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**Basket-Based Stablecoin: A
Cross-Country Perspective**

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Glossary

ADF	Augmented Dickey-Fuller
ART	Asset-referenced token
BRICS	Brazil, Russia, India, China and South Africa
BRL	Brazilian real
CAD	Canadian dollar
CNY	Chinese renminbi
DLT	Distributed ledger technology
EBA	European Banking Authority
ECB	European Central Bank
EMT	E-money token
EUR	Euro
FCA	Financial Conduct Authority
FEVD	Forecast error variance decomposition
FSMA	Financial Services and Markets Act
GBP	Pound sterling
GFEVD	Generalized forecast error variance decomposition
HHI	Herfindahl index
HQLA	High-quality liquid assets
IMF	International Monetary Fund
INR	Indian rupee
IOSCO	International Organization of Securities Commissions
JPY	Japanese yen
MiCAR	Markets in Crypto-Assets Regulation
MRC	Marginal risk contribution
NATO	North Atlantic Treaty Organization
NVAL	Normalized value in exchange

RC	Risk contribution
RNVAL	Reduced normalized value in exchange
RUB	Russian ruble
SDR	Special Drawing Right
SEC	Securities and Exchange Commission
SLSQP	Sequential least squares programming
USD	U.S. dollar
USDC	USD Coin
USDT	Tether
VAR	Vector autoregression
ZAR	South African rand

Chapter 1

Introduction

Since 2020 the search for a stable form of digital money has moved from the edge of the crypto market to the center of monetary debate. Stablecoins promise the settlement speed of a crypto-asset with the steady value of a national currency, and the pandemic tested that promise, as remote work and a sharp rise in digital payments raised demand for instruments that move value quickly and cheaply. The largest of these coins peg to a single fiat currency, almost always the U.S. dollar (USD), and two questions about them stay open. One is whether the peg is genuinely stable, since a coin backed by USD reserves inherits both the USD's own movements and the liquidity and counterparty stress of the venues where it trades. The other is how shocks travel among the currencies and markets around such a coin, a question of spillovers that a headline stability figure cannot answer. The clearest applied case is remittances, where migrant workers still pay high fees to send small sums home.

What a coin is pegged to is not a neutral choice. A coin denominated in U.S. dollars is, in effect, a fast vehicle for dollarization, and dollarization carries documented costs. Financial dollarization, meaning elevated shares of foreign currency deposits and credit in the banking system, remains common across developing economies long after the inflation and the loss of confidence in the domestic currency that first drove residents and banks toward foreign money. Bannister, Turunen and Gardberg find that deposit dollarization weighs on financial deepening on average, with some evidence of lower financial efficiency, so that reducing it can support faster and safer financial development.¹ A digital instrument that spreads USD

¹ See Bannister, Geoffrey J., Jarkko Turunen, and Malin Gardberg, *Dollarization and Financial Development*, 2018, available at <https://www.imf.org/en/publications/wp/issues/2018/09/11/dollarization-and-financial-development-46164>.

balances through phones rather than cash or bank accounts can accelerate that process, and add the currency mismatch and the loss of monetary autonomy that come with it. A stable value alone is therefore not enough; the currency in which it is fixed shapes the risk a country takes on.

This thesis constructs a stablecoin whose value is fixed to a basket of currencies rather than to one. The rationale is diversification. A basket whose weights minimize the variance of its own value holds steadier than any single constituent, because their movements partly offset, and it does not tie the holder to the policy of one issuer. For international payments and remittances the payoff is direct: a unit that keeps its value across several currencies lowers the exchange cost and the exchange risk of moving money between them, without the concentrated dependence a single peg creates. The design problem is to define such a basket so that its value does not depend on the arbitrary currency in which it is quoted.

The contribution is methodological and applied. On the method, the basket value is built from the numeraire-free reduced normalized value in exchange (RNVAL) index, which removes the base currency from the measurement, and its weights are set by minimizing that index's variance; the internal risk of each basket is then read with the generalized spillover framework, which traces how a shock to one currency reaches the others. On the application, the method is run on three baskets that map distinct configurations of the international monetary system, Global, NATO (North Atlantic Treaty Organization) and BRICS (Brazil, Russia, India, China and South Africa), each benchmarked against the Special Drawing Right (SDR) and against the two largest USD stablecoins, Tether (USDT) and USD Coin (USDC). The chapters that follow set out the theory and regulation of stablecoins, the data and currency selection, the construction and stability of the three coins, their volatility spillovers, and a final comparison that places the basket coins beside the fiat-backed ones and asks what a stable digital unit can do for payments and remittances.

Chapter 2

Theoretical Framework

2.1 Overview of Cryptocurrencies and Blockchain

A blockchain is a distributed digital ledger maintained collectively by a network of participants, with no central repository or governing authority. Transactions are recorded in discrete units called blocks; each block contains a cryptographic hash of its predecessor, forming an ordered chain. This chaining mechanism provides tamper-evidence: any modification to a historical block invalidates the hashes of all subsequent blocks, rendering the alteration detectable by every participant in the network.

The integrity of the system depends on two well established cryptographic primitives.

- Cryptographic hash functions transform input data of arbitrary length into a fixed length digest; the computational infeasibility of producing two distinct inputs that yield the same digest precludes undetected tampering.
- Asymmetric-key cryptography provides each participant with a private key, known exclusively to its holder, and a corresponding public address derivable from it. A transaction signed with the private key can be authenticated by any network participant holding the public address, establishing proof of authorization without disclosing the underlying secret.

In 2008, Satoshi Nakamoto integrated these cryptographic foundations with a decentralized consensus mechanism, designated Proof of Work, to produce Bitcoin, the first blockchain-based cryptocurrency. Under this protocol, authorization of

transfers is not delegated to a central institution; instead, network participants, referred to as miners, compete to solve computationally intensive mathematical problems, with the successful participant granted the right to append a new block to the chain. The network accepts the longest valid chain as the canonical ledger, a convention that makes retroactive falsification computationally prohibitive.

Although cryptocurrencies constitute the most widespread application of blockchain technology, the architecture admits broader use. Permissioned variants, in which network access is restricted to authorized parties, have found application in inter-bank settlement and supply-chain management. Stablecoins, the subject of the present thesis, occupy an intermediate position: they operate on public blockchain infrastructure but incorporate a price-stabilization mechanism designed to mitigate the exchange-rate volatility that renders conventional cryptocurrencies unsuitable for international payments and remittances.²

2.2 Stablecoins: Definition, Origins and Regulation

2.2.1 Definition and Classification

A stablecoin is a type of cryptocurrency designed to hold a stable price, with low volatility, relative to a reference point: a fiat currency, a commodity, or a basket of assets. Standard monetary theory requires money to function as a medium of exchange, a store of value, and a unit of account, and all three depend on price stability. An asset that swings sharply in value cannot reliably serve any of these roles. Conventional cryptocurrencies, despite their technical properties, have seen limited adoption as payment instruments precisely because of this volatility.³

Stablecoins address this by anchoring their value to an external reference, and the literature classifies them by the type of collateral used to sustain that anchor. Fiat-collateralized stablecoins hold reserves of a national currency with a custodian and issue tokens redeemable at a fixed rate against those reserves. Commodity-backed variants follow the same logic but substitute physical assets, typically gold, for cash. Collateralized stablecoins use other digital assets as collateral,

² See Yaga, Dylan et al., Blockchain Technology Overview, 2018, available at <https://doi.org/10.6028/NIST.IR.8202>.

³ See Mita, Makiko et al., What is Stablecoin?: A Survey on Its Mechanism and Potential as Decentralized Payment Systems, 2020, available at <https://arxiv.org/pdf/1906.06037>.

usually in excess of the issued value, to absorb fluctuations in the backing asset. Non-collateralized stablecoins carry no reserve at all; instead, they adjust token supply algorithmically in response to market signals, drawing on the quantity theory of money to hold the price steady.⁴

Each category involves different tradeoffs among stability, decentralization, and operational complexity. These tradeoffs inform the design discussion in the sections that follow.

2.2.2 Risks and Regulation

Stablecoins introduce a distinctive set of financial risks that differ from those associated with conventional crypto-assets, largely because their design creates an implicit promise of price stability that reserve mechanics may not always be able to honor.⁵

The most immediate vulnerability is run risk. Unlike a bank deposit backed by an explicit institutional guarantee, a stablecoin's value depends on the quality and liquidity of the assets held in reserve. If holders doubt the completeness or soundness of that backing, they may redeem en masse. The resulting dynamics are self-fulfilling: early redeemers obtain full value while later ones face a depleted reserve. During periods of market stress this vulnerability becomes acute, particularly when reserve assets are illiquid or invested in instruments whose value falls precisely when redemption pressure is highest. A run on a widely adopted stablecoin could trigger fire sales of backing assets, transmitting instability into the broader financial system.

A closely related risk concerns the incentive structure of issuers. Stablecoin issuance is economically analogous to deposit-taking: the issuer holds a portfolio of assets and issues liabilities redeemable, in principle, at par. Without binding regulatory constraints, however, issuers face a clear incentive to invest reserves in higher-yielding or less liquid instruments, or to lend them to affiliated entities, while passing residual risk to stablecoin holders. The history of private currency issuance is instructive on this point. The case of Tether, whose issuer was accused

⁴ See Moin, Amani, Emin Gün Sirer, and Kevin Sekniqi, A Classification Framework for Stablecoin Designs, 2019, available at <https://arxiv.org/pdf/1910.10098>. See also Mita, Makiko et al., What is Stablecoin?: A Survey on Its Mechanism and Potential as Decentralized Payment Systems, 2020, available at <https://arxiv.org/pdf/1906.06037>.

⁵ See Arner, Douglas W., Raphael Auer, and Jon Frost, Stablecoins: risks, potential and regulation, 2020, available at <https://www.bis.org/publ/work905.pdf>.

by the New York Attorney General of having lent at least seven hundred million U.S. dollars to Bitfinex, an affiliated crypto-asset trading platform, illustrates how quickly reserve composition can diverge from public representations. Arner, Auer and Frost draw an explicit parallel to the Bank of Amsterdam in the late eighteenth century, which abandoned full reserve backing through loans to the Dutch East India Company before its eventual collapse.⁶

Systemic risk constitutes a qualitatively different concern. A stablecoin operating at limited scale poses negligible threat to financial stability; the problem arises when network effects and the distribution power of large technology platforms allow rapid mass adoption. At that point, failure would not be confined to its immediate users: a systemically important stablecoin could impair monetary policy transmission by diverting a substantial share of the payment system outside the central bank's reach. In jurisdictions without an established locally denominated stablecoin, the widespread use of a global instrument could give rise to currency substitution, eroding monetary sovereignty. These risks compound the traditional *too big to fail* and *too connected to fail* considerations that have long informed macroprudential policy.

Governance risk adds a further layer of uncertainty. The operational and decision-making frameworks of stablecoin arrangements frequently lack the transparency required of systemically significant financial infrastructure. The review of the Libra 2.0 proposal demonstrated this gap: voting rules, contingency plans, and resolution frameworks were described only in outline, leaving holders and regulators without adequate assurance that the arrangement could withstand stress. Membership criteria for governance bodies introduce additional scope for conflicts of interest that are difficult to assess from the outside.

Operational and cyber risks are also relevant. For a stablecoin relying on distributed ledger technology (DLT) infrastructure, vulnerabilities may exist at the protocol level, in custodial arrangements for reserve assets, or in the wallet and exchange infrastructure used by retail participants. These risks are not unique to stablecoins, but they are intensified by the global, round-the-clock character of DLT-based systems and by the absence, in most current arrangements, of the incident-response and continuity requirements imposed on traditional financial market infrastructures.

Stablecoins also raise concerns around market integrity and consumer protection. The pseudonymous nature of crypto-asset transactions has long drawn regulatory

⁶ *Id.*

scrutiny for its potential to facilitate money laundering and illicit finance, and stablecoins are no exception. The involvement of unregulated wallet providers and the uneven reach of anti-money laundering frameworks across jurisdictions amplify this risk. From a consumer protection standpoint, the collapse of a widely used stablecoin could destroy the financial resources of many retail users, who may have limited experience with digital financial products and correspondingly greater exposure to fraud and account-takeover attacks.

Following the announcement of Facebook’s Libra project in 2019, which placed the question of global stablecoins squarely on the agenda of financial authorities worldwide, a broad consensus formed around a set of functional regulatory principles calibrated to the scale and systemic significance of each arrangement.⁷

The starting point is a registration or licensing requirement coupled with mandatory monitoring. Without such a framework, financial stability risks can accumulate unobserved; in particular, a stablecoin that begins as a narrow-purpose instrument may acquire a user base sufficient to make it systemically significant before any regulatory perimeter has been established. The graduated approach proposed by the European Union in its September 2020 digital finance package operationalizes this principle through a tiered taxonomy: utility tokens, e-money stablecoins, asset-backed stablecoins, and significant stablecoins are each subject to different requirements, with the last category facing the most stringent prudential and governance obligations.

Beyond prudential requirements, authorities must address market integrity. The Financial Action Task Force’s anti-money laundering and counter-terrorism financing standards apply to stablecoins as they do to general crypto and assets; the International Organization of Securities Commissions (IOSCO) is separately examining market manipulation, fraud, and consumer protection concerns specific to digital assets. Asset segregation and mandatory disclosure are central to investor protection, given the issuer incentive noted above to deploy reserves in ways that serve proprietary returns at the expense of holder security.

For global stablecoins, cross-border coordination is indispensable. The Financial Stability Board’s 2020 framework for global stablecoin arrangements sets out the need for supervisory authorities to hold adequate powers across jurisdictions, for comprehensive governance and risk management frameworks, and for resolution mechanisms proportionate to the scale of the arrangement. Instruments such as supervisory colleges and multilateral memoranda of understanding provide

⁷ *Id.*

one avenue; the direct embedding of supervisory requirements into stablecoin infrastructure, described in the literature as “embedded supervision”, offers a more automated path. The Markets in Crypto-Assets Regulation (MiCAR), adopted at European level, is the most comprehensive legislative codification of these principles to date and is examined in the dedicated section that follows.

2.2.3 Taxonomy

A systematic classification of stablecoin initiatives requires criteria that go beyond the simple observation that they aim to hold a stable price. Bullmann, Klemm and Pinna, in a 2019 occasional paper published by the European Central Bank (ECB), propose a three-dimensional framework to this end. They distinguish stablecoins according to: whether a liable issuer exists who can be held accountable for any claim attached to the stablecoin; the extent to which responsibilities over the initiative are centralized in identifiable institutions or distributed among network participants; and what actually underpins the stablecoin’s value in the reference currency. This framework, which the authors term the “Crypto Cube” and which is shown in Figure 2.1, yields four primary categories, placed inside the cube in Figure 2.2 and examined in the subsections below.⁸

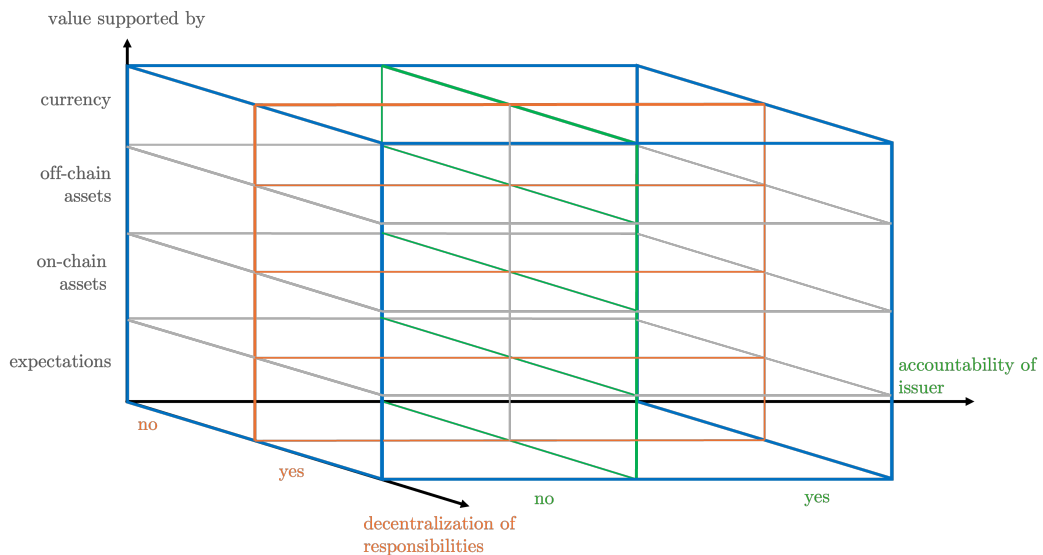


Figure 2.1: *Crypto Cube*

As of mid-2019, at least 54 stablecoin initiatives were in existence, of which 24

⁸ See Bullmann, Dirk, Jonas Klemm, and Andrea Pinna, In search for stability in crypto-assets: are stablecoins the solution?, 2019, available at <https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op230~d57946be3b.en.pdf>.

were operational. Their aggregate market capitalization had grown from €1.5 billion in January 2018 to more than €4.3 billion in July 2019, with average monthly transaction volumes of €13.5 billion. Roughly half of all initiatives ran on the Ethereum network, using the ERC-20 smart contract standard.

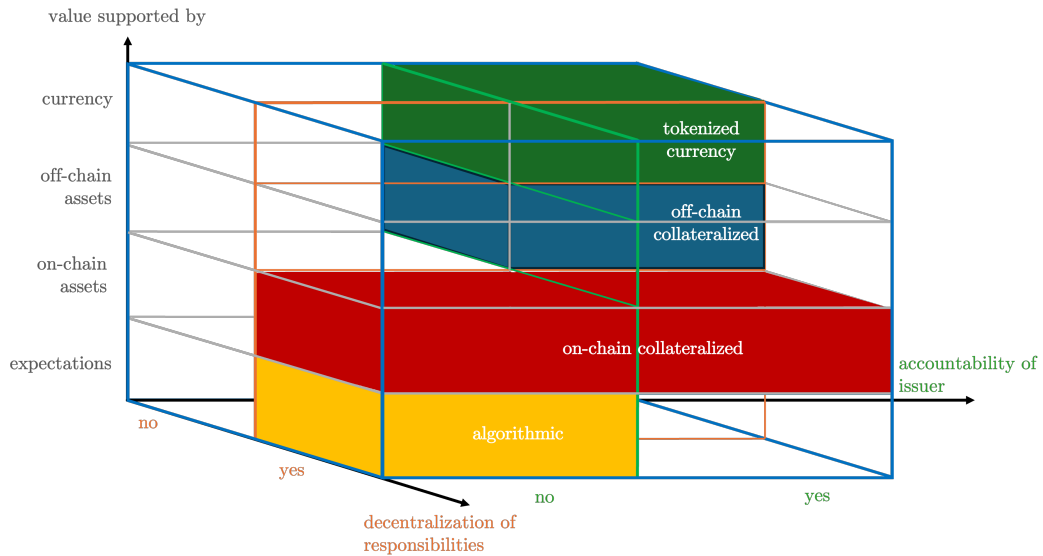


Figure 2.2: Taxonomy of stablecoins inside the Crypto Cube

Tokenized Funds

Tokenized funds are stablecoin units that represent a direct claim on the issuer for an equivalent amount of currency held in reserve. The issuer receives funds from a user, creates an equal number of stablecoin tokens on the distributed ledger, and commits to redeeming those tokens at par on demand. When a user redeems, the tokens are destroyed and the custodian releases the corresponding funds. No new type of asset is created in this process: the stablecoin is a representation of existing currency units recorded through new infrastructure rather than through a traditional electronic money system.⁹

USDT, the first stablecoin of this kind to achieve scale, accounted for 99% of the total stablecoin market capitalization in February 2018 and 81% in July 2019. Its average daily trading volume was €12.7 billion, a figure the authors caution is inflated by wash trading on exchange platforms. The historical price volatility of USDT, measured as the annualized average of seven-day rolling standard deviations, is approximately 10%, the lowest among the representative cases examined by the authors.

⁹ *Id.*

The stability of tokenized funds depends not on structural design but on the reliability of the issuer. A holder redeeming tokens must trust that the issuer has maintained adequate reserves. In the absence of mandatory auditing or licensing requirements, there is a persistent risk that reserves have been partially deployed for the issuer's own purposes. Tether illustrates this: a law firm inspection in 2018 confirmed that Tether's assets exceeded outstanding tokens, but the review was a snapshot rather than a full audit. Following public controversy about its relationship with the affiliated exchange Bitfinex, Tether revised its Terms of Service to allow reserve composition to be altered at the sole discretion of the issuer, without disclosure to token holders. USDC, by contrast, obtained an e-money institution license for its issuer in the United Kingdom, representing a step toward the regulatory legitimization that the tokenized funds model requires to function reliably at scale.

Collateralized Stablecoins

In collateralized stablecoin initiatives, each unit is backed by assets other than currency held at par; the collateral's price in the reference currency fluctuates. To absorb those fluctuations and maintain the peg, positions are overcollateralized and subject to margin calls. Two configurations arise depending on whether collateral is held outside or inside the DLT network.

Off-chain Collateralized Stablecoins Off-chain collateral consists of assets that cannot be fully represented or transferred through a distributed ledger without the involvement of a custodian. Commodities and real estate are examples: only a digital token representing the asset can move on the ledger, while the underlying asset must be held, verified, and released by an accountable institution. This structural dependence on traditional custodians limits the decentralization that DLT is otherwise intended to provide. When the value of posted collateral falls below the minimum overcollateralization ratio, margin calls require the user to post additional assets. If the user fails to do so, the issuer instructs the custodian to liquidate the position, using the proceeds to buy back and burn the corresponding stablecoin units. Off-chain collateralized stablecoins are rare in practice; as of mid-2019, only one initiative of this type, Sweetbridge, was identified.

On-chain Collateralized Stablecoins On-chain collateral consists of crypto-assets recorded directly on the distributed ledger. Because custody can be handled

by the smart contract itself, the arrangement can operate without any central institution, placing it closer to the decentralized end of the “crypto cube.” MakerDAO’s Dai, which pegs to the USD and uses Ether as collateral, is the leading example. Given the high price correlation among crypto-assets and the extreme volatility of Ether (which fell 92% from its all-time high during the period studied), MakerDAO maintained an aggregate collateralization ratio of approximately 300% in 2018, with the ratio never falling below 215%.¹⁰ The daily maximum deviation of Dai from its USD peg was 6.5 U.S. cents over the period December 2017 to July 2019, with deviations below 1 cent observed on 76% of trading days; historical volatility was 28%. Governance of the initiative rests with holders of a secondary token, MKR, who vote on risk parameters and bear indirect liability for funding shortfalls through dilution of their token holdings.

Algorithmic Stablecoins

Algorithmic stablecoins carry no backing assets. Their price is meant to remain near par solely through the smart contract’s management of token supply: new units are issued when demand exceeds supply, and units are withdrawn from circulation when supply is excessive, either by selling secondary tokens in exchange for stablecoins or by drawing on accumulated fee reserves. No entity is accountable for the outcome; the mechanism is entirely self-contained.

Proponents describe this arrangement as an “algorithmic central bank” capable of implementing a publicly auditable monetary rule. The ECB paper questions this characterization on two grounds. First, a central bank’s value derives from its capacity to respond to unobservable shocks and to revise its instruments as circumstances change; a smart contract executes a fixed algorithm that cannot easily adapt to novel contingencies. Second, altering the algorithm to reflect changed conditions would require users to understand complex technical tradeoffs and reach consensus, a process that has proven difficult even for simple governance decisions in unrestricted DLT networks.

NuBits, launched in 2014, is the oldest algorithmic stablecoin. It survived a temporary loss of confidence in June 2016 but permanently lost its USD peg in March 2018; its market value subsequently fell to €0.05 per unit. Historical volatility in the functional period preceding the permanent peg failure was 37%. More broadly, of the eleven active algorithmic stablecoin initiatives identified

¹⁰ *Id.*

by the authors, only two were operational at the time of writing, compared to seven of twelve on-chain collateralized initiatives, with a combined peak market capitalization of only €60 million against €106 million for the latter group.¹¹

Secondary Stability Mechanisms

Most stablecoin initiatives supplement their primary mechanism with secondary tools that can be deployed when the stablecoin trades away from par. These secondary mechanisms vary in nature and by stablecoin type.

Fee reserves are a common tool: transaction fees are collected by the smart contract over time and used to purchase stablecoins from the market when excess supply drives the price below par. Governance tokens are secondary units whose sale generates additional reserves and whose holders receive voting rights over the stablecoin's operating parameters, creating a class of participants with both a financial interest in stability and formal authority over the mechanism. Staking allows users to lock circulating tokens temporarily, contracting supply without permanent redemption. Redemption limits cap the rate of conversion into reserve assets, limiting the speed at which a loss of confidence can drain reserves. Kill switches allow operations to be suspended and collateral liquidated to holders if recovery becomes infeasible. Price bands formalize a tolerance for limited deviations from par, activating the stabilization mechanism only when the stablecoin price moves beyond a defined threshold.

More complex configurations arise from combinations of these tools. Hybrid stablecoins may draw on both off-chain and on-chain collateral, inheriting custodian requirements from the former while retaining programmable liquidation from the latter. Morphing stablecoins may begin as tokenized funds and transition to algorithmic operation, though in such cases central governance of the smart contract typically remains.

Stablecoins and New Technical Infrastructures

The classification exercise in the ECB paper makes explicit a distinction that the public discussion on stablecoins often blurs: many projects labelled as stablecoins are not new types of assets but new uses of DLT as payment and settlement infrastructure. Tokenized funds, in particular, do not create new money; they

¹¹ *Id.*

record existing currency units on a distributed ledger rather than in a traditional account system. When a consortium of credit institutions uses a shared DLT network to clear interbank payments, the innovation is in the infrastructure layer, not in the nature of the assets transferred.¹²

The distinction carries regulatory consequences. Applying the oversight framework designed for new asset classes to what is in substance an infrastructure upgrade risks misallocating supervisory resources and may impede the adoption of technology-neutral arrangements capable of improving payment efficiency. The paper also identifies a tendency toward the “platformification” of payment infrastructure: technology providers increasingly offer DLT platforms as a service layer on which issuers of different stablecoin types may build, standardizing technical standards while preserving competition at the issuance level. Whether such architectures promote interoperability or produce fragmentation depends substantially on the governance of the shared platform and the degree to which technical standards are open to competing participants.

2.2.4 Regulatory Framework

The European Union: the Markets in Crypto-Assets Regulation

Regulation (EU) 2023/1114 on markets in crypto-assets (MiCAR) was published in the Official Journal on June 9, 2023, with stablecoin-specific provisions effective from June 30, 2024. It is the first comprehensive and directly applicable crypto-asset regulatory framework adopted across a multi-state jurisdiction.¹³

MiCAR avoids the term “stablecoin” and creates two distinct categories. E-money tokens (EMTs) reference a single official currency; they must be issued by credit institutions or electronic money institutions and are integrated into the existing Electronic Money Directive regime. Asset-referenced tokens (ARTs) reference a basket of currencies, commodities, or other assets. ART issuers must obtain authorization from a national competent authority, maintain diversified and segregated reserves, publish an approved white paper, and are prohibited from paying any form of interest to holders.¹⁴ ARTs meeting at least three of the seven

¹² *Id.*

¹³ See Annunziata, Filippo, An Overview of the Markets in Crypto-Assets Regulation (MiCAR), 2023, available at <https://ssrn.com/abstract=4660379>.

¹⁴ See Annunziata, Filippo, Crypto-Asset and Stablecoin Regulation: A Comparative Analysis of MiCAR, the United States GENIUS Act, and the UK Regulatory Framework, 2026, available at <https://ssrn.com/abstract=6459583>.

criteria in Article 43(1), among them more than ten million holders and a value of tokens issued, market capitalization, or reserve of assets above five billion euros, are classified as significant by the European Banking Authority (EBA) and fall under its direct supervision rather than that of national competent authorities.¹⁵

MiCAR contains no third-country passporting provisions. Issuers outside the Union wishing to offer tokens to EU holders must comply with EU requirements in full, an approach Annunziata describes as an attempt to produce a “Brussels effect” in crypto-asset markets by establishing EU rules as the standard to which internationally active issuers must conform.¹⁶

The United States: the GENIUS Act

Prior to 2025, the United States had no dedicated federal stablecoin framework. Regulatory authority was divided among the Securities and Exchange Commission (SEC), the Commodity Futures Trading Commission, the Office of the Comptroller of the Currency, the Federal Reserve, and state regulators, and the SEC pursued a strategy of case-by-case “regulation by enforcement.” The GENIUS Act (Public Law 119-27), signed on July 18, 2025, establishes a dual federal and state framework for “payment stablecoins,” defined as digital assets used for payment or settlement that the issuer must redeem at a fixed monetary value and that maintain a stable value relative to a fixed amount of monetary value.¹⁷ Section 17 of the Act removes payment stablecoins issued by permitted issuers from the statutory definitions of “security” and “commodity,” resolving a long-standing classification dispute by statute rather than case law.

Permitted issuers must hold reserves on a one-to-one basis in a restricted list of high-quality liquid assets: cash and Federal Reserve balances, Treasury bills with remaining maturity of up to 93 days, overnight repurchase agreements backed by qualifying Treasuries, government money market fund shares, and tokenized versions of certain of these assets.¹⁸ Rehypothecation of reserves is prohibited

¹⁵ See European Parliament and Council of the European Union, Regulation (EU) 2023/1114 on Markets in Crypto-Assets (MiCAR), 2023, available at <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R1114>.

¹⁶ See Annunziata, Filippo, An Overview of the Markets in Crypto-Assets Regulation (MiCAR), 2023, available at <https://ssrn.com/abstract=4660379>.

¹⁷ See Ahmed, Rashad et al., Stablecoins: A Revolutionary Payment Technology with Financial Risks, 2025, available at <https://www.nber.org/papers/w34475>.

¹⁸ See Annunziata, Filippo, Crypto-Asset and Stablecoin Regulation: A Comparative Analysis of MiCAR, the United States GENIUS Act, and the UK Regulatory Framework, 2026, available at <https://ssrn.com/abstract=6459583>.

except for limited operational purposes, and all forms of interest or yield payments to holders are banned. As of mid-2025, USDT, the largest stablecoin by market capitalization at between roughly 150 and 160 billion U.S. dollars, was not GENIUS-compliant because its reserves included bitcoin, gold, and non-USD sovereign debt.¹⁹

Issuers fall into one of three permitted categories: subsidiaries of insured depository institutions approved by the parent's primary federal banking regulator; federally licensed nonbank entities approved by the Comptroller of the Currency; and state-qualified issuers operating under regimes certified as substantially similar to the federal requirements. State-qualified issuers reaching ten billion U.S. dollars in outstanding issuance must transition to joint federal and state supervision within 360 days or halt new issuance. Section 11 provides stablecoin holders with a ratable priority claim on required reserves ranking ahead of all other creditors in insolvency.²⁰

The United Kingdom: Integration into the FSMA Framework

Rather than enacting a standalone framework, the United Kingdom has incorporated crypto-asset regulation into its existing Financial Services and Markets Act (FSMA) architecture, applying established regulatory structures to new technological contexts rather than building a separate body of law.²¹ The Financial Services and Markets Act 2000 (Cryptoassets) Regulations 2026 (SI 2026/102), coming into force on October 25, 2027, requires Financial Conduct Authority (FCA) authorization for stablecoin issuance.

A “qualifying stablecoin” is limited to fiat-referenced instruments backed by actual assets; basket-referenced and commodity-backed tokens are excluded. This narrows the U.K. perimeter relative to MiCAR’s ART category and aligns it more closely with the GENIUS Act’s payment stablecoin concept. Issuers must maintain a backing pool equal in value to all tokens in issuance. Core assets, consisting of on-demand bank deposits and sovereign debt maturing within one year, form the default; a minimum five percent must be immediately on-demand deposits under the On-Demand Deposit Requirement. Issuers using an expanded

¹⁹ See Ahmed, Rashad et al., *Stablecoins: A Revolutionary Payment Technology with Financial Risks*, 2025, available at <https://www.nber.org/papers/w34475>.

²⁰ See Annunziata, Filippo, *Crypto-Asset and Stablecoin Regulation: A Comparative Analysis of MiCAR, the United States GENIUS Act, and the UK Regulatory Framework*, 2026, available at <https://ssrn.com/abstract=6459583>.

²¹ *Id.*

asset range must continuously recalculate a Backing Asset Composition Ratio based on their own redemption stress modelling, an approach more dynamic than MiCAR’s static composition rules.²² Systemically important qualifying stablecoins fall under Bank of England oversight rather than the FCA.

Convergences and Divergences

All three frameworks share baseline features: a prohibition on interest payments to holders, a one-to-one reserve backing requirement, anti-money laundering obligations applicable to issuers, and a clear separation between stablecoins and bank deposits.²³

On scope, MiCAR regulates basket-referenced ARTs; the U.K. and the GENIUS Act both limit their perimeters to fiat-referenced instruments. Algorithmic stablecoins cannot satisfy the reserve backing requirements of any of the three frameworks in their current form, although the GENIUS Act defers formal treatment through a directed study of “endogenously collateralized” stablecoins rather than an outright prohibition.

Reserve composition differs across jurisdictions. MiCAR requires a minimum fraction of ART reserves in bank deposits, privileging established credit institutions as custodians. The GENIUS Act restricts reserves to a narrower High-quality liquid assets (HQLA) menu without a minimum deposit share, favoring near-sovereign assets over bank intermediation.²⁴ The U.K. imposes a stress-modelled ratio calibrated to each issuer’s own redemption history.

The supervisory architectures reflect different institutional choices about the governance of private digital money. The EU concentrates oversight of significant tokens in the EBA, removing it from national competition. The U.S. preserves a dual federal and state structure with a size threshold determining supervisory mix. The U.K. separates conduct regulation (FCA) from systemic risk oversight (Bank of England), maintaining central bank primacy over financial stability.²⁵

²² *Id.*

²³ See Ostercamp, Pierre, Stablecoin Regulation: EU, UK and US Perspectives, 2022, available at <https://ssrn.com/abstract=4038843>.

²⁴ See Ahmed, Rashad et al., Stablecoins: A Revolutionary Payment Technology with Financial Risks, 2025, available at <https://www.nber.org/papers/w34475>.

²⁵ See Martino, Edoardo D., Comparative Cryptocurrencies and Stablecoins Regulation: A Framework for a Functional Comparative Analysis, 2023, available at <https://ssrn.com/abstract=4500090>. See also Annunziata, Filippo, Crypto-Asset and Stablecoin Regulation: A Comparative Analysis of MiCAR, the United States GENIUS Act, and the UK Regulatory Framework, 2026, available at <https://ssrn.com/abstract=6459583>.

On the distinction between crypto-asset and stablecoin regulation, all three jurisdictions apply stricter prudential requirements to stablecoins than to unbacked crypto-assets, on the basis that stablecoins' liquidity and safety promises generate banking-like run risk that disclosure rules alone cannot address.²⁶

2.3 Single-Currency Peg vs. Currency Basket Peg

2.3.1 Peg and Depeg Analysis

A stablecoin peg is not simply a price promise: it is a dynamic equilibrium that must be actively maintained against demand fluctuations by an issuer with both the means and the incentive to do so. The conditions under which that equilibrium holds, and the circumstances under which it breaks, are the subject of this section.

A Theoretical Framework for Peg Stability

D'Avernas, Maurin, and Vandeweyer develop a continuous-time model of a monopolist stablecoin platform to characterize the conditions under which pegs can be maintained and the mechanisms by which they collapse.²⁷ In the model, users enjoy a convenience yield from holding stablecoins, but only when the price is pegged to the reference currency. The platform earns seigniorage revenues from this convenience yield and adjusts the supply of stablecoins to sustain the peg. Because stablecoin dividends depend on the price being pegged, a zero-price equilibrium always exists: stablecoins may be worth nothing even under full algorithmic commitment, for the same reason that fiat money is worth nothing absent shared belief in its value. The peg-sustaining equilibrium, when it exists, is fragile by nature.

In the peg-sustaining equilibrium under full commitment, the platform issues stablecoins when demand rises and buys them back when demand falls, maintaining a target supply ratio. Repurchases are financed by issuing equity tokens to new

²⁶ See Martino, Edoardo D., Comparative Cryptocurrencies and Stablecoins Regulation: A Framework for a Functional Comparative Analysis, 2023, available at <https://ssrn.com/abstract=4500090>. See also Ostercamp, Pierre, Stablecoin Regulation: EU, UK and US Perspectives, 2022, available at <https://ssrn.com/abstract=4038843>.

²⁷ See d'Avernas, Adrien, Vincent Maurin, and Quentin Vandeweyer, Can Stablecoins be Stable?, 2022, available at <https://ssrn.com/abstract=4226027>.

investors, diluting existing holders. For small demand shocks this mechanism works: the platform can always raise enough equity to fund the necessary buyback. After a sufficiently large negative shock, however, the repurchase cost exceeds the present value of future seigniorage revenues that equity holders can rationally expect. No further equity dilution can finance the buyback; the peg breaks. This result establishes that every uncollateralized platform is vulnerable to large demand shocks, regardless of its algorithmic commitment. The collapse of the Terra-Luna platform in May 2022 is the empirical instance of this prediction: by May 12, the protocol had burned approximately eight billion U.S. dollars of Terra stablecoins, minting Luna equity tokens at an exponential rate; Luna's price fell to zero, and Terra's peg was lost permanently.²⁸

Full collateralization resolves this fragility at a cost. When the collateralization ratio equals one, any stablecoin buyback is financed entirely from collateral holdings; limited liability never binds and the peg is always maintained. The cost is the opportunity cost of holding low-yield collateral: the platform earns seigniorage only if the convenience yield users attach to stablecoins exceeds the return differential that the platform forgoes by holding cash, Treasury bills, or bank deposits instead of higher-return assets. The optimal collateralization ratio for an intermediate platform trades off stability benefits against this cost. Numerically, the model shows that higher probabilities of large negative demand shocks shift the optimal ratio upward, and that without collateral a platform cannot exist at all above certain shock intensities.²⁹

A further source of instability, independent of demand shocks, is the platform's incentive to overissue stablecoins even in calm conditions. Without full commitment to its issuance-repurchase policy, the platform faces the durable-good monopolist problem identified by Coase (1972): issuing new tokens today depresses the convenience yield enjoyed by existing holders, but the platform does not internalize this cost at the moment of issuance. The result is a leverage ratchet: the platform systematically overissues and never voluntarily conducts buybacks. Overissuance erodes the convenience yield that sustains the peg, eventually causing it to fail. The paper shows that a state-contingent interest rate rule, coded into the smart contract, can eliminate overissuance: the interest rate the platform pays to holders must increase when demand falls, creating a direct cost from excess supply that incentivizes voluntary repurchases and can achieve local stability even without

²⁸ *Id.*

²⁹ *Id.*

collateral.³⁰

For decentralized platforms such as DAI, issuance is open to any participant who locks sufficient collateral in a smart contract, or vault. Vault owners buy cheap stablecoins from the market when the price falls below par, closing their position and reducing supply in the process. This external arbitrage condition ties the platform's fee and interest rate decisions to market discipline, eliminating its discretion to overissue. The platform's income is transformed from an upfront seigniorage gain into a flow of fees, which removes the time-inconsistency problem in a manner analogous to Coase's leasing solution. Decentralization thus substitutes for algorithmic commitment.³¹

Finally, an existence condition for uncollateralized platforms (Corollary 1) requires that stablecoin demand grow continuously over time at a rate sufficient to cover the interest the platform must pay to maintain the peg. If demand growth stops permanently, equity value falls to zero and the peg collapses. The authors note that this condition matches informal descriptions of algorithmic stablecoins as economically Ponzi-like: not because they are necessarily fraudulent, but because their viability depends on the expectation of uninterrupted demand growth. An unexpected permanent fall in demand growth is sufficient to cause platform failure, irrespective of the algorithmic rule in place.

Empirical Evidence on Peg Deviations

Lyons and Viswanath-Natraj analyze stablecoin peg deviations through the lens of fixed-exchange-rate economics, studying signed-trade and order-book data across multiple stablecoin platforms and exchanges.³² Their empirical work identifies two distinct types of price deviation. Premiums, where the stablecoin trades above par, are driven primarily by safe-haven demand: when broader crypto-asset markets fall sharply, investors move into stablecoins for USD liquidity, bidding the price above parity. During the market stress of March 2020, USDT premiums exceeded 100 basis points as COVID-19 uncertainty triggered this flight. Discounts, where the stablecoin trades below par, reflect liquidity constraints and concerns about reserve adequacy. Across both types of deviation, the paper finds that supply issuance by the platform, the closest analogue to central-bank intervention,

³⁰ *Id.*

³¹ *Id.*

³² See Lyons, Richard K. and Ganesh Viswanath-Natraj, What Keeps Stablecoins Stable?, 2023, available at <https://www.nber.org/papers/w27136>.

played a limited stabilizing role; arbitrage by market participants was the more effective restoring mechanism. Following Tether’s deployment to the Ethereum blockchain in 2019, improved arbitrage access contracted cross-exchange spreads from approximately 70 basis points to 30 basis points.³³

The cross-platform evidence from the May 2022 crash illustrates the empirical force of the theoretical predictions. USDC, a fully collateralized custodial stablecoin, maintained its peg throughout the episode and saw its outstanding supply increase, consistent with flight-to-safety inflows. Tether experienced a temporary depeg but absorbed approximately five billion U.S. dollars in redemptions and reanchored within days, supported by its custodial reserve structure. DAI maintained parity through orderly liquidations of approximately three billion U.S. dollars in collateral without requiring additional governance token issuance. Terra-Luna, the only fully algorithmic platform in the group, collapsed irreversibly, with the twenty billion U.S. dollars of outstanding Terra stablecoin losing its peg within five days and the Luna governance token falling to zero.³⁴ These outcomes map directly onto the theoretical taxonomy: custodial and overcollateralized stablecoins absorbed the shock through reserves and arbitrage, while the algorithmic platform, lacking any asset buffer, could not sustain the buyback chain once equity value reached zero.

2.3.2 Volatility Spillovers and Portfolio Risk

Volatility spillovers describe the transmission of uncertainty across financial markets: a shock originating in one market increases the forecast error variance of another, beyond what that second market’s own history would predict. The concept is well established in the fixed-income and equity literature, but measuring it precisely has long required an identification scheme that dictates how contemporaneous shocks relate to one another. Diebold and Yilmaz address this problem by embedding volatility spillover measurement in a generalized vector autoregressive (VAR) framework in which forecast-error variance decompositions are invariant to variable ordering.³⁵ The approach replaces the Cholesky factorization used in earlier work, which produces order-dependent results, with the generalized variance decomposition of Koop, Pesaran, and Potter (1996) and

³³ *Id.*

³⁴ See d’Avernas, Adrien, Vincent Maurin, and Quentin Vandeweyer, Can Stablecoins be Stable?, 2022, available at <https://ssrn.com/abstract=4226027>.

³⁵ See Diebold, Francis X. and Kamil Yilmaz, Better to Give than to Receive: Predictive Directional Measurement of Volatility Spillovers, 2012, available at <https://ssrn.com/abstract=1536123>.

Pesaran and Shin (1998), which allows for correlated shocks and accounts for them using the historically observed error distribution. The same framework has since been applied to crypto-asset markets by Iyer and Popescu.³⁶

Data and Volatility Estimation

Diebold and Yilmaz apply the framework to four U.S. asset classes: the S&P 500 equity index, the 10-year Treasury bond yield, the New York Board of Trade U.S. dollar index futures, and the Dow-Jones/UBS commodity index. The sample covers January 25, 1999 through January 29, 2010, yielding 2,771 daily observations. Daily volatility for each market i on day t is estimated from high and low prices as:

$$\sigma_{it}^2 = 0.361 \left[\ln P_{it}^{\max} - \ln P_{it}^{\min} \right]^2 \quad (2.1)$$

and annualized to a percentage standard deviation by $\hat{\sigma}_{it} = 100\sqrt{365 \cdot \sigma_{it}^2}$. All VAR estimations use order $p = 4$ and a forecast horizon of $H = 10$ days; the authors verify that both the total spillover index and its directional decompositions are insensitive to alternative choices of VAR order (2 through 6) and horizon (4 through 10 days).

Full-sample and Dynamic Results

Across the entire sample, the total volatility spillover index averages 12.6 percent, meaning that on average roughly one-eighth of each market's forecast error variance originates in shocks from the other three markets rather than from its own innovations. Within this aggregate, the bond market is the largest receiver of volatility from others (18.5 percent of its forecast error variance), followed by the foreign exchange market (14.2 percent). The stock market is the largest net transmitter over the full sample, with its outward directional spillover exceeding its inward one by 5.05 percentage points (16.29 minus 11.24); the foreign exchange market is the principal net receiver, with an inward excess of 2.8 percentage points.³⁷

The full-sample average conceals substantial time-variation. Estimated over rolling

³⁶ See Iyer, Roshan and Adina Popescu, New Evidence on Spillovers Between Crypto Assets and Financial Markets, 2023, available at <https://www.imf.org/en/publications/wp/issues/2023/09/30/new-evidence-on-spillovers-between-crypto-assets-and-financial-markets-539476>.

³⁷ See Diebold, Francis X. and Kamil Yilmaz, Better to Give than to Receive: Predictive Directional Measurement of Volatility Spillovers, 2012, available at <https://ssrn.com/abstract=1536123>.

200-day windows, the total spillover index fluctuates between ten and twenty percent in calm periods, with brief excursions above twenty percent. The first meaningful rise occurred during the technology bubble burst beginning in 2000, when the index climbed from around 13 percent to 20 percent. A second cycle, from mid-2002 to mid-2003, reflected the technology sector's continued contraction and the buildup to the Iraq war; during that period the stock market was a net transmitter to the bond market by close to 3 percent while simultaneously receiving spillovers from the commodity market, consistent with the geopolitical oil price movements of the period. A further rise in mid-2006 followed the Federal Reserve's signal of continued tightening, which elevated bond and foreign exchange volatility and spilled over into equities and commodities.

The most pronounced episode is the global financial crisis of 2007-2009. The total spillover index exceeded thirty percent on two occasions: the first quarter of 2008 (following the Bear Stearns near-failure and the Federal Reserve's emergency rate cut of 75 basis points in January) and the fourth quarter of 2008 (following the collapse of Lehman Brothers in September). Net directional spillovers from the stock market reached approximately three percent in the first episode and approximately seven percent in the second. During the post-Lehman phase, the foreign exchange market absorbed close to five percent of net volatility from equities, with bond and commodity markets also receiving material net inflows. The commodity market itself was a net transmitter in four distinct episodes: 2002, the immediate pre- and post-invasion period in early 2003, late 2004 through 2005 when rising Chinese demand surprised commodity markets, and the second half of 2009 as commodity prices recovered.³⁸

Implications for Basket Reserve Portfolios

For a basket-pegged stablecoin whose reserves hold positions across multiple asset classes, the Diebold-Yilmaz results have concrete implications for reserve risk management. Under normal market conditions, cross-asset volatility spillovers are contained at around ten to fifteen percent of total forecast error variance, and the diversification argument for holding a multi-asset basket holds empirically. The structure breaks down during systemic stress: precisely the asset categories most commonly included in basket reserves, government bonds, foreign exchange positions, and commodity instruments, become jointly more volatile as crisis conditions develop, and the stock market begins transmitting volatility outward

³⁸ *Id.*

at rates several multiples of its calm-period level. Net pairwise decompositions show that individual bilateral relationships shift direction across episodes, so a static asset-weight rule calibrated to normal-period correlations will systematically underestimate tail-period co-movement. A reserve manager defending a basket peg during a crisis faces both falling asset values and rising cross-asset correlations at the same time, compressing the margin available for orderly rebalancing or redemption.

Chapter 3

Data and Sampling

The preceding chapter established the case for pegging a stablecoin to a basket rather than to a single currency, and set out the volatility-spillover mechanism used later to assess how a basket behaves under stress. This chapter turns from theory to data, explaining which currencies enter the reserve basket and why, describes the historical series on which the empirical work rests, and reports a first descriptive benchmark of the candidate baskets against their constituent currencies. A closing section examines the SDR, the currency basket of the International Monetary Fund (IMF), which serves throughout the empirical part as the natural point of comparison for the baskets constructed here.

3.1 Currency Selection and Geopolitical Scenarios

A basket peg is only as sound as the currencies that back it. The selection problem is therefore not a technical detail but a design choice with economic and political content: the currencies must be liquid enough to hold and settle in size,³⁹ widely enough used to be relevant for international payments and remittances,⁴⁰ and representative of the monetary area the instrument is meant to serve. Rather than fix a single basket, this work constructs three, each corresponding to a

³⁹ See Bank for International Settlements, Triennial Central Bank Survey of Foreign Exchange and Over-the-Counter Derivatives Markets in 2022, 2022, available at <https://www.bis.org/statistics/rpfx22.htm>.

⁴⁰ See World Bank, Migration and Development Brief: Remittance Flows to Low- and Middle-Income Countries, 2024, available at <https://www.knomad.org/publication/migration-and-development-brief-40>.

distinct configuration of the international monetary system. The comparison is deliberate; if the same construction method yields a stable basket across very different geopolitical groupings, the result speaks to the robustness of the approach rather than to a fortunate choice of currencies.

3.1.1 Three Geopolitical Configurations

The analysis covers three currency baskets, each composed of five currencies and observed at daily frequency over eleven years, starting from January 1, 2015 to December 31, 2025.

The *Global* basket collects the five most internationally used currencies without regard to political grouping: the USD, the euro (EUR), the Japanese yen (JPY), the pound sterling (GBP), and the Chinese renminbi (CNY), the five that lead the official reserve, foreign exchange turnover and payment-share rankings.⁴¹ These are, by construction, the five currencies that also make up the SDR, which makes the Global basket the most direct counterpart to the Fund's benchmark.

The *NATO* basket restricts the perimeter to the currencies of NATO member states. It comprises the USD, the EUR, the GBP, the JPY (Japan, although not a formal NATO member, is treated as a strategic partner of the alliance), and the Canadian dollar (CAD). This grouping isolates the behavior of a basket drawn entirely from mature, freely convertible currencies issued by economies with closely coordinated monetary and financial policies.

The *BRICS* basket covers the leading emerging-market economies: the CNY, the Indian rupee (INR), the Brazilian real (BRL), the Russian ruble (RUB), and the South African rand (ZAR). These currencies are more volatile, less freely convertible, and more exposed to capital controls and sanctions than their advanced-economy counterparts. The BRICS basket therefore functions as a stress case, and the sample supplies a real one. It spans the collapse of the RUB in early 2022, when Russia's invasion of Ukraine and the sanctions that followed cut the currency's external value sharply within a few weeks. A single constituent losing much of its value in near isolation is close to the hardest test the diversification argument can face. If the basket still dampens volatility across an episode of that

⁴¹ See International Monetary Fund, Currency Composition of Official Foreign Exchange Reserves (COFER), 2025, available at <https://data.imf.org/cofer>. See also SWIFT, RMB Tracker: Monthly Reporting and Statistics on Renminbi Progress Towards Becoming an International Currency, 2025, available at <https://www.swift.com/our-solutions/compliance-and-shared-services/business-intelligence/renminbi/rmb-tracker>.

severity, the argument is on its strongest footing.

3.1.2 A Note on Geopolitical Fragmentation

The three baskets are not merely three samples; they map onto a real fault line in the international monetary system. The advanced-economy currencies share deep, open capital markets and a long record of convertibility, and their central banks operate within a dense web of swap lines and supervisory cooperation. The emerging-market currencies do not share these features to the same degree. Several are managed against the USD within official bands, most notably the CNY, whose onshore and offshore rates can diverge under capital controls; others, such as the RUB, have been subject to financial sanctions that at times cut them off from the USD and EUR settlement systems altogether.

These differences are not incidental to a basket stablecoin: they are the reason its geography matters. A basket weighted towards convertible reserve currencies inherits their stability but also their concentration around the USD, since the EUR, JPY, and GBP tend to move together against it. A basket weighted towards emerging-market currencies gains genuine diversification, because those currencies are driven by more idiosyncratic domestic factors, but pays for it in higher average volatility and in the political risk that convertibility may be restricted at short notice. The BRICS grouping has itself advanced proposals for settlement in local currencies and for reduced reliance on the USD, which gives the third basket a policy relevance beyond the purely statistical. Constructing all three, and comparing them against a common benchmark, keeps the design honest about these trade-offs rather than assuming them away.

3.2 Data and Sampling Design

The empirical work uses daily exchange rates for the currencies in each basket, each quoted against the USD and sourced from Bloomberg. The window is long enough to contain both calm and turbulent regimes, and it brackets the events that any candidate reserve basket must be able to survive: the CNY devaluation and the commodity slump of 2015 and 2016, the market dislocation of the COVID-19 shock in early 2020, the inflation and monetary tightening cycle of 2022, and the sanctions and currency stress that followed the same year. A sample confined to tranquil years would flatter any diversification strategy; the deliberate inclusion

of crisis episodes is what allows the later chapters to test whether a basket holds when it matters.

For each basket the data give each of the five currencies' rate against the USD at every date, from which the full set of bilateral rates among them follows as simple ratios. The USD is only the common quotation unit here, not a privileged one: shared by all five series, it cancels when the rates are taken relative to one another, and the numeraire-free measure the next chapter derives removes it entirely, so the basket index does not inherit a bias from the choice of reference currency. This matters precisely because the USD's role as the default unit of account is one of the features the analysis seeks to relax. Missing observations from national holidays that fall on different days across markets are handled by carrying forward the last available quotation, and returns are computed as daily log differences, the standard transformation for financial series and the one used consistently throughout the thesis.

3.3 Preliminary Benchmark

Before any optimization, the candidate currencies are benchmarked against one another with a set of standard descriptive measures, computed on the same daily series and reported for each basket. The purpose is diagnostic: to see how the individual currencies behave, how they co-move, and whether the raw material for diversification is present, before weights are ever assigned.

Two features emerge consistently across the three baskets and motivate the methodology that follows. First, the advanced-economy currencies are markedly less volatile than the emerging-market ones, and their rolling volatility spikes in the same episodes, in early 2020 above all, which shows that averaging alone does not remove crisis risk. Second, correlations are far from one and shift over time, which is exactly the condition under which a variance-minimizing combination can outperform any single currency. This descriptive result is consistent with the peg and depeg mechanics reviewed earlier: a claim that trades at a stable value must be backed by something whose value does not move in lockstep with the shocks it is meant to withstand.

3.4 The Special Drawing Right

Every basket constructed in this thesis is measured against a single external reference. The SDR is not a stablecoin, and it is not a currency in the ordinary sense, but it is the longest-standing official example of a value defined by a basket of currencies, and its design choices throw the choices made here into relief.

3.4.1 Definition and Purpose

The SDR is an international reserve asset created by the International Monetary Fund in 1969 to supplement the official reserves of its member countries.⁴² It is not money that can be spent directly and it is not a claim on the Fund itself; rather, it is a potential claim on the freely usable currencies of IMF members. A holder in need of foreign exchange can exchange SDRs for such currencies with other members, either by voluntary agreement or under Fund arrangements. SDRs are allocated to members in proportion to their quotas, and the largest general allocation, equivalent to about 650 billion U.S. dollars, was made in 2021 to help member economies meet the liquidity strain of the pandemic.⁴³ The unit also serves as the unit of account of the IMF and of several other international organizations.

3.4.2 Valuation and the Currency Basket

The value of the SDR is defined by a basket of currencies rather than by any single one. Since the last review took effect, the basket has comprised five currencies: the USD, the EUR, the CNY, the JPY, and the GBP.⁴⁴ Each day the Fund sets the value of one SDR as the sum of fixed quantities of these five currencies, converted into U.S. dollars at prevailing market exchange rates. Because the currency amounts are fixed between reviews while exchange rates move, the effective weight of each currency in the basket drifts from day to day, rising when a currency appreciates and falling when it depreciates. This is the same mechanism, a fixed

⁴² See International Monetary Fund, Special Drawing Rights (SDR): What is the SDR?, 2023, available at <https://www.imf.org/en/about/factsheets/sheets/2023/special-drawing-rights-sdr>.

⁴³ See International Monetary Fund, Questions and Answers on Special Drawing Rights, 2021, available at <https://www.imf.org/en/about/faq/special-drawing-right>.

⁴⁴ See International Monetary Fund, Special Drawing Rights (SDR): What is the SDR?, 2023, available at <https://www.imf.org/en/about/factsheets/sheets/2023/special-drawing-rights-sdr>.

quantity of each constituent whose relative weight then floats with the market, that any basket peg must confront, and it is why the empirical work distinguishes carefully between the quantities that are held and the weights they imply.

3.4.3 Weight Determination and Periodic Review

The Fund reviews the composition of the basket, in normal circumstances every five years, to ensure that it reflects the relative importance of currencies in the world's trading and financial systems.⁴⁵ A currency qualifies for inclusion if it is issued by a member, or monetary union, that is among the largest exporters and if the Fund has determined it to be freely usable, meaning widely used to make payments for international transactions and widely traded in the principal exchange markets. The weight assigned to each qualifying currency is then built from indicators of the issuer's exports and of the currency's role in official reserves, foreign exchange turnover, and international banking and debt. Under the weights fixed at the most recent review, the USD carries about 43.4 percent of the basket, the EUR about 29.3 percent, the CNY about 12.3 percent, the JPY 7.6 percent, and the GBP 7.4 per cent.⁴⁶ The interest rate on the SDR, used to charge and remunerate members on their positions, is likewise derived from the basket, as a weighted average of short-term rates on instruments in the five constituent currencies.⁴⁷

3.4.4 The SDR as a Benchmark and its Limits

The SDR is the right yardstick for this thesis because it answers the same question, how to define a stable value from several currencies, with the full authority of an official institution behind it. It is also, for the same reason, a revealing contrast. The SDR weights are the product of a periodic administrative judgement about the relative importance of national economies, based on exports and reserve use and settled through the Fund's governance. They are, in a precise sense, political: they encode a view of which economies matter and by how much, and they change only at scheduled reviews, several years apart. The baskets constructed in this thesis are determined differently. Their weights come from minimizing the variance

⁴⁵ *Id.*

⁴⁶ *Id.*

⁴⁷ See International Monetary Fund, Questions and Answers on Special Drawing Rights, 2021, available at <https://www.imf.org/en/about/faq/special-drawing-right>.

of the basket's value over the sample, subject only to the requirements that the weights be non-negative and sum to one. No judgement about the standing of any economy enters the calculation; the same data and the same objective would yield the same weights in any hands. This difference, between a benchmark whose composition is negotiated and one whose composition is computed, is the conceptual axis of the empirical chapters, and it is why the SDR is present at every stage of the comparison that follows. Because the five SDR currencies coincide with the Global basket, the two can be placed side by side directly, so that the cost or benefit of replacing an export-and-reserve weighting with a variance-minimizing one can be read off the data rather than argued in the abstract.

Chapter 4

The Basket-Based Stablecoins Construction

4.1 The RNVAL Methodology

A currency's value in exchange cannot be observed directly. What is observed is a rate, an amount of one currency per unit of another, so every time series of currency values carries the numeraire in which it was quoted. That choice is not innocuous. On monthly data for 1981 to 1998, Hovanov, Kolari and Sokolov report a correlation of $+0.75$ between the reduced values of the French franc and the JPY when the USD serves as base currency, and -0.69 between the same two currencies when the German mark does.⁴⁸ The observations are identical. Only the numeraire changed. A minimum variance basket estimated on such series inherits the problem at its root, since the covariance matrix that determines the weights is itself a function of an arbitrary choice. The construction has already been applied to a basket-based stablecoin by Pagnottoni, whose treatment is the closest antecedent to the one developed here.⁴⁹

The construction proceeds from a simple exchange model. Let $G = \{g_1, \dots, g_n\}$ be a fixed finite set of infinitely divisible goods, here currencies, and let the positive coefficient c_{ij} give the amount of currency j obtained for one unit of currency i . The exchange matrix $C = (c_{ij})$ and the set G define a simple market. One

⁴⁸ See Hovanov, Nikolai V., James W. Kolari, and Mikhail V. Sokolov, Computing Currency Invariant Indices with an Application to Minimum Variance Currency Baskets, 2004, available at [https://doi.org/10.1016/S0165-1889\(02\)00087-8](https://doi.org/10.1016/S0165-1889(02)00087-8).

⁴⁹ See Pagnottoni, Paolo, Network Connectedness and Financial Technologies: from Systemic Risk to Investment Management, 2020.

restriction is imposed on C , transitivity: $c_{ij}c_{jk} = c_{ik}$ for all $i, j, k = 1, \dots, n$. Transitivity rules out arbitrage between different parts of the market. It also forces $c_{ii} = 1$ and $c_{ji} = 1/c_{ij}$, makes every column of C proportional to every other, and reduces the rank of C to one. It is necessary and sufficient for the elements of C to admit the representation $c_{ij} = \text{Val}([u_i])/\text{Val}([u_j])$, in which $\text{Val}([u_i])$ is the unobservable value in exchange of one unit $[u_i]$ of currency i . An observed rate is a ratio of two unobservable values. Estimating those values by the j th column of C sets $\text{Val}([u_j]) = c_{jj} = 1$ and makes currency j the numeraire, which is the source of the dependence described above.

Value in exchange is measured on a ratio scale, hence determined only up to a positive factor e . Fixing e as the inverse of the geometric mean of the j th column produces the normalized value in exchange

$$\text{NVal}_{ij} = e \text{Val}_{ij} = \frac{c_{ij}}{(\prod_{r=1}^n c_{rj})^{1/n}}, \quad (4.1)$$

which is sufficient for independence from the base currency: $\text{NVal}_{ij} = \text{NVal}_{il}$ for every pair j, l , so the second subscript is dropped and the invariant currency value index is written NVal_i . The numeraire is not abolished but replaced. The new unit of account is the basket of all n currencies, valued at their geometric mean, and it lies outside G . No currency in G is privileged, because the standard is not one of them.

When every currency is quoted against one common numeraire at prices $P_i(t)$, the exchange matrix follows as $c_{ij}(t) = P_i(t)/P_j(t)$ and is transitive by construction. Substituting into equation (4.1) cancels the common numeraire and gives

$$\text{NVal}_i(t) = \frac{P_i(t)}{(\prod_{r=1}^n P_r(t))^{1/n}}, \quad (4.2)$$

so that the column normalization coincides with the geometric mean taken along row i of C . The identity $\prod_{i=1}^n \text{NVal}_i(t) = 1$ holds at every date and serves as a computational check.

Empirical use requires a common origin. Dividing by the value at a base date t_0 chosen by the investigator gives the RNVAl equation:

$$\text{RNVal}_i(t/t_0) = \frac{\text{NVal}_i(t)}{\text{NVal}_i(t_0)}, \quad (4.3)$$

with $\text{RNVal}_i(t_0/t_0) = 1$ for every i . Reduction rescales each series without

disturbing the invariance, and the product identity survives: $\prod_{i=1}^n \text{RNVal}_i(t/t_0) = 1$ at every t .

An aggregate currency $\text{AC}(q) = \{q_1[u_1], \dots, q_n[u_n]\}$ is a basket holding $q_i \geq 0$ units of currency i .

Taking logarithms of that identity gives $\sum_{i=1}^n \ln \text{RNVal}_i(t/t_0) = 0$ at every date, so the covariance matrix has rank $n - 1$ and the off-diagonal covariances sum to the negative of the total own variance. Aggregate negative co-movement is in this sense imposed by the geometric-mean normalization rather than observed in the market, and the currency with the largest own variance is the one that will appear as the offsetting leg. The same rank deficiency leaves the objective nearly flat around its minimum, which is why the solution is interior and close to equal weight in all three baskets, with an effective number of currencies between 4.90 and 4.97; both properties are the price of numeraire invariance. The variance minimized here is therefore variance measured against the basket itself.

If its value in exchange is the sum of the values of its components, its own RNVAl is the weighted arithmetic mean

$$\text{Ind}(w, t) = \sum_{i=1}^n w_i \text{RNVal}_i(t/t_0) = \text{RNVal}(\text{AC}(q), t/t_0), \quad (4.4)$$

whose weights

$$w_i = \frac{q_i c_{ij}(t_0)}{\sum_{r=1}^n q_r c_{rj}(t_0)}, \quad w_i \geq 0, \quad \sum_{i=1}^n w_i = 1, \quad (4.5)$$

are the share of each currency in the basket's value at t_0 . The index is therefore not an arithmetic average adopted for convenience. It is the invariant value of a holding that can be specified in units.

Volatility of the basket is measured by the variance of the index about its own time mean over the period $[1, T]$, which expands into a quadratic form in the weights:

$$S^2(w) = \frac{1}{T} \sum_{t=1}^T [\text{Ind}(w, t) - \text{MInd}(w)]^2 = \sum_{i,k=1}^n w_i w_k \text{cov}(i, k). \quad (4.6)$$

Here $\text{MInd}(w)$ is the mean of $\text{Ind}(w, t)$ over the period and $\text{cov}(i, k)$ is the covariance between the series $\text{RNVal}_i(t/t_0)$ and $\text{RNVal}_k(t/t_0)$. The optimal vector w^* minimizes $S^2(w)$ subject to $w_i \geq 0$ and $\sum_i w_i = 1$. The objective is defined on

the level of the index rather than on its returns, so $\text{cov}(i, k)$ is the covariance of the level series. This departs from mean-variance portfolio theory on two counts: no expected return enters the objective, and no constraint fixes one. The problem is a quadratic form under linear constraints and is solved numerically.

The solution w^* is a vector of pure numbers, while a reserve is a vector of quantities. The two are linked by

$$q_i^* = \frac{w_i^*}{c_{ij}(t_0)} r, \quad (4.7)$$

where r is an arbitrary positive constant setting the scale of one basket unit, so that $r = 1$ makes one unit of the basket worth one unit of currency j at t_0 . Any q^* with components proportional to $w_i^*/c_{ij}(t_0)$ is optimal and defines the stable aggregate currency $\text{AC}^* = \text{AC}(q^*)$, whose value is the minimum variance series $\text{Ind}(w^*, t) = \text{RNVal}(\text{AC}^*, t/t_0)$. Equation (4.7) converts an index into a holdable claim. The vector q^* states how many units of each currency the reserve must contain, and $\text{RNVal}(\text{AC}^*, t/t_0)$ states what one unit of that reserve is worth at any date, measured against no national currency in particular.

4.2 The Global Basket

The Global coin is estimated on three weight vectors compared. The equal-weight vector assigns 1/5 to each currency and serves as the naive reference. The IMF SDR vector uses the Fund's official basket shares, renormalized to sum to one, and stands in for an externally chosen benchmark of the same five currencies. The minimum-variance vector solves

$$w^* = \arg \min_w w^\top \Sigma_{\text{lev}} w \quad \text{s.t.} \quad \sum_i w_i = 1, \quad 0 \leq w_i \leq 1,$$

where Σ_{lev} is the sample covariance of the RNVAl level series. The program is convex, since Σ_{lev} is positive semidefinite and the constraints are linear, so any local minimum is global. It is solved by sequential least squares programming from eighteen starting points, all of which converged to the same optimum.

	Equal (1/N)	IMF SDR	Minimum variance
USD	20.00	43.38	17.61
EUR	20.00	29.31	20.20
GBP	20.00	7.44	21.11
JPY	20.00	7.59	19.08
CNY	20.00	12.28	22.00
Basket	100.00	100.00	100.00

Table 4.1: Allocation weights (%)

The allocations shown in Table 4.1 reflect a cost: the SDR allocation has an RIVAL-level standard deviation of 2.28×10^{-2} , against 1.67×10^{-3} for equal weight and 7.64×10^{-4} for the minimum-variance vector. The optimized coin is the least volatile of the three by a wide margin, and the analysis below uses it.

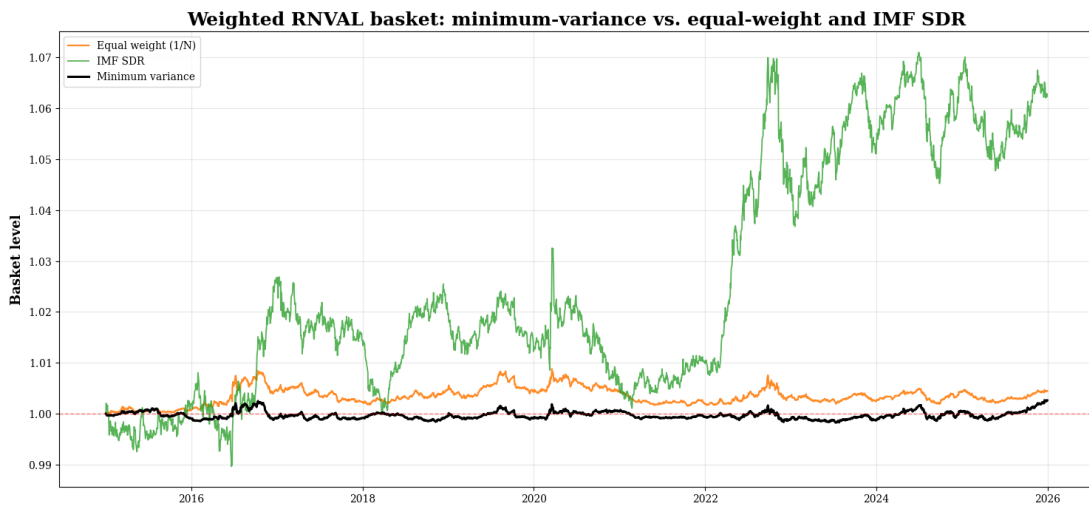


Figure 4.1: The three weighted RIVAL baskets over the full sample: equal weight, IMF SDR shares, and minimum variance. Note the magnified vertical axis, which runs from 0.99 to 1.07.

Figure 4.1 compares the three allocations on a magnified axis from 0.99 to 1.07. The SDR basket drifts up to about 1.07, because its 43 percent USD share carries the USD’s post-2022 appreciation into the basket. Equal weight holds near 1.005 with a mild positive slope. The allocation that stays nearest one across the whole sample is the minimum variance basket, which is the reason it is used for the coin.

Coin-level Metrics

Table 4.2 reports, for each currency and for the optimized basket, the annualized volatility and mean return of the RIVAL log-return series, the Sharpe ratio at a

zero risk-free rate, and the risk contribution (RC) inside the minimum-variance basket. Returns are measured against the RIVAL numeraire (e.g. a mean of +0.99 percent for the USD means its invariant value rose about one percent a year relative to the geometric mean of the five currencies).

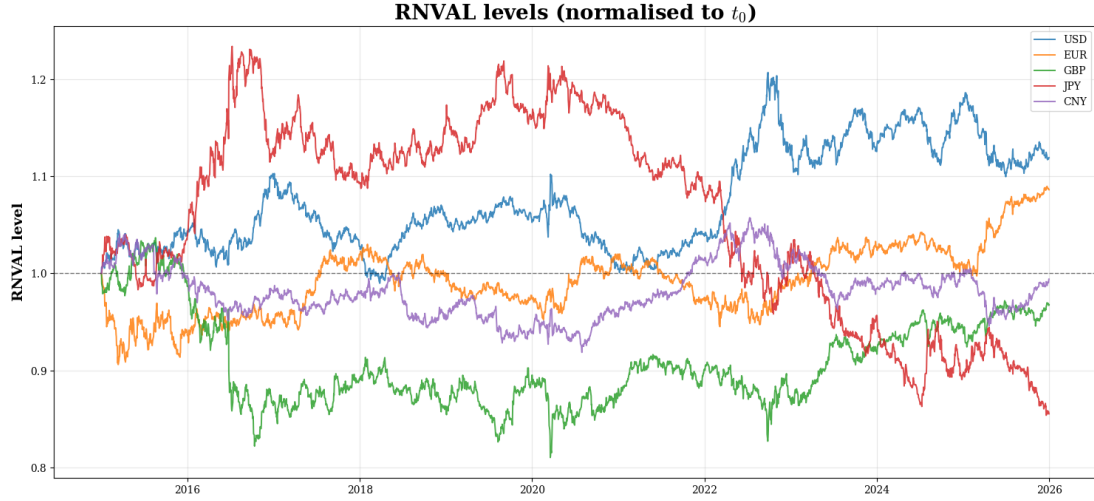


Figure 4.2: The five RIVAL level series, each normalized to one at the base date in January 2015.

	Ann. vol. (%)	Mean ret. (%)	Sharpe	Risk contr. (%)
USD	4.52	+0.99	0.219	17.6
EUR	4.68	+0.73	0.155	20.2
GBP	6.22	−0.29	−0.047	21.1
JPY	6.63	−1.37	−0.207	19.1
CNY	4.15	−0.05	−0.013	22.0
Basket	0.206	+0.02	0.111	100.0

Table 4.2: RIVAL coin metrics over the full sample. Volatility, mean return and Sharpe are return-based and annualized; RC is within the minimum-variance basket.

RC measures the share of basket risk attributable to each currency, accounting for both its weight and its covariance with the rest. Write the basket standard deviation as $\sigma_p = \sqrt{w^\top \Sigma_{\text{lev}} w}$. The marginal risk contribution (MRC) of currency i is the partial derivative $\text{MRC}_i = \partial \sigma_p / \partial w_i = (\Sigma_{\text{lev}} w)_i / \sigma_p$, and its component contribution is $\text{RC}_i = w_i \text{MRC}_i$. Because σ_p is homogeneous of degree one in the weights, the component contributions sum to σ_p by Euler's theorem, and the reported percentage is RC_i / σ_p . A negative value would mark a currency that hedges the basket, one whose covariance with the whole is negative. None of the five does at the optimum. The RCs in Table 4.2 equal the weights almost exactly.

That equality is the optimality condition of the global minimum-variance portfolio: the marginal contributions are all identical, at 7.64×10^{-4} , so no reallocation can lower σ_p . The JPY is the point worth noting. It carries the highest standalone level variance, 1.02×10^{-2} , roughly fourteen times the CNY's, yet the optimizer keeps it at 19 percent rather than pushing it down, because its co-movement with the other four offsets its own variability.

Correlation Structure

The reason the JPY can be volatile on its own and still earn a near-equal weight is in the correlation matrix of the RIVAL levels as shown in Table 4.3. This matrix is meaningful in a way a raw exchange-rate correlation is not. Correlations computed from rates quoted against a base currency change with the base: in the same five-currency setting, the franc and the JPY correlate at +0.75 under a USD numeraire and at -0.69 under a mark numeraire, as already described above. The RIVAL series carry no base currency, so their correlations measure co-movement in world value rather than co-movement induced by a shared denominator.

	USD	EUR	GBP	JPY	CNY
USD	1.000	0.394	0.041	-0.712	0.259
EUR	0.394	1.000	0.038	-0.490	-0.259
GBP	0.041	0.038	1.000	-0.650	0.379
JPY	-0.712	-0.490	-0.650	1.000	-0.522
CNY	0.259	-0.259	0.379	-0.522	1.000

Table 4.3: Correlation matrix of the RIVAL level series, full sample.

Positive association among the currencies is weak. The largest positive entries are the USD with the EUR at +0.39 and the GBP with the CNY at +0.38, both far from one. The negative side is where the structure sits, and it is concentrated in one currency. The JPY is negatively correlated with all four others, most strongly with the USD at -0.712 , then the GBP at -0.650 , the CNY at -0.522 , and the EUR at -0.490 . The JPY moves against the rest of the basket as a group, which is what allows a high-variance currency to lower total risk rather than add to it, a configuration the normalization makes likely for whichever currency carries the largest own variance. No other currency shows this pattern.

Basket Stability over the Full Sample

The optimized coin has an annualized volatility of 0.21 percent, against a five-currency average near 5.24 percent. That is a reduction of 96.07 percent against the average constituent, and 95 to 97 percent against every individual currency. Measured on the objective the optimizer minimizes, the RNVAL-level standard deviation, the coin is 54.36 percent below the equal-weight basket.

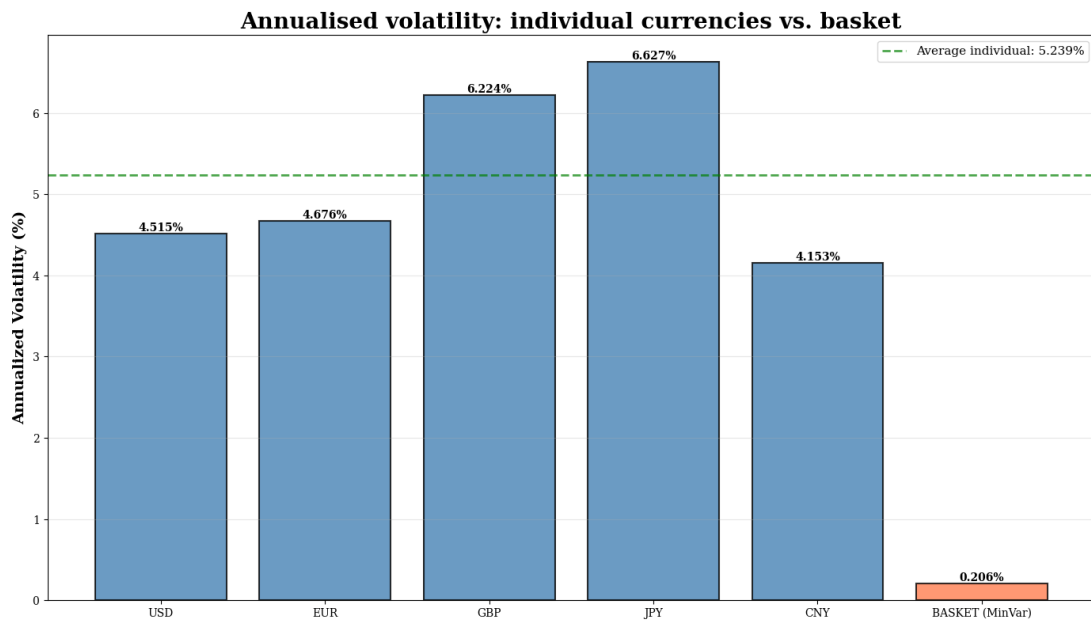


Figure 4.3: Annualized volatility of the five currencies and of the minimum-variance basket. The dashed line marks the average individual volatility of 5.239 percent.

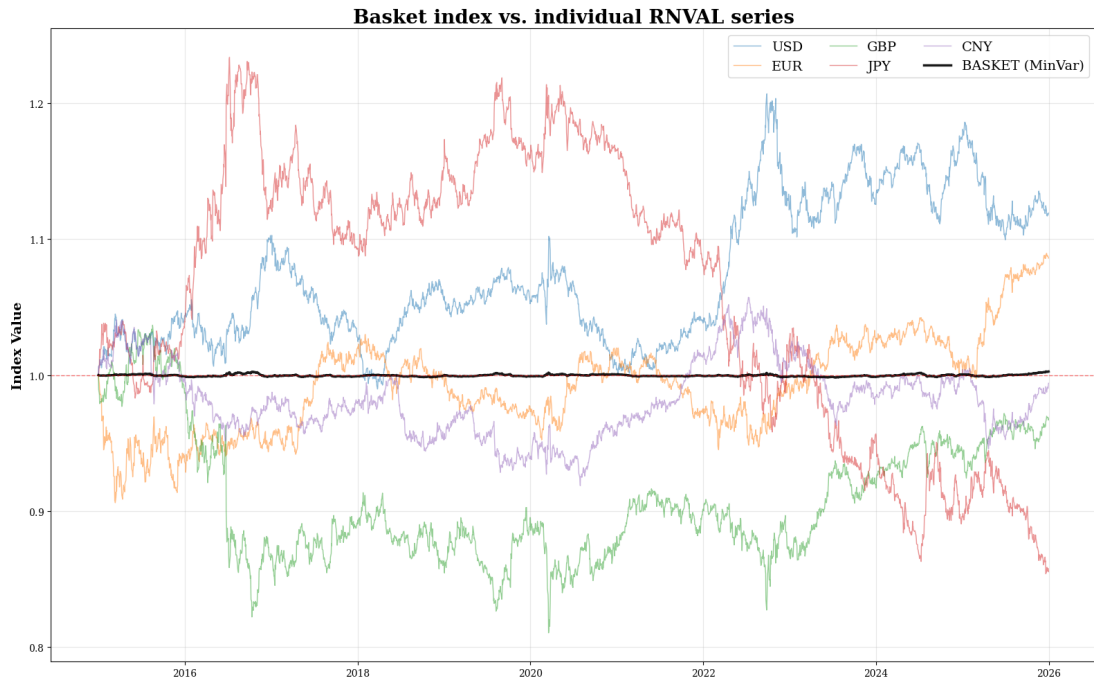


Figure 4.4: The minimum-variance basket index (black) against the five individual RIVAL series, all normalized to one at the base date.

Figure 4.4 places the coin on the same axis as its constituents. The five RIVAL series range over roughly 0.80 to 1.25 across the sample. The basket is the black line along 1.0, flat enough to read as a single horizontal mark beside them. The constituents move; the weighted combination holds. This is where the peg stability can be seen directly, considering also that the maximum drawdown over eleven years is -0.43 percent, and the average drawdown is -0.26 percent, so the worst peak-to-trough loss stays under half a percent. Peg stability is measured against the coin's own initial value of one, since the RIVAL index is numeraire-free and is not pegged to any single currency. The value stays within ± 0.26 percent of one across the sample, with a mean absolute deviation of 0.07 percent, and spends 100 percent of the days inside a ± 1 percent band. Over the closing stretch of the sample the maximum deviation from that period's own starting value is ± 0.33 percent and volatility rises by about eight percent, so the stability holds late in the period as well as early.

4.3 The NATO Basket

The IMF SDR benchmark applied to the Global basket is not available here, because its fifth currency is not an SDR constituent, so the SDR allocation is

reported only for the Global basket.

	Equal ($1/N$)	Minimum variance
USD	20.00	17.35
EUR	20.00	19.71
GBP	20.00	21.50
JPY	20.00	19.04
CAD	20.00	22.41
Basket	100.00	100.00

Table 4.4: Allocation weights (%)

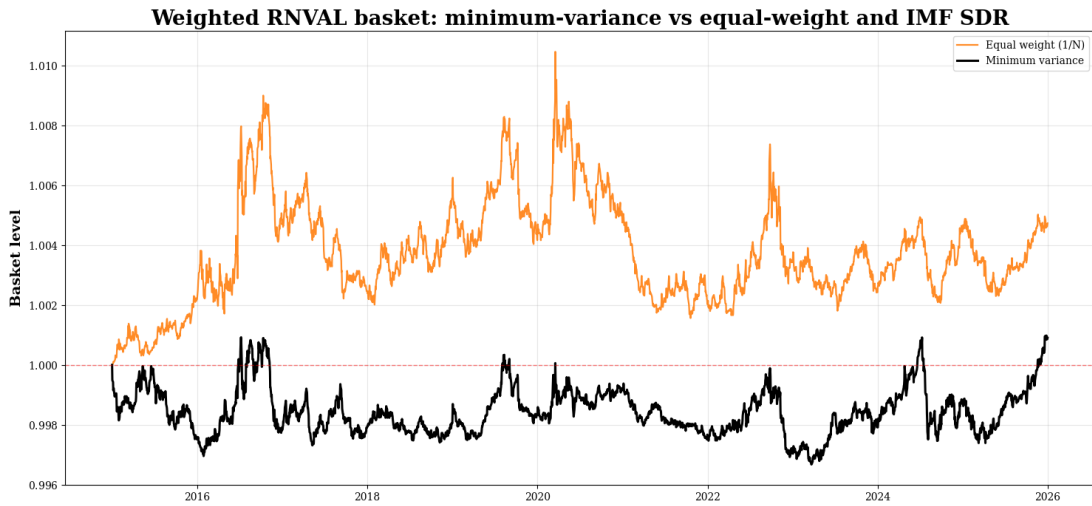


Figure 4.5: The two weighted RIVAL baskets over the full sample: equal weight and minimum variance. The magnified vertical axis runs from about 0.996 to 1.010.

Figure 4.5 compares the two allocations on a magnified axis. The equal-weight basket sits above one throughout, drifting between roughly 1.002 and 1.008, while the minimum-variance line stays just under one and moves in a narrower band. Neither wanders far, which is expected for a basket of advanced-economy currencies, but the minimum-variance line is the flatter of the two. The distance between them is the 55.10 percent reduction in level standard deviation the optimizer buys over equal weight. The optimizer spreads risk almost uniformly rather than concentrating it, the same pattern found in the Global basket.

Coin-level Metrics

Figure 4.6 plots the five RIVAL series from a common start of one. The JPY (red) leads early, rising above 1.20 by 2016, then declines through 2022 onward as

the USD (blue) takes over and climbs above 1.15. The GBP (green) steps down after 2016 and stays low. The USD and the CAD (purple) move together, the +0.53 correlation of the matrix seen over time, even though the USD trades above its base value throughout the sample and the CAD below it, while the JPY runs opposite the USD, the -0.745 entry drawn out across the panel.

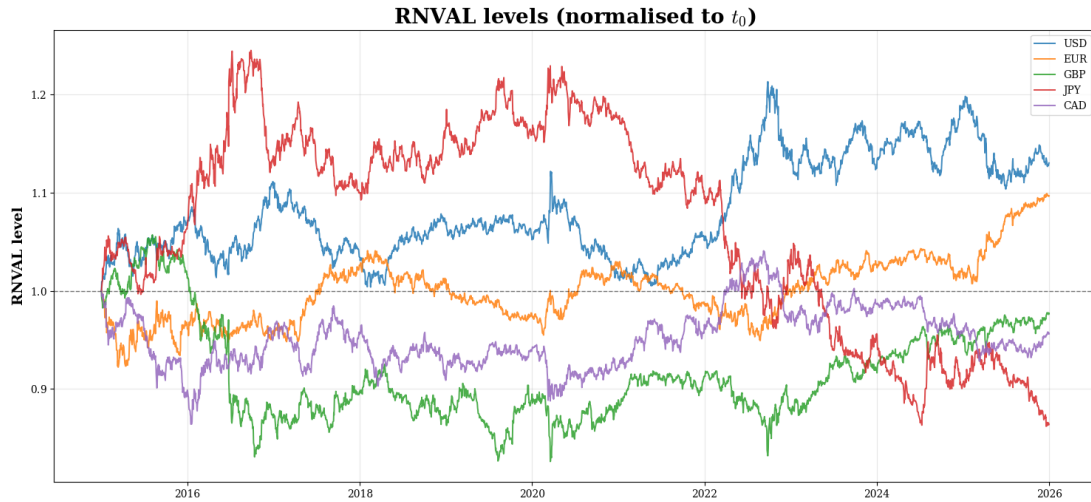


Figure 4.6: The five RNVAL level series, each normalized to one at the base date in January 2015.

Table 4.5 reports, for each currency and for the optimized basket, the annualized volatility and mean return of the RNVAL log-return series, the Sharpe ratio at a zero risk-free rate, and the RC inside the minimum-variance basket. Returns are measured against the RNVAL numeraire, so a mean of +1.07 percent for the USD means its invariant value rose about one percent a year relative to the geometric mean of the five currencies.

	Ann. vol. (%)	Mean ret. (%)	Sharpe	Risk contr. (%)
USD	4.97	+1.07	0.216	17.3
EUR	4.51	+0.81	0.180	19.7
GBP	5.93	-0.20	-0.034	21.5
JPY	6.89	-1.29	-0.187	19.0
CAD	5.33	-0.40	-0.074	22.4
Basket	0.198	+0.01	0.040	100.0

Table 4.5: RNVAL coin metrics over the full sample. Volatility, mean return and Sharpe are return-based and annualized; RC is within the minimum-variance basket.

As in the Global basket, the contributions equal the weights almost exactly, because at the minimum-variance point the marginal contributions are all identical, here

at 7.68×10^{-4} , so no reallocation can lower the basket standard deviation. The currency that carries the most standalone volatility, the JPY at 6.89 percent, is not pushed to the bottom of the weights; its co-movement with the rest offsets its own variability.

Correlation Structure

The reason a volatile currency can hold a near-equal weight is in the correlation matrix of the RNVAL levels, as shown in Table 4.6. The RNVAL series carry no base currency, so their correlations measure co-movement in world value rather than co-movement induced by a shared denominator.

	USD	EUR	GBP	JPY	CAD
USD	1.000	0.322	0.045	-0.745	0.526
EUR	0.322	1.000	0.057	-0.515	0.032
GBP	0.045	0.057	1.000	-0.573	0.004
JPY	-0.745	-0.515	-0.573	1.000	-0.579
CAD	0.526	0.032	0.004	-0.579	1.000

Table 4.6: Correlation matrix of the RNVAL level series, full sample.

Positive association among the five is weak, with one exception. The largest positive entry is the USD with the CAD at +0.526, the two North American currencies, followed by the USD and the EUR at +0.322; every other positive pair is below +0.06. The structure is on the negative side, and it is concentrated in the JPY, which is negatively correlated with all four others, most strongly with the USD at -0.745, then the CAD at -0.579, the GBP at -0.573 and the EUR at -0.515. Read from a NATO angle, the positive association sits in the North American pair, the USD and the CAD, while the GBP is near zero against the other members. The diversification that lowers basket risk comes from the JPY, the alliance's one Pacific partner currency, which moves against all four.

Basket Stability over the Full Sample

The optimized coin has an annualized volatility of 0.20 percent against a five-currency average near 5.53 percent, a reduction of 96.41 percent, and 95 to 97 percent against every individual currency. Measured on the objective the optimizer minimizes, the basket is 55.10 percent below the equal-weight allocation.

Figure 4.7 sets the coin's annualized volatility against the five currencies and their 5.527 percent average. Only the GBP and the JPY clear the average line, the JPY highest at 6.891 percent, while the CAD sits just below it. The basket bar on the right, at 0.198 percent, is a fraction of even the calmest currency, the EUR at 4.512 percent. The gap between it and the shortest blue bar is the 96.41 percent reduction reported above, seen at a single scale.

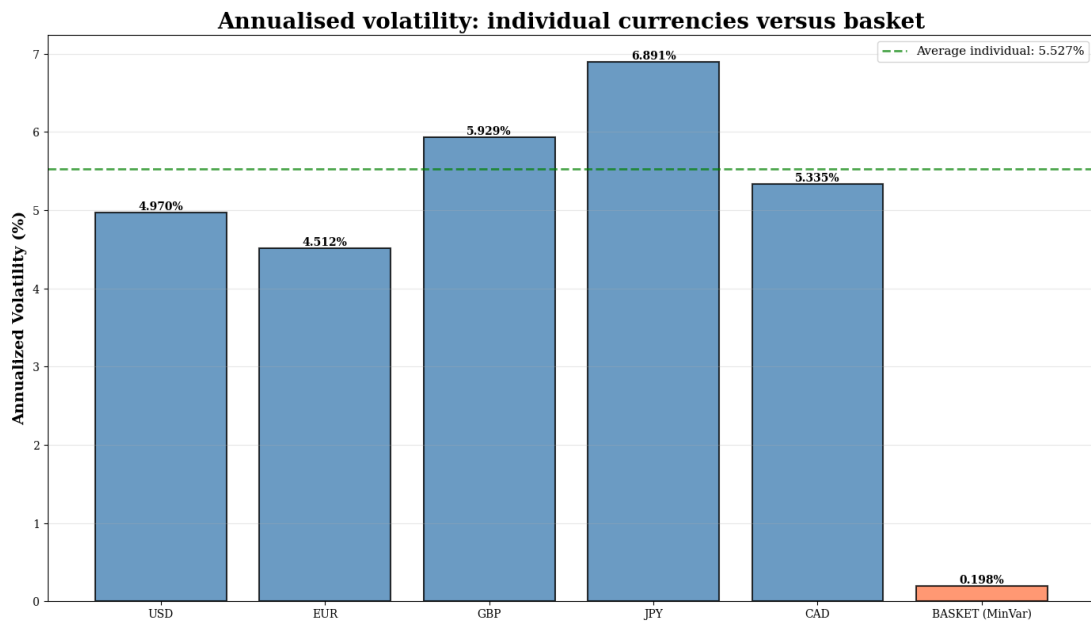


Figure 4.7: Annualized volatility of the five currencies and of the minimum-variance basket. The dashed line marks the average individual volatility of 5.527 percent.

Figure 4.8 places the coin on the same axis as its constituents. The five series range over roughly 0.85 to 1.25 across the sample, the JPY and the USD trading the lead while the GBP sits low. The basket is the black line along 1.0, flat enough to read as a single horizontal mark beside them. The constituents move; the weighted combination holds.

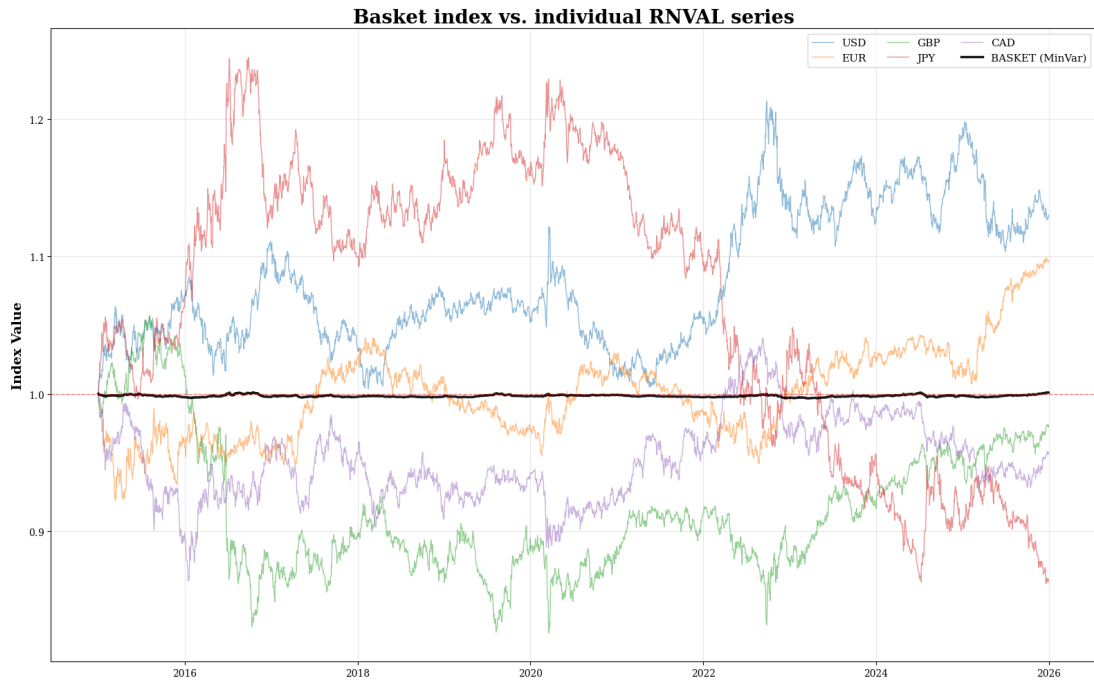


Figure 4.8: The minimum-variance basket index (black) against the five individual RIVAL series, all normalized to one at the base date.

Two properties describe the coin as a store of value. Its maximum drawdown over eleven years is -0.42 percent, with an average drawdown of -0.24 percent, so the worst peak-to-trough loss stays under half a percent. Peg stability is measured against the coin's own initial value of one, since the RIVAL index is numeraire-free and is not pegged to any single currency. The value stays within ± 0.33 percent of one across the sample, with a mean absolute deviation of 0.16 percent, and spends 100 percent of the days inside a ± 1 percent band. Over the closing stretch of the sample the maximum deviation from that period's own starting value is ± 0.26 percent, no wider than over the full sample, and volatility rises by about eleven percent, so the stability holds late in the period as well as early.

4.4 The BRICS Basket

The BRICS coin is estimated on the same eleven-year window, as with the NATO basket, only two weight vectors apply. The equal-weight vector holds $1/5$ in each currency, and the minimum-variance vector minimizes the variance of the RIVAL basket levels under non-negative weights that sum to one. The SDR allocation used for the Global basket has no counterpart here, since only the CNY belongs to the SDR, so it is reported for the Global basket alone.

	Equal (1/N)	Minimum variance
BRL	20.00	25.43
RUB	20.00	19.06
INR	20.00	18.89
CNY	20.00	16.70
ZAR	20.00	19.92
Basket	100.00	100.00

Table 4.7: Allocation weights (%)

The optimizer departs from equal weight more than it did for the advanced-economy baskets, lifting the BRL to 25.4 percent and holding the CNY down to 16.7 percent. The reason is in the correlation structure below, and it is not about each currency’s own volatility.

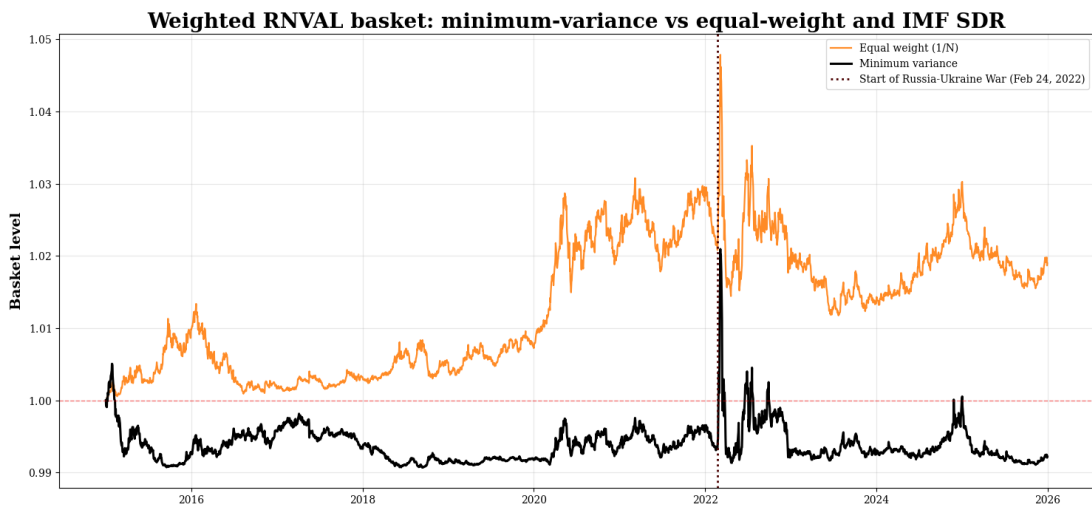


Figure 4.9: The two weighted RIVAL baskets over the full sample: equal weight and minimum variance. The dotted line marks February 24, 2022, the start of the Russian invasion of Ukraine.

Figure 4.9 compares the two allocations. The equal-weight basket drifts up to roughly 1.02 to 1.05 and carries visible chop throughout, while the minimum-variance line holds close to one. At the war marker both lines show a single sharp spike, after which the minimum-variance basket returns to its level and the equal-weight basket does not settle as cleanly. The gap between the two curves is the 71.81 percent reduction in level standard deviation that the optimizer buys over naive diversification.

Coin-level Metrics

Figure 4.10 plots the five RNVAL series. The spread is far wider than in the advanced-economy baskets: the BRL (blue) drifts down toward 0.65 by 2021, the CNY (red) climbs above 1.3, and the INR (green) tracks it upward. At the war marker the RUB (orange) drops almost vertically, from near one to about 0.63 within days, then recovers over the following weeks, regaining its pre-war level on April 22 and overshooting it through mid-2022. The opposing paths of the BRL and the CNY are the -0.807 entry of the correlation matrix seen over time, available in the section below.

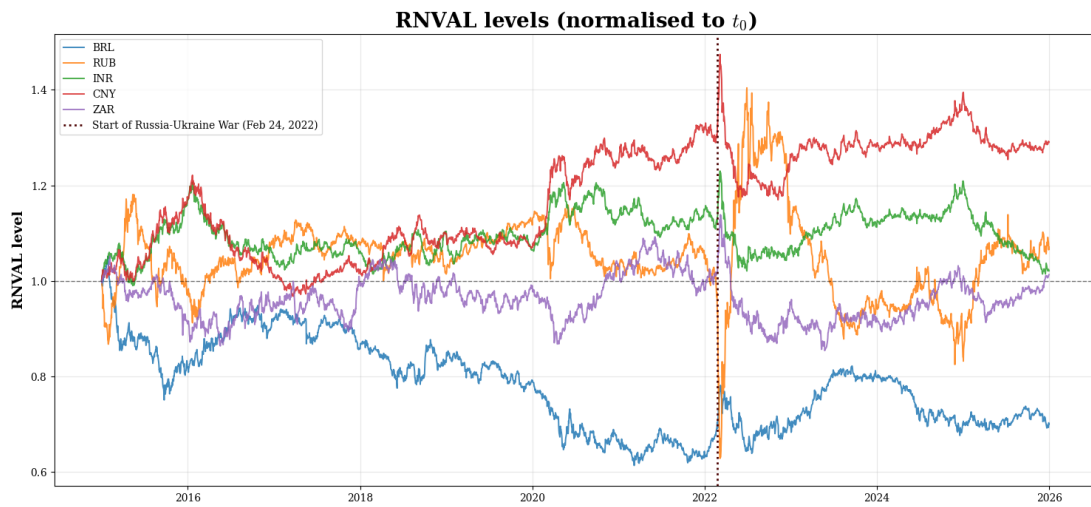


Figure 4.10: The five RNVAL level series, each normalized to one at the base date in January 2015. The dotted line marks February 24, 2022.

Table 4.8 reports the annualized volatility and mean return of the RNVAL log-return series, the Sharpe ratio at a zero risk-free rate, and the risk contribution inside the minimum-variance basket. Returns are measured against the RNVAL numeraire, the geometric mean of the five currencies.

	Ann. vol. (%)	Mean ret. (%)	Sharpe	Risk contr. (%)
BRL	11.89	-3.14	-0.264	25.4
RUB	17.25	+0.60	0.035	19.1
INR	7.36	+0.18	0.025	18.9
CNY	7.93	+2.24	0.282	16.7
ZAR	10.43	+0.11	0.011	19.9
Basket	0.887	-0.07	-0.078	100.0

Table 4.8: RNVAL coin metrics over the full sample. Volatility, mean return and Sharpe are return-based and annualized; RC is within the minimum-variance basket.

These currencies are far more volatile than those of the other two baskets. The RUB runs at 17.2 percent a year and the BRL at 11.9, against single-digit figures for most advanced-economy currencies. The RCs again match the weights, because the minimum-variance solution equalizes the marginal contributions, here at 2.50×10^{-3} . The BRL carries the largest weight and the largest RC at 25.4 percent, yet it is one of the more volatile legs and the worst performer, losing 3.1 percent a year. A mean-variance reading on each currency alone would not choose it, even if the covariance does.

Correlation Structure

Table 4.9 gives the correlation matrix of the RNVAL levels. Its meaning does not depend on a base currency: a correlation read off USD or EUR cross-rates would shift with that choice, whereas the RNVAL series are denominated in no currency, so the numbers describe how these five move in world value.

	BRL	RUB	INR	CNY	ZAR
BRL	1.000	-0.144	-0.492	-0.807	-0.170
RUB	-0.144	1.000	-0.510	-0.334	-0.290
INR	-0.492	-0.510	1.000	0.657	-0.067
CNY	-0.807	-0.334	0.657	1.000	0.016
ZAR	-0.170	-0.290	-0.067	0.016	1.000

Table 4.9: Correlation matrix of the RNVAL level series, full sample.

The pattern differs from the advanced-economy baskets, where a single currency hedged the rest. Here the CNY is the pivot, a role that is in part structural, since the normalization forces each currency's covariances with the rest to sum to the negative of its own variance. It moves with the INR at +0.657, the only material positive pair in the matrix, and against the BRL at -0.807, the strongest association of either sign. The remaining entries are negative but moderate, the INR against the BRL and the RUB near -0.5, the ZAR loosely negative against most. This explains the weights. The BRL earns its large share by hedging the CNY almost one for one, while the CNY is held down because it duplicates the INR's movement and adds correlated risk. The optimizer buys the offsetting currency and discounts the redundant one.

Basket Stability and the 2022 Volatility Episode

Over the full sample the coin has an annualized volatility of 0.89 percent against a five-currency average of 10.97 percent, a reduction of 91.92 percent, and 88 to 95 percent against each currency. This is a wider basket volatility than the Global coin at 0.21 percent, which is expected: the inputs are several times more volatile and their correlations are less stable. Peg stability reflects the same. The value stays within one percent of its initial level on 99.76 percent of days, against 100 percent for the Global and NATO coins, and its maximum deviation reaches ± 2.09 percent.

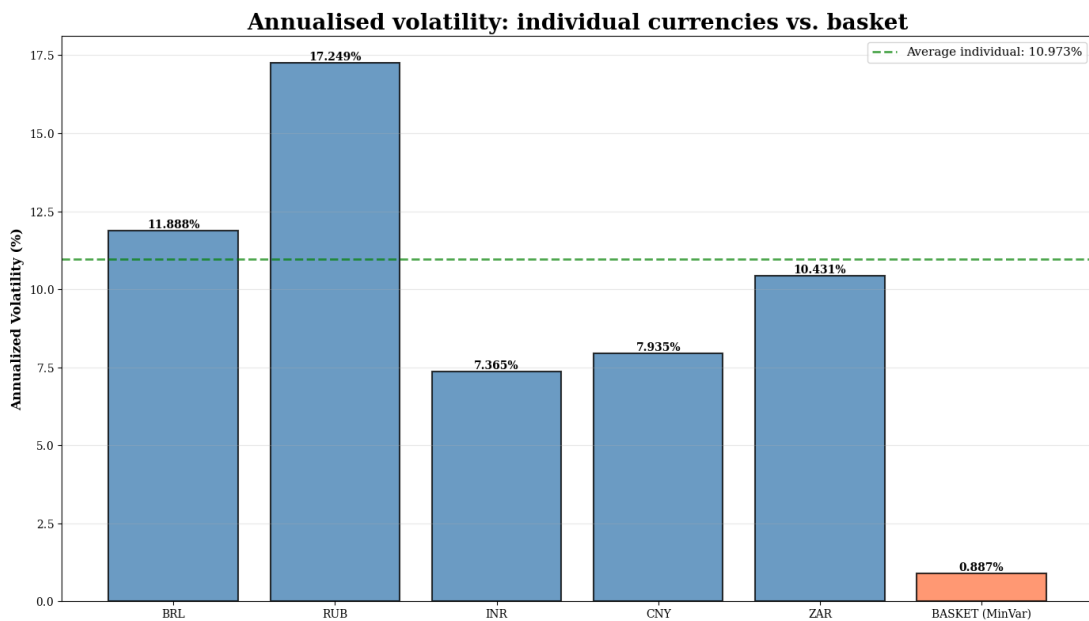


Figure 4.11: Annualized volatility of the five currencies and of the minimum-variance basket. The dashed line marks the average individual volatility of 10.97 percent.

Figure 4.11 sets the coin’s annualized volatility against the five currencies and their 10.97 percent average. Only the RUB and the BRL clear the average line, the RUB alone at 17.2 percent. The basket bar on the right, at 0.887 percent, is a fraction of even the calmest currency, the INR at 7.4 percent. The visual distance from the shortest blue bar to the basket bar is the 91.92 percent reduction reported above, and it holds even though these inputs are several times more volatile than those of the Global basket.

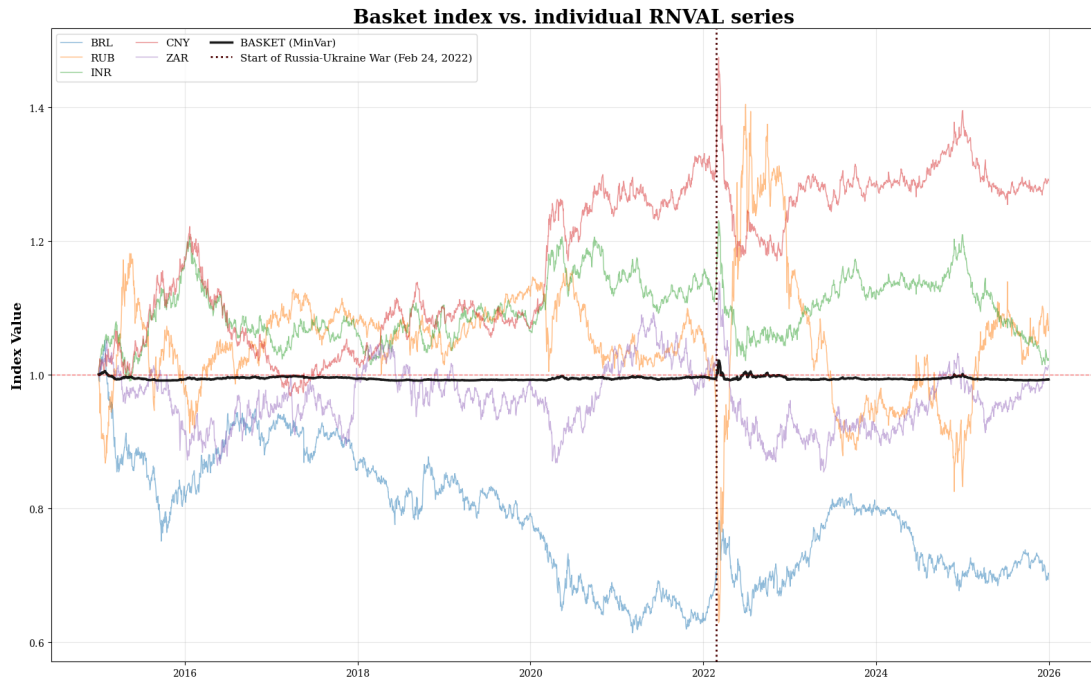


Figure 4.12: The minimum-variance basket index (black) against the five individual RIVAL series, all normalized to one at the base date. The dotted line marks February 24, 2022.

Figure 4.12 places the coin on the same axis as its constituents. The five series range from about 0.6 to 1.4 over the sample, and at the war marker the RUB tears through the panel while the basket holds its line. A constituent at 19 percent of the basket lost a third of its value in a fortnight, and on this axis the basket barely registers it.

Almost all of that instability is one event. The stress event was on February 24, 2022, the date of the Russian invasion of Ukraine, and the contrast across it is sharp. Table 4.10 collects the figures: volatility from the invasion onward is 2.9 times its pre-invasion level. The rolling one-year measure peaks at 2.60 percent in mid-2022.

Period	Basket ann. volatility (%)
Full sample	0.89
Before February 24, 2022	0.47
From February 24, 2022	1.36
Acute window (February to May 2022)	4.37

Table 4.10: Basket volatility before and after the 2022 invasion.

The source is the RUB alone. Its RIVAL value fell from 0.99 on February 18, 2022 to 0.63 on March 7, a loss of about a third in two weeks, then recovered

to 0.94 by the end of the month once capital controls took hold. Its annualized volatility went from 11.5 percent before the invasion to 24.6 percent after, while the other four currencies barely moved, their volatility ratios between 0.99 and 1.14. The coin absorbed most of the shock. Even with the RUB at 19 percent of the basket and down a third, the basket's largest deviation from its peg was 2.09 percent on March 7, and its only week outside a one-percent band ran from March 4 to March 14, 2022, seven days in eleven years. The maximum drawdown of 2.92 percent dates from that same peak and has not fully recovered. A single constituent lost a third of its value in a fortnight, and the coin moved about two percent.

4.5 Comparison on RNVAL Results Across the Three Baskets

The three coins are built by the same procedure on the same eleven-year window, so their headline figures can be read side by side. Tables 4.11 and 4.12 collect the six main metrics.

	Ann. vol. (%)	Std. dev. (%)	Max DD (%)	Max dev. (%)
Global Basket	0.206	0.076	−0.43	0.26
NATO Basket	0.198	0.077	−0.42	0.33
BRICS Basket	0.887	0.252	−2.92	2.09

Table 4.11: The three basket coins on volatility metrics.

	Mean ret. (%)	Sharpe
Global Basket	+0.023	0.111
NATO Basket	+0.008	0.040
BRICS Basket	−0.069	−0.078

Table 4.12: The three basket coins on return metrics.

The table splits into two tiers. The Global and NATO coins are close to indistinguishable: annualized volatility of 0.21 and 0.20 percent, level dispersion near 0.08 percent, and a worst drawdown inside half a percent. The BRICS coin sits apart on every column. Its volatility is more than four times theirs, its variance about ten times, its worst drawdown 2.92 percent, and its largest departure from par 2.09 percent against roughly a third of a percent for the other two.

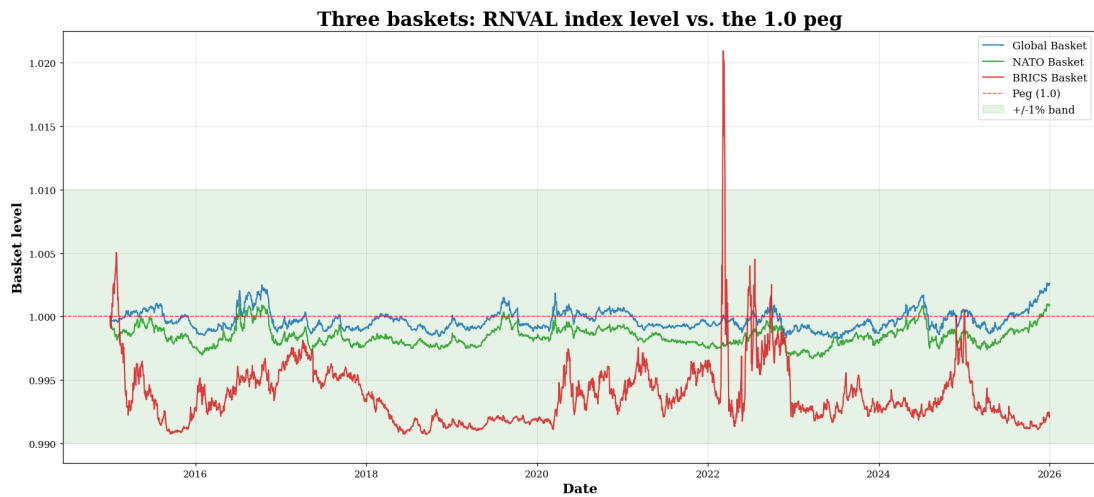


Figure 4.13: The three basket coins as index levels against the 1.0 peg over the full sample, with the $\pm 1\%$ band shaded.

Figure 4.13 is the visual counterpart of Table 4.11. Global and NATO stay pinned just under one for the whole decade, close enough to overlap for long stretches. BRICS rides lower, around 0.995, spending most of the sample in the bottom half of the band rather than at par, which is the negative mean return of the table read as a level. It crosses the upper edge of the band once, in 2022, and returns inside within weeks. Two coins hold par almost flat, and the third holds a lower line with more movement.

Between the two advanced-economy coins, the Global basket is the tighter peg. It holds the smaller maximum deviation, 0.26 against 0.33 percent, and the higher Sharpe, 0.11 against 0.04, though both mean returns are within a rounding of zero. Neither coin is meant to appreciate, and neither does. The store-of-value property shows up as a flat mean rather than as a trend, which is the behavior a unit of account should have.

The BRICS coin pays for its inputs. Its five currencies are several times more volatile and move against each other less cleanly, so more variance survives the optimization. The mean return is mildly negative and the Sharpe below zero, both traceable to the 2022 drawdown rather than to a design fault. Even so, the coin it produces is far steadier than any currency inside it, and it stays within about two percent of par across a decade that included a currency collapse.

Read together, the three coins sort into a hard-peg group and a wider one, divided by the economies behind the currencies rather than by the method. All three hold a value near one without the stability depending on any single issuer's currency through diversification across the five constituents alone. The Global and NATO

baskets behave like tight pegs; the BRICS basket behaves like a looser band that still holds. The construction carries from one currency set to another, and the stability of the coin follows the stability of its inputs.

Chapter 5

Volatility Spillover Analysis

5.1 Diebold-Yilmaz Framework

The spillover analysis asks how a shock to one currency's value inside the basket travels to the others. It uses the generalized framework of Diebold and Yilmaz, which reads the answer from a vector autoregression's (VAR) forecast error variance decomposition (FEVD): for each series, the share of its H -step-ahead forecast error variance that traces back to its own past shocks, and the share that traces back to shocks in each of the other series. The second set of shares is the spillovers. The decomposition is the generalized one of Koop, Pesaran and Potter and of Pesaran and Shin, not the Cholesky version, so it leaves the shocks correlated and returns the same shares whatever order the currencies are placed in. That invariance is what lets the numeraire currency sit in the system alongside the others, with no arbitrary ranking deciding which currency looks like a transmitter and which like a receiver. The variables in the model are the daily RIVAL log returns of the basket currencies, and the forecast horizon is ten days, the value used by Diebold and Yilmaz and stable across nearby horizons.⁵⁰

The starting point is a covariance-stationary N -variable VAR(p) with moving-average representation $x_t = \sum_{i=0}^{\infty} A_i \varepsilon_{t-i}$, where the coefficient matrices A_i obey the recursion $A_i = \Phi_1 A_{i-1} + \dots + \Phi_p A_{i-p}$. The H -step-ahead generalized forecast

⁵⁰ See Diebold, Francis X. and Kamil Yilmaz, Better to Give than to Receive: Predictive Directional Measurement of Volatility Spillovers, 2012, available at <https://ssrn.com/abstract=1536123>.

error variance share attributable to shocks in market j for market i is:

$$\theta_{ij}^g(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (e_i' A_h \Sigma e_j)^2}{\sum_{h=0}^{H-1} (e_i' A_h \Sigma A_h' e_i)} \quad (5.1)$$

where Σ is the covariance matrix of the innovation vector ε , σ_{jj} is the standard deviation of the j -th equation's error, and e_i is the corresponding selection vector. Because the shocks are not orthogonalized, the row sums $\sum_j \theta_{ij}^g(H)$ do not equal one. Each entry is therefore row-normalized:

$$\tilde{\theta}_{ij}^g(H) = \frac{\theta_{ij}^g(H)}{\sum_{j=1}^N \theta_{ij}^g(H)} \quad (5.2)$$

so that $\sum_j \tilde{\theta}_{ij}^g(H) = 1$ by construction for each i . The off-diagonal entries $\tilde{\theta}_{ij}^g(H)$ with $i \neq j$ are the cross-market spillover shares.

From the normalized decomposition matrix, Diebold and Yilmaz construct a hierarchy of spillover measures. The total spillover index aggregates all off-diagonal entries relative to total forecast error variance:

$$S^g(H) = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^N \tilde{\theta}_{ij}^g(H)}{\sum_{i,j=1}^N \tilde{\theta}_{ij}^g(H)} \times 100 \quad (5.3)$$

Beyond this aggregate, directional spillovers received by market i from all others and directional spillovers transmitted by market i to all others are computed separately from, respectively, the off-diagonal row and column sums of the normalized matrix. Their difference yields the net directional spillover:

$$S_i^g(H) = S_{i \rightarrow \bullet}^g(H) - S_{i \leftarrow \bullet}^g(H) \quad (5.4)$$

A positive net value identifies market i as a net transmitter of volatility; a negative value identifies it as a net receiver. At the pairwise level, one can further decompose net spillovers into bilateral contributions between any two markets i and j , giving a net pairwise spillover $S_{ij}^g(H)$ that isolates which bilateral relationship is driving the aggregate directional result.

In practice these measures are read from one table. The normalized decomposition is an $N \times N$ matrix whose (i, j) entry is the share of currency i 's forecast error variance traced to currency j . Its off-diagonal row sums give what each currency receives from the rest, its off-diagonal column sums give what each currency transmits, and the sum of all off-diagonal entries is the total spillover index, reported in the corner. The net spillover defined above is the difference between the column sum and the row sum, and it carries the reading in the paper's title: a net transmitter gives more volatility than it takes, so it is a currency whose stress propagates into the rest of the basket and therefore into the coin, while a net receiver absorbs volatility coming from elsewhere. The net pairwise measure then names the single bilateral link behind a currency's directional position.⁵¹

5.2 The Global Basket

Table 5.1 reports the directional spillovers by counterparty at the ten-day horizon. Each entry is the share of the whole five-currency system's forecast error variance that runs from one currency to another: the row is the currency that receives, the column the currency that gives. Own contributions are left out, since a currency is not its own counterparty. The right-hand column, FROM, adds up what each currency receives from the rest; the bottom row, TO, adds up what it sends; and the corner is the total spillover index, 37.85 percent.

receives \ gives	USD	EUR	GBP	JPY	CNY	FROM
USD	–	2.21	2.29	0.98	3.72	9.21
EUR	2.84	–	0.11	0.63	2.52	6.11
GBP	2.70	0.10	–	2.54	1.90	7.24
JPY	1.21	0.64	2.72	–	1.81	6.38
CNY	3.81	2.00	1.64	1.47	–	8.92
TO	10.56	4.96	6.76	5.63	9.95	37.85

Table 5.1: Directional volatility spillover by counterparty, percent of total system forecast error variance. Rows receive, columns give. FROM is the total received, TO the total transmitted, and the corner is the total spillover index. Entries may not sum exactly to the margins because of rounding.

The bilateral picture has two poles. The USD and the CNY trade the most volatility with each other, 3.72 percent from the CNY into the USD and 3.81 percent the other way, and both send a large share to the EUR. The GBP and

⁵¹ *Id.*

the JPY form a second, weaker pair, each supplying the other about 2.5 to 2.7 percent. The EUR sits at the receiving end of almost everything and gives back very little, 0.10 to 0.11 percent to the GBP and modest amounts elsewhere. So the EUR reads as an absorber, while the USD and the CNY read as sources.

Net directional spillover, transmission minus reception, makes this split explicit as shown in Figure 5.1. The USD and the CNY are net transmitters, at +1.35 and +1.03 percentage points, and the EUR, the JPY and the GBP are net receivers, at -1.15, -0.75 and -0.48. The net volatility spillover network as described in Figure 5.2 shows where the flows go. Seven of the eight net arrows leave the USD or the CNY. The USD is the larger source, sending its biggest net flow to the EUR (0.63) and smaller flows to the GBP (0.41), the JPY (0.23) and the CNY (0.08); the CNY sends 0.52 to the EUR, 0.34 to the JPY and 0.26 to the GBP. The one exception inside the receiver group is the GBP, which is a net receiver overall yet a small net transmitter to the JPY (0.18). For the basket, this means the EUR, JPY and GBP absorb volatility rather than generate it, and a shock that raises basket co-movement is most likely to start in the USD or the CNY.

The rolling record also says how stable each role is, not just its average. Across the 119 windows the USD is a net transmitter in 99 percent of them and the EUR a net receiver in 99 percent; the JPY is a receiver in 93 percent and the CNY a transmitter in 82 percent. The GBP is the only currency without a settled role: it transmits in 66 percent of windows and receives in 21 percent. Four of the five legs therefore keep the sign that Figure 5.1 assigns them, so that summary is a fair description of them. For the GBP it is not, and its bar should be read as an average over two opposite phases rather than a fixed position.

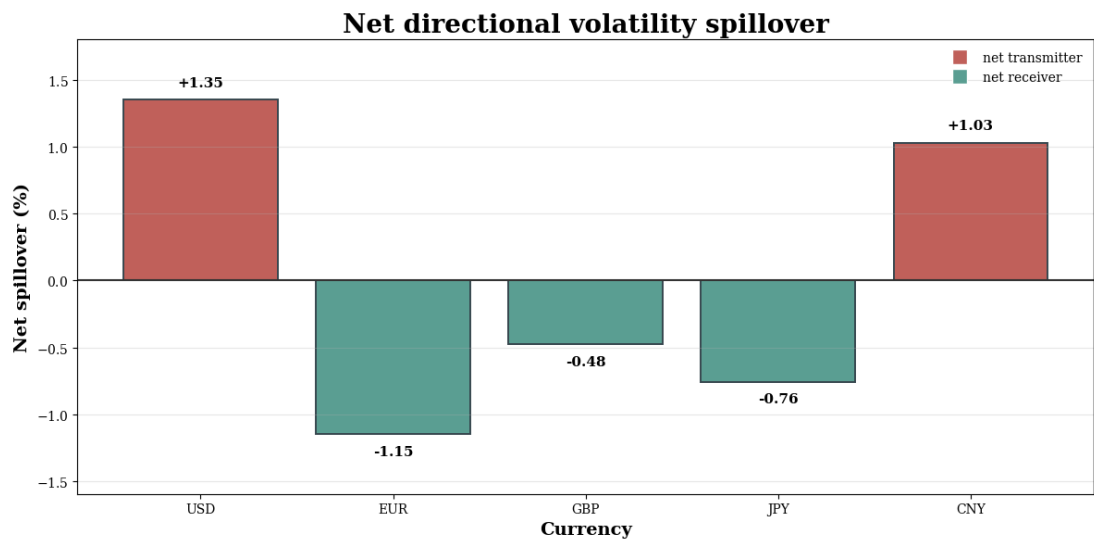


Figure 5.1: Net directional volatility spillover. Transmission minus reception for each currency; positive bars are net transmitters, negative bars net receivers.

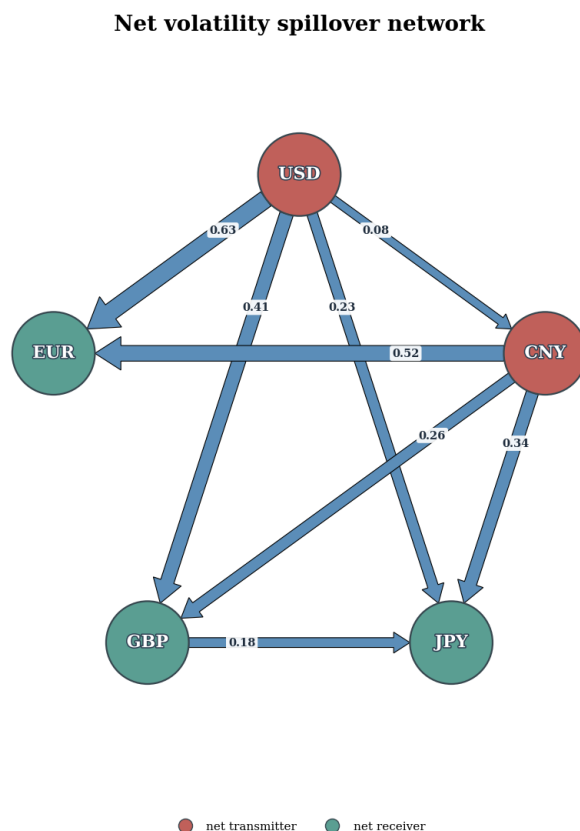


Figure 5.2: Net volatility spillover network. Each arrow runs from the net transmitter to the net receiver of a pair, with the net pairwise spillover on the arrow.

Connectedness is at its sample high now, which means the residual co-movement the min-variance weights have to offset is larger in the recent period than at any

earlier point. The net network points to where that pressure comes from: the USD and the CNY both send their largest net flows to the EUR, 0.63 and 0.52, and the CNY also feeds the JPY and the GBP. The EUR is the common sink of the two sources. For the design of the basket, this ordering works as an early-warning map: a shock originating in the USD or the CNY is the one most likely to move the whole index, so those two legs are the ones to monitor for the peg, with the EUR as the first to register the effect. On both the received side and the transmitted side, as shown below in Figure 5.3 and Figure 5.4, the USD and the CNY sit at the top and rise together toward 2025, the USD's transmission reaching about 14 percent and the CNY's about 13. The EUR sits at the bottom of both for most of the sample, though the GBP falls below it on each side after 2024. The GBP is the mover: its transmission holds near 9 to 10 percent through 2023 and then falls to about 4.5 percent, so it stops being a source late in the sample.

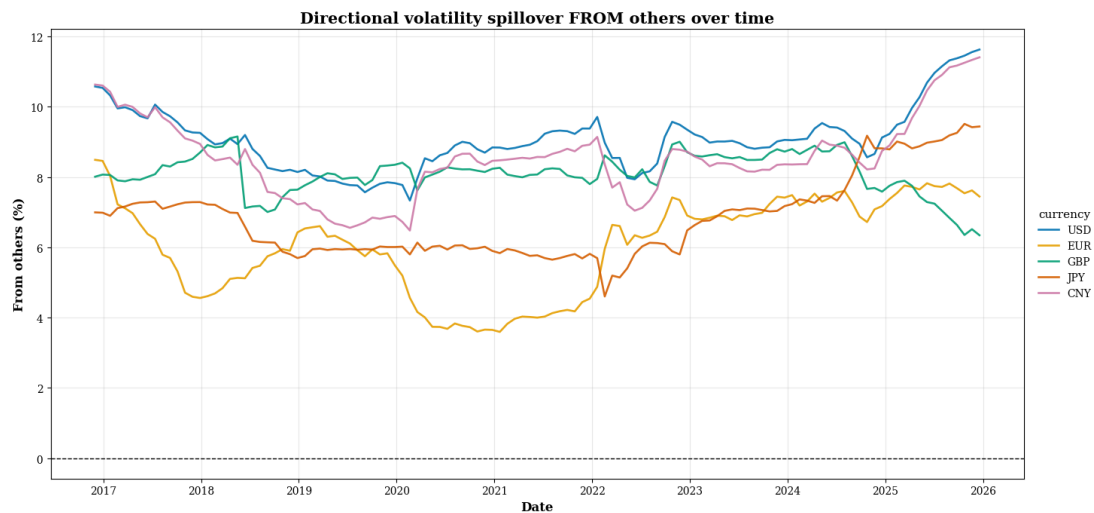


Figure 5.3: Directional volatility spillover FROM others over time, by currency.

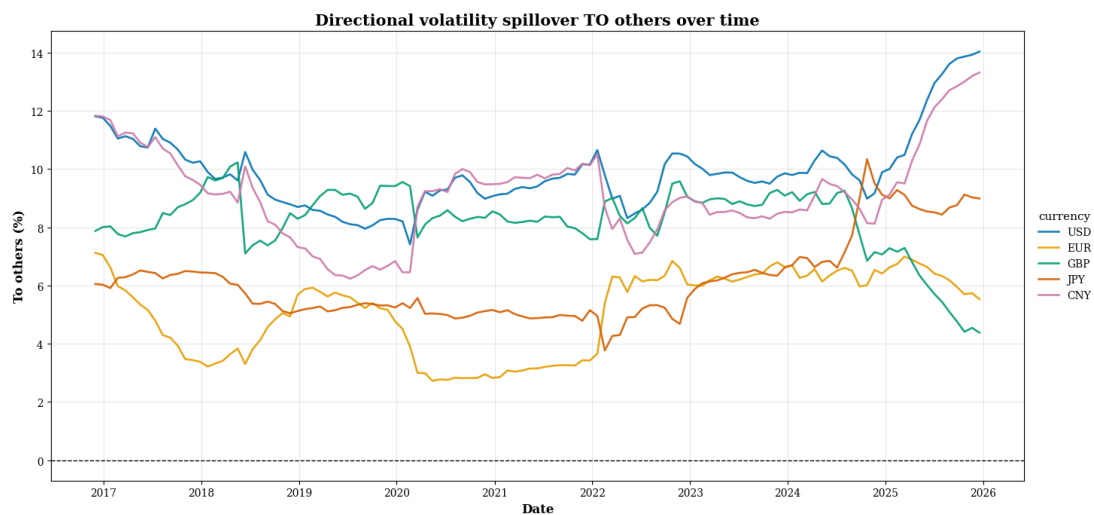


Figure 5.4: Directional volatility spillover TO others over time, by currency.

Figure 5.5 shows the net-over-time graph, which ties these together. Two currencies are stable poles: the USD is a net transmitter across almost the whole sample and the EUR a net receiver across almost all of it. The two Asian currencies each switch role once. The CNY is a net receiver only between 2018 and 2020 and a net transmitter for the rest of the period, ending the sample strongly positive near +1.9. The JPY shows the opposite pattern, since it is a net receiver for most of the period and became the strongest transmitter only from late 2024 to early 2025. The GBP runs a third path, a net transmitter around 2019 to 2021 and then a steady slide into net receiver territory, close to -2 by 2025. The static table is therefore a snapshot of a system whose center of gravity has shifted toward the USD and the CNY.

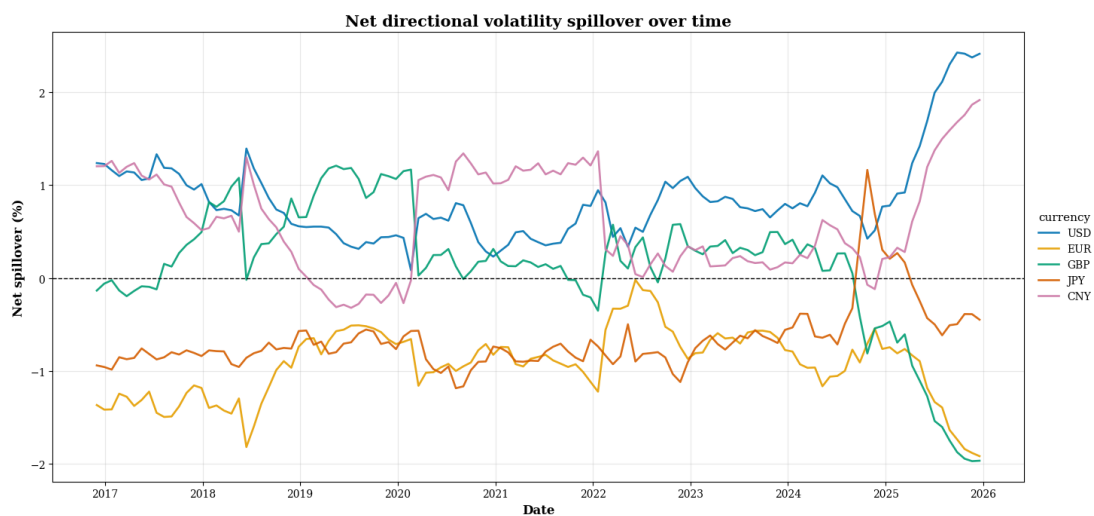


Figure 5.5: Net directional volatility spillover over time, by currency.

The end of the sample is more polarized than the full-sample average. By 2025 the USD and the CNY both climb to the top of the net range, while the EUR and the GBP fall together to about -2 and the JPY sits mildly negative as shown in Figure 5.5. The CNY has converged toward the USD as a second source rather than replacing it: on the transmitted side both rise together in the last two years, the USD toward 14 percent and the CNY toward 13. So the recent structure is a two-source, two-sink system, with the USD and CNY feeding volatility and the EUR and GBP absorbing it, and the static net bar, being a time average, understates how sharp that split has become.

These patterns bear on the basket in two ways. First, the joint climb in USD and CNY transmission, at the end of 2024, means the basket's currencies co-move more in the later years than in the middle of the sample, which is the same period in which the RIVAL basket held its peg most tightly but leaned on offsetting moves to do so. More common movement leaves less room for that offsetting. Second, the CNY's turn into a net transmitter matters for a basket that carries a 22 percent CNY weight: the leg with the largest weight is also the one whose role has moved from absorbing shocks to sending them, while the EUR and the JPY remain steady absorbers. The USD stays the main channel through which a shock would spread across the basket, so it is the currency whose stress the coin is least insulated from.

5.3 The NATO Basket

Table 5.2 reports the directional spillovers by counterparty at the ten-day horizon. Each entry is the share of the whole five-currency system's forecast error variance that runs from one currency to another: the row is the currency that receives, the column the currency that gives. Own contributions are left out, since a currency is not its own counterparty.

receives \ gives	USD	EUR	GBP	JPY	CAD	FROM
USD	–	1.93	2.70	0.34	0.09	5.07
EUR	2.08	–	0.02	0.54	1.29	3.93
GBP	2.58	0.01	–	2.89	0.29	5.77
JPY	0.28	0.48	2.66	–	3.38	6.81
CAD	0.04	1.13	0.26	3.82	–	5.24
TO	4.98	3.54	5.64	7.59	5.06	26.81

Table 5.2: Directional volatility spillover by counterparty, percent of total system forecast error variance. Rows receive, columns give. FROM is the total received, TO the total transmitted, and the corner is the total spillover index. Entries may not sum exactly to the margins because of rounding.

The bilateral picture has a single center. The JPY and the CAD trade the most volatility with each other, 3.82 percent from the JPY into the CAD and 3.38 percent the other way. The GBP sits between two smaller pairs, supplying the USD about 2.6 percent and the JPY about 2.9 percent and receiving similar amounts back.

Net directional spillover, transmission minus reception, makes this split explicit as shown in Figure 5.6. The JPY is the only net transmitter, at +0.78 percentage points; the USD is neutral at -0.08 ; and the EUR, the CAD and the GBP are net receivers, at -0.39 , -0.19 and -0.13 . The net volatility spillover network as described in Figure 5.7 shows where the flows go. The JPY carries the largest net flows and is the only currency that transmits to all four others: it sends its largest net flow to the CAD (0.43) and smaller flows to the GBP (0.23), the EUR (0.06) and the USD (0.06). The CAD, a net receiver overall, redistributes part of what it takes, sending 0.17 to the EUR, 0.05 to the USD and 0.03 to the GBP. The GBP passes 0.12 to the USD, and the USD passes 0.15 on to the EUR. For the basket, this means the JPY generates volatility while the EUR, the GBP and the CAD absorb it, and a shock that raises basket co-movement is most likely to start in the JPY.

The rolling record also says how stable each role is, not just its average. Across the 119 windows the JPY is a net transmitter in 96 percent of them, the clearest role in the basket. The EUR is a net receiver in 86 percent, the CAD in 67 percent, and the USD in 61 percent, even though its full-sample net is neutral. The GBP is the currency without a settled role: it transmits in 39 percent of windows and receives in 29 percent. So the JPY and the EUR keep the sign the static bar assigns them, the USD leans receiver across the windows despite its neutral bar, and the GBP's bar should be read as an average over opposite phases rather than

a fixed position.

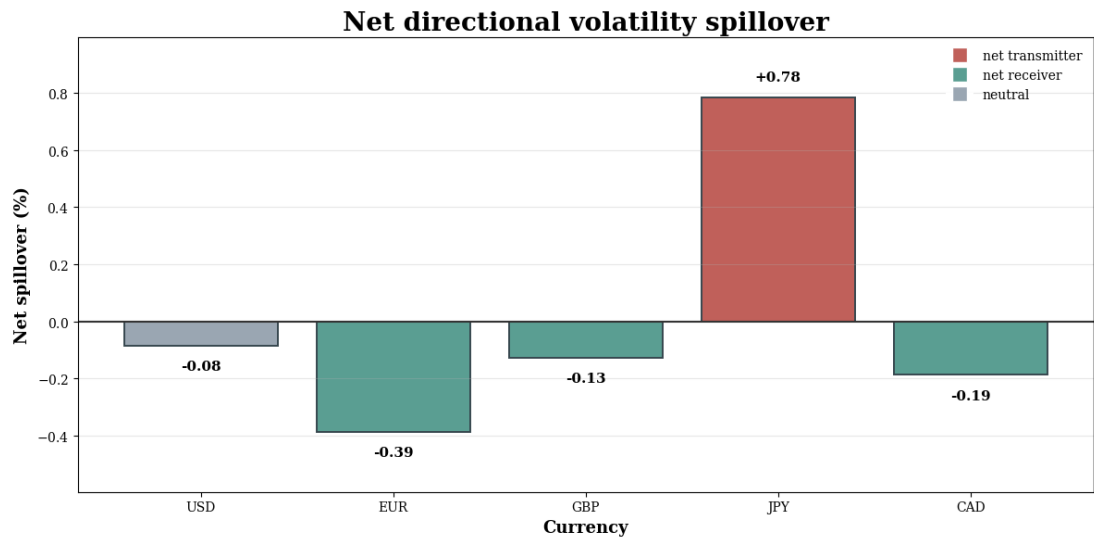


Figure 5.6: Net directional volatility spillover. Transmission minus reception for each currency; positive bars are net transmitters, negative bars net receivers.

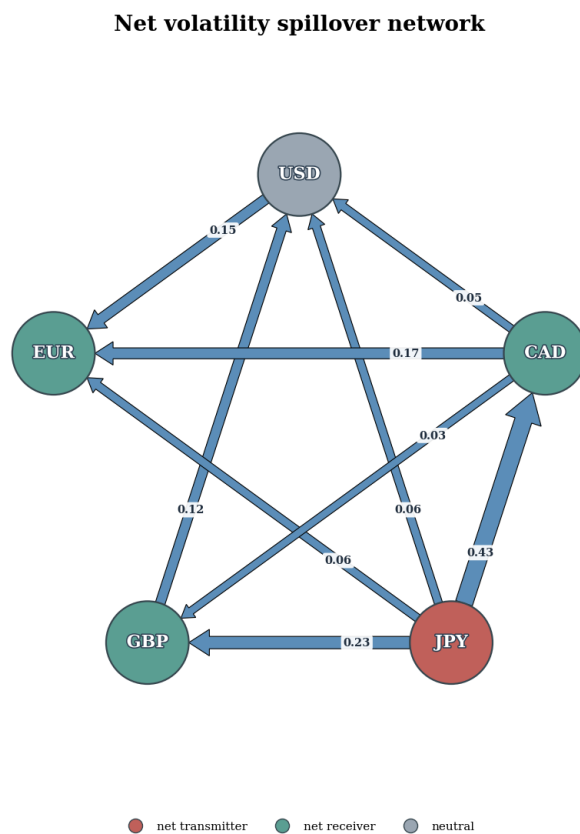


Figure 5.7: Net volatility spillover network. Each arrow runs from the net transmitter to the net receiver of a pair, with the net pairwise spillover on the arrow.

Connectedness is near its sample high at the end, which means the residual

co-movement the min-variance weights have to offset is larger in the recent period than at any earlier point. The net network points to where that pressure comes from: the JPY feeds the CAD, the GBP, the EUR and the USD, and the CAD and the USD pass part of it on to the EUR. The EUR is the common sink. For the design of the basket, this ordering works as an early-warning map: the JPY is the one leg whose stress would move the whole index, so it is the currency to monitor for the peg, with the EUR as the first to register the effect. On both the received side and the transmitted side, as shown below in Figure 5.8 and Figure 5.9, the JPY sits at the top and climbs steeply after 2024, its transmission reaching about 11.5 percent and its reception about 9. The USD rises with it on both sides, toward 8 percent. The EUR stays near the bottom of both, the most insulated of the five. The GBP is the mover: its transmission holds near 7 to 8 percent through 2023 and then falls to about 3.6 percent, so it stops being a source late in the sample.

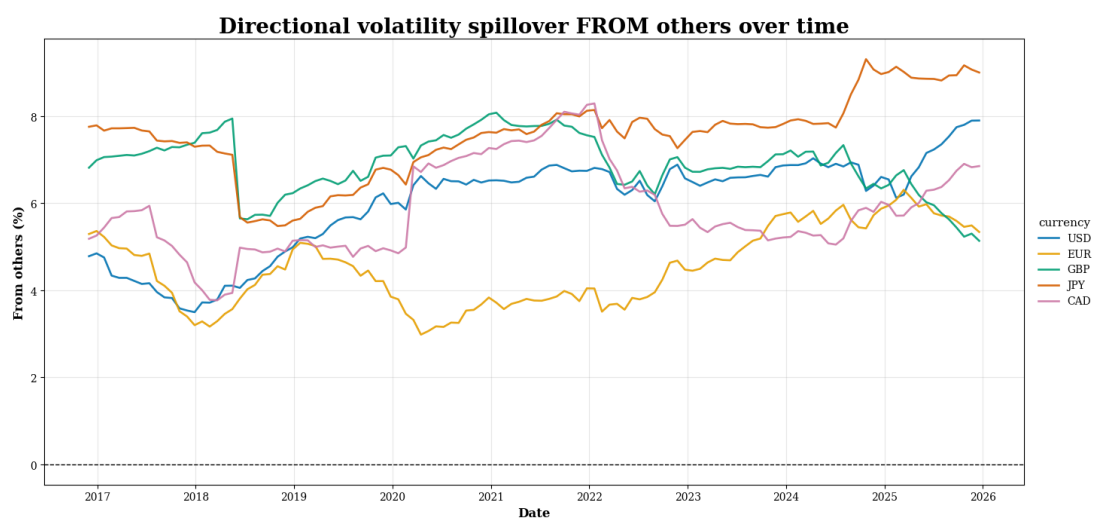


Figure 5.8: Directional volatility spillover FROM others over time, by currency.

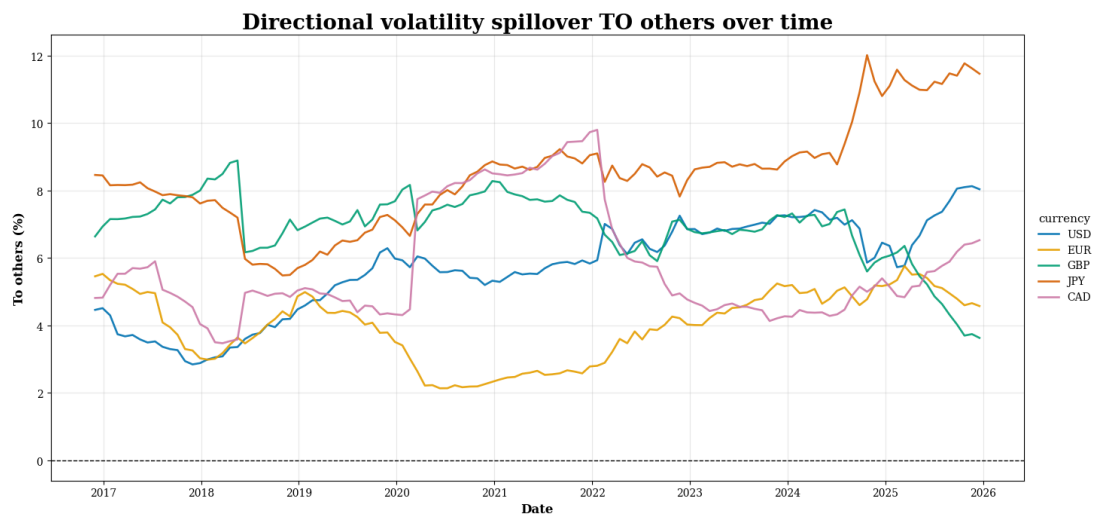


Figure 5.9: Directional volatility spillover TO others over time, by currency.

Figure 5.10 shows the net-over-time graph, which ties these together. The JPY stands apart as the source: it is a net transmitter across the whole sample and pulls away sharply after late 2024, ending near +2.5. The EUR is its mirror, a net receiver across almost all of the period, deepest around 2021 and ending near -0.8 . The USD hovers close to zero, a mild receiver through the early 2020s and near neutral at the end, which is why the full-sample bar reads neutral. The other two move. The CAD is a receiver early, turns into a transmitter through the 2020 to 2022 window, peaking near +1.5 in 2022, then reverses sharply into receiver territory. The GBP runs the opposite path, a net transmitter around 2018 to 2020 and then a steady slide into strong receiver territory, close to -1.5 by 2025. The static table is therefore a snapshot of a system whose center of gravity has settled on the JPY.

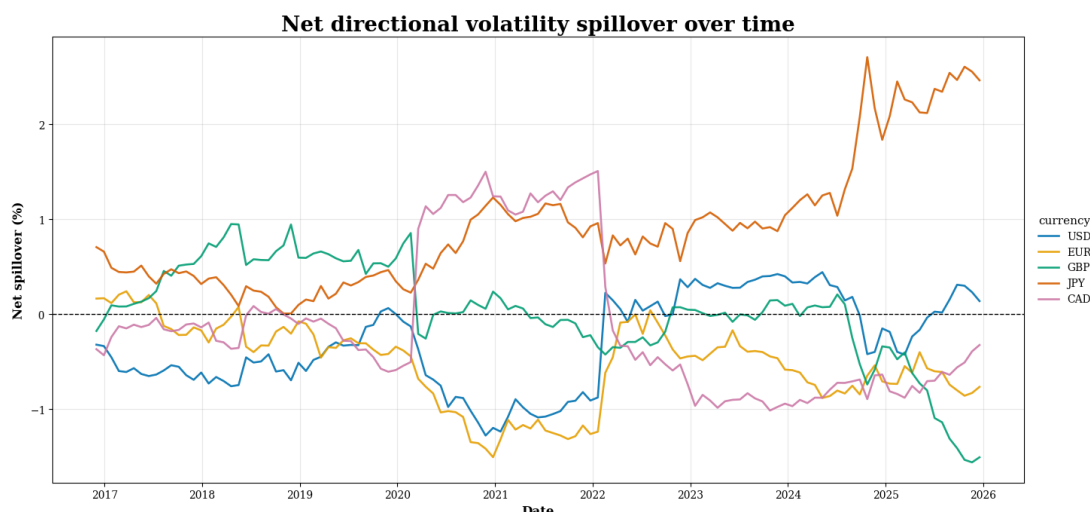


Figure 5.10: Net directional volatility spillover over time, by currency.

The end of the sample is a one-source system rather than the balanced picture the full-sample bar suggests. By 2025 the JPY climbs alone to the top of the net range, near +2.5, while the GBP and the EUR fall to the bottom, near -1.5 and -0.8, and the USD and the CAD sit close to neutral as shown in Figure 5.10. The JPY has become the single dominant transmitter, and its rise since late 2024 has widened the gap, so the recent structure concentrates the source of volatility on one leg while the rest absorb it. The static net bar, being a time average, understates how far the JPY has pulled ahead.

These patterns bear on the basket in two ways. First, the connectedness of the NATO basket is lower than the Global one, 26.8 against 37.9 percent, so its currencies share less common movement and the min-variance weights have less residual co-movement to offset. Second, the source and the weight sit on different legs. The JPY is the one transmitter, yet it carries only a 19 percent weight, while the largest weight, 22 percent, is on the CAD, a net receiver that absorbs rather than sends. The basket therefore places its heaviest weight on an absorber and a lighter weight on the source, which works in favor of stability. The one caution is that the JPY's transmission has risen steeply since late 2024, so the recent period concentrates the basket's shock channel on that single leg, and the JPY is the currency whose stress the coin is least insulated from.

5.4 The BRICS Basket

Table 5.3 reports the directional spillovers by counterparty at the ten-day horizon. Each entry is the share of the whole five-currency system's forecast error variance that runs from one currency to another: the row is the currency that receives, the column the currency that gives. Own contributions are left out, since a currency is not its own counterparty.

receives \ gives	BRL	RUB	INR	CNY	ZAR	FROM
BRL	–	3.22	0.80	0.76	0.05	4.82
RUB	2.27	–	2.62	2.73	1.67	9.30
INR	0.56	2.61	–	5.79	0.40	9.36
CNY	0.54	2.72	5.75	–	0.41	9.41
ZAR	0.06	2.55	0.61	0.63	–	3.85
TO	3.43	11.09	9.77	9.91	2.53	36.74

Table 5.3: Directional volatility spillover by counterparty, percent of total system forecast error variance. Rows receive, columns give. FROM is the total received, TO the total transmitted, and the corner is the total spillover index. Entries may not sum exactly to the margins because of rounding.

The bilateral picture is built around one very tight pair. The INR and the CNY trade the most volatility with each other, each supplying about 5.8 percent of the other's forecast error variance, the strongest link in the basket. The RUB sits apart, connected moderately to the INR and the CNY at about 2.6 to 2.7 percent and feeding the BRL more heavily, 3.22 percent. The BRL and the ZAR barely interact with each other, 0.05 to 0.06 percent, and take far more than they give, the most isolated of the five. So the BRL and the ZAR read as absorbers, while the RUB, the INR and the CNY read as sources.

Net directional spillover, transmission minus reception, makes this split explicit as shown in Figure 5.11. The RUB is the largest net transmitter, at +1.80 percentage points, followed by the CNY and the INR at +0.50 and +0.41; the BRL and the ZAR are net receivers, at –1.39 and –1.32. The net volatility spillover network as described in Figure 5.12 shows where the flows go. The RUB is the dominant source, sending its two largest net flows to the BRL (0.95) and the ZAR (0.88); the INR and the CNY each add smaller flows to the same two, about 0.21 to 0.24. Between the INR and the CNY the net flow is almost nothing (0.04), even though they share the tightest bilateral link, so the two move together and feed the receivers as a bloc. For the basket, this means the BRL and the ZAR absorb volatility while the RUB, the INR and the CNY generate it, and a shock that

raises basket co-movement is most likely to start in the RUB.

The rolling record also says how stable each role is, not just its average. Across the 119 windows the ZAR is a net receiver in 100 percent of them and the BRL in 96 percent, the two clearest roles in the basket. The INR and the CNY lean transmitter, at 66 and 64 percent. The RUB is the split case, and it is the interesting one: its full-sample net is the largest positive of any currency, +1.80, yet across the rolling windows it is a receiver in 58 percent of them and a transmitter in only 42. The reason is the war. The RUB's dominance is concentrated in a roughly two-year window after the invasion, and that window pulls the full-sample average up even though the RUB spends most of the rest of the sample receiving. Its static bar should therefore be read as an average distorted by one episode, not a settled position.

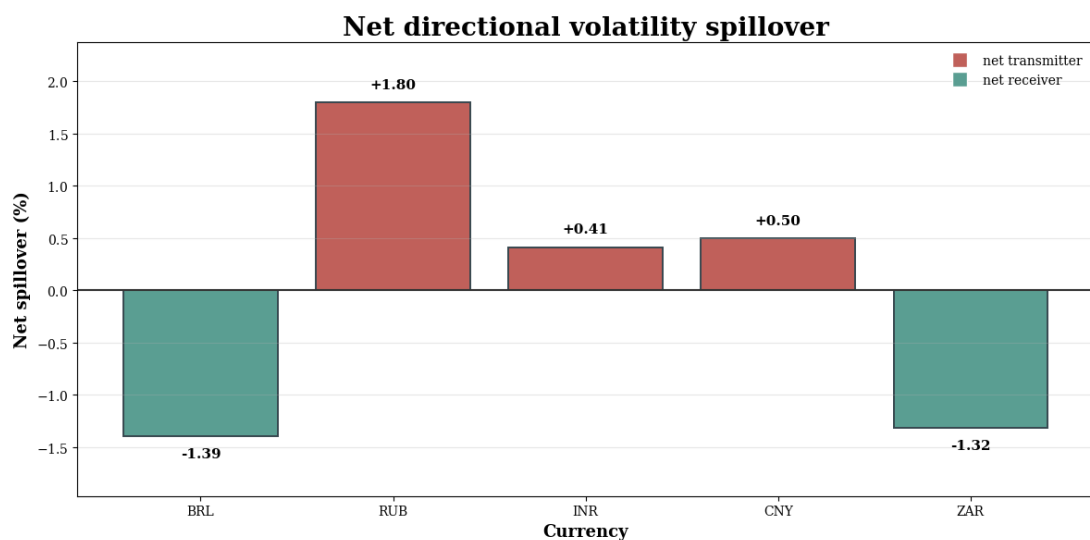


Figure 5.11: Net directional volatility spillover. Transmission minus reception for each currency; positive bars are net transmitters, negative bars net receivers.

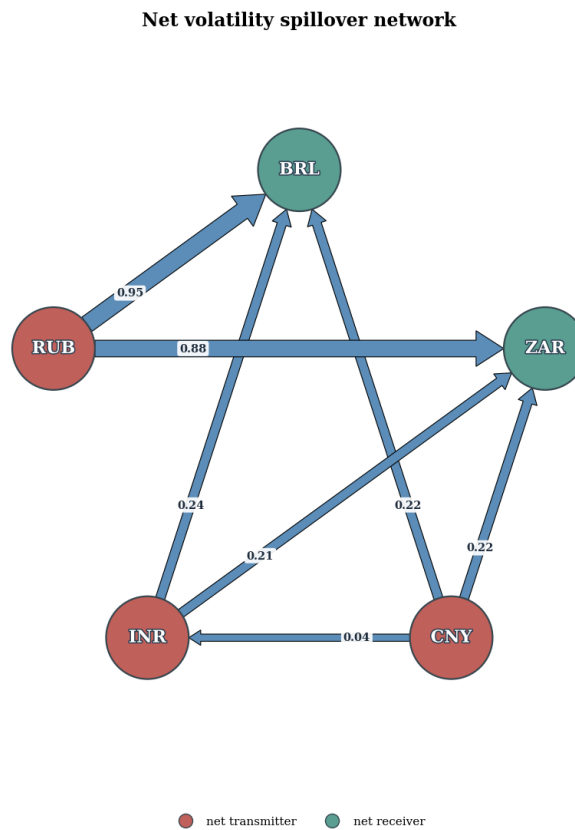


Figure 5.12: Net volatility spillover network. Each arrow runs from the net transmitter to the net receiver of a pair, with the net pairwise spillover on the arrow.

The basket's connectedness moves more than in the other two baskets, and the largest movement sits on the war. The total spillover reaches its sample maximum near 50 percent during the post-invasion period and settles near 40 by the end. The from and to graphs show the RUB driving that swing. On the transmitted side, as shown in Figure 5.14, the RUB's transmission jumps from about 3.5 percent just before the invasion to about 20 percent immediately after, holds there through early 2024, then collapses back to about 9 percent and climbs again to about 15 by the end. On the received side, as shown in Figure 5.13, its reception rises too, from about 5 to about 13 percent, but by less than its transmission, which is why its net turns strongly positive. The INR and the CNY stay near the middle of both as the tight pair, while the BRL and the ZAR sit low and absorb. For the design of the basket, the early-warning map is clear: the RUB is the leg whose stress moves the whole index, with the BRL and the ZAR the first to register it.

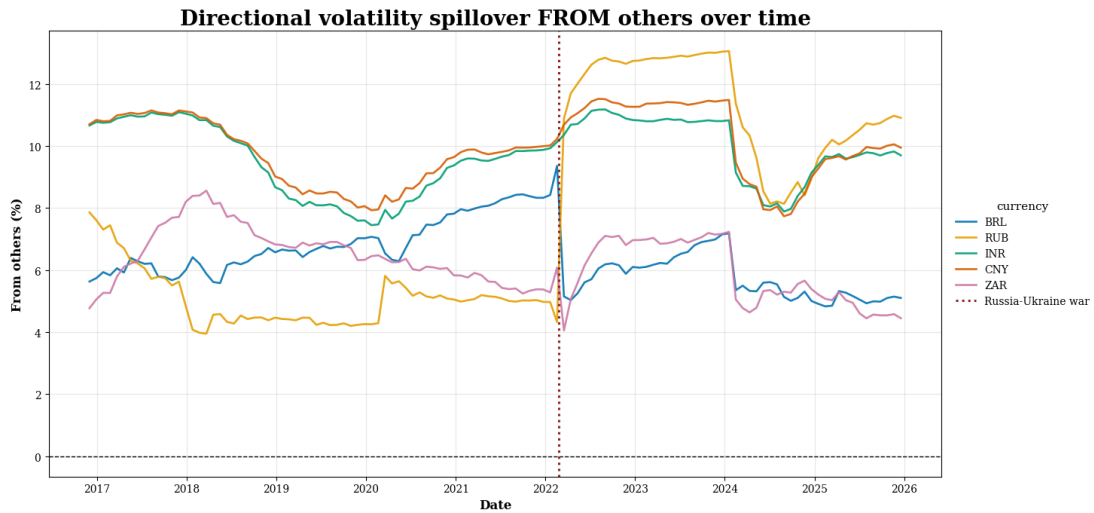


Figure 5.13: Directional volatility spillover FROM others over time, by currency.

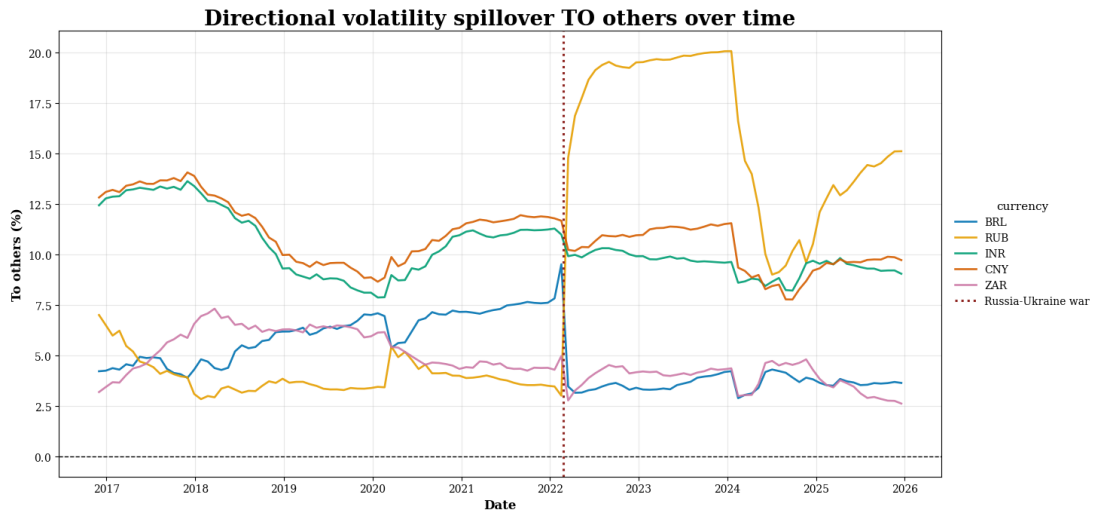


Figure 5.14: Directional volatility spillover TO others over time, by currency.

Figure 5.15 shows the net-over-time graph, and it is organized by the war line at February 2022. Before the invasion the transmitters are the two Asian currencies: the CNY and the INR run positive through 2017 to 2022, while the RUB, the BRL and the ZAR are receivers, the RUB sitting near -1 . At the war line the RUB's net jumps almost vertically, from about -1 to about $+7$, and it becomes the dominant transmitter of the basket, holding near $+6.5$ to $+7$ from 2022 into early 2024. Over the same period the BRL and the ZAR fall to their deepest, near -2.7 , absorbing the RUB's shocks, while the CNY and the INR are pushed down toward zero. In early 2024 the RUB's net collapses from about $+7$ back toward $+1$, then rises again to about $+4$ by the end. The static table is therefore

a snapshot taken across a sample that the war splits in two: a pre-war system led by the Asian pair and a post-war system led by the RUB.

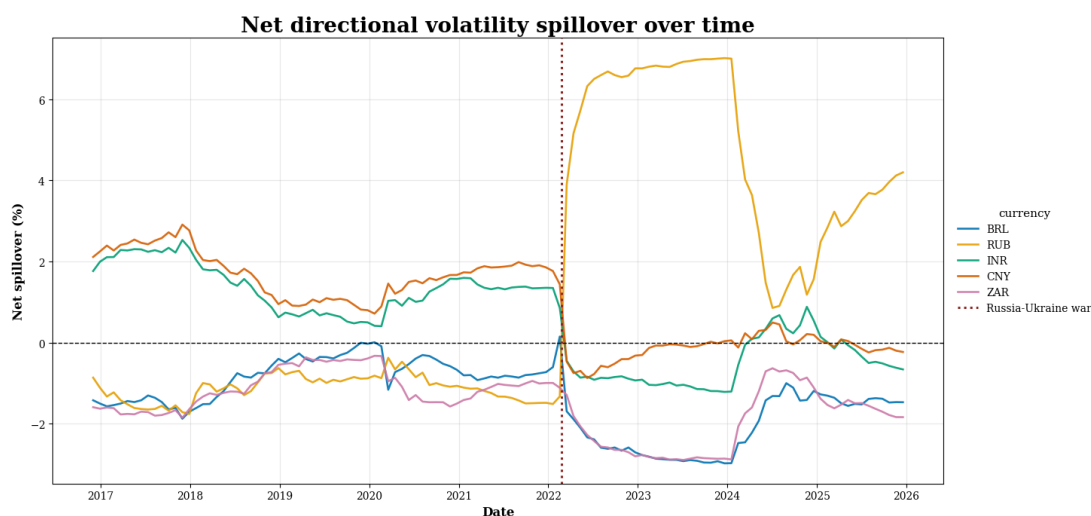


Figure 5.15: Net directional volatility spillover over time, by currency.

The war does not just move one line, it reorganizes the whole basket. Before 2022 the split is mild, with the CNY and the INR modestly positive and the others modestly negative. After the invasion the split is extreme: the RUB alone near +7 and the BRL and the ZAR near -2.7 , a one-source system built around Russia. By the end of the sample the picture has relaxed but not returned to its pre-war shape, with the RUB still the only clear transmitter, near +4, and the BRL and the ZAR still the deepest receivers. The static net bar, being an average over both regimes, sits between them and describes neither period well.

These patterns bear on the basket in two ways, both tied to the war. First, the episode concentrates the basket's shock channel on a single leg, the RUB, whose transmission went from marginal to dominant in a matter of days and stayed there for two years. A basket that carries a 19 percent RUB weight therefore has its main volatility source on a currency subject to sanctions and capital controls, a different kind of risk from the market-driven sources in the other two baskets. Second, the basket's heaviest weight, 25.4 percent, sits on the BRL, a net receiver that absorbed the RUB's shocks rather than passing them on, and the ZAR, the other absorber, takes another 19.9 percent. So more than 45 percent of the basket sits on the two currencies that soaked up the war, which is part of why the coin held its value through the episode even as one of its legs became the loudest transmitter in the sample. The RUB is the currency whose stress the coin is least insulated from, and the war shows how fast that stress can arrive.

5.5 Comparison on Spillover Results Across the Three Baskets

The three baskets are estimated with the same generalized decomposition, the same ten-day horizon and the same rolling window, so their numbers can be read side by side. They differ first in how much volatility they pass around. The NATO coin is the least connected, at a total spillover of 26.8 percent, and it has only one weak source, the JPY. The Global and BRICS coins are more connected and close to each other, at 37.9 and 36.7 percent, but for different reasons. Global's figure comes from a standing USD and CNY axis that feeds the European currencies. BRICS's comes largely from the war, which lifted the RUB from the margins to the loudest transmitter in any of the three samples. So a similar number describes a structural feature in one basket and a single episode in the other.

NATO and BRICS place their heaviest weight on absorbers, the CAD in one and the BRL and the ZAR in the other, so the loudest transmitter carries a smaller share, and that weighting is part of why the BRICS coin stayed near its peg through the war even as one of its legs became the loudest transmitter in the sample. Global is the exception: its top weight sits on the CNY, a rising source, so the leg most likely to spread a shock is also the one the coin leans on most. Read together, the spillover analysis works as a systemic-risk map that is specific to each basket, and it shows that the min-variance weights usually, though not always, keep the heaviest weight off the currency that transmits the most.

Chapter 6

Comparison and Economic Implications

6.1 Comparison with Fiat-Backed Stablecoins

The three basket coins can be set against the two largest fiat-backed stablecoins, USDT and USDC, which hold a one-to-one USD reserve and are redeemable at par. The comparison starts on November 20, 2018, the earliest date for which both stablecoins were available to populate the dataset. The basket figures and the two stablecoins are restricted to the sampled window solely because the stablecoins' price history is shorter. Tables 6.1 and 6.2 report the two groups on the same metrics used for the baskets.

	Ann. vol. (%)	Std. dev. (%)	Max DD (%)	Max dev. (%)
Global Basket	0.204	0.074	−0.36	0.26
NATO Basket	0.189	0.075	−0.37	0.33
BRICS Basket	1.044	0.259	−2.92	2.09
USDT	2.361	0.310	−4.01	4.29
USDC	4.527	0.367	−10.40	6.05

Table 6.1: Basket coins and stablecoins on volatility metrics, all measured from November 20, 2018, the first date on which USDT and USDC are quoted.

	Mean ret. (%)	Sharpe
Global Basket	+0.051	0.249
NATO Basket	+0.044	0.234
BRICS Basket	+0.005	0.005
USDT	+0.579	0.245
USDC	−0.567	−0.125

Table 6.2: Basket coins and stablecoins on return metrics, over the same window as Table 6.1.

On volatility the gap is an order of magnitude. The Global and NATO coins sit near 0.20 percent annualized and the BRICS coin at 1.04 percent, while USDT runs at 2.36 percent and USDC at 4.53. Even the noisiest basket, BRICS, is less than half as volatile as USDT and under a quarter of USDC. The standard deviation of the level says the same, 0.08 to 0.25 percent for the baskets against 0.31 and 0.37 for the two coins.

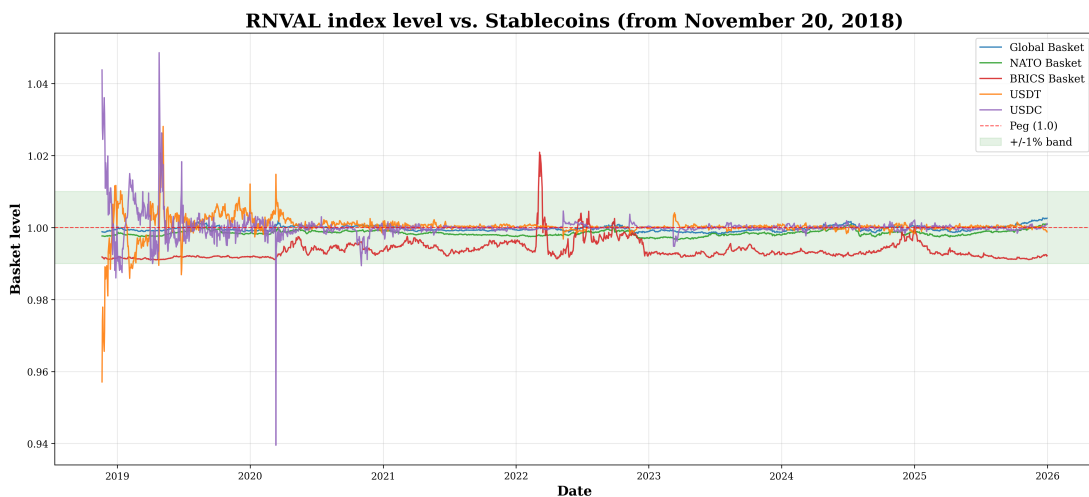


Figure 6.1: RNVAL basket index levels against USDT and USDC, from November 20, 2018, with the 1.0 peg and a $\pm 1\%$ band.

The peg holds better for the baskets, which is the result that matters for a unit meant to keep its value. The Global and NATO coins never leave a one-percent band and their largest single deviation is 0.26 and 0.33 percent; BRICS stays inside one percent 99.6 percent of the time, with a worst deviation of 2.09 percent during the 2022 war. The stablecoins are looser on both counts. USDT spends 97.9 percent of days inside one percent and reaches 4.29 percent at its worst, USDC 97.7 percent and 6.05 percent. Figure 6.1 shows why. The two stablecoin lines swing widely in their first two years, USDC reaching 1.05 and falling to 0.94 across 2019 and 2020 and USDT dropping to 0.96, while the three basket lines hug the

peg throughout. The drawdowns confirm the ranking: the worst peak-to-trough loss is 0.4 percent for Global and NATO and 2.9 percent for BRICS, against 4.0 percent for USDT and 10.4 percent for USDC, the last driven by that early swing from 1.05 to 0.94. No basket has an event of that size.

On returns the baskets behave like the store of value they are meant to be. Their mean return is close to zero, +0.051 percent a year for Global, +0.044 for NATO and +0.005 for BRICS, so the value neither trends up nor drifts away. The stablecoins carry larger means with opposite signs, +0.579 for USDT and -0.567 for USDC, the residue of their wider swings rather than any real appreciation. Sharpe ratios are not very informative for assets meant to be flat, but they follow the same split, small and positive for the baskets and USDT and negative for USDC.

The comparison points to one conclusion. The basket coins hold a tighter peg than either fiat-backed stablecoin, and they do it without a USD reserve or a redemption promise, through currency diversification alone. USDT and USDC carry a full one-to-one reserve and can be redeemed at par, yet they deviate more, because they trade on venues exposed to liquidity and counterparty stress that an index built from exchange rates does not face. Even the emerging-market basket, the least stable of the three, stays closer to its peg than the better of the two stablecoins. Over this sample, diversification across currencies substitutes for collateral, and it does so with room to spare.

6.2 Practical Applications, the El Salvador Case, and Effects on the Domestic and External Economy

Standard monetary theory holds that money must work as a medium of exchange. This section asks how far crypto-assets, and stablecoins in particular, already meet that requirement in practice, and what follows when they do. Two questions organize the discussion. The first is empirical: where are stablecoins actually used to pay for goods, services and transfers, and how large is that use once the headline figures are stripped of trading that never touches the real economy? The second is macroeconomic: if the residents of a country begin to hold and transact in a foreign digital currency, what happens to the domestic economy, and what happens to its external trade, meaning its exports and its imports? The El

Salvador experiment with bitcoin as legal tender offers a rare field test for the first question. The second needs theory, because the country that ran the experiment had no monetary lever left to observe.

Stablecoins do function as a means of payment. Their combined market capitalization passed 300 billion U.S. dollars in 2026, as Figure 6.2 shows, and estimated cross-border transaction volumes exceeded 400 billion U.S. dollars in 2024. Read at face value, those numbers suggest a payment system already operating at scale. The face value is misleading. Once the raw on-chain figures are adjusted for intra-exchange transfers, high-frequency trading, bot-driven arbitrage and wash trading, the volume that plausibly corresponds to real economic activity falls to about one percent of the unadjusted total.⁵²



Figure 6.2: Aggregate market capitalization of all outstanding stablecoins, in U.S. dollars. The series is negligible before 2020, climbs to a first peak near \$190 billion in 2022, contracts through 2023, and expands again to above \$300 billion by 2026.

Within that adjusted measure, transactions small enough to be retail, under 250 U.S. dollars, account for only 0.4 to 0.9 percent of the flow, which is hard to square with the claim that stablecoins already settle remittances and everyday purchases at scale. Acceptance for goods and services has begun in a handful of places, through selected payment gateways, but wider use still depends on integration that does not yet exist. The honest description is that stablecoins are a large asset and a genuine but still narrow medium of exchange: most of the recorded turnover circulates inside the crypto system itself, and the retail and remittance

⁵² See Aldasoro, Iñaki, Jon Frost, and Hiro Ito, The Impact of Stablecoins on the International Monetary and Financial System, 2026, available at <https://www.bis.org/publ/bppdf/bispap170.pdf>.

applications remain at pilot stage.

El Salvador supplies the clearest real-world test of a crypto-asset used as everyday money. In September 2021 it became the first country to make bitcoin legal tender, requiring businesses to accept it as payment and launching a state digital wallet, Chivo, that let users hold and convert bitcoin and U.S. dollars at no fee. The government pushed adoption hard, paying a 30 USD bitcoin bonus to every citizen who downloaded the app, an amount equal to about 3.75 daily minimum wages. The push produced a spike, not a habit. Just over half of all adults downloaded Chivo, but 40 percent of the downloads happened in the launch month and almost none followed in 2022. Only about a fifth of users kept transacting after spending the bonus, and fewer than one in ten used it for bitcoin rather than U.S. dollars. Firms behaved the same way: roughly 20 percent accepted bitcoin, only 4.9 percent of sales were paid in it, and 88 percent of the businesses that took bitcoin converted it into U.S. dollars straight away.⁵³ The IMF's later review reached the same verdict, finding no evidence of a beneficial payment use case more than a year in, and noting that even the Treasury held no bitcoin accounts and converted its bitcoin receipts to U.S. dollars.⁵⁴

The pattern of firm behavior is the informative part. Access was not the obstacle. The wallet was free, acceptance was mandatory, and the state subsidized the on-ramp. What businesses would not do was hold the asset, converting almost all of it to U.S. dollars on receipt. The binding constraint was volatility, not availability, which is exactly the constraint a stablecoin is built to remove. One caveat frames how far this evidence travels. El Salvador had already adopted the USD as legal tender in 2001, so its economy ran on a foreign currency long before bitcoin arrived. The experiment is therefore valid evidence on practical adoption, on whether people will actually transact in a crypto medium of exchange, but it says nothing about exchange-rate or trade effects, because the country had no domestic currency left to move.

For a country that still has its own currency, the domestic case for a USD stablecoin rests on three familiar attractions. The first is a store of value. Where inflation is high and the local currency unreliable, a dollar-denominated stablecoin offers

⁵³ See Alvarez, Fernando E., David Argente, and Diana Van Patten, *Are Cryptocurrencies Currencies? Bitcoin as Legal Tender in El Salvador*, 2023, available at https://www.nber.org/system/files/working_papers/w29968/w29968.pdf.

⁵⁴ See International Monetary Fund, *El Salvador: Selected Issues*, 2025, available at <https://www.imf.org/-/media/Files/Publications/CR/2025/English/1slvea2025003-print-pdf.ashx>.

a hedge that is easier to obtain than a foreign bank account.⁵⁵ The second is the cost of remittances. Sending 500 U.S. dollars over stablecoin rails has been estimated at 5 to 10 U.S. dollars, against 20 to 30 through traditional channels, a saving that matters most in the low-income corridors where remittances are a large share of income.⁵⁶ The third is financial inclusion: a smartphone and an internet connection can reach households that banks find too costly to serve, and the added competition can lower fees for everyone.

These are real gains, but it helps to see what channel they run through. None of them is new. Households in fragile monetary regimes have long protected savings by holding physical U.S. dollars and sending money through informal networks, so the effect of stablecoins is to accelerate an existing informal dollarization rather than to open a fresh channel. The difference is speed and reach. Traditional dollarization needs cash or a foreign account; a dollar stablecoin spreads through phones, settles at any hour, and gains ground through network effects, so it can displace the local currency faster and make it harder for a domestic alternative to compete.⁵⁷ Since 2020, stablecoin holdings have risen from virtually zero to 1.5 percent of total deposits in Africa and the Middle East and 2.7 percent in Latin America and the Caribbean by 2024, still small beside the foreign-currency deposit shares of 20 and 25 percent respectively, but climbing quickly.⁵⁸ The domestic story is less a new mechanism than an old one moving faster.

The external side is where intuition most often misleads. The conventional assumption, drawn from the Mundell-Fleming framework, is that a weaker currency helps a country's trade: cheaper exports abroad, dearer imports at home, and an automatic rebalancing through both. On that view, giving up a national currency, or letting a USD stablecoin displace it, would cost the country the competitive boost that its own weak currency could deliver. The dominant currency paradigm shows the assumption is largely wrong on the export side. Because most trade is invoiced in U.S. dollars rather than in the exporter's currency, a depreciation does not lower the USD price foreign buyers face, so their demand barely changes and export volumes respond little in the short run. The adjustment that does happen runs almost entirely through imports: a depreciation raises the home-currency price of USD-invoiced imports and compresses them noticeably, an effect that balance-sheet strains on import-financing firms reinforce. The two sides rebalance

⁵⁵ See Adrian, Tobias et al., *Understanding Stablecoins*, 2025, available at <https://www.imf.org/-/media/files/publications/dp/2025/english/usea.pdf>.

⁵⁶ *Id.*

⁵⁷ *Id.*

⁵⁸ *Id.*

only later, as USD prices slowly adjust and the standard expenditure-switching mechanism reemerges through both exports and imports over the medium term. The magnitudes fit the story: a 10 percent depreciation is estimated to improve the trade balance of a typically open economy by about 0.3 percent of GDP in the short run and 1.2 percent over the medium term, with the export contribution arriving late and only in part.⁵⁹

This reframes what a country actually loses by ceding its currency to a foreign stablecoin. It is not a fixed level of export competitiveness, since a weak currency never bought much of that in the short run to begin with. What it loses is the exchange rate as a shock absorber, the medium-term channel through which the currency can adjust to a bad shock and pull trade quantities back toward balance. Exchange-rate flexibility is the durable adjustment mechanism, and that is the mechanism digital dollarization removes.⁶⁰ A final point cuts against the framing of the loss as giving up a strong currency. Partial, informal stablecoin adoption tends to weaken the local currency rather than strengthen it: as residents shift savings into USD stablecoins at the first sign of stress, measured stablecoin inflows are followed by domestic-currency depreciation and by widening gaps between stablecoin-implied and official exchange rates.⁶¹ The country is not trading a strong currency for a stable one. It is watching a fragile currency depreciate faster, while surrendering the one instrument that could have cushioned the shock.

⁵⁹ See Adler, Gustavo et al., *Dominant Currencies and External Adjustment*, 2020, available at <https://www.imf.org/-/media/files/publications/sdn/2020/english/sdnea2020005.pdf>.

⁶⁰ *Id.*

⁶¹ See Aldasoro, Iñaki, Jon Frost, and Hiro Ito, *The Impact of Stablecoins on the International Monetary and Financial System*, 2026, available at <https://www.bis.org/publ/bppdf/bispap170.pdf>.

Chapter 7

Conclusion

This thesis asked whether currency diversification alone can hold a digital unit at a stable value, without pegging it to any single national currency. The construction answers in two steps. It measures each currency's worth through the numeraire-free RIVAL index, which strips out the base currency that would otherwise make any measured basket an artifact of the unit it was quoted in, and it sets the basket weights by minimizing the variance of that index. The weights are computed, not negotiated, so the same data and the same objective would return the same coin in any hands.

Run on three baskets, the method holds. The Global and NATO coins sit near 0.20 percent annualized volatility, stay inside a one-percent band on every trading day of the eleven-year sample, and never lose more than half a percent from peak to trough, across a window that contains the 2020 dislocation and the 2022 tightening. The BRICS coin is wider, at 0.89 percent, because its five currencies are several times more volatile and move against each other less cleanly, yet it held to about two percent of par even when the RUB lost a third of its value in a fortnight after the invasion of Ukraine. A constituent at nearly a fifth of the basket collapsed, and the coin barely registered it. All three hold a value near one without the stability depending on any single issuer's currency, through diversification alone.

Set against the two largest fiat-backed stablecoins, the baskets held the tighter peg over the same period. USDT and USDC carry a full one-to-one USD reserve and can be redeemed at par, and they still deviated more, because they trade on venues exposed to liquidity and counterparty stress that an index built from exchange rates does not face. The concentration that a single-currency peg imposes, and

the dollarization it quietly spreads, is therefore not the only route to a steady digital unit.

The spillover analysis answered how shocks travel inside a basket, which a single volatility figure cannot show. Each basket has its own transmitter: the USD and the CNY feed the Global coin, the JPY dominates the NATO one, and the war turned the RUB from a marginal receiver into the loudest transmitter of the BRICS basket. The minimum-variance weights usually keep the heaviest weight off the loudest source, placing it on the CAD in the NATO coin and on the BRL and the ZAR in the BRICS coin, which is part of why both held through stress. The Global coin is the exception, since its largest weight sits on the CNY, a rising source. Read this way, the analysis is an early-warning map of where a shock would enter each coin, not a static ranking.

The field evidence from El Salvador supports the premise from the outside. Firms there had a free wallet and a legal duty to accept bitcoin, yet 88 percent converted their bitcoin receipts into U.S. dollars on the spot, so the binding constraint on a crypto medium of exchange was its volatility, not access to the technology, which is exactly the constraint a basket coin is built to remove.⁶² The one thing that experiment cannot show is the exchange rate side, since the country had already given up its own currency in 2001.

What a basket peg removes is the concentration that a single-currency peg imposes: the dependence on one issuer's policy, and the exposure to sanctions or to convertibility restrictions falling on one currency, both of which the construction spreads across five issuers instead. What it does not remove is currency substitution. A resident who moves out of a domestic currency into a basket unit gives up the exchange rate as a shock absorber exactly as one who moves into a dollar unit does, and the argument of the previous chapter was that this absorber, rather than short-run export competitiveness, is what a country actually loses.⁶³ The contribution here therefore concerns the concentration of that dependence and not monetary sovereignty, which no privately issued unit restores whatever its composition.

The coin studied here is a measured construct, priced on exchange rates, and a deployed version would meet a set of problems the recent literature catalogs.

⁶² See Alvarez, Fernando E., David Argente, and Diana Van Patten, Are Cryptocurrencies Currencies? Bitcoin as Legal Tender in El Salvador, 2023, available at https://www.nber.org/system/files/working_papers/w29968/w29968.pdf.

⁶³ See Adler, Gustavo et al., Dominant Currencies and External Adjustment, 2020, available at <https://www.imf.org/-/media/files/publications/sdn/2020/english/sdnea2020005.pdf>.

Mahrous, Caprolu and Di Pietro group them into reserve transparency and auditing, since a claim of backing is only as good as its verification; regulatory fragmentation, as jurisdictions diverge, with MiCAR admitting a basket-referenced token while the current U.K. and U.S. perimeters take only fiat-referenced ones; monetary sovereignty and currency substitution, the macro risk this thesis has kept in view; smart-contract, security and privacy risk at the protocol level; the governance of the arrangement; cross-chain interoperability and its failure modes; and the demonstrated fragility of purely algorithmic designs.⁶⁴ A basket coin does not sidestep any of these, and it adds two of its own. The weights have to be re-estimated as correlations move, and the spillover chapter showed the Global basket's structure drifting toward the USD and the CNY by the end of the sample. The reserve has to actually hold the constituent currencies, with the custody and settlement that implies. What the thesis establishes is narrower and firmer than a finished product: diversification across currencies can produce a steadier unit than a single peg, and the same tools that build it also map the risks a real version would have to manage.

⁶⁴ See Mahrous, Ahmed, Maurantonio Caprolu, and Roberto Di Pietro, *Stablecoins: Fundamentals, Emerging Issues, and Open Challenges*, 2025, available at <https://arxiv.org/pdf/2507.13883>.

Appendices

Appendix A: Numeraire Invariance and Index Identities

The RNVAl construction rests on three algebraic properties: the exchange matrix is transitive, the normalized value is invariant to the base currency, and the product of the five normalized values equals one at every date. Each property is verified numerically on the full sample of 2,870 daily observations, for all three baskets. Table A.1 reports the largest absolute residual of each identity; every figure is at the level of double-precision rounding error, which confirms that the invariance holds in the data and not only in the derivation of Section 4.1.

Identity (maximum absolute residual over all dates)	Global	NATO	BRICS
Geometric-mean normalization $ \text{GM}_i \text{NVal}_i - 1 $	4.44×10^{-16}	3.33×10^{-16}	6.66×10^{-16}
Product identity $ \prod_i \text{NVal}_i - 1 $	1.55×10^{-15}	1.78×10^{-15}	3.55×10^{-15}
Transitivity $ c_{ij}c_{jk} - c_{ik} $	3.55×10^{-15}	2.84×10^{-14}	3.55×10^{-15}
Base-date reset $ \text{RNVAl}(t_0) - 1 $	0	0	0
Reduced product $ \prod_i \text{RNVAl}_i - 1 $	1.55×10^{-15}	2.11×10^{-15}	4.22×10^{-15}

Table A.1: Numerical verification of the RNVAl identities. The bilateral checks $c_{ii} = 1$ and $c_{ij}c_{ji} = 1$ hold exactly at every date. Residuals are at machine precision, confirming that the index is numeraire-free in practice.

Appendix B: Order Invariance of the Generalized Decomposition

Because the five RNVAL log-return series sum to zero at every date, their innovation covariance matrix has rank $N - 1$. The vector autoregression is therefore estimated on a free block of four series and the fifth restored by the adding-up identity (Appendix D). The generalized forecast-error variance decomposition is invariant to which series is dropped and restored: Table B.1 reports the largest absolute difference between the decomposition obtained when the first currency is restored and the one obtained when a second currency is restored instead. The differences are at machine precision, which is the empirical counterpart of the order-invariance property that motivates the generalized decomposition over the Cholesky factorization.

	Global	NATO	BRICS
Currency restored by identity	USD	USD	BRL
$\max \theta^g(\text{drop A}) - \theta^g(\text{drop B}) $	4.00×10^{-15}	2.35×10^{-15}	1.44×10^{-15}

Table B.1: Order invariance of the generalized FEVD ($H = 10$). The decomposition is unchanged whichever currency is recovered by the adding-up identity.

Appendix C: Minimum-Variance Optimization Diagnostics

The minimum-variance weights are obtained by sequential least-squares programming (SLSQP) under the constraints $\sum_i w_i = 1$ and $0 \leq w_i \leq 1$, with a numerical tolerance of 1.0×10^{-10} and a fixed random seed of 42. For each basket the program is solved from eighteen distinct starting points, and all eighteen converge to the same optimum, consistent with the convexity of the level-covariance objective.

Table C.1 reports the dispersion of the weighted index under each weighting scheme. The minimum-variance allocation lowers the level standard deviation by 54.36, 55.10 and 71.81 percent relative to equal weight for the Global, NATO and BRICS baskets respectively; the IMF SDR allocation, available only for the Global basket, is the most concentrated and the most volatile of the three.

Basket	Weighting	Var(levels)	Std(levels)	HHI	Eff. N	Std. red. (%)
Global	Equal ($1/N$)	2.80×10^{-6}	1.674×10^{-3}	0.200	5.00	–
	IMF SDR	5.18×10^{-4}	2.277×10^{-2}	0.300	3.33	–
	Minimum var.	5.84×10^{-7}	7.641×10^{-4}	0.201	4.97	54.36
NATO	Equal ($1/N$)	2.93×10^{-6}	1.711×10^{-3}	0.200	5.00	–
	Minimum var.	5.90×10^{-7}	7.683×10^{-4}	0.202	4.96	55.10
BRICS	Equal ($1/N$)	7.86×10^{-5}	8.868×10^{-3}	0.200	5.00	–
	Minimum var.	6.25×10^{-6}	2.500×10^{-3}	0.204	4.90	71.81

Table C.1: Level-variance diagnostics by weighting scheme. The Herfindahl index (HHI) of the weights and Eff. $N = 1/\text{HHI}$ the effective number of currencies. Std. red. is the reduction in level standard deviation relative to equal weight.

Table C.2 reports the risk decomposition at the optimum. The marginal risk contribution is identical across currencies within each basket (7.64×10^{-4} for Global, 7.68×10^{-4} for NATO, 2.50×10^{-3} for BRICS), so the percentage risk contribution equals the weight. This equality of marginal contributions is the first-order condition of the global minimum-variance portfolio and confirms that no reallocation can lower the basket standard deviation.

Basket	Currency	Weight (%)	Component RC	RC (%)
Global	USD	17.61	1.35×10^{-4}	17.61
	EUR	20.20	1.54×10^{-4}	20.20
	GBP	21.11	1.61×10^{-4}	21.11
	JPY	19.08	1.46×10^{-4}	19.08
	CNY	22.00	1.68×10^{-4}	22.00
NATO	USD	17.35	1.33×10^{-4}	17.35
	EUR	19.71	1.51×10^{-4}	19.71
	GBP	21.50	1.65×10^{-4}	21.50
	JPY	19.04	1.46×10^{-4}	19.04
	CAD	22.41	1.72×10^{-4}	22.41
BRICS	BRL	25.43	6.36×10^{-4}	25.43
	RUB	19.06	4.77×10^{-4}	19.06
	INR	18.89	4.72×10^{-4}	18.89
	CNY	16.70	4.18×10^{-4}	16.70
	ZAR	19.92	4.98×10^{-4}	19.92

Table C.2: Risk contributions at the minimum-variance optimum. Component $RC_i = w_i MRC_i$ and the marginal contribution MRC_i is constant within each basket, so RC_i as a share equals the weight. Component contributions sum to the basket standard deviation by Euler's theorem.

Appendix D: Vector-Autoregression and Spillover Diagnostics

The spillover analysis of Chapter 5 rests on a vector autoregression estimated on the daily RNVAL log returns. Table D.1 reports the augmented Dickey-Fuller test for each series: every statistic is far below the one-percent critical value, so the stationarity required for the decomposition holds for all currencies in all three baskets.

Basket	Currency	ADF statistic	p -value
Global	USD	−52.75	< 0.001
	EUR	−18.90	< 0.001
	GBP	−51.31	< 0.001
	JPY	−54.41	< 0.001
	CNY	−57.89	< 0.001
NATO	USD	−52.85	< 0.001
	EUR	−18.69	< 0.001
	GBP	−51.00	< 0.001
	JPY	−54.46	< 0.001
	CAD	−56.70	< 0.001
BRICS	BRL	−55.95	< 0.001
	RUB	−21.86	< 0.001
	INR	−53.10	< 0.001
	CNY	−26.19	< 0.001
	ZAR	−52.56	< 0.001

Table D.1: Augmented Dickey-Fuller tests on the RNVAL log-return series.

Because the five RNVAL log returns sum to zero at every date, their innovation covariance matrix has rank four rather than five. The vector autoregression is therefore estimated on a free block of four currencies and the fifth series recovered from the adding-up identity, a reduction that leaves the generalized decomposition unchanged (Appendix B). Each model uses a lag order of $p = 2$ and a forecast horizon of $H = 10$ days. Table D.2 reports the estimated system for each basket.

Basket	Free block (restored series)	Obs.	Log-likelihood	AIC	BIC
Global	EUR, GBP, JPY, CNY (USD)	2867	51650.4	−47.36	−47.28
NATO	EUR, GBP, JPY, CAD (USD)	2867	50183.3	−46.33	−46.26
BRICS	RUB, INR, CNY, ZAR (BRL)	2867	44084.3	−42.08	−42.00

Table D.2: Vector-autoregression specification. Each system has four equations, lag order $p = 2$ and horizon $H = 10$; the fifth currency is restored by the adding-up identity.

Appendix E: Generalized Forecast-Error Variance Decompositions

Tables E.1–E.3 report the full normalized generalized forecast-error variance decomposition at the ten-day horizon for each basket. Entry (i, j) is the share of currency i 's ten-day forecast-error variance attributable to currency j ; each row sums to 100 percent up to rounding. The diagonal is the own-variance share and the off-diagonal entries are the cross-currency spillovers. The counterparty tables in Chapter 5 are these off-diagonal entries expressed as a share of the whole five-currency system, that is, divided by the number of currencies.

receives \ from	USD	EUR	GBP	JPY	CNY
USD	53.97	11.07	11.45	4.89	18.61
EUR	14.21	69.47	0.56	3.16	12.60
GBP	13.49	0.50	63.81	12.72	9.48
JPY	6.05	3.21	13.60	68.08	9.05
CNY	19.04	10.02	8.18	7.37	55.39

Table E.1: Generalized FEVD, Global basket ($H = 10$, percent of each currency's own forecast error variance).

receives \ from	USD	EUR	GBP	JPY	CAD
USD	74.67	9.66	13.52	1.72	0.43
EUR	10.40	80.36	0.08	2.70	6.47
GBP	12.91	0.03	71.17	14.44	1.46
JPY	1.41	2.39	13.31	65.96	16.92
CAD	0.19	5.63	1.30	19.09	73.79

Table E.2: Generalized FEVD, NATO basket ($H = 10$, percent of each currency's own forecast error variance).

receives \ from	BRL	RUB	INR	CNY	ZAR
BRL	75.88	16.09	3.98	3.80	0.25
RUB	11.35	53.52	13.08	13.67	8.37
INR	2.80	13.05	53.21	28.95	1.99
CNY	2.70	13.58	28.75	52.93	2.04
ZAR	0.29	12.75	3.05	3.15	80.77

Table E.3: Generalized FEVD, BRICS basket ($H = 10$, percent of each currency's own forecast error variance).

Bibliography

1. Adler, Gustavo, Camila Casas, Luis Cubeddu, Gita Gopinath, Nan Li, Sergii Meleshchuk, Carolina Osorio Buitron, Damien Puy, and Yannick Timmer, Dominant Currencies and External Adjustment, 2020, available at <https://www.imf.org/-/media/files/publications/sdn/2020/english/sdnea2020005.pdf>.
2. Adrian, Tobias, Parma Bains, Marianne Bechara, Eugenio Cerutti, Stephanie Forte, Federico Grinberg, Alessandro Gullo, Martina Hengge, Agnija Jekabsone, Kathleen Kao, Tommaso Mancini Griffoli, Soledad Martinez Peria, Marcello Miccoli, Marco Reuter, and Nobuyasu Sugimoto, Understanding Stablecoins, 2025, available at <https://www.imf.org/-/media/files/publications/dp/2025/english/usea.pdf>.
3. Ahmed, Rashad, James A. Clouse, Fabio Natalucci, Alessandro Rebucci, and Geyue Sun, Stablecoins: A Revolutionary Payment Technology with Financial Risks, 2025, available at <https://www.nber.org/papers/w34475>.
4. Aldasoro, Iñaki, Jon Frost, and Hiro Ito, The Impact of Stablecoins on the International Monetary and Financial System, 2026, available at <https://www.bis.org/publ/bppdf/bispap170.pdf>.
5. Alvarez, Fernando E., David Argente, and Diana Van Patten, Are Cryptocurrencies Currencies? Bitcoin as Legal Tender in El Salvador, 2023, available at https://www.nber.org/system/files/working_papers/w29968/w29968.pdf.
6. Annunziata, Filippo, An Overview of the Markets in Crypto-Assets Regulation (MiCAR), 2023, available at <https://ssrn.com/abstract=4660379>.

7. Annunziata, Filippo, Crypto-Asset and Stablecoin Regulation: A Comparative Analysis of MiCAR, the United States GENIUS Act, and the UK Regulatory Framework, 2026, available at <https://ssrn.com/abstract=6459583>.
8. Arner, Douglas W., Raphael Auer, and Jon Frost, Stablecoins: risks, potential and regulation, 2020, available at <https://www.bis.org/publ/work905.pdf>.
9. Bank for International Settlements, Triennial Central Bank Survey of Foreign Exchange and Over-the-Counter Derivatives Markets in 2022, 2022, available at <https://www.bis.org/statistics/rpfx22.htm>.
10. Bannister, Geoffrey J., Jarkko Turunen, and Malin Gardberg, Dollarization and Financial Development, 2018, available at <https://www.imf.org/en/publications/wp/issues/2018/09/11/dollarization-and-financial-development-46164>.
11. Bullmann, Dirk, Jonas Klemm, and Andrea Pinna, In search for stability in crypto-assets: are stablecoins the solution?, 2019, available at <https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op230~d57946be3b.en.pdf>.
12. Coase, Ronald H., Durability and Monopoly, 1972.
13. d'Avernas, Adrien, Vincent Maurin, and Quentin Vandeweyer, Can Stablecoins be Stable?, 2022, available at <https://ssrn.com/abstract=4226027>.
14. DefiLlama, Stablecoins: Aggregate Market Capitalization, 2026, available at <https://defillama.com/stablecoins>.
15. Diebold, Francis X. and Kamil Yilmaz, Better to Give than to Receive: Predictive Directional Measurement of Volatility Spillovers, 2012, available at <https://ssrn.com/abstract=1536123>.
16. European Parliament and Council of the European Union, Regulation (EU) 2023/1114 on Markets in Crypto-Assets (MiCAR), 2023, available at <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R1114>.
17. Hovanov, Nikolai V., James W. Kolari, and Mikhail V. Sokolov, Computing Currency Invariant Indices with an Application to Minimum Variance

- Currency Baskets, 2004, available at [https://doi.org/10.1016/S0165-1889\(02\)00087-8](https://doi.org/10.1016/S0165-1889(02)00087-8).
18. International Monetary Fund, Currency Composition of Official Foreign Exchange Reserves (COFER), 2025, available at <https://data.imf.org/cofer>.
19. International Monetary Fund, El Salvador: Selected Issues, 2025, available at <https://www.imf.org/-/media/Files/Publications/CR/2025/English/1slvea2025003-print-pdf.ashx>.
20. International Monetary Fund, Questions and Answers on Special Drawing Rights, 2021, available at <https://www.imf.org/en/about/faq/special-drawing-right>.
21. International Monetary Fund, Special Drawing Rights (SDR): What is the SDR?, 2023, available at <https://www.imf.org/en/about/factsheets/sheets/2023/special-drawing-rights-sdr>.
22. Iyer, Roshan and Adina Popescu, New Evidence on Spillovers Between Crypto Assets and Financial Markets, 2023, available at <https://www.imf.org/en/publications/wp/issues/2023/09/30/new-evidence-on-spillovers-between-crypto-assets-and-financial-markets-539476>.
23. Koop, Gary, M. Hashem Pesaran, and Simon M. Potter, Impulse Response Analysis in Nonlinear Multivariate Models, 1996.
24. Lyons, Richard K. and Ganesh Viswanath-Natraj, What Keeps Stablecoins Stable?, 2023, available at <https://www.nber.org/papers/w27136>.
25. Mahrous, Ahmed, Maurantonio Caprolu, and Roberto Di Pietro, Stablecoins: Fundamentals, Emerging Issues, and Open Challenges, 2025, available at <https://arxiv.org/pdf/2507.13883>.
26. Martino, Edoardo D., Comparative Cryptocurrencies and Stablecoins Regulation: A Framework for a Functional Comparative Analysis, 2023, available at <https://ssrn.com/abstract=4500090>.
27. Mita, Makiko, Kensuke Ito, Shohei Ohsawa, and Hideyuki Tanaka, What is Stablecoin?: A Survey on Its Mechanism and Potential as Decentralized Payment Systems, 2020, available at <https://arxiv.org/pdf/1906.06037>.

28. Moin, Amani, Emin Gün Sirer, and Kevin Sekniqi, A Classification Framework for Stablecoin Designs, 2019, available at <https://arxiv.org/pdf/1910.10098>.
29. Ostercamp, Pierre, Stablecoin Regulation: EU, UK and US Perspectives, 2022, available at <https://ssrn.com/abstract=4038843>.
30. Pagnottoni, Paolo, Network Connectedness and Financial Technologies: from Systemic Risk to Investment Management, 2020.
31. Pesaran, M. Hashem and Yongcheol Shin, Generalized Impulse Response Analysis in Linear Multivariate Models, 1998.
32. SWIFT, RMB Tracker: Monthly Reporting and Statistics on Renminbi Progress Towards Becoming an International Currency, 2025, available at <https://www.swift.com/our-solutions/compliance-and-shared-services/business-intelligence/renminbi/rmb-tracker>.
33. World Bank, Migration and Development Brief: Remittance Flows to Low- and Middle-Income Countries, 2024, available at <https://www.knomad.org/publication/migration-and-development-brief-40>.
34. Yaga, Dylan, Peter Mell, Nik Roby, and Karen Scarfone, Blockchain Technology Overview, 2018, available at <https://doi.org/10.6028/NIST.IR.8202>.