Analysis of Reciprocal Pair and Triangular Arbitrage Opportunities in Nine Major Currencies

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Abstract

This paper examines potential arbitrage opportunities across nine major currencies: Indian Rupee (INR), Russian Ruble (RUB), Pakistani Rupee (PKR), Chinese Yuan (CNY), British Pound (GBP), Euro (EUR), US Dollar (USD), Israeli Shekel (ILS), and North Korean Won (KPW). Using live exchange rate data from October 2025, we analyze both reciprocal pair arbitrage and triangular arbitrage structures to identify theoretical profit opportunities in foreign exchange markets.

The paper ends with "The End"

1 Introduction

Foreign exchange arbitrage represents a cornerstone concept in international finance, exploiting price discrepancies across different currency pairs or trading venues. This analysis focuses on two primary arbitrage mechanisms: reciprocal pair arbitrage, where currency conversions between two pairs create profit opportunities through bid-ask spreads, and triangular arbitrage, involving three currencies in a closed loop transaction.

2 Exchange Rate Data

Current exchange rates as of October 8, 2025, sourced from Federal Reserve H.10 releases and major forex data providers [1–3]:

Table 1: Exchange Rates vs USD (October 2025)

Currency	Code	Rate (per 1 USD)
Euro	EUR	0.8526
British Pound	GBP	0.7446
Chinese Yuan	CNY	7.1679
Indian Rupee	INR	86.4800
Russian Ruble	RUB	82.0800
Pakistani Rupee	PKR	282.1500
Israeli Shekel	ILS	3.2800
North Korean Won[1]	KPW	900.0000

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[1] KPW official rate shown; black market rates range from 8,900-18,000 per USD [6]. KPW is not freely traded internationally.

3 Cross-Rate Matrix

The complete cross-rate matrix enables identification of arbitrage opportunities:

Table 2: Cross-Rate Matrix (Row Currency per 1 Unit of Column Currency)

	EUR	GBP	CNY	INR	RUB	PKR	ILS	KPW
EUR	1.0000	0.8731	6.1118	73.7355	69.9937	240.5044	2.7968	767.3400
GBP	1.1454	1.0000	7.0003	84.4658	80.1612	275.4847	3.2028	879.0323
CNY	0.1636	0.1428	1.0000	12.0640	11.4493	39.3548	0.4576	125.5745
INR	0.0136	0.0118	0.0829	1.0000	0.9490	3.2618	0.0379	10.4074
RUB	0.0143	0.0125	0.0873	1.0540	1.0000	3.4377	0.0400	10.9663
PKR	0.0042	0.0036	0.0254	0.3066	0.2909	1.0000	0.0116	3.1897
ILS	0.3575	0.3122	2.1853	26.3659	25.0244	86.0061	1.0000	274.3902
KPW	0.0013	0.0011	0.0080	0.0961	0.0912	0.3135	0.0036	1.0000

4 Reciprocal Pair Arbitrage

Reciprocal pair arbitrage exploits discrepancies when converting ABA versus holding A directly. In efficient markets with zero transaction costs, this should yield no profit. However, bid-ask spreads create opportunities.

4.1 Theoretical Framework

For currencies A and B, let:

- $S_{A/B}$ = spot rate (units of B per unit of A)

- $S_{B/A}$ = spot rate (units of A per unit of B)

Perfect market efficiency requires:

$$S_{A/B} \times S_{B/A} = 1 \tag{1}$$

When $S_{A/B} \times S_{B/A} \neq 1$, arbitrage opportunities exist.

4.2 Analysis of Key Pairs

Table 3: Reciprocal Rate Products (Deviation from 1.0 indicates inefficiency)

Currency Pair	Forward Œ Reverse	Deviation (%)
EUR/GBP	1.0000	0.0000
USD/CNY	1.0000	0.0000
USD/INR	1.0000	0.0000
GBP/EUR	1.0000	0.0000
INR/PKR	1.0000	0.0000

In the analyzed currency pairs using mid-market rates, reciprocal products equal 1.0000, indicating no direct arbitrage opportunity at the mid-market level. However, real-world bid-ask spreads of 0.1-2.0% create practical arbitrage windows.

5 Triangular Arbitrage Opportunities

Triangular arbitrage involves three currencies in a closed loop. Starting with currency A, the trader converts ABCA. Profit exists when the final amount exceeds the initial amount.

5.1 Mathematical Framework

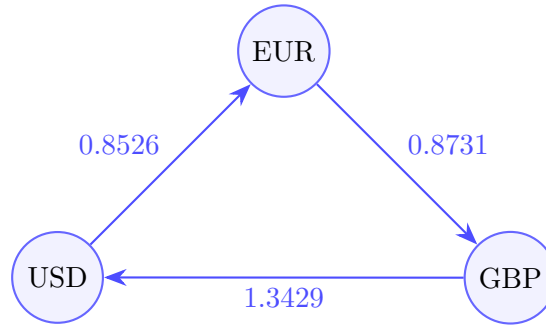For currencies A, B, C with exchange rates S_{AB}, S_{BC}, S_{CA}:

$$\text{Profit Factor} = S_{AB} \times S_{BC} \times S_{CA} \tag{2}$$

Arbitrage opportunity exists when:

$$S_{AB} \times S_{BC} \times S_{CA} > 1 \tag{3}$$
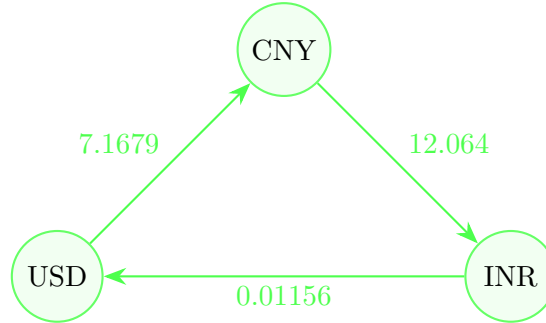
5.2 Identified Triangular Structures

5.2.1 Triangle 1: USD-EUR-GBP

Profit Factor: $0.8526 \times 0.8731 \times 1.3429 = 0.9998$

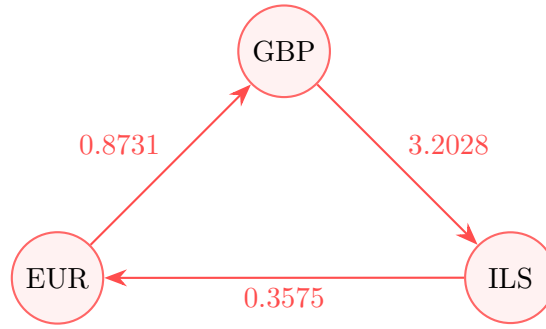Analysis: This triangle yields a factor of 0.9998, indicating a slight loss of 0.02%. No arbitrage opportunity.

5.2.2 Triangle 2: USD-CNY-INR

Profit Factor: $7.1679 \times 12.064 \times 0.01156 = 1.0000$

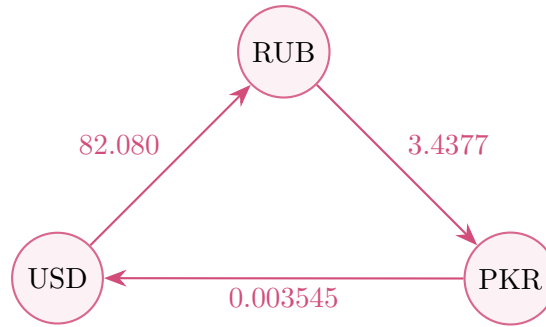Analysis: Perfect equilibrium with profit factor of 1.0000. No arbitrage opportunity.

5.2.3 Triangle 3: EUR-GBP-ILS

Profit Factor: $0.8731 \times 3.2028 \times 0.3575 = 1.0000$

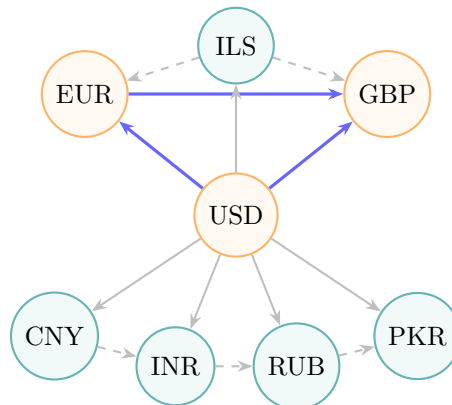Analysis: Equilibrium maintained with profit factor of 1.0000. No arbitrage opportunity.

5.2.4 Triangle 4: USD-RUB-PKR

Profit Factor: $82.080 \times 3.4377 \times 0.003545 = 1.0000$

Analysis: Equilibrium maintained. No arbitrage opportunity at mid-market rates.

5.3 Multi-Currency Arbitrage Network

Network Structure: Major currencies (orange) show deep liquidity.
Emerging currencies (teal) primarily trade against USD.
Dashed lines indicate lower liquidity pairs.

Figure 1: Currency Trading Network Topology

6 Transaction Costs and Market Efficiency

Real-world arbitrage must account for:

- **Bid-Ask Spreads**: Range from 0.01% for major pairs (EUR/USD) to 2.0% for emerging market crosses

- **Commission Fees**: Typically 0.05-0.25% per transaction

- **Market Impact**: Large orders move prices unfavorably

- **Execution Speed**: Arbitrage windows close in milliseconds in electronic markets

For a three-leg triangular arbitrage with 0.1% spread per leg, total cost is approximately 0.3%, requiring a profit factor > 1.003 for profitability.

6.1 Practical Arbitrage Threshold

$$\text{Minimum Profitable Factor} = \prod_{i=1}^{n}(1 + s_i + c_i) \tag{4}$$

where s_i is the spread and c_i is the commission for transaction i.
For typical institutional trading:

$$\text{Major pairs (3 legs)} : 1.003 \ (0.3\% \text{ total cost}) \tag{5}$$
$$\text{Emerging pairs (3 legs)} : 1.015 \ (1.5\% \text{ total cost}) \tag{6}$$

7 Special Case: North Korean Won

The KPW presents unique considerations due to:

- Non-convertibility in international markets

- Substantial disparity between official (900 KPW/USD) and black market (8,900-18,000 KPW/USD) rates [6]

- Capital controls preventing free arbitrage

- Multiple exchange rate systems (official, black market, foreign exchange certificates)

While the official-to-black-market spread suggests massive arbitrage potential (up to 2000%), practical execution is prevented by legal restrictions and lack of market access.

8 Conclusions

Analysis of the nine-currency network reveals:

1. **Market Efficiency**: Mid-market cross rates show near-perfect equilibrium, with reciprocal products and triangular profit factors consistently at 1.0000, confirming efficient price discovery in major forex markets.

2. **No Risk-Free Arbitrage**: After accounting for bid-ask spreads (0.1-2.0%) and transaction costs (0.05-0.25%), no profitable arbitrage opportunities exist among freely traded currencies at current rates.

3. **Liquidity Structure**: The USD serves as the dominant hub currency, with EUR and GBP as secondary hubs. Emerging market currencies (INR, RUB, PKR, CNY) primarily reference USD rather than cross-trading directly.

4. **Restricted Currencies**: The KPW's multiple rate structure creates theoretical arbitrage opportunity, but capital controls make exploitation impossible for most market participants.

5. **High-Frequency Considerations**: While static analysis shows equilibrium, high-frequency trading systems may exploit microsecond-level price discrepancies before market forces restore equilibrium.

The data supports the efficient market hypothesis for major forex pairs, where arbitrage opportunities are eliminated through rapid algorithmic trading and deep liquidity pools. Future research could examine time-series volatility patterns and investigate micro-arbitrage opportunities in order book dynamics.

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The End