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Evaluating Oil- and Gold-Backed Cryptocurrencies in Sanctioned Economies: Valuation, Stability, and Cryptographic Dimensions

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Highlights

- **Demonstrates the feasibility of oil- and gold-backed cryptocurrencies in sanction-affected, high-inflation economies.**
- **Applies Jensen's conditional dynamic alpha and GARCH modeling to assess risk-adjusted asset performance.**
- **Shows gold outperforms the U.S. dollar in terms of stability and risk-adjusted returns, supporting dual-commodity backing.**
- **Discusses cryptographic mechanisms, including secure oracles, smart contracts, and zero-knowledge proofs, to enhance transparency and trust.**

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Abstract

Countries facing high inflation and sanctions, particularly resource-rich economies such as Iran and Venezuela, may benefit from resource-backed cryptocurrencies as tools for monetary stability. In this study, global oil and gold prices were converted into the Iranian Rial using the free-market U.S. dollar exchange rate. We assess the viability of a crude oil-pegged digital asset using daily data on Iran's free-market exchange rates, global gold prices, and the Rial value of crude oil. Applying Jensen's conditional dynamic alpha and GARCH-modeled volatility, we find that gold consistently outperforms the U.S. dollar in risk-adjusted returns, supporting the case for dual oil- and gold-backing. Integrating gold into an oil-backed cryptocurrency enhances stability and resilience against macroeconomic shocks. To ensure credibility and transparency, we examine cryptographic mechanisms including zero-knowledge reserve proofs, secure oracles, and smart contract governance. The results provide a replicable valuation framework for resource-backed cryptocurrencies, demonstrate their potential to deliver stable, risk-adjusted returns, and offer policy-relevant insights for sanctioned or inflation-prone economies with natural resources seeking alternative monetary instruments. This study contributes to the literature on asset-backed digital currencies by combining financial modeling with cryptographic design, highlighting the role of multi-commodity collateralization in strengthening decentralized monetary systems under economic and geopolitical constraints.

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1. Introduction

Cryptocurrencies have challenged the foundations of traditional monetary systems by introducing decentralized, cryptographically secured alternatives to fiat currencies. Initially driven by speculative demand and ideological motivations, the crypto-asset ecosystem has evolved to include mechanisms that anchor digital assets to real-world commodities and macroeconomic indicators. This development has led to the emergence of asset-backed cryptocurrencies (ABCs), particularly those collateralized by tangible assets such as gold, oil, and real estate, aiming to enhance price stability and transparency (Chohan, 2024; Hou et al., 2024). In resource-rich but economically unstable countries, characterized by high inflation, fiscal imbalances, and restricted access to global capital, macroeconomically anchored cryptocurrencies offer a potentially viable alternative.

Oil-exporting nations such as Venezuela and Iran exhibit macro-financial conditions that make them relevant candidates for such instruments. Their economic structures are heavily dependent on the global oil market, while domestic currencies remain vulnerable to inflationary pressures driven by fiscal mismanagement, external sanctions, and geopolitical instability (Baumeister & Kilian, 2016; Chatziantoniou et al., 2023). Under these conditions, fiat-based monetary systems often fail to maintain purchasing power or public trust. Resource-backed digital currencies especially, those anchored in globally traded commodities may enhance monetary credibility and promote financial inclusion. This study examines the design and valuation of crude oil-backed cryptocurrencies from a macroeconomic and financial perspective. It introduces a dual-commodity tokenization framework that uses crude oil and gold as collateral assets, targeting resource-dependent, export-oriented economies susceptible to currency depreciation. The model aligns with the Real-World Asset (RWA) tokenization literature, which links blockchain-based tokens to economic fundamentals to facilitate programmable, transparent financial instruments (Gong, 2024). Performance is evaluated using Jensen's conditional alpha, which accounts for time-varying risk exposures, to assess the returns and stability of key assets specifically, the Iranian free market dollar and global gold benchmarked against the Rial-denominated price of crude oil. A model based on balanced trade–monetary theory shows that in 2018, the U.S. dollar was undervalued against the Yuan, Pound, and Yen by 1.41, 1.149, and 1.126 times, respectively. This indicates that Japan and the U.K. had a more favorable trade balance with the U.S. than China, highlighting the key role of currency valuation in international trade (Tajdini et al., 2021).

The rationale for anchoring cryptocurrencies to oil and gold is grounded in both theoretical and empirical literature. Crude oil remains a dominant export and fiscal driver in oil-rich economies, influencing exchange rate dynamics and monetary stability (Hamilton, 2009; Kilian, 2008). Gold, by contrast, functions as a traditional store of value and hedge against inflation, particularly during macroeconomic uncertainty and geopolitical shocks (Mushaddik et al., 2023).

Combining both commodities within a single tokenized system may reduce volatility and increase resilience across asset cycles. The analysis focuses on Iran, where multiple exchange rates coexist, and the free-market dollar functions as a more accurate reflection of economic fundamentals than official rates. Both the Rial and the free-market dollar are sensitive to oil price fluctuations, making Iran an instructive case for evaluating oil-linked cryptocurrencies. While earlier initiatives, such as Venezuela's Petro, failed due to governance deficiencies and lack of international confidence (Guo, 2022), the core concept warrants reconsideration using more rigorous valuation techniques and governance structures. This research advances such a re-evaluation by proposing a dual-commodity framework and applying Jensen's conditional alpha, a performance metric not previously applied to RWA token assessments. Unlike earlier projects such as Petro or OilCoin, which lacked empirical backing and used single-asset collateralization, our approach employs dynamic, risk-adjusted analysis and volatility modeling. The proposed design incorporates decentralized governance and real-time asset price oracles to ensure transparency and analytical robustness suitable for high-volatility, resource-dependent economies. Extreme speculation, sanctions, and economic pressures in 2018 caused excessive fluctuations in Iran's exchange rate, revealing that conventional purchasing power parity theory fails under such conditions. A risk-based, short-term approach better explains exchange rate changes during periods of low and high volatility (Tajdini, et al., 2023). During Iran's 2018 currency crisis, dollar speculation offered the highest daily returns but ranked lowest in performance when accounting for risk using the conditional Sharpe ratio. Portfolios solely composed of Tehran Stock Exchange indices outperformed mixed portfolios with dollar speculation, highlighting the higher risk of undiversified investments compared to accepting greater but diversified risk (Mehrara et al., 2020).

Jensen's conditional alpha, originally developed for mutual fund performance evaluation (Jensen, 1968) and extended to account for time-varying market conditions (Ferson & Schadt, 1996), provides a suitable metric for assessing returns influenced by external macroeconomic shocks, such as oil price volatility and sanctions. Empirical results indicate that gold exhibits higher risk-adjusted returns than the free-market dollar when benchmarked against crude oil, supporting its inclusion in a composite backing structure. This aligns with principles in decentralized finance (DeFi), where multi-asset collateralization is used to reduce systemic risk (Davydov et al., 2023). Beyond asset performance, the study considers policy and operational implications of deploying crude oil-backed cryptocurrencies in politically constrained environments. For countries excluded from international financial systems, a blockchain-based, commodity-collateralized currency may offer a sovereign alternative to fiat and foreign-denominated stablecoins. Tokenization of export commodities also opens avenues for programmable revenue sharing, cross-border settlements, and conditional contracts aligned with national fiscal and monetary goals (Chen et al., 2024).

However, the implementation of such instruments requires a robust infrastructure for price oracles, custodial validation, and decentralized governance. Existing ABCs such as PAX Gold, Tether Gold (XAUT) and Perth Mint Gold Token (PMGT) which refer to Stablecoins Pegged to Commodities, DigixDAO, and OilCoin (Oil-Backed Cryptocurrencies) demonstrate that transparency, legal enforceability, and third-party auditing are essential for adoption (Gottschalk, 2023; Jalan et al., 2021). Our framework incorporates GARCH-based volatility modeling to address persistence in asset price fluctuations, thereby improving the robustness of real-world valuation (Kilian, 2008).

1.1 Cryptographic Dimensions of Oil- and Gold-Backed Cryptocurrencies

Building on prior research on cryptographic techniques and algorithms, including AES, RSA, ECC, and homomorphic encryption (Sharma et al., 2022), this study explores their application in securing oil- and gold-backed cryptocurrencies, ensuring transaction integrity, privacy, and verifiable reserve proofs. While financial modelling provides insight into volatility and market dynamics, the viability of an oil- and gold-backed cryptocurrency ultimately depends on its underlying cryptographic design. Robust cryptographic mechanisms are necessary to ensure trust, transparency, and resilience against manipulation. This section outlines key cryptographic dimensions relevant to commodity-backed digital currencies.

1.1.1 Reserve Verification and Proof of Backing

A fundamental challenge for asset-backed cryptocurrencies is the verifiable link between digital tokens and physical reserves. Zero-Knowledge Proofs (ZKPs) offer a mechanism for issuers to prove that oil barrels or gold deposits exist without disclosing sensitive information such as location or storage conditions. In practice, ZKP-based reserve audits can provide real-time assurance of solvency, mitigating the credibility issues faced by projects like Venezuela's Petro.

2.1.1. Consensus and Energy Considerations

The choice of consensus mechanism is particularly salient for resource-dependent economies. While Proof-of-Work (PoW) provides high security, it also entails significant energy consumption, which is contradictory for oil-backed projects seeking sustainability narratives. Alternative designs—such as Proof-of-Stake (PoS) combined with periodic Proof-of-Reserves attestations—can maintain security while reducing environmental and economic costs.

3.1.1 Smart Contracts for Redemption and Governance

Smart contracts play a crucial role in ensuring that the token can be redeemed for oil futures, gold bars, or fiat equivalents under transparent rules. Multi-signature custody arrangements—where government agencies, independent

auditors, and possibly international organizations jointly control reserves—can mitigate single-point governance risks. Additionally, programmable contracts can enforce compliance with international trade standards, enhancing adoption.

4.1.1 Privacy and Transparency Trade-Offs

In sanctioned economies, privacy-preserving cryptography introduces both opportunities and risks. Techniques such as confidential transactions or homomorphic encryption can obscure transaction volumes while maintaining integrity, enabling cross-border trade under restricted conditions. However, excessive opacity may undermine trust with international markets. Thus, a hybrid model that combines selective transparency with cryptographic privacy is recommended.

5.1.1 Secure Oracles and Interoperability

Oil- and gold-backed tokens require reliable price feeds to reflect real-world market values. Secure oracles, such as those implemented through decentralized oracle networks, can cryptographically authenticate external data (e.g., Brent crude or COMEX gold spot prices). Furthermore, interoperability protocols are essential to enable integration with emerging Central Bank Digital Currencies (CBDCs), ensuring the token's role within the broader financial ecosystem.

6.1.1 Implications for Sanctioned Economies

From a policy standpoint, cryptographic assurance mechanisms are not merely technical; they constitute the foundation of credibility. Without rigorous cryptographic proof of reserves, secure consensus, and transparent governance, oil- and gold-backed cryptocurrencies risk replicating the failures of earlier initiatives. By contrast, a carefully engineered cryptographic framework can transform such tokens into a credible instrument for financial stability, even under conditions of restricted international access.

This research contributes to the literature at the intersection of monetary economics, digital finance, commodity markets, and blockchain-based innovation. Situating oil-backed cryptocurrencies within an empirical macroeconomic framework enhances understanding of how decentralized financial technologies can be adapted to address structural vulnerabilities in emerging markets. The application of Jensen's conditional alpha offers a more precise evaluation of asset suitability, moving beyond speculative narratives toward evidence-based design of monetary instruments. The remainder of the paper is organized as follows. Section 2 reviews the relevant literature and identifies existing research gaps. Section 3 presents the study model (methodological framework), including data sources, variable construction, and econometric models. Section 4 reports the empirical results, focusing on asset performance and volatility dynamics. Section 5 discusses Conclusions and policy implications.

The primary innovation of this study lies in combining financial modeling and cryptographic design to evaluate the feasibility of dual-commodity (oil- and gold-backed) cryptocurrencies in sanctioned and high-inflation economies. While prior research on asset-backed cryptocurrencies (ABCs) has largely been descriptive or focused on single-asset collateralization (e.g., Venezuela's Petro), this study introduces a replicable framework that integrates Jensen's conditional dynamic alpha and GARCH-based volatility modeling to measure risk-adjusted performance of commodities relative to the Iranian Rial.

The purpose of the article is twofold:

1. Empirical Assessment: To provide evidence that integrating gold into oil-backed cryptocurrencies enhances stability and delivers superior risk-adjusted returns compared to fiat-based or single-commodity digital assets.

2. Design Guidance: To explore cryptographic mechanisms—including smart contracts, secure oracles, and zero-knowledge proofs—that ensure transparency, trust, and resilience, offering practical insights for implementing ABCs in economies with restricted access to international financial systems.

While previous studies on resource-backed cryptocurrencies have largely focused on single-asset collateralization or conceptual design, this paper addresses a critical gap by proposing a dual-commodity framework (oil and gold) and empirically testing its risk-adjusted performance using Jensen's conditional alpha in a sanctioned, high-inflation economy. Unlike earlier work, which often overlooks volatility dynamics and practical implementation challenges, this study combines financial modeling with cryptographic design considerations, offering a replicable, evidence-based approach for stabilizing digital assets in unstable fiat systems.

In essence, the study bridges macroeconomic analysis, financial modeling, and blockchain-based cryptographic design, contributing both to the academic literature on ABCs and to policy-relevant strategies for resource-rich, sanction-affected economies.

2. Literature Review

Real-World Assets (RWAs) are physical or financial assets represented digitally on a blockchain, with their value derived from tangible or intangible economic inputs. Common RWAs include commodities such as crude oil, precious metals, and fiat currencies (Hou et al., 2024). Asset-backed cryptocurrencies (ABCs), a subset of RWAs, aim to integrate blockchain technology with real-world fundamentals to reduce volatility and introduce intrinsic value into digital financial systems. Gold-backed tokens, among the earliest ABCs, have demonstrated inflation-hedging capabilities and value preservation during periods of financial stress (Mushaddik et al., 2023). Their linkage to global benchmarks and reserve transparency distinguishes them from uncollateralized cryptocurrencies like Bitcoin or Ethereum, which lack intrinsic backing and are prone to speculative volatility (Chohan, 2024). The study examined volatility and herd behavior in the S&P 500, Bitcoin, and gold markets,

finding that Bitcoin is significantly more volatile—3.3 times the S&P 500 and 4.6 times gold—and exhibits herding behavior over 26 times the global average. The results highlight that energy-intensive cryptocurrencies like Bitcoin carry higher risk, while sustainable investments with lower carbon footprints may offer more stability and long-term viability (Qezelbash et al., 2023).

Crude oil has been proposed as another viable collateral asset, particularly in oil-exporting economies where fiscal performance and exchange rates are tightly correlated with global oil prices (Chatziantoniou et al., 2023). Fluctuations in oil prices directly affect monetary stability in these contexts, highlighting the potential of oil-backed tokens as instruments for macroeconomic stabilization. Assessing the viability of ABCs requires appropriate financial performance metrics. Jensen's alpha (Jensen, 1968) is a standard tool that measures excess returns over expected market returns. However, in volatile and dynamic macroeconomic environments, the conditional variant proposed by Ferson & Schadt (1996). (Ferson & Schadt, 1996) is more appropriate, as it allows for time-varying beta coefficients and accommodates shifts in risk exposure. This model is particularly useful for analyzing assets exposed to external shocks, such as oil price volatility and sanctions.

Emerging economies with high dependence on commodity exports increasingly explore blockchain-based financial instruments to address structural weaknesses such as inflation, limited financial inclusion, and restricted capital flows. Blockchain-linked financial systems, especially those integrated with macroeconomic indicators, are viewed as tools for increasing resilience and transparency (Javaid et al., 2022). ABCs, particularly those backed by commodities, are gaining relevance in these settings. Projects such as DigixDAO (2016) introduced gold-backed tokens verified through physical reserves. More recent initiatives like PAX Gold (PAXG) and Tether Gold (XAUT) enhanced transparency by embedding blockchain-based verification mechanisms (Goutte et al., 2021).

Oil-backed digital currencies have also emerged. Venezuela's Petro (2018) and the OilCoin initiative sought to collateralize digital currencies with oil reserves. While promising in theory, these projects encountered barriers related to transparency, market trust, and legal credibility (Guo, 2022). Notably, they did not employ formal financial valuation frameworks to assess asset performance. Existing literature remains primarily descriptive, lacking empirical metrics such as conditional alpha or volatility-adjusted models. This study addresses this gap by applying Jensen's conditional alpha and GARCH modeling to assess real asset performance in unstable macroeconomic settings, offering a replicable analytical approach for future design. Stablecoins such as USDT and USDC achieve price stability by pegging to fiat currencies (Adrian & Mancini-Griffoli, 2021). Commodity-backed cryptocurrencies further extend this stability by tying tokens to the value of assets like gold, oil, or real estate. In addition, Blockchain technology ensures transparency in asset ownership and facilitates the auditing of

reserves. Smart contracts are often employed to automate processes like redemptions and ensure compliance (Chen et al., 2024).

By tokenizing assets, ABCs provide fractional ownership and liquidity to traditionally illiquid markets. For example, gold-backed cryptocurrencies allow investors to own small amounts of gold without storage or transport concerns (Jalan et al., 2021). Tokenized RWAs are increasingly applied across sectors:

A. Commodity Markets: Gold and oil-backed tokens are used as hedging instruments and investment vehicles. They serve as digital proxies for physical commodities, offering global accessibility and ease of trade (Goutte et al., 2021).
B. Supply Chain Transparency: Asset tokenization via blockchain ensures traceability in supply chains, particularly for commodities like precious metals, reducing fraud and improving trust (Sunny et al., 2020).
C. Monetary and Fiscal Policies: Governments in sanction-affected or inflation-prone economies have experimented with ABCs to bypass restricted financial systems and stabilize domestic markets. However, adoption has been constrained by limited trust and regulatory uncertainty (Guo, 2022).

Despite their potential, ABCs face structural and operational challenges. Lack of global consensus on cryptocurrency regulation creates barriers to adoption and legal compliance. ABCs are particularly vulnerable to jurisdictional differences in asset and cryptocurrency regulation (Adrian & Mancini-Griffoli, 2021). Further, while blockchain offers transparency, the credibility of asset backing depends on verifiable reserves and independent audits. Failures like the Gold Reserve Token highlight the importance of robust auditing mechanisms (Chen et al., 2024). While ABCs offer stability, their growth is limited by market adoption, scalability of the underlying technology, and competition with fiat-backed stablecoins (Jalan et al., 2021).

The key areas of ABCs evolution in future include enhancing third-party reserve audits and aligning with regulatory frameworks; also integrating ABCs with decentralized finance (DeFi) platforms to improve liquidity and functionality; and diversifying collateral strategies (e.g., combining oil and gold) to reduce exposure to idiosyncratic risks (Goutte et al., 2021). Recent studies on classical and quantum cryptography highlight the complementary strengths of traditional encryption techniques and quantum-based protocols, emphasizing secure key distribution, eavesdropping detection, and enhanced data integrity (Subramani et al., 2023); these insights inform the design of robust cryptographic mechanisms for commodity-backed cryptocurrencies, ensuring secure, transparent, and tamper-resistant value transfer. Although literature on asset-backed cryptocurrencies (ABCs) and real-world asset (RWA) tokenization is growing, significant gaps still persist. Empirical analyses of oil-backed tokens like Petro and OilCoin remain scarce, with most studies being descriptive rather than model-based (Guo, 2022; Gottschalk, 2023). Comparative evaluations of tokens backed by different assets (e.g., gold, oil, fiat) under inflationary or sanction-

driven conditions are limited (Jalan et al., 2021; Goutte et al., 2021). Furthermore, dynamic financial models suitable for volatile economies such as conditional alpha or GARCH-based volatility are underutilized. This study addresses these gaps by proposing a dual-commodity framework (oil and gold) for a macroeconomically anchored token; applying Jensen's conditional alpha to assess asset performance under exchange rate stress; designing a programmable RWA-backed token with real-asset oracles and volatility modeling; and focusing on sanctioned, inflation-prone economies to explore ABCs as potential monetary stabilization tools.

Although prior research has examined gold- or oil-backed cryptocurrencies and the broader category of stablecoins, much of this literature remains descriptive rather than analytical, with limited critical evaluation of their empirical robustness or long-term viability. Studies often highlight potential benefits but rarely test these claims against market volatility, sustainability, or implementation in sanctioned economies, leaving important contradictions and methodological gaps unresolved. This paper addresses these gaps by situating the proposed dual-commodity framework within these shortcomings, thereby advancing a more rigorous and context-specific contribution. While crude oil, gold, and the free-market dollar are presented as natural anchors for a resource-backed cryptocurrency, the theoretical justification for their selection is underdeveloped. The link between these commodities and long-term price stability is largely assumed rather than systematically explained, and the model does not fully articulate the economic mechanisms—such as hedging behavior, market liquidity, or inflation resistance—that make them uniquely suited compared to other assets. Similarly, the cryptographic design elements are framed as technical features rather than theoretically necessary components that integrate with the broader economic logic of stability. A clearer articulation of these connections would enhance the model's explanatory depth and originality.

3. The Study Model

Crude oil-backed cryptocurrencies represent a class of Real-World Assets (RWA) that tokenize physical commodities, aiming to integrate traditional markets with blockchain-based financial systems (Gong, 2024). This study adopts a quantitative framework to evaluate the feasibility and financial performance of oil-backed cryptocurrencies in export-oriented economies, focusing on Iran, a country where monetary value is closely tied to oil revenues and constrained by geopolitical factors. To assess asset performance and stability, we apply Jensen's conditional dynamic alpha, a risk-adjusted return metric that captures time-varying excess returns relative to a benchmark (Jensen, 1968; Ferson & Schadt, 1996). The analysis benchmarks gold and foreign exchange (FX) values against the Iranian Rial (IRR)-equivalent price of crude oil. In addition, there is a study that introduces an improved framework for portfolio performance evaluation by refining Jensen's alpha with dynamic conditional beta. Unlike traditional static models, this approach captures time-varying risk, providing a more accurate

measure of risk-adjusted returns. Applied to subsidiaries of the Golrang Industrial Group, the results show the superiority of the dynamic model during volatile market conditions, offering investors and managers a more reliable tool for performance assessment and strategic decision-making (Bayati et al., 2025).

3.1 Data collection and Processing

Daily valuation data for these assets is collected from publicly available financial and commodity market databases for the study period. The methodology involves setting crude oil prices as the baseline market basket and calculating the alpha, which represents the excess return of an asset relative to its expected return based on crude oil price movements. This conditional dynamic approach accounts for the time-varying nature of crude oil's influence on asset performance.

3.2 Variable definitions

The key financial variables used in the analysis are:

- Crude Oil in IRR: Global crude oil prices (USD/barrel) were converted into IRR using the Iranian free market USD/IRR exchange rate.
- Free Market Dollar (USD/IRR): The unregulated market exchange rate between the U.S. dollar and the Iranian Rial, reflecting actual purchasing power, tracked daily.
- Global Gold price in IRR: Global gold prices (USD/oz), converted to IRR using the same exchange rate to enable consistent cross-asset comparison.

These data were collected over a specified time frame and converted into Iranian Rial (IRR) values.

Although the study specifies its variables—oil in IRR, the free-market USD/IRR, and global gold in IRR—their treatment remains descriptive rather than analytical. The definitions provided are fairly basic, and the discussion does not critically engage with the reliability or limitations of the data sources. This is particularly important in the case of unregulated Iranian exchange rates, where issues such as volatility, opacity, and potential manipulation could significantly influence results. A deeper examination of data quality, measurement validity, and potential biases would strengthen the empirical foundation of the work.

3.3 Analytical Framework

Daily percentage changes in asset values were computed to generate return series. Jensen’s conditional alpha was applied to evaluate the abnormal performance of gold and the free market dollar relative to the oil benchmark. This model allows beta to vary over time, capturing shifts in market risk exposure which is an essential feature in volatile macroeconomic contexts such as Iran (Ferson & Qian, 2004). Key computations include:

Benchmark (Oil Basket): The daily Rial value of crude oil was used to create a market basket, which served as the base value for asset comparison. The crude oil Rial value was calculated as 0.0023, as shown in Table 3.

Conditional Dynamic Alpha – USD/IRR: Based on this crude oil value, the dynamic alpha for the Iranian free market dollar was calculated as 0.0018, indicating lower risk-adjusted performance.

Conditional Dynamic Alpha – Gold/IRR: Gold showed stronger performance relative to the free market dollar, suggesting that a gold-backed cryptocurrency linked to crude oil would be more stable.

To validate the study results in how the value of crude oil influenced the Rial's exchange rate and the relative performance of gold, a time-series comparison of conditional alpha values conducted over the study period. In addition, to evaluate the robustness of results under varying market conditions a sensitivity analysis applied to ensure that the findings are applicable across different economic scenarios including stress events such as oil shocks and geopolitical disturbances (Hamilton, 2009). Furthermore, volatility persistence was modeled using a GARCH(1,1) specification to account for short- and long-term risk exposures. This allows assessment of asset suitability based on stability criteria relevant to cryptocurrency design.

The proposed methodology provides a replicable, valuation-driven framework to evaluate the potential of commodity-backed digital currencies in settings marked by inflation, capital restrictions, and external sanctions to allow them to increase their financial stability.

3.4 Cryptographic Dimensions

In addition to financial evaluation, implementing oil- and gold-backed cryptocurrencies requires robust cryptographic mechanisms to ensure trust, transparency, and security. This study considers key dimensions including:

- Smart Contracts: Programmable rules enforce token issuance, redemption, and collateral management, minimizing the need for intermediaries and ensuring predictable operations.
- Secure Oracles: Real-time price data for crude oil and gold are integrated via cryptographic oracles, preventing tampering and ensuring accurate asset valuation.
- Zero-Knowledge Proofs (ZKPs): Enable verification of asset reserves without disclosing sensitive information, enhancing privacy while maintaining transparency.
- Consensus and Validation Protocols: Blockchain consensus mechanisms secure transactions and maintain the integrity of tokenized assets, ensuring resistance to double-spending or fraudulent manipulation.
- Cryptographic Audit Trails: Immutable and verifiable transaction logs provide transparency and accountability, allowing regulators and investors to confirm asset backing.

These cryptographic mechanisms complement the financial modeling (Jensen's conditional alpha and GARCH-based volatility), providing a secure technical foundation that supports the credibility and practical deployment of commodity-backed cryptocurrencies in high-inflation or sanctioned economies.

The study employs Jensen's conditional alpha alongside GARCH modeling, but its methodological rigor is weakened by the absence of robust validation. Sensitivity analysis is only briefly addressed, and the paper does not incorporate alternative specifications such as EGARCH, TGARCH, or stochastic volatility models that could capture asymmetries and leverage effects. Similarly, sub-period analysis or rolling-window estimations are not performed to test stability across different market regimes. Without these robustness checks, the empirical results risk appearing context-specific rather than broadly generalizable.

4. Empirical Results

This study evaluates the performance of different assets in crude oil-exporting economies by linking their daily valuations to the national currency value of crude oil, utilizing Jensen's conditional dynamic alpha as the key analytical measure. The analysis focuses on comparing the IRR valuations of two assets, the free market dollar and global gold per ounce, using the Rial value of crude oil as the benchmark market basket. As presented in Table 3, the conditional dynamic alpha for global gold relative to crude oil's Rial value stands at 0.0023, whereas the alpha for the free-market dollar is 0.0018. These results demonstrate that global gold outperformed the dollar-denominated asset throughout the study period. Therefore, a theoretical cryptocurrency backed by crude oil and linked to global gold would be expected to deliver superior performance compared to one pegged to the free market dollar. This implies that integrating gold-backed characteristics into crude oil-backed cryptocurrencies may improve their overall stability and attractiveness.

Table 1. Performance Metrics of Key Assets Against the Iranian Rial

	Average return	Max of return	Min of return	Standard deviation
USD vs RIAL	0.0007	0.0428	-0.0286	0.0081
GOLD	0.0013	0.0487	-0.038	0.0117
OIL	0.0006	0.0522	-0.0568	0.0172

***Source**:research finding*

Table 1 provides a comparative summary of the performance metrics for three key assets, USD (free market), gold, and crude oil, relative to IRR. The table presents the average return, maximum return, minimum return, and standard deviation of each asset. These metrics offer insights into the volatility and return potential of each asset during the studied period. Notably, gold shows the highest average return and the greatest volatility, while crude oil exhibits the widest range of returns, highlighting its sensitivity to market fluctuations. The USD demonstrates relatively lower volatility and more stable returns compared to the other two assets. This table serves as a foundational analysis for understanding the behavior of these assets in the context of a potential crude oil-backed cryptocurrency.

Table 2. Volatility Dynamics of Key Assets Using GARCH Model Parameters

	α	B
USD VS RIAL	0.19	0.75
GOLD	-0.05	1.02
OIL	0.04	0.91

Source: *research finding*

Table 2 presents the GARCH (Generalized Autoregressive Conditional Heteroskedasticity) model parameters—α (short-term volatility persistence) and β (long-term volatility persistence)—for USD, gold, and crude oil relative to the Iranian Rial. These parameters provide insights into the volatility behavior of each asset:

USD vs. Rial: Displays a moderate α (0.19) and high β (0.75), indicating stable and predictable volatility over time.

Gold: Shows a negative α (-0.05) and β greater than 1 (1.02), suggesting extreme sensitivity and potential overshooting in response to market changes.

Crude Oil: Exhibits a low α (0.04) and high β (0.91), reflecting long-term persistence in volatility with less immediate responsiveness to shocks (Kilian, 2008).

This table highlights the distinct volatility dynamics of these assets, which are crucial for assessing their potential integration into financial systems such as crude oil-backed cryptocurrencies.

Table 3. Conditional Jensen's Alpha Analysis of Asset Returns

	Average (return)	Beta of OLS	Dynamic conditional Beta	Average(dynamic conditional Jensen's alpha)
USD vs Rial	0.0007	0.26	0.160	0.0018
GOLD	0.0013	0.31	0.252	0.0023

Source: *research finding*

Table 3 summarizes the performance metrics derived from the dynamic conditional Jensen's alpha framework for USD (free market) and gold, measured against the Iranian Rial. Key parameters include the average return, beta calculated via ordinary least squares (OLS), dynamic conditional beta, and the average of dynamic conditional Jensen's alpha.

- USD vs. Rial: Exhibits a lower average return (0.0007) and a lower average dynamic conditional Jensen's alpha (0.0018), indicating moderate performance relative to market fluctuations.
- Gold: Shows a higher average return (0.0013) and a greater dynamic conditional Jensen's alpha (0.0023), reflecting better performance and superior risk-adjusted returns.

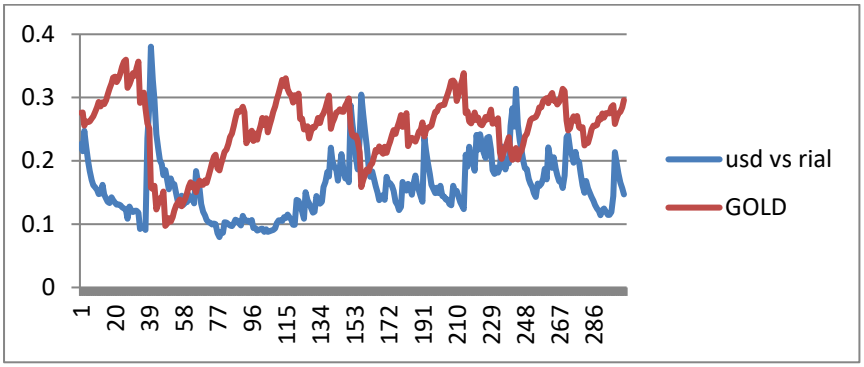

Figure 1. Dynamic Conditional Beta of Key Assets
Source: *research finding*

This table highlights the comparative advantage of gold over USD during the analyzed period, emphasizing its stability and higher alignment with crude oil price dynamics as part of a potential market basket.

This figure illustrates the dynamic conditional beta values for the free market USD and global gold assets in relation to the Iranian Rial (IRR) value of crude oil. The dynamic beta reflects the sensitivity of each asset's returns to changes in the crude oil price over time. The results demonstrate how each asset responds to fluctuations in the crude oil market, providing insight into their risk characteristics. The observed trends highlight the comparative stability and adaptability of global gold as a potential component of a crude oil-backed cryptocurrency.

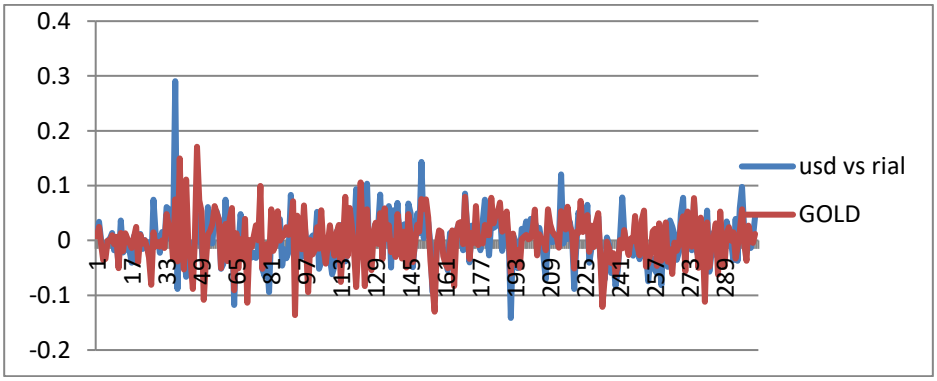

Figure 2. Dynamic Conditional Jensen's Alpha of Key Assets
Source: *research finding*

This figure presents the dynamic conditional Jensen's alpha for the free-market USD and global gold assets relative to the Iranian Rial (IRR) value of crude oil. The alpha values indicate the performance of these assets after adjusting for their systematic risk. The data reveals that global gold consistently achieved

higher alpha values compared to USD, emphasizing its superior risk-adjusted returns. This finding supports the argument for integrating global gold into the framework for a crude oil-backed cryptocurrency to enhance performance and stability.

The descriptive statistics are confined to reporting returns and volatility, which limits their usefulness. There is no deeper exploration of the underlying data distributions, such as skewness, kurtosis, or normality tests, which are critical in studies of financial assets with heavy tails. Additionally, the time-period coverage is not critically justified—leaving uncertainty as to whether the sample adequately captures structural breaks, crises, or regime shifts. Potential biases, such as survivorship bias, data-snooping, or distortions from informal currency markets, are not acknowledged. A more comprehensive statistical treatment would provide stronger context for the empirical results.

5. Conclusion and policy implications

This study evaluated the feasibility and performance of macroeconomically anchored cryptocurrencies in oil-exporting economies, with a focus on Iran. By applying Jensen's conditional dynamic alpha to assess the performance of the Iranian free market dollar and global gold, benchmarked against the Rial-denominated price of crude oil, this research offers empirical evidence to guide the design of asset-backed digital currencies. The findings support a dual-commodity model, combining crude oil and gold, as a more stable and resilient basis for cryptocurrency valuation frameworks. Also, global oil and gold prices were converted into the Iranian Rial using the free-market U.S. dollar exchange rate. A central finding is that gold exhibited a higher conditional alpha than the Iranian free market dollar, indicating superior risk-adjusted returns under conditions of macroeconomic stress. This result is consistent with prior financial literature identifying gold as an effective hedge against inflation and currency depreciation (Baur & McDermott, 2010; Mushaddik et al., 2023). Gold-backed tokens may offer greater monetary stability and credibility in environments characterized by high volatility, fragmented exchange rate regimes, and unanchored inflation expectations, such as Iran. Incorporating gold into oil-backed cryptocurrencies can improve price predictability and investor confidence.

Beyond the empirical analysis, this study offers design-oriented insights for developing stable, resource-backed digital currencies. Existing stablecoins such as USDT and USDC primarily peg to fiat currencies, assuming monetary stability in their reserves (Adrian & Mancini-Griffoli, 2021). However, in oil-exporting economies subject to capital controls or geopolitical isolation, fiat-pegged models may be impractical. The proposed dual-commodity framework addresses this limitation by linking digital currency value to two globally traded, economically significant assets: crude oil and gold. For policymakers in structurally constrained economies such as Iran and Venezuela, the proposed model presents a potential semi-sovereign monetary instrument. Properly governed and transparently collateralized, such a token could facilitate regional trade, protect household

savings from inflation, and enhance trust in public finance. Implementation, however, requires robust legal frameworks, transparent custodial arrangements, and integration with real-time pricing oracles and smart contract protocols (Hou et al., 2024).

In addition to financial design, the practical implementation of such dual-commodity cryptocurrencies relies on cryptographic mechanisms to ensure security and transparency. Smart contracts can automate issuance and redemption, while secure oracles provide tamper-proof price feeds for oil and gold. Cryptographic audit trails and consensus protocols further guarantee transaction integrity and verifiable asset backing, enhancing trust among users and regulators in high-risk, sanction-affected environments.

This research has several policy-relevant implications for emerging economies that face monetary instability and restricted access to global capital:

First, the empirical findings suggest that a dual-commodity token backed by oil and gold may offer a viable alternative to unstable fiat currencies. This model can serve as a monetary anchor in economies where central banks have limited credibility or operational autonomy.

Second; resource-backed digital currencies could be leveraged for cross-border trade settlements among sanction-affected or capital-restricted economies. The use of commodity-linked tokens may reduce dependency on dollar-based systems and mitigate exposure to secondary sanctions.

Third; a gold-oil-backed digital currency may serve as a store of value and inflation hedge for domestic users in economies experiencing currency fragmentation and inflation volatility.

Fourth; effective deployment requires institutional frameworks for asset custody, transparent price oracles, decentralized governance, and smart contract enforcement. Policymakers must align regulatory, fiscal, and technological capacities to operationalize these tools.

Fifth; central banks and sovereign wealth funds in resource-rich economies may use such instruments to partially back domestic monetary liabilities or issue programmable reserves tied to export earnings.

In addition, several limitations need to be considered for example this study relies on unregulated exchange rate data from Iran's informal market. While this rate reflects actual transaction values, it lacks formal verification and may be subject to information asymmetry. Furthermore, the analysis does not explicitly model governance quality, institutional trust, or political risk factors that significantly influence the adoption and legitimacy of digital currencies. Future studies could incorporate institutional indices or sentiment analysis to address this gap.Real-World Asset (RWA)-backed cryptocurrencies, which collateralize digital tokens with tangible commodities such as crude oil and gold, present viable instruments for enhancing financial stability in resource-dependent economies. In contexts marked by high inflation and external sanctions such as Iran and Venezuela these instruments offer an alternative to unstable fiat systems by anchoring value to globally traded assets.

This study presents a novel framework for evaluating the performance of asset-backed cryptocurrencies in resource-dependent economies, with a focus on Iran. By applying Jensen's conditional alpha and GARCH modeling, we demonstrate that global gold delivers superior risk-adjusted returns compared to the Iranian free market dollar when both are benchmarked against Rial-denominated oil prices. These findings support the viability of a dual-commodity digital currency model, combining oil and gold as collateral assets in macroeconomically unstable contexts.

Beyond theoretical innovation, this research contributes to the policy discourse on monetary reform in economies subject to sanctions, inflation, and capital account restrictions. Resource-backed cryptocurrencies could offer a decentralized, transparent, and programmable mechanism for enhancing monetary stability and promoting cross-border financial integration outside traditional channels. Future research should validate these results in other oil-exporting countries, incorporate institutional and governance quality indices, and extend the modeling framework to include regime-switching or multi-factor approaches. The integration of such designs with existing central bank digital currency (CBDC) architectures also warrants further exploration.

While the results clearly show that gold outperforms the U.S. dollar in terms of risk-adjusted returns, these findings should be interpreted with caution given the correlational nature of the analysis. The superior performance of gold is not presented as a causal mechanism but as an empirical indication of its comparative stability relative to the dollar in a sanction-affected, inflationary context. Gold's global liquidity, limited exposure to U.S. monetary policy, and historical role as a safe-haven asset help explain this relative advantage. This reinforces the policy relevance of incorporating gold into dual-commodity digital currencies while also highlighting the need for further robustness checks, such as regime-switching or multi-factor models, to confirm the sensitivity of these outcomes under alternative specifications.

This study situates its findings within the broader context of resource-backed digital currencies by directly addressing limitations observed in prior projects and empirical research. Unlike initiatives such as Venezuela's Petro, which suffered from governance, transparency, and adoption challenges, the proposed dual-commodity framework combines oil and gold with cryptographically verifiable mechanisms to enhance credibility and stability. By quantitatively evaluating risk-adjusted performance using Jensen's conditional alpha and GARCH-modeled volatility, this work not only reinforces the role of gold as a hedge against macroeconomic instability but also demonstrates how integrating multiple commodities can improve financial resilience in sanctioned or high-inflation economies. This positions the study as both a practical guide for policymakers and a theoretical advancement in the literature on asset-backed cryptocurrencies. To enhance practical relevance, future implementations of dual-commodity-backed cryptocurrencies in sanctioned economies should consider institutional integration, decentralized governance, and transparent auditing mechanisms.

Phased deployment strategies — starting with pilot programs anchored to verified commodity reserves — could mitigate political and operational risks, while adherence to international compliance standards may foster trust among foreign partners. Such operational guidance complements the theoretical framework, offering a roadmap for translating resource-backed digital assets into viable monetary instruments under constrained economic conditions.

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Conflicts of Interest

The authors declare no conflict of interest.

Data Availability Statement

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