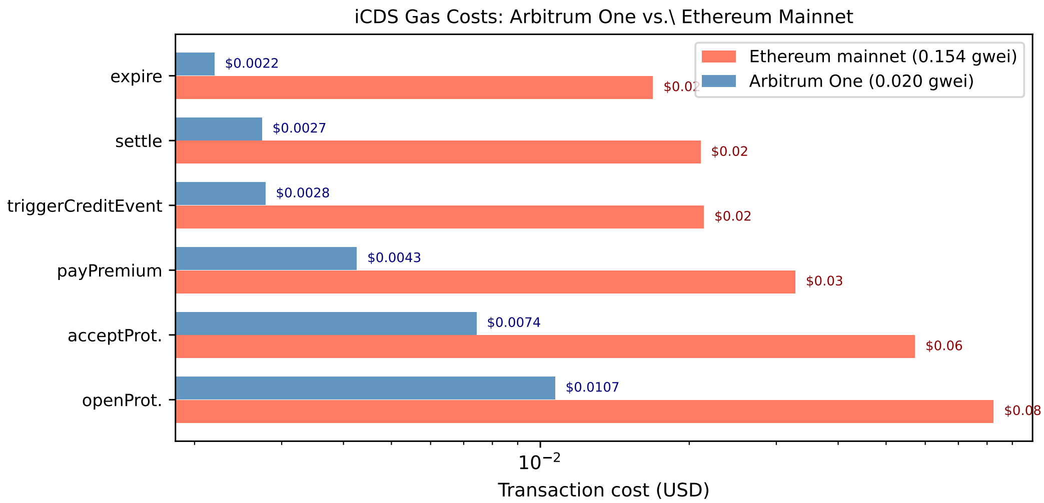

Figure 6: Per-function gas: real measured values (`forge --gas-report`), Arbitrum One versus Ethereum mainnet. The L2 dollar saving over mainnet equals the live gas-price ratio (uniform across functions, time-varying): ≈87% at the 2026-05-30 snapshot (Arbitrum 0.020 / mainnet 0.154 gwei), exceeding 99% at a typical 20 gwei mainnet, keeping the frequent premium payments at sub-cent cost.

6 Legal Analysis

6.1 Assessment against AAOIFI Shariah Standards

The Accounting and Auditing Organisation for Islamic Financial Institutions has issued no standard that explicitly addresses credit default swaps. The most closely applicable of its Shariah Standards [12] are Standard No. 20 (*Sale of Commodities in Organized Markets* — the standard governing futures- and options-like structures and the canonical source of the derivatives objections), Standard No. 5 (*Guarantees*, whose *kafala* analysis is the nearest analogue of the protection leg), Standard No. 49 (*Promises and Bilateral Promises*), and Standard No. 26 (*Islamic Insurance / takaful* [11]). We assess the iCDS against the relevant criteria, deferring the final reading of each standard to a qualified Shariah supervisory board.

(a) Wa'd structure. The iCDS uses a wa'd-based architecture: the seller makes a unilateral promise (*wa'd*) to pay the LGD upon a credit event; the buyer makes a separate unilateral promise to pay periodic premiums. Under Standard No. 49, a unilateral promise can be binding, but *muwa'adah* (mutually binding bilateral promises) is restricted where the paired promises amount to the underlying contract itself [12]. The iCDS open/accept architecture is structured with that constraint in view: no bilateral obligation exists at `openProtection` (the open offer is revocable by the seller until acceptance), and the binding relationship arises only at `acceptProtection`, the operative moment of contract formation — whether this structure satisfies Standard No. 49 in a given school is a determination for the supervisory board.

(b) Premium as halal consideration. The premium is computed as the put-option-priced expected loss per period, not as a pre-specified annuity. This distinction is crucial: a fixed annuity on notional resembles a debt-service obligation with riba characteristics, whereas a dynamically re-priced risk premium is the actuarially fair tabarru (charitable contribution for mutual insurance purposes). The AAOIFI takaful model [11] (Standard No. 26) explicitly permits dynamic tabarru contributions adjusted to current risk.

(c) Real risk, not simulated gambling. The reference entity's default (sovereign debt restructuring) is a real, verifiable economic event. The seller must post full notional as collateral, so no uncovered protection can be written; the buyer-side insurable-interest requirement (condition (2) below) excludes naked protection buying. Together these structurally address the maysir objection — neither party is positioned for a purely speculative wager — with the final determination resting with the supervisory board.

(d) Gharar minimisation. The credit event is defined as *oracle price* $\leq$ *recovery floor*: an objective, continuously observable, publicly verifiable condition. This replaces the ambiguous ISDA credit events committee with a mathematical threshold, directly addressing the gharar objection identified in Jobst & Solé [21].

Conclusion. The iCDS structure addresses each criterion examined above, subject to two conditions: (1) the seller posts full notional as collateral (anti-naked-CDS rule, enforced by the contract); and (2) the buyer holds the reference sukuk off-chain and provides a Shariah attestation to this effect at the time of `acceptProtection`. Formal determination of conformity with AAOIFI standards rests with a qualified Shariah supervisory board; no fatwa is claimed here.

These two conditions, together with the objective oracle settlement and fixed tenor, instantiate the four product-layer rules of the companion Shariah-boundaries study [10]: asset-backing (a real reference obligation), possession-gating (the buyer's attested holding), insurable interest / no naked positions (both conditions above), and expiry with objective settlement (or *tabarru* risk-sharing). In the launch taxonomy of that study, the iCDS is risk transfer on a real, owned sukuk exposure — a hedging utility in the takaful spirit, not a cash-settled wager — and the same $\iota = 0$ pricing applies unchanged to protection on tokenised sukuk holdings, the natural first deployment alongside sukuk-linked instruments.

6.2 ISDA/IIFM Tahawwut Documentation

The ISDA/IIFM Tahawwut Master Agreement [20] was designed for OTC Islamic hedging transactions and can be adapted to cover iCDS. Three modifications distinguish the iCDS from a standard CDS confirmation under the Tahawwut framework:

1. **Premium formula.** Replace the market-quoted spread with $s^* = \hat{\kappa}(1 - \delta)$ computed from the oracle price and the AR(1) OLS estimated convergence intensity.

2. **Credit event definition.** Replace the ISDA credit events list (Failure to Pay, Restructuring, Repudiation) with the on-chain oracle condition: $\texttt{spot} \leq \texttt{recoveryFloor}$. A supplemental schedule should specify the oracle contract address and the reference asset.

3. **Settlement.** Replace the ISDA auction settlement with the LGD formula: payout $=$ notional $\times\ (1 - \delta)$, settled immediately on-chain upon keeper confirmation.

Appendix C provides a draft term sheet in Tahawwut format.

6.3 Jurisdictional Analysis

Table 8 summarises the regulatory status across six jurisdictions.

Table 8: Jurisdictional Analysis: On-Chain iCDS Regulatory Status.

Jurisdiction	Primary Framework	Status	Key Requirement
UAE / VARA	VARA Virtual Asset Reg. 2023	**Permissible**	Virtual asset derivative; seller must be lice
Malaysia / BNM	IFSA 2013 + SC Guidelines	**Permissible**	AAOIFI-compliant structure acceptable; B
Singapore / MAS	CMS Act + SF Act	*Conditional*	OTC derivative: requires CMS licence; EM
UK / FCA	UK MAR + CMAR	*Conditional*	Treated as OTC swap; EMIR UK reportin
US / CFTC	CEA + Dodd-Frank	Uncertain	Likely classified as swap; SEF registration
Bahrain / CBB	CBB Rulebook Vol. 2	**Permissible**	Gulf-friendly pilot jurisdiction; CBB Modu

Sources: VARA Virtual Asset and Related Activities Regulation (2023); BNM Islamic Financial Services Act 2013; MAS Capital Markets Services Act; FCA UK CMAR; CFTC Commodity Exchange Act §2(h); CBB Rulebook Vol. 2 (Capital Markets, Module CM). Status reflects the authors' legal assessment; independent regulatory counsel advised before commercial launch.

UAE / VARA. The Virtual Assets and Related Activities Regulation [22] (effective June 2023) establishes a comprehensive licensing regime for virtual asset service providers (VASPs) in Dubai. VARA's virtual-asset derivatives regime — formalised in its Exchange Services Rulebook — permits exchange-traded derivatives (contracts for difference, futures, and options referenced to virtual assets) for appropriately licensed virtual asset service providers (VASPs), with the relevant authorisation falling under VARA's activity-based licences (notably Exchange Services and/or Broker-Dealer Services) and subject to retail leverage caps and suitability requirements. A smart-contract-based credit derivative settled in USDC, such as the iCDS, falls within the scope of that derivatives framework. VARA's KYC/AML and market-conduct obligations apply. The DIFC (Dubai International Financial Centre) *may* additionally require authorisation under the DFSA Rulebook if the contract is marketed to DIFC-based clients, but the Arbitrum blockchain deployment is outside DIFC territorial jurisdiction for domestic users.

Malaysia / BNM. The Islamic Financial Services Act 2013 (IFSA) and Securities Commission Guidelines on Digital Assets (2020) provide the applicable framework. Section 10 of IFSA permits Islamic derivative transactions that are AAOIFI-compliant. BNM would require a Shariah advisory board endorsement of the iCDS structure prior to commercial deployment. The SC's digital asset guidelines classify smart-contract-settled instruments as capital-markets products requiring a Capital Markets Services licence.

Singapore / MAS. The Securities and Futures Act 2001 (SFA) governs OTC derivatives. A credit default swap – even if Islamic – is classified as an OTC derivative, and dealing in it requires a Capital Markets Services (CMS) licence issued under the SFA. OTC derivative trade reporting to a licensed trade repository (DTCC Data Repository (Singapore)) applies. MAS has not issued specific Islamic finance guidance for DeFi instruments; the iCDS would be assessed on its economic substance as a credit derivative.

UK / FCA. The Financial Services and Markets Act 2000 (FSMA) and the UK's post-Brexit retained derivatives framework (UK EMIR, UK MiFIR) regulate OTC credit derivatives. The iCDS would require FCA authorisation under FSMA Section 19 for any dealing activity and trade reporting to an FCA-approved Trade Repository under UK EMIR Article 9. The FCA has actively supported Islamic finance development: its Discussion Paper DP22/2 (2022) explored regulatory accommodations for Shariah-compliant instruments, and HM Treasury's Islamic Finance Task Force positioned London as a global Islamic finance hub. An iCDS would be assessed on its economic substance as a credit derivative, with no current Islamic finance carve-out from standard OTC derivative rules. London's concentration of AAOIFI-accredited advisers and sukuk-experienced legal counsel makes the UK a viable secondary pilot jurisdiction once commercial mainnet deployment proceeds.

US / CFTC. The Commodity Exchange Act Section 2(h) and Dodd-Frank Title VII classify most single-name credit default swaps as swaps subject to CFTC jurisdiction. A Shariah-compliant structure does not alter this classification. To operate commercially, the iCDS would require either registration on a Swap Execution Facility (SEF) or bilateral documentation under an ISDA/IIFM Master Agreement with eligible contract participants (ECPs). The CFTC has shown interest in blockchain-based derivatives (RFI on DeFi, June 2023) but has not provided specific Islamic finance guidance.

Bahrain / CBB. The Central Bank of Bahrain Rulebook Volume 2 (Capital Markets, Module CM) permits credit derivatives for licensed entities. Bahrain's long-standing tradition as an Islamic finance centre and the CBB's Shariah governance framework (Module CM-4) create a permissive environment. We identify Bahrain as a viable alternative pilot jurisdiction to UAE if VARA licensing timelines extend beyond the project's commercial roadmap.

6.4 Recommended Pilot: UAE / VARA

We recommend UAE/VARA as the optimal first commercial jurisdiction on the basis of four factors. *Speed*: VARA operates a published, formal licensing process for virtual-asset derivative activity, providing a predictable authorisation pathway. *Geographic alignment*: the primary reference entities (UAE, Saudi Arabia, Qatar sovereigns) are GCC-domiciled, minimising cross-border regulatory friction. *Legal clarity*: VARA explicitly regulates virtual asset derivatives, removing uncertainty about whether the smart-contract settlement mechanism constitutes a licensing trigger. *Shariah ecosystem*: the UAE has an established network of AAOIFI-accredited Shariah scholars available for the mandatory advisory board function.

The regulatory pathway for commercial launch is therefore:

1. Obtain the applicable VARA VASP licence authorising virtual-asset derivative activity.
2. Engage AAOIFI-accredited Shariah board; obtain written fatwa endorsing the iCDS structure as described herein.
3. Upgrade the credit event oracle from Option A to Option C (3-of-5 keeper multi-sig referencing ISDA committee determinations).
4. Deploy on Arbitrum One mainnet (not Sepolia testnet).

5. Launch with initial reference entities: UAE sovereign, Saudi Arabia sovereign, Qatar sovereign.

7 Liquidity Bootstrapping

7.1 Market Structure

Two market structures are viable for the iCDS market. For small notionals ($1k–$500k), a single-sided automated market maker (AMM) is optimal: a protection seller deposits notional into an AMM pool; buyers can atomically open protection at the oracle-quoted put price. For large notionals ($500k+), a central-limit order book (CLOB) allows price discovery across heterogeneous recovery rate assumptions. The current deployment supports peer-to-peer bilateral matching; an AMM wrapper is planned for a future version.

7.2 Governance Token Incentive Mechanism

A fixed-supply protocol governance token (GT) provides liquidity incentives aligned with the long-run sustainability of the iCDS market.[3]

- **Protection sellers (risk-takers)**: earn GT rewards at rate λ_{GT} proportional to notional deposited and time open: $R_{\text{seller}} = \lambda_{\text{GT}} \cdot N \cdot \Delta t$.
- **Protection buyers (hedgers)**: receive a GT fee discount on premiums paid, proportional to GT holdings.
- **Keepers**: earn GT per successful `triggerCreditEvent` call with valid oracle proof.

The GT emission schedule tapers over four years (60% / 25% / 10% / 5% of the liquidity allocation), after which fee revenue ($s^* \times$ total notional outstanding) sustains the market without token subsidy.

7.3 Participation Condition and Market Viability

Proposition 7.1 (Seller Participation Condition)**.** *Let λ_{GT} denote the governance-token reward rate to sellers (GT per dollar-year of notional posted) and p_{GT} the prevailing GT*

[3] In the Baraka Protocol reference implementation, GT = BRKX (100M fixed supply; ERC-20+Votes, deployed on Arbitrum Sepolia). Specific parameters: 10M GT allocated to liquidity incentives over four years; fee tiers: 20% discount for ≥1,000 GT held, 30% for ≥50,000 GT. Source: https://github.com/Arcus-Quant-Fund/BarakaDapp.

market price. A capital allocator with outside return r_f weakly prefers participating as an iCDS protection seller if and only if:

$$\lambda_{GT} \cdot p_{GT} \;\geq\; r_f. \tag{17}$$

When equation (17) holds, participation is a best response for every seller regardless of others' choices; hence a symmetric equilibrium with positive aggregate liquidity exists.

Proof sketch. The seller's expected profit per unit notional per period is the premium received, minus the expected default loss, plus the governance-token reward:

$$\begin{aligned}\pi_s &= s^* \cdot \Pr[\text{survive}] - \text{LGD} \cdot \Pr[\text{default}] + \lambda_{\text{GT}}\, p_{\text{GT}} \\ &= \kappa(1-\delta)(1-p_D) - (1-\delta)p_D + \lambda_{\text{GT}}\, p_{\text{GT}},\end{aligned}$$

with $p_D \approx \kappa\,\Delta t$ for a period of length Δt. At the fair spread $s^* = \kappa(1-\delta)$ the insurance leg is zero-NPV: per unit time the premium rate $\kappa(1-\delta)$ exactly offsets the expected-loss rate (intensity κ times LGD $1-\delta$), so $\pi_s = \lambda_{\text{GT}}\, p_{\text{GT}} + O(\kappa^2)$. The posted collateral earns no interest, so the seller's only excess return is the governance-token yield. Setting $\pi_s \geq r_f$ therefore yields the participation condition (17): the token reward alone must cover the outside return, since the fair insurance spread contributes nothing on a risk-adjusted basis. □ □

As a calibration check, at 2025 SOFR ($r_f = 4.24\%$), equation (17) requires the governance-token yield to sellers to cover the full outside return, $\lambda_{\text{GT}}\, p_{\text{GT}} \geq 4.24\%$ per annum (the fair insurance spread $\kappa(1-\delta)$ is zero-NPV and does not contribute). With a Year-1 GT emission of 6% of total supply directed to sellers and a target TVL of \$1M, the required GT-price threshold is approximately $p^* \approx \$0.007$ – a low bar relative to comparable DeFi governance token valuations, implying that even modest market adoption sustains the Nash equilibrium condition.

7.4 Liquidity Milestones

1. **Minimum viable (\$1M notional)**: price discovery becomes possible; bid-offer spreads on iCDS terms compressible below 10 bps.

2. **Useful scale (\$50M notional)**: comparable to a small conventional CDS market; GT rewards self-sustaining from fee revenue.

3. **Target ($500M by Year 3)**: comparable to a medium CDS market on individual reference entities; attractive to institutional Islamic finance participants seeking hedging against GCC sovereign sukuk exposure.

8 Systemic Risk

8.1 Lessons from 2008

Beyond bootstrapping liquidity, an Islamic CDS market must avoid the systemic failures that discredited the conventional one. The 2008 financial crisis demonstrated three systemic failure modes of conventional CDS markets. First, *uncollateralised selling*: AIG and others wrote billions in CDS notional without posting collateral against the contingent liability, creating uncovered exposures that failed exactly when triggered [15]. Second, *underestimated correlation*: Gaussian copula models underestimated joint default probabilities, leading to catastrophic concentration of credit risk in protection sellers. Third, *opacity*: the OTC bilateral market had no central counterparty; regulators could not monitor aggregate exposure.

8.2 iCDS Safeguards

The iCDS smart contract addresses each failure mode by design.

Full collateralisation. Every seller must deposit the full notional in the contract before a protection can be opened (line 209 of `iCDS.sol`, which calls `safeTransferFrom` to escrow the full notional). Naked positions are mechanically impossible.

Transparent exposure. All open protections are visible on-chain: any observer can query `protections[id]` and `_nextId` to enumerate the full aggregate exposure. Regulators can monitor positions in real time without relying on mandatory reporting regimes.

No synthetic leverage chains. Because each seller funds their own position individually, there are no synthetic CDS-on-CDS structures. The aggregate exposure of the iCDS market is bounded by the sum of collateral actually deposited, not by a notional multiple of underlying assets.

8.3 Circuit Breakers and Position Limits

The `Pausable` mechanism allows the contract owner to halt all new interactions in the event of an oracle manipulation attempt or black-swan default event. Future versions will implement:

- Per-seller notional caps (e.g., max 20% of TVL from a single seller).
- Per-reference-entity notional caps (diversification across sovereigns).
- Automatic pause if oracle price moves $> 30\%$ in 24 hours (flash-crash protection).

These circuit breakers directly address the correlation and concentration risks that amplified the 2008 crisis.

9 Conclusion

We have presented the complete scientific, engineering, and regulatory case for the first Islamic Credit Default Swap on public blockchain infrastructure.

Theoretically, the iCDS spread $s^* = \kappa(1 - \delta)$ is the actuarially fair credit protection premium, and — because both legs terminate at default and the discount cancels — the par spread is independent of the rate ι at every maturity, so a correctly-priced conventional CDS quotes the same fair spread. The par spread is therefore automatically riba-neutral; the riba is confined to the present value, where we define $\Pi^{\mathrm{PV}}_{\mathrm{riba}}(T)$, the discounting haircut on the future loss — increasing in ι, vanishing at $\iota = 0$, and a small fraction of notional at realistic maturities. The iCDS removes it both by pricing at $\iota = 0$ and structurally: collateral held in a non-interest-bearing *tabarru* pool, full collateralisation, and an objective on-chain credit event. Empirically, the analysis runs on a cross-section of 62 real, actively-quoted sovereign USD sukuk (Cbonds, 12 issuers), with no synthetic panel: κ read from those sukuk G-spreads recovers the hazard independent instruments imply — agreeing within 6–16 bp with same-issuer conventional bonds and co-moving with sovereign CDS at correlation 0.97. The discount-independence of the par spread also explains why sovereign CDS stayed at 48–100 bps in the near-zero-rate era 2012–2018 while policy rates sat near zero.

Technically, `iCDS.sol` implements the full lifecycle (open, accept, quarterly dynamic premiums, credit event trigger, LGD settlement) on Arbitrum, removing riba and structurally addressing maysir and gharar through smart-contract mechanics rather than legal workarounds. The full lifecycle is ≈897,000 gas (Foundry-measured) — a few US cents on Arbitrum, with an L2-vs-L1 saving equal to the live gas-price ratio (order 90–99%), enabling economically viable micro-notional Islamic credit hedging.

Legally, UAE/VARA is identified as the most permissive immediate jurisdiction. The five-step commercial pathway (VARA licence, Shariah board fatwa, Oracle upgrade, mainnet deployment, GCC sovereign reference entities) is executable within 12–18 months of this paper's publication.

Taken together, these contributions provide the academic foundation, deployed engineering artefact, and regulatory roadmap for an Islamic CDS market whose riba content is settled at the pricing layer, whose product-layer safeguards are designed for Shariah-board review, and which is technically operational (testnet) and legally mappable. The iCDS described in this paper is not purely a theoretical construct: it is running as a pre-audit prototype on Arbitrum Sepolia today; a commercial launch additionally requires an independent security audit (including the premium-flow correction of Section 5), the oracle upgrade to Option C, Shariah-board review, regulatory authorisation, and the liquidity bootstrapping mechanisms described here.

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A iCDS.sol Key Functions (Solidity)

The following listings reproduce the core functions of `iCDS.sol` (deployed at `0x77a98785...521b` on Arbitrum Sepolia). *Full source:* https://github.com/Arcus-Quant-Fund/BarakaDapp.

Everlasting put formula at $\iota = 0$. The `EverlastingOption.quotePut()` function implements Proposition 6 of Ackerer, Hugonnier & Jermann [7] at $\iota = 0$, in the two-region closed form derived in the companion paper [9]. For an everlasting put with current spot S and strike K (recovery floor),

$$\Pi_{\text{put}}(S, K; \kappa) \;=\; \begin{cases} C_p\, S^{\beta_p}, & S \geq K, \\ (K - S) + \dfrac{K^{1-\beta_c}}{\beta_c - \beta_p}\, S^{\beta_c}, & S < K, \end{cases} \qquad C_p = \frac{K^{1-\beta_p}}{\beta_c - \beta_p}, \tag{18}$$

where

$$\beta_p = \tfrac{1}{2} - \sqrt{\tfrac{1}{4} + \tfrac{2\kappa}{\sigma^2}} \;<\; 0, \qquad \beta_c = \tfrac{1}{2} + \sqrt{\tfrac{1}{4} + \tfrac{2\kappa}{\sigma^2}} \;>\; 1, \tag{19}$$

are the negative and positive roots of the characteristic equation $\frac{\sigma^2}{2}\beta(\beta-1) = \kappa$ at $\iota = 0$, and σ^2 is the variance parameter of the reference asset price process. The two-region form (value-matching and smooth-pasting at $S = K$, with the intrinsic value $K - S$ as the particular solution in the money) is essential: a single power law extended through $S < K$ would omit the intrinsic value and misprice the floor [9]. The deployed `EverlastingOption` contract computes exactly this two-region formula (`_exponents()` returns β_p and β_c; `_quotePut()`

switches regions at the strike). The contract uses $S =$ `spotWad` and $K =$ `recoveryFloorWad` from the oracle, with σ^2 estimated from the historical volatility of the reference asset price.

```
function openProtection(
    address refAsset, address token,
    uint256 notional, uint256 recoveryRateWad, uint256 tenorDays
) external nonReentrant whenNotPaused returns (uint256 id) {
    uint256 spotWad         = oracle.getIndexPrice(refAsset);
    uint256 recoveryFloorWad = (spotWad * recoveryRateWad) / WAD;
    id = _nextId++;
    protections[id] = Protection({
        seller: msg.sender, buyer: address(0),
        refAsset: refAsset,  token: token,
        notional: notional,  recoveryRateWad: recoveryRateWad,
        recoveryFloorWad: recoveryFloorWad,
        tenorEnd: block.timestamp + tenorDays * 1 days,
        lastPremiumAt: 0, premiumsCollected: 0, status: Status.Open
    });
    IERC20(token).safeTransferFrom(msg.sender, address(this), notional);
}
```

Listing 2: openProtection: seller deposits notional as collateral

```
function _computePremium(Protection storage prot)
    internal view returns (uint256)
{
    uint256 spotWad    = oracle.getIndexPrice(prot.refAsset);
    uint256 putRateWad = evOption.quotePut(
        prot.refAsset, spotWad, prot.recoveryFloorWad
    );
    return (putRateWad * prot.notional) / WAD;
}
```

Listing 3: _computePremium: put-option-priced premium at iota=0

```
function triggerCreditEvent(uint256 id) external whenNotPaused {
    require(authorisedKeepers[msg.sender], "iCDS: not keeper");
    Protection storage prot = protections[id];
    uint256 spotWad = oracle.getIndexPrice(prot.refAsset);
    require(spotWad <= prot.recoveryFloorWad, "iCDS: no default");
    prot.status = Status.Triggered;
}
```

Listing 4: triggerCreditEvent: on-chain oracle credit event

B Real Constant-Maturity $\hat{\kappa}$ Dynamics

Table 9: Real Constant-Maturity $\hat{\kappa}$ Dynamics (Cbonds daily G-spread histories).

Issuer	Tenor	$\hat{\bar{\kappa}}$ (%)	$\hat{\alpha}$ (p.a.)	Half-life (mo., bc)	Feller
Malaysia	7y	0.89	5.83	1.4	Yes
Saudi Arabia	7y	2.31	2.53	3.3	Yes
Indonesia	7y	2.80	1.95	4.3	Yes
Bahrain	7y	5.22	3.11	2.7	Yes
Turkey	5y	7.44	0.79	10.5	Yes

Source: Cbonds daily constant-maturity G-spread histories (roll-down removed), 2018–2026, via the companion κ-yield-curve study [8]. $\hat{\alpha}$ and half-life are Kendall bias-corrected (bc); Feller condition $2\hat{\alpha}\hat{\bar{\kappa}} \geq \hat{\nu}^2$ satisfied in every series. All values are estimated from real traded sukuk, not a synthetic panel.

C Draft iCDS Term Sheet (ISDA/IIFM Tahawwut Format)

Field	**Value / Description**
Transaction Type	Islamic Credit Default Swap (iCDS) under ISDA/IIFM Tahawwut Master Agreement [20]
Reference Entity	[e.g., Kingdom of Saudi Arabia]
Reference Obligation	[e.g., Saudi Arabia 5yr USD Sukuk, ISIN: XS0000000000]
Protection Seller	[VARA-licensed entity or bilateral ECP]
Protection Buyer	[Must hold Reference Obligation off-chain; Shariah attestation required]
Notional Amount	[e.g., USD 1,000,000]
Premium Formula	$s^* \times$ Notional $\times \Delta t$ per payment date, with $s^* = \hat{\kappa}(1-\delta)$ and $\Delta t = 0.25$ (quarterly), $\hat{\kappa}$ computed from the oracle at each payment date (dynamic, not fixed)
Premium Payment Dates	Quarterly (every 90 days from Effective Date)
Convergence Intensity ($\hat{\kappa}$)	AR(1) OLS estimate from Table 9; or live oracle feed (future)
Recovery Rate (δ)	0.60 (60%), per Moody's sovereign tables

Field	Value / Description
Credit Event Definition	On-chain: oracle spot price $\leq$ Recovery Floor $= \delta \times$ Spot at Effective Date
Credit Event Oracle	`OracleAdapter` at `0x4f6C...2999`; confirmed by 3-of-5 keeper multi-sig (recommended Option C)
Settlement	Cash settlement (physical-equivalent economics): Protection Buyer receives Notional $\times (1 - \delta)$ in USDC on-chain within 1 block of Buyer calling `settle(id)`
Tenor	[e.g., 5 years from Effective Date]
Governing Law	[e.g., DIFC law / English law]
Shariah Adviser	[AAOIFI-accredited scholar; fatwa reference number]
Smart Contract	`iCDS.sol` at `0x77a98785...521b` (Arbitrum Sepolia testnet; mainnet address TBD)
VARA Licence	[VARA VASP derivatives licence no.; TBD]

CRediT Author Contribution Statement. S.A.: conceptualisation, software, methodology, writing (original draft); R.B.: supervision, writing (review), resources.

Conflict of Interest Statement. S.A. is the principal architect of the smart contracts described in this paper and holds governance tokens in the project. R.B. declares no conflicts.

Data Availability. All data, code, and pipeline scripts are available at https://github.com/Arcus-Quant-Fund/BarakaDapp.