Macro-Finance

- Lecture 6 -

Fatih Kansoy

https://macrofinance.info

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– Oxford Saïd Business School –

Today: Outline

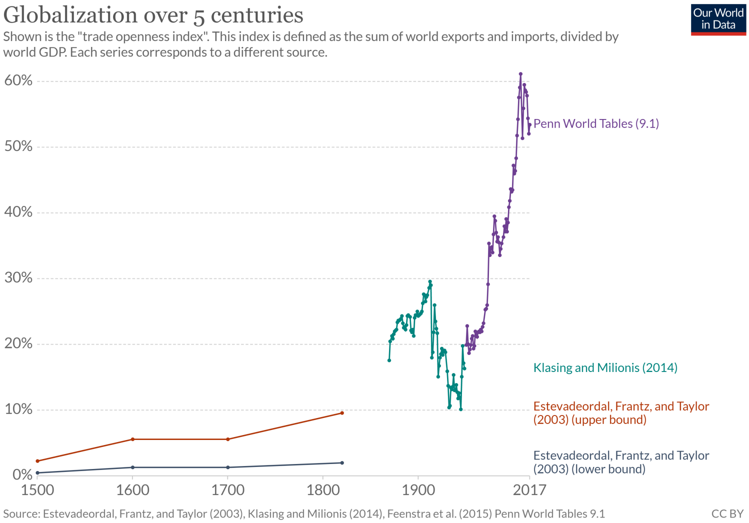
1. Globalisation
2. Covered Interest-Rate
3. Offshore-Onshore
4. Uncovered Interest Rate
5. Equilibrium
6. Carry Trade as a Test of UIP
7. The Forward Premium Puzzle
8. Summary

Financial Globalisation

Globalisation

- Over the last five centuries there are two main globalisation waves.
- Until 1800 there was a long period characterised by persistently low international trade.
- This then changed over the course of the 19^{th} century, when technological advances triggered a period of marked growth in world trade – the so-called '**first wave of globalisation**'.
- The first wave of globalisation end with the First World War.

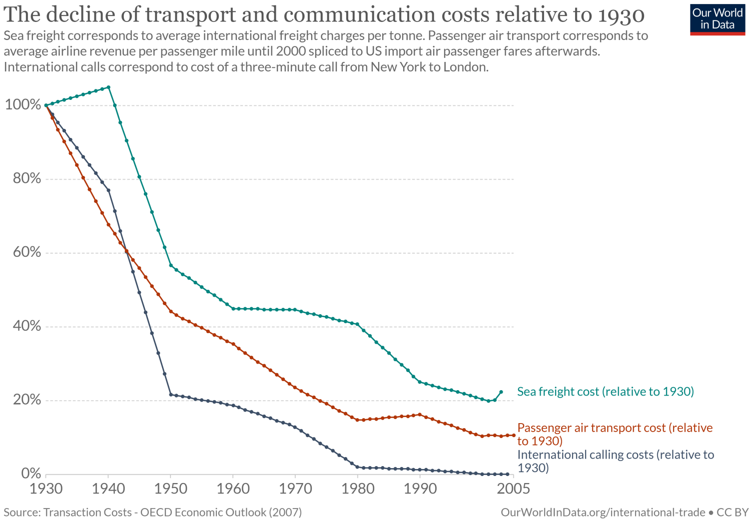
The First Wave



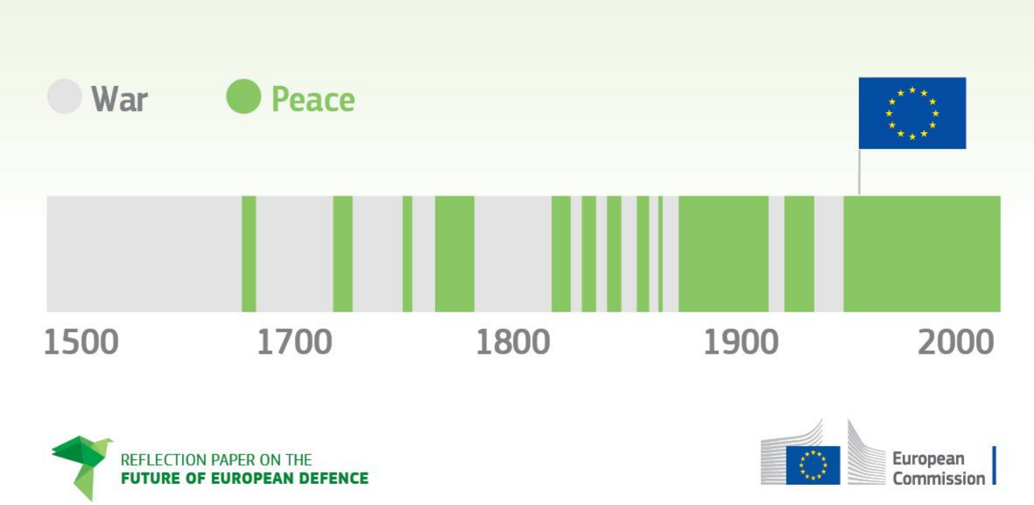
Globalisation

- The world-wide expansion of trade after the Second World War was largely possible because of reductions in transaction costs
- The reductions in transaction costs had an impact, not only on the volumes of trade, but also on the types of exchanges that were possible and profitable.
- The increasing level of globalisation after the Second World War is known as **the second wave of globalisation**.
- For more visit `https://ourworldindata.org/trade-and-globalisation`

The Second Wave

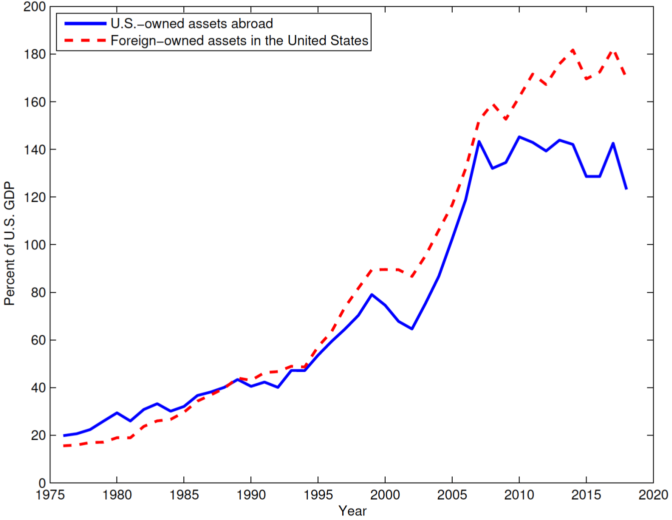


Globalisation, Interdependence, and Peace



THE LONGEST PEACE PERIOD: Last 75 years is the longest peace period in Europe's troubled history.

U.S.-Owned Assets Abroad and Foreign-Owned Assets in the U.S.



From *International Macroeconomics* by Stephanie Schmitt-Grohe, Martin Uribe and Michael Woodford

Financial Globalisation: Empirical Evidence

- Explosion in cross-border financial positions:
  - U.S. gross international liabilities: 15% of GDP (1970s) $\rightarrow$ 170% (2018)
  - U.S. gross international assets: 20% of GDP (1970s) $\rightarrow$ 130% (2018)
- **Key drivers of financial globalisation:**
  1. Technological advancements reducing financial transaction costs
  2. Entrance of smaller investors (market atomization)
  3. Abandonment of Bretton-Woods fixed exchange rate system (early 1970s)
  4. Creation of eurozone (mid-1980s) and euro (1999)
  5. China's emergence as economic power and capital supplier

Covered Interest-Rate Parity

Covered Interest-Rate Parity

- In a world with perfect capital mobility, the rate of return on risk-free financial investments should be equalised across countries. (**Law of one price: LOOP**)
- Otherwise, arbitrage opportunities would arise, inducing capital to flow out of the low-return countries and into the high-return countries.
- This movement of capital across national borders will tend to eliminate differences in interest rates.
- If, on the other hand, one observes that interest rate differentials across countries **persist over time,** it must be the case that **restrictions** on international capital flows are in place in some countries.

Interest Rate Return: China 2021

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QUOTES & COMPANIES

VIEW ALL COMPANIES

China 10 Year Government Bond

AMBMKRM-10Y (Tullett Prebon)

5:00 PM CST 03/02/21

YIELD

3.264%

-0.033 ▼

PRICE

100.05

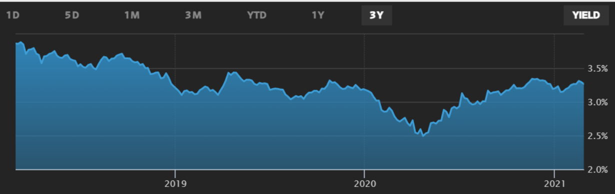
0.274 (0.27%) ▲

1 Day Range
3.256 - 3.297

52 Week Range (Yield)
2.492 - 3.365
(04/24/20 - 11/20/20)

Coupon
3.270%

Maturity
11/19/30



Open 3.297 Prior Close (Yield) 3.297

1 Day Price Chg AMBMKRM-10Y 0.27% ▲ U.S. 10 Year -0.04% ▼ Germany 10 Year -0.12% ▼ Japan 10 Year 0.25% ▲

OVERVIEW HISTORICAL PRICES MONEY RATES TREASURY QUOTES BOND & INDEX BENCHMARKS LIBOR

Interest Rate Return: US 2021

Interest Rate Return: China 2023

Interest Rate Return: China 2023

Interest Rate Return: China 2023

Source: Refinitiv Eikon • Created with Datawrapper

Perfect Capital Mobility: Theoretical Foundation

- Under perfect capital mobility:
  - Risk-free financial investments should yield equal returns across countries
  - Otherwise, arbitrage opportunities arise
  - Capital flows from low-return to high-return countries
  - This process tends to eliminate interest rate differentials
- If interest rate differentials persist:
  - Suggests impediments to international capital flows
  - Cross-country interest rate differentials can provide an empirical test
- Key challenge: Interest rates across currencies are not directly comparable due to exchange rate risk (and other factors).

The Exchange Rate Problem

- Example: Interest rates are 7% in U.S. and 3% in Germany
- 4% differential doesn't necessarily trigger capital flows because:
  - If dollar depreciates by more than 4%, German investment could yield higher dollar returns
  - Interest rate differences may exist due to:
    1. Expectations of exchange rate changes
    2. Compensation for exchange rate risk
- A meaningful measure of interest rate differentials must account for exchange rate factors

Investment Decision with Currency Risk

Consider a U.S. investor with $\$1$ (billion) deciding between domestic and German investment:

1. U.S. investment yields $(1 + i_t)$ dollars
2. German investment requires:
   * Convert $\$1$ to $\frac{1}{E_t}$ euros (where E_t = spot exchange rate)
   * Invest at rate i_t^* to get $\frac{1 + i_t^*}{E_t}$ euros
   * Convert back at future rate E_{t+1} to get $\frac{(1 + i_t^*)E_{t+1}}{E_t}$ dollars

For optimal decision, compare:

$$1 + i_t \quad \text{versus} \quad \frac{(1 + i_t^*)E_{t+1}}{E_t} \tag{1}$$

Key problem: At time t, the investor doesn't know E_{t+1}

Forward Exchange Markets

- Forward exchange markets eliminate exchange rate uncertainty
- **Forward contract:** Agreement at time t to exchange currencies at time $t+1$ at a predetermined rate
- Let F_t = forward rate (dollar price at time t of 1 euro to be delivered at $t+1$)
- Important characteristics:
  - No money exchanges hands when arranged (time t)
  - Money exchange occurs at execution (time $t+1$)
- With forward contract, dollar return of German investment: $\dfrac{(1+i_t^*)F_t}{E_t}$
- This return is known with certainty at time t, making it comparable to domestic return $(1+i_t)$

Covered Interest Rate Differential

Covered Interest Rate Differential

The difference between the domestic return and the foreign return expressed in domestic currency using the forward exchange rate:

$$\text{Covered Interest Rate Differential} = (1 + i_t) - (1 + i_t^*)\frac{F_t}{E_t} \tag{2}$$

- ***Covered*** because forward exchange rate eliminates exchange rate risk
- Also known as **cross-currency basis**
- When differential equals zero, **covered interest rate parity (CIP)** holds:

$$\boxed{(1 + i_t) = (1 + i_t^*)\frac{F_t}{E_t}} \tag{3}$$

- CIP represents the no-arbitrage condition between domestic and foreign interest rates

Arbitrage Example: Step-by-Step

Assume:

- U.S. interest rate: $i_t = 7\%$
- German interest rate: $i_t^* = 3\%$
- Spot exchange rate: $E_t = \$0.50$ per euro
- Forward exchange rate: $F_t = \$0.51$ per euro

Forward discount: $\frac{F_t}{E_t} = \frac{0.51}{0.50} = 1.02$

Covered interest rate differential: $1.07 - 1.03 \times 1.02 = 0.0194$ (1.94%)

This nonzero differential creates an arbitrage opportunity!

Arbitrage Example: Exploitation Strategy

1. Borrow 1 euro in Germany (future liability: 1.03 euros)
2. Exchange for \$0.50 in spot market
3. Invest \$0.50 in U.S. at 7% interest
4. Buy 1.03 euros in forward market at \$0.51/euro
5. After one year:
   * U.S. investment yields: \$0.50 × 1.07 = \$0.535
   * Pay \$0.51 × 1.03 = \$0.5253 to acquire 1.03 euros
   * Use euros to repay German loan
   * Profit: \$0.535 - \$0.5253 = \$0.0097

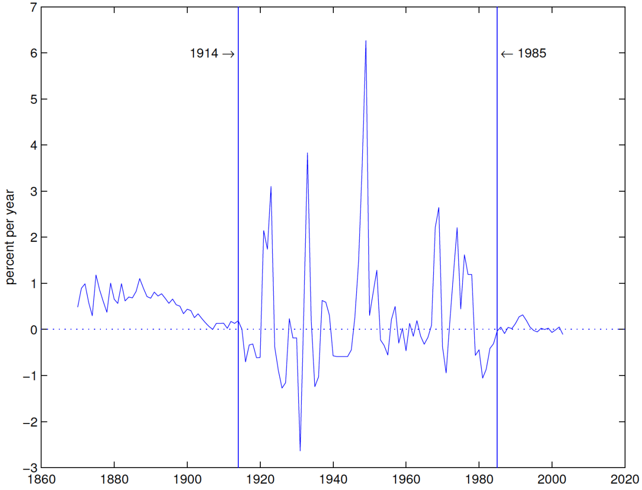
This operation:

- Involves no exchange rate risk
- Requires no initial capital
- Yields pure profit

Implications of CIP

- Under free capital mobility and no default risk:
  - Covered interest rate differential should equal zero
  - Nonzero differentials indicate barriers to international capital flows
- CIP violations represent clear arbitrage opportunities:
  - Enable unbounded profits without risk
  - Should be rapidly eliminated in well-functioning markets
- In practice, transaction costs and other frictions create small nonzero differentials even in integrated markets

Dollar-Pound CIP: 1870-2003



From *International Macroeconomics* by Stephanie Schmitt-Grohe, Martin Uribe and Michael Woodford

Historical Evidence: 1870-2003

Figure shows dollar-sterling covered interest rate differentials from 1870 to 2003, revealing three distinct periods:

1. **Pre-WWI (before 1914):**
    * Small, stable differentials (< 0.5 percentage points)
    * High international capital market integration
2. **Interwar & Post-WWII (1914-1985):**
    * Large, volatile differentials (2-7 percentage points)
    * Financial system disruptions and regulations
3. **Modern Period (after 1985):**
    * Return to small differentials (similar to pre-WWI era)
    * Renewed financial integration

Key Historical Events

- **Pre-WWI Integration (1870-1914):**
  * Gold Standard era
  * Minimal capital controls
  * Stable exchange rate expectations
- **Disintegration (1914-1985):**
  * World War I (1914-1918)
  * Great Depression (1929-1939)
  * World War II (1939-1945)
  * Bretton Woods system (1944-1971)
  * Oil shocks (1973, 1979)
  * Widespread capital controls and financial regulations
- **Reintegration (post-1985):**
  * Financial deregulation (Thatcher/Reagan reforms)
  * Information technology advances
  * Globalisation of banking

Economic Interpretation and Lessons

- **Non-linear historical development:**
  - Capital market integration is not uniquely modern
  - World experienced substantial financial globalisation before WWI
  - Integration doesn't follow a linear historical trajectory
- **Fragility of financial integration:**
  - Integration is reversible under extreme conditions
  - Shocks (wars, depressions, financial crises) can cause disintegration
  - 2008 crisis demonstrated vulnerability (though less severe than 1914-1985)
- **Policy relevance:**
  - Financial regulations must balance efficiency and stability
  - History suggests cycles of integration and fragmentation
  - Current integration levels may not be permanent

Covered Interest-Rate Parity

$$\textit{Covered Interest Rate Differential} = (1 + i_t) - (1 + i_t^*)\frac{F_t}{\epsilon_t} \tag{4}$$

- This interest rate differential is called covered because the use of the forward exchange rate covers the investor against exchange rate risk.
- When the covered interest rate differential is zero, we say that *covered interest rate parity* (CIP) holds which is Eq.-5.

$$(1 + i_t) = (1 + i_t^*)\frac{F_t}{\epsilon_t} \tag{5}$$

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$$(1 + i_t) \lesseqgtr (1 + i_t^*)\frac{F_t}{\epsilon_t}$$

- In the absence of barriers to international capital mobility, this violation of CIP implies that it is possible to make profits by borrowing in Germany, investing in the United States, and buying euros in the forward market to eliminate the exchange rate risk.

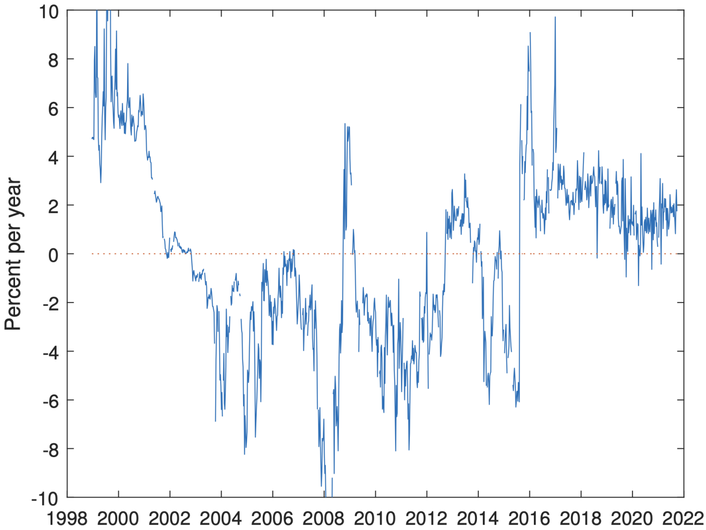
Real World Example: China-US

- In 2001 China became a member of the World Trade Organization. This required lowering barriers to trade in goods and services (tariffs and quotas).
- In this way, China became more integrated with the rest of the world in markets for goods and services.
- **Question:** Did China also become more integrated with world financial markets?
- Let's look at the observed behaviour of the dollar-renminbi-covered interest rate differential

$$(1 + i_t) - (1 + i_t^*)\frac{F_t}{\epsilon_t}$$

- i_t: dollar interest rate in the United States,
- i_t^*: renminbi interest rate in China
- ϵ_t: spot exchange rate (dollars per renminbi), and
- F_t: forward exchange rate (dollars per renminbi).

Dollar-Renminbi Covered Interest Rate Differentials



MARTIN URIBE : International Macroeconomics: A Modern Approach, 2022

Interpreting Dollar-Renminbi CIP Deviations

The figure shows the annualised Covered Interest Rate Parity (CIP) deviation, X_t, between USD and RMB:

$$X_t = (1 + i_t^{\$}) - (1 + i_t^{RMB}) \frac{F_t^{\$/RMB}}{E_t^{\$/RMB}}$$

Persistent non-zero X_t implies significant impediments to capital flows, as arbitrage should otherwise enforce $X_t \approx 0$. The sign of X_t indicates the nature of these restrictions:

- **Positive Differential ($X_t > 0$): USD Covered Return Premium**
  - *Arbitrage Pressure:* Induces capital outflow from China (borrow RMB, invest USD covered).
  - *Persistent $X_t > 0$ Implies:* **Impediments to capital outflow from China** (e.g., outward investment controls, FX conversion restrictions for capital account). This is seen pre-$\approx$2002 and post-$\approx$2015.
- **Negative Differential ($X_t < 0$): RMB Covered Return Premium**
  - *Arbitrage Pressure:* Induces capital inflow into China (borrow USD, invest RMB covered).
  - *Persistent $X_t < 0$ Implies:* **Impediments to capital inflow into China** (e.g., foreign investment quotas, restrictions on foreign access to onshore financial/hedging markets). This is seen $\approx$2003-2014.

The observed average deviation (e.g., $\approx$3.1 percentage points) underscores substantial, policy-driven market segmentation between the USD and RMB financial systems.

Offshore-Onshore

The Laundromat

Conceptual Framework

- Alternative approach to measuring capital mobility:
  - Compare interest rates on instruments in same currency but different locations
  - Completely eliminates exchange rate considerations
- Example comparison:
  - Onshore rate (i_t): Interest on dollar deposits in New York
  - Offshore rate (i_t^*): Interest on dollar deposits in London
- Offshore-onshore differential:

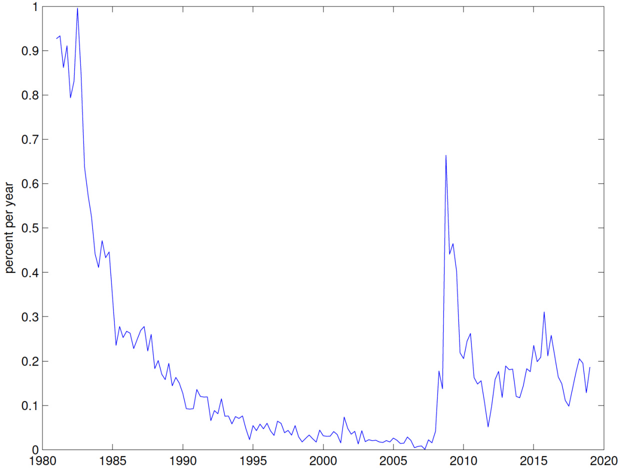
$$\text{Offshore-Onshore Differential} = i_t^* - i_t \tag{6}$$

- Under free capital mobility and no default risk:
  - Differential should equal zero
  - Nonzero differentials indicate capital flow impediments

The Eurocurrency Market

- **Eurocurrency deposits:** Foreign currency deposits outside home market of currency
  - Eurodollar: USD deposit outside US (e.g., London)
  - Euro yen: JPY deposit outside Japan (e.g., Singapore)
- **London dominance factors:**
  - Favorable regulatory environment
  - Sophisticated financial infrastructure
  - Strategic time zone position
  - Deep financial expertise pool

Offshore-Onshore Interest Rate Differential of the U.S. Dollar



From *International Macroeconomics* by Stephanie Schmitt-Grohe, Martin Uribe and Michael Woodford

Empirical Evidence: 1981-2019

Figure shows U.K.-U.S. offshore-onshore interest rate differential for the U.S. dollar (1981Q1-2019Q1), revealing four distinct phases:

1. **Early 1980s (1981-1986):**
   * High differentials (50-90 basis points)
   * Significant regulatory barriers
2. **Pre-Crisis Period (1990-2007):**
   * Near-zero differentials (<10 basis points)
   * Substantial capital mobility
3. **Global Financial Crisis (2008):**
   * Spike to 60 basis points
   * Severe market dysfunction
4. **Post-Crisis Period (2009-2019):**
   * Stabilization at 15-25 basis points
   * Higher than pre-crisis but lower than 1980s

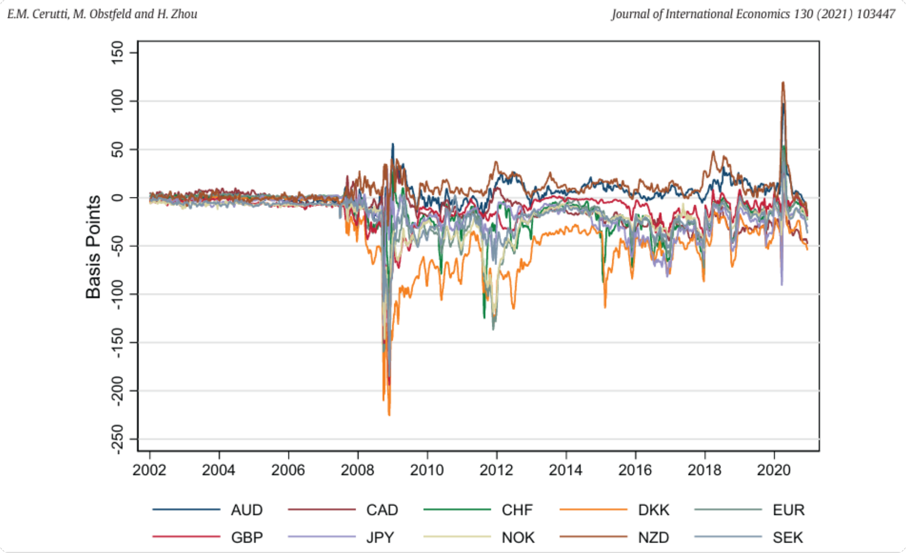
Crisis and Post-Crisis Dynamics

- **2008 Crisis factors:**
  - Acute dollar funding pressures for non-US banks
  - Counterparty credit concerns
  - Market liquidity evaporation
  - Wide bid-ask spreads
- **Post-crisis regulatory changes:**
  - Money market reforms limiting US CD market access
  - Basel III capital requirements
  - Liquidity coverage ratio requirements
  - Leverage ratio constraints
- **Trade-off implication:**
  - Enhanced financial stability vs. perfect capital mobility
  - Persistent differentials as "price" of regulatory safety
  - Frictionless capital markets potentially incompatible with robust prudential regulation

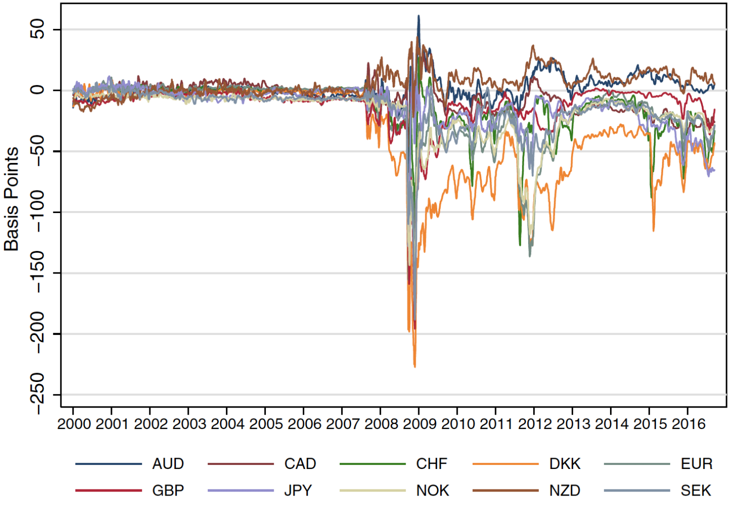
Global Pattern and Policy Implications

- **Widespread phenomenon:**
  - Similar patterns between US and multiple economies:
  - Canada, Euro area, Japan, Norway, New Zealand, Sweden
- **Cerutti, Obstfeld, and Zhou (2021) findings:**
  - Persistent differentials reflect regulatory trade-offs
  - Prudential measures inhibit arbitrage activities
  - Financial stability requires some capital mobility limitations
- **Historical perspective:**
  - Post-2008 deviations much smaller than 1914-1985 period
  - Fundamental architecture of global financial integration remains intact
  - Modern regulatory approach represents "managed integration" rather than disintegration

Interest Rate Differentials: US and G10

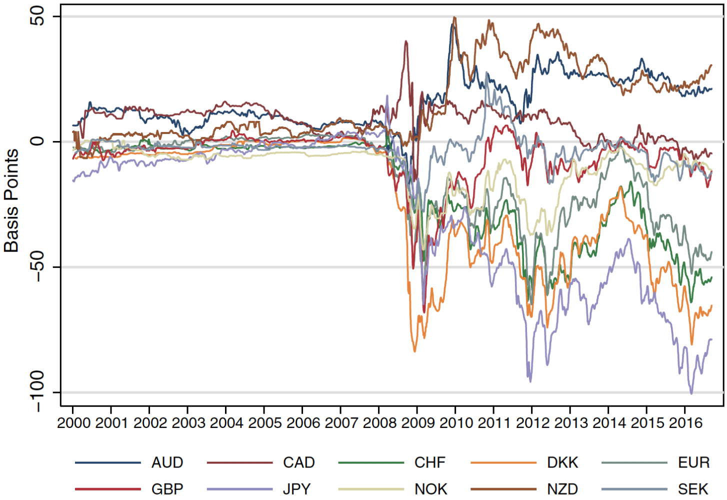


CIP Violations after the Financial Crisis- Short-term Libor-based



Source: Du, Tepper and Verdelhan (2018) Journal of Finance

CIP Violations after the Financial Crisis - Long-term Libor-based



Source: Du, Tepper and Verdelhan (2018) Journal of Finance

Uncovered Interest Rate Parity

The Concept of Uncovered Interest Rate Parity

Do exchange-rate adjusted returns equalise across countries?

- Suppose we could see future exchange rates with certainty:
  - The return on 1 dollar invested domestically: $(1 + i_t)$ dollars
  - The return on 1 dollar invested abroad:

$$\frac{(1 + i_t^*)E_{t+1}}{E_t} \text{ dollars} \tag{7}$$

  where:
    - i_t = domestic interest rate
    - i_t^* = foreign interest rate
    - E_t = spot exchange rate (domestic per foreign)
    - E_{t+1} = future spot exchange rate

From Certainty to Uncertainty

- Under certainty and no arbitrage:

$$1 + i_t = \frac{(1 + i_t^*)E_{t+1}}{E_t} \tag{8}$$

- Reality: E_{t+1} is unknown at time t
  - Domestic return is certain: $1 + i_t$
  - Foreign return is uncertain: $\frac{(1 + i_t^*)E_{t+1}}{E_t}$
  - Not directly comparable due to uncertainty

- Intuition suggests these returns should be equal *on average*
  - Using $\mathbb{E}_t[\cdot]$ to denote conditional expectations:

$$\boxed{1 + i_t = (1 + i_t^*)\mathbb{E}_t\left[\frac{E_{t+1}}{E_t}\right]} \tag{9}$$

- This condition is known as **Uncovered Interest Rate Parity (UIP)**

UIP Intuition

- UIP reflects the idea that investors are risk-neutral and have rational expectations
- The right-hand side of UIP has two components:
  1. Foreign interest rate: $1 + i_t^*$
  2. Expected rate of currency depreciation: $\mathbb{E}_t \left[\frac{E_{t+1}}{E_t} \right]$
- Intuitive interpretation:
  - If $i_t > i_t^*$, the domestic currency is expected to depreciate
  - If $i_t < i_t^*$, the domestic currency is expected to appreciate
  - This adjustment prevents "free lunches" from simply investing in the higher interest rate currency
- UIP represents equilibrium in international capital markets where:
  - Interest rate differentials reflect expected currency movements
  - No excess returns from holding one currency over another

The Uncovered Interest Rate Differential

Uncovered Interest Rate Differential

$$\text{Uncovered Interest Rate Differential} = (1 + i_t) - (1 + i_t^*)\mathbb{E}_t\left[\frac{E_{t+1}}{E_t}\right] \tag{10}$$

- UIP states this differential should be zero
- Unlike Covered Interest Parity (CIP):
  - CIP eliminates exchange rate risk using forward contracts
  - UIP relies on exchange rate expectations
  - UIP involves risk (foreign exchange exposure)
- Exchange rate expectations component:

$$\mathbb{E}_t\left[\frac{E_{t+1}}{E_t}\right] = \text{Expected rate of depreciation of domestic currency} \tag{11}$$

Model Environment

To analyze whether UIP holds theoretically, we need a formal model:

- Small open endowment economy with free capital mobility
- Timeline:
  - Period 1: No uncertainty
  - Period 2: Two possible states
    - Good state (g): occurs with probability π
    - Bad state (b): occurs with probability $1 - \pi$
- Three types of bonds available:
  1. B_1: Domestic currency bonds (interest rate i)
  2. B_1^*: Foreign currency bonds with forward cover (no FX risk)
  3. $\tilde{B}_1^*$: Foreign currency bonds without forward cover (exposed to FX risk)

Household Budget Constraints

- Period 1 budget constraint:

$$P_1 C_1 + B_1 + E_1 B_1^* + E_1 \tilde{B}_1^* = P_1 Q_1 \tag{12}$$

- Period 2 budget constraint (good state):

$$P_2^g C_2^g = P_2^g Q_2^g + (1+i)B_1 + F_1(1+i^*)B_1^* + E_2^g(1+i^*)\tilde{B}_1^* \tag{13}$$

- Period 2 budget constraint (bad state):

$$P_2^b C_2^b = P_2^b Q_2^b + (1+i)B_1 + F_1(1+i^*)B_1^* + E_2^b(1+i^*)\tilde{B}_1^* \tag{14}$$

where:

* P_t = domestic price level
* C_t = consumption
* Q_t = endowment
* F_1 = forward exchange rate
* E_t = spot exchange rate

Substituting Budget Constraints

We can solve the budget constraints for consumption:

- Period 1 consumption:

$$C_1(B_1, B_1^*, \tilde{B}_1^*) = \frac{P_1 Q_1 - B_1 - E_1 B_1^* - E_1 \tilde{B}_1^*}{P_1} \tag{15}$$

- Period 2 consumption (good state):

$$C_2^g(B_1, B_1^*, \tilde{B}_1^*) = \frac{P_2^g Q_2^g + (1+i)B_1 + (1+i^*)(F_1 B_1^* + E_2^g \tilde{B}_1^*)}{P_2^g} \tag{16}$$

- Period 2 consumption (bad state):

$$C_2^b(B_1, B_1^*, \tilde{B}_1^*) = \frac{P_2^b Q_2^b + (1+i)B_1 + (1+i^*)(F_1 B_1^* + E_2^b \tilde{B}_1^*)}{P_2^b} \tag{17}$$

These expressions will be used in the utility maximization problem.

Household Preferences and Optimization

- Expected utility function:

$$U(C_1) + \pi U(C_2^g) + (1-\pi)U(C_2^b) \tag{18}$$

- Household maximizes expected utility subject to budget constraints
- First-order conditions for optimal portfolio choice:
  1. For domestic bonds (B_1):

$$U'(C_1)\frac{1}{P_1} = \pi U'(C_2^g)\frac{1+i}{P_2^g} + (1-\pi)U'(C_2^b)\frac{1+i}{P_2^b} \tag{19}$$

  2. For foreign bonds with forward cover (B_1^*):

$$U'(C_1)\frac{E_1}{P_1} = \pi U'(C_2^g)\frac{F_1(1+i^*)}{P_2^g} + (1-\pi)U'(C_2^b)\frac{F_1(1+i^*)}{P_2^b} \tag{20}$$

  3. For foreign bonds without forward cover ($\tilde{B}_1^*$):

$$U'(C_1)\frac{E_1}{P_1} = \pi U'(C_2^g)\frac{E_2^g(1+i^*)}{P_2^g} + (1-\pi)U'(C_2^b)\frac{E_2^b(1+i^*)}{P_2^b} \tag{21}$$

FOC for Domestic Bonds

Starting with the FOC for B_1:

$$U'(C_1)\frac{1}{P_1} = \pi U'(C_2^g)\frac{1+i}{P_2^g} + (1-\pi)U'(C_2^b)\frac{1+i}{P_2^b} \tag{22}$$

We can rewrite as:

$$U'(C_1)\frac{1}{P_1} = (1+i)\left[\pi U'(C_2^g)\frac{1}{P_2^g} + (1-\pi)U'(C_2^b)\frac{1}{P_2^b}\right] \tag{23}$$

$$= (1+i)\mathbb{E}_1\left[\frac{U'(C_2)}{P_2}\right] \tag{24}$$

Rearranging:

$$1 = (1+i)\frac{P_1}{U'(C_1)}\mathbb{E}_1\left[\frac{U'(C_2)}{P_2}\right] \tag{25}$$

$$= (1+i)\mathbb{E}_1\left[\frac{U'(C_2)}{U'(C_1)}\frac{P_1}{P_2}\right] \tag{26}$$

This gives us the Euler equation for domestic bonds.

The Pricing Kernel

- We can rewrite the Euler equation for domestic bonds as:

$$1 = (1+i)\mathbb{E}_1\left[\frac{U'(C_2)}{U'(C_1)}\frac{P_1}{P_2}\right] \tag{27}$$

- The expression within expectations is the pricing kernel:

$$M_2 \equiv \frac{U'(C_2)}{U'(C_1)}\frac{P_1}{P_2} \tag{28}$$

- Economic interpretation:
  - Ratio of marginal utility of one unit of domestic currency in period 2 to period 1
  - "Stochastic discount factor" in finance terminology
  - Determines how future payoffs are valued in present terms
- Using the pricing kernel notation, the Euler equations become:

$$1 = (1+i)\mathbb{E}_1\{M_2\} \qquad \text{(Domestic bonds)}$$

$$1 = (1+i^*)\frac{F_1}{E_1}\mathbb{E}_1\{M_2\} \qquad \text{(Foreign bonds with forward cover)}$$

$$1 = (1+i^*)\mathbb{E}_1\left\{\frac{E_2}{E_1}M_2\right\} \qquad \text{(Foreign bonds without forward cover)}$$

Pricing Kernel: Intuition

- The pricing kernel M_2 has two components:

$$M_2 = \underbrace{\frac{U'(C_2)}{U'(C_1)}}_{\text{Intertemporal MRS}} \times \underbrace{\frac{P_1}{P_2}}_{\text{Inflation adjustment}} \tag{29}$$

- Intuition:
  - $\frac{U'(C_2)}{U'(C_1)}$: Marginal rate of substitution between future and present consumption
  - $\frac{P_1}{P_2}$: Converts nominal payoffs to real consumption units
- High value of M_2 occurs when:
  - Future consumption is low (high marginal utility of consumption)
  - Future inflation is low (high purchasing power of money)
- Assets that pay well when M_2 is high are valuable:
  - They provide payoffs when money is most needed
  - Investors accept lower expected returns on such assets
  - This creates risk premia in equilibrium

Equilibrium Conditions

Deriving CIP from Optimality Conditions

- Combining the Euler equations for domestic bonds and foreign bonds with forward cover:

$$(1+i)\mathbb{E}_1\{M_2\} = 1 \tag{30}$$

$$(1+i^*)\frac{F_1}{E_1}\mathbb{E}_1\{M_2\} = 1 \tag{31}$$

- Setting these equations equal:

$$(1+i)\mathbb{E}_1\{M_2\} = (1+i^*)\frac{F_1}{E_1}\mathbb{E}_1\{M_2\} \tag{32}$$

- Canceling $\mathbb{E}_1\{M_2\}$ from both sides:

$$\boxed{(1+i) = (1+i^*)\frac{F_1}{E_1}} \tag{33}$$

- This shows that Covered Interest Rate Parity (CIP) is not just a no-arbitrage condition but also an equilibrium condition that emerges naturally from household optimization.

Comparing UIP to CIP

- Recall the UIP condition:

$$1 + i_t = (1 + i_t^*)\mathbb{E}_t\left[\frac{E_{t+1}}{E_t}\right] \tag{34}$$

- And the CIP condition:

$$(1 + i_t) = (1 + i_t^*)\frac{F_t}{E_t} \tag{35}$$

- Comparing these equations, we see that UIP holds if and only if:

$$\boxed{\frac{F_t}{E_t} = \mathbb{E}_t\left[\frac{E_{t+1}}{E_t}\right]} \tag{36}$$

- Multiplying both sides by E_t:

$$\boxed{F_t = \mathbb{E}_t[E_{t+1}]} \tag{37}$$

- That is, UIP holds if and only if the forward rate equals the expected future spot rate
- So the question becomes: Does $F_t = \mathbb{E}_t[E_{t+1}]$ hold in equilibrium?

Forward Rate vs. Expected Future Spot Rate

- Combining the optimality conditions for foreign bonds with and without forward cover:

$$(1+i^*)\frac{F_1}{E_1}\mathbb{E}_1\{M_2\} = 1 \tag{38}$$

$$(1+i^*)\mathbb{E}_1\left\{\frac{E_2}{E_1}M_2\right\} = 1 \tag{39}$$

- Setting these equal:

$$(1+i^*)\frac{F_1}{E_1}\mathbb{E}_1\{M_2\} = (1+i^*)\mathbb{E}_1\left\{\frac{E_2}{E_1}M_2\right\} \tag{40}$$

$$\frac{F_1}{E_1}\mathbb{E}_1\{M_2\} = \mathbb{E}_1\left\{\frac{E_2}{E_1}M_2\right\} \tag{41}$$

$$F_1\mathbb{E}_1\{M_2\} = \mathbb{E}_1\{E_2M_2\} \tag{42}$$

The General Failure of UIP

- From our previous equation:

$$F_1 \mathbb{E}_1\{M_2\} = \mathbb{E}_1\{E_2 M_2\} \tag{43}$$

- For UIP to hold, we need $F_1 = \mathbb{E}_1[E_2]$, which requires:

$$F_1 \mathbb{E}_1\{M_2\} = \mathbb{E}_1\{E_2\}\mathbb{E}_1\{M_2\} \tag{44}$$

- This equality holds only if E_2 and M_2 are uncorrelated:

$$\mathbb{E}_1\{E_2 M_2\} = \mathbb{E}_1\{E_2\}\mathbb{E}_1\{M_2\} \tag{45}$$

$$\Leftarrow \text{Cov}_1(E_2, M_2) = 0 \tag{46}$$

- But generally, E_2 and M_2 are correlated, so:

$$\boxed{F_1 \neq \mathbb{E}_1[E_2]} \tag{47}$$

- Implication: Under free capital mobility, UIP generally fails to hold

The Covariance Expression

We can explicitly show the relationship between the forward rate and expected exchange rate:

- For any pair of random variables a and b, their conditional covariance is:

$$\text{Cov}_1(a, b) = \mathbb{E}_1(ab) - \mathbb{E}_1(a)\mathbb{E}_1(b) \tag{49}$$

- Applying this to our expression:

$$\mathbb{E}_1\{E_2 M_2\} = \text{Cov}_1(E_2, M_2) + \mathbb{E}_1\{E_2\}\mathbb{E}_1\{M_2\} \tag{50}$$

$$F_1 \mathbb{E}_1\{M_2\} = \text{Cov}_1(E_2, M_2) + \mathbb{E}_1\{E_2\}\mathbb{E}_1\{M_2\} \tag{51}$$

$$F_1 = \frac{\text{Cov}_1(E_2, M_2)}{\mathbb{E}_1\{M_2\}} + \mathbb{E}_1\{E_2\} \tag{52}$$

- This shows that the forward rate differs from the expected future spot rate by a risk premium term:

$$\boxed{F_1 - \mathbb{E}_1\{E_2\} = \frac{\text{Cov}_1(E_2, M_2)}{\mathbb{E}_1\{M_2\}}} \tag{53}$$

Risk Premium: Intuition and Dynamics

The risk premium term has a clear economic interpretation:

$$\text{Risk Premium} = \frac{\text{Cov}_1(E_2, M_2)}{\mathbb{E}_1\{M_2\}} \tag{54}$$

- Sign of risk premium depends on the covariance:
  - **Case 1:** $\text{Cov}_1(E_2, M_2) > 0$
    - Exchange rate and pricing kernel move together
    - Foreign currency tends to strengthen when marginal utility is high
    - Foreign assets provide a valuable hedge
    - Investors accept lower expected return on foreign assets
    - $F_1 > \mathbb{E}_1\{E_2\}$ (forward rate exceeds expected future spot rate)
  - **Case 2:** $\text{Cov}_1(E_2, M_2) < 0$
    - Exchange rate and pricing kernel move inversely
    - Foreign currency tends to weaken when marginal utility is high
    - Foreign assets increase risk exposure
    - Investors demand higher expected return on foreign assets
    - $F_1 < \mathbb{E}_1\{E_2\}$ (forward rate is less than expected future spot rate)

Special Case: When UIP Holds

- UIP does hold in the special case where the pricing kernel is uncorrelated with the exchange rate:

$$\text{Cov}_1\left(\frac{E_2}{E_1}, M_2\right) = 0 \tag{55}$$

- In this case:

$$\mathbb{E}_1\left\{\frac{E_2}{E_1}M_2\right\} = \mathbb{E}_1\left\{\frac{E_2}{E_1}\right\}\mathbb{E}_1\{M_2\} \tag{56}$$

$$1 = (1+i^*)\mathbb{E}_1\left\{\frac{E_2}{E_1}\right\}\mathbb{E}_1\{M_2\} \tag{57}$$

$$\frac{1}{\mathbb{E}_1\{M_2\}} = (1+i^*)\mathbb{E}_1\left\{\frac{E_2}{E_1}\right\} \tag{58}$$

$$(1+i) = (1+i^*)\mathbb{E}_1\left\{\frac{E_2}{E_1}\right\} \tag{59}$$

- This is the UIP condition
- However, this scenario is theoretically special and empirically rare

Economic Scenarios where UIP Might Hold

- UIP requires $\text{Cov}_1(E_2, M_2) = 0$, which could occur in specific scenarios:
- **Complete asset markets**:
  - When markets are complete, risk sharing is perfect (remember previous lecture and which is not the case in the data)
  - Consumption is perfectly correlated across countries
  - Exchange rate movements perfectly offset relative price changes
  - Real exchange rate becomes constant
- **Risk-neutral investors**:
  - With linear utility functions, marginal utility is constant
  - Pricing kernel varies only with inflation
  - If inflation is independent of exchange rate, UIP could hold
- **Specific utility functions and shocks**:
  - With carefully calibrated utility functions
  - And particular distributions of economic shocks
  - Exchange rate movements could be uncorrelated with marginal utility
- These conditions are highly restrictive and unlikely in practice

Carry Trade as a Test of UIP

The Carry Trade Strategy

Carry Trade A trading strategy that involves:

1. Borrowing in a low interest rate currency
2. Investing in a high interest rate currency
3. Not hedging the exchange rate risk

- If UIP holds, then:

$$1 + i_t = (1 + i_t^*)\mathbb{E}_t \left[\frac{E_{t+1}}{E_t} \right] \tag{60}$$

- When $i_t > i_t^*$, UIP implies:

$$\mathbb{E}_t \left[\frac{E_{t+1}}{E_t} \right] > 1 \tag{61}$$

- This means: when interest rates are higher in the domestic currency, that currency should be expected to depreciate

Carry Trade Payoff Structure: Detailed Derivation

- Starting with the payoff calculation:

$$\text{Payoff from Carry Trade} = (1 + i_t) - (1 + i_t^*)\frac{E_{t+1}}{E_t} \tag{62}$$

- We can rewrite this as:

$$\text{Payoff} = (1 + i_t) - (1 + i_t^*)\frac{E_{t+1}}{E_t} \tag{63}$$

$$= (1 + i_t) - (1 + i_t^*) - (1 + i_t^*)\left(\frac{E_{t+1}}{E_t} - 1\right) \tag{64}$$

$$= (i_t - i_t^*) - (1 + i_t^*)\left(\frac{E_{t+1}}{E_t} - 1\right) \tag{65}$$

Carry Trade Payoff Structure: Detailed Derivation

$$Payoff = (i_t - i_t^*) - (1 + i_t^*)\left(\frac{E_{t+1}}{E_t} - 1\right)$$

- Decomposition of payoff:
  1. Interest rate differential: $(i_t - i_t^*)$ (positive for carry trade)
  2. Currency movement effect: $-(1 + i_t^*)\left(\frac{E_{t+1}}{E_t} - 1\right)$
- The carry trade is profitable when:

$$(i_t - i_t^*) > (1 + i_t^*)\left(\frac{E_{t+1}}{E_t} - 1\right) \tag{66}$$

- In other words, the interest rate differential exceeds the currency depreciation

Carry Trade Profitability: UIP vs. Reality

- Under UIP, expected payoff should be zero:

$$
\begin{aligned}
\mathbb{E}_t[\text{Payoff}] &= (i_t - i_t^*) - (1 + i_t^*)\mathbb{E}_t\left[\frac{E_{t+1}}{E_t} - 1\right] && (67)\\
&= (i_t - i_t^*) - (1 + i_t^*)\left[\frac{1 + i_t}{1 + i_t^*} - 1\right] \quad \text{(using UIP)} && (68)\\
&= (i_t - i_t^*) - \left[(1 + i_t) - (1 + i_t^*)\right] && (69)\\
&= (i_t - i_t^*) - (i_t - i_t^*) && (70)\\
&= 0 && (71)
\end{aligned}
$$

- In reality, expected payoffs are persistently positive:
  - High-interest currencies depreciate less than UIP predicts
  - Sometimes high-interest currencies even appreciate
  - This violates UIP and creates profitable trading opportunities
- The systematic nature of carry trade profits suggests a fundamental failure of UIP

Empirical Evidence: Burnside et al. (AER, 2007)

- Burnside, Eichenbaum, Kleshchelski, and Rebelo (2006) study:
  - Analyzed returns to carry trade for pound sterling against 10 currencies
  - Monthly data from 1976 to 2005
  - Currencies included: Belgian franc, Canadian dollar, French franc, German mark/euro, Italian lira, Japanese yen, Dutch guilder, Swiss franc, U.S. dollar
- Key findings:
  - Average monthly payoff: 0.0029 (0.29%) for one pound invested
  - Small but consistently positive returns
  - To generate substantial profits, traders wager large sums
  - Example: £1 billion investment yields average monthly profit of £2.9 million
- Critical implication:
  - Non-zero average payoffs mean UIP fails
  - Interest rate differentials are not offset by exchange rate movements

Risk-Adjusted Returns: The Sharpe Ratio

- The Sharpe ratio measures risk-adjusted returns:

$$\text{Sharpe Ratio} = \frac{\text{mean(payoff)}}{\text{std(payoff)}} \tag{72}$$

- Burnside et al. findings:
  - Carry trade Sharpe ratio: 0.145
  - S&P 500 Sharpe ratio over same period: 0.140
- Interpretation:
  - Carry trade offers comparable risk-adjusted returns to equity market
  - Not obviously riskier than standard stock market investment
  - Challenges risk-based explanations for UIP failure
- This presents a puzzle:
  - Why don't arbitrageurs eliminate these excess returns?
  - What market frictions or risks are being missed?

Carry Trade in Practice: Institutional Details

- Major carry trade currency pairs (historically):
  - Japanese yen (low interest) vs. Australian dollar (high interest)
  - Swiss franc (low interest) vs. New Zealand dollar (high interest)
  - U.S. dollar vs. emerging market currencies (Brazilian real, Turkish lira)
- Key market participants:
  - Hedge funds
  - Proprietary trading desks at investment banks
  - Currency overlay managers
  - Retail FX traders (especially in Japan)
- Implementation methods:
  - Spot market transactions
  - Currency futures
  - Exchange-traded funds (ETFs)
  - FX swaps without using the forward leg

Carry Trade Example: The Yen Carry Trade

- The Japanese yen carry trade was particularly popular in the 1990s and 2000s
- Mechanics of a typical yen carry trade (circa 2006):
  - Japanese interest rate: 0.25%
  - Australian interest rate: 5.75%
  - Interest differential: 5.5%
- Example transaction:
  1. Borrow 100 million yen at 0.25%
  2. Convert to Australian dollars (AUD) at current rate
  3. Invest AUD at 5.75%
  4. After one year (assuming exchange rate unchanged):
     - Yen loan repayment: 100.25 million yen
     - AUD investment value: equivalent to 105.75 million yen
     - Profit: 5.5 million yen
- Estimated size of yen carry trade at peak (2007): $1 trillion
- This massive position created systemic risk in global financial markets

Crash Risk in Carry Trades

- Despite favorable average returns, carry trades face significant crash risk:
  - Low-frequency, high-impact events
  - Sudden unwinding of carry positions during market stress
- Historical example: October 6-8, 1998
  - Japanese Yen appreciated 14% against U.S. dollar in just 2 days
  - Sudden reversals triggered by:
    1. Russian debt default (August 1998)
    2. LTCM hedge fund collapse
    3. Unwinding of yen carry trades
  - A trader with $1 billion short in yen would lose $140 million
- Similar episodes:
  - Global Financial Crisis (2008): Unwinding of AUD/JPY carry trade
  - "Flash crash" in yen (January 2019)
  - COVID-19 market turmoil (March 2020)

The "Picking Up Nickels" Analogy

- The Economist famously likened carry trade to "*picking up nickels in front of steamrollers*"
  - Small, consistent profits most of the time
  - Catastrophic losses occasionally
- Crash risk characteristics:
  - Negatively skewed returns (frequent small gains, rare large losses)
  - Fat-tailed distribution (extreme events more common than normal distribution would predict)
  - Correlations spike during crises (diversification benefits disappear)
- Risk management implications:
  - Traditional risk measures (like Sharpe ratio) may understate true risk
  - Value-at-Risk models often fail to capture tail events
  - Leverage amplifies both returns and risks

The Forward Premium Puzzle/ Fama Puzzle

The Forward Premium & UIP's Core Prediction

- **Forward Premium/Discount** (FP_t): The difference between the forward exchange rate (F_t) and the spot exchange rate (E_t), usually expressed as a percentage of the spot rate, $FP_t = (F_t - E_t)/E_t$.
  - If $F_t > E_t$ ($FP_t > 0$): The foreign currency is at a forward premium (domestic currency at a discount).
  - If $F_t < E_t$ ($FP_t < 0$): The foreign currency is at a forward discount (domestic currency at a premium).
- **Covered Interest Rate Parity (CIP)** links the forward premium to interest rate differentials (i_t domestic, i_t^* foreign):

$$\frac{F_t}{E_t} = \frac{1 + i_t}{1 + i_t^*}$$

  This implies that if $F_t > E_t$, then $i_t > i_t^*$ (domestic interest rates are higher). (Further mathematical details on next slide).
- **Uncovered Interest Rate Parity (UIP)** connects expected exchange rate changes to the interest rate differential:

$$\mathbb{E}_t \left[\frac{E_{t+1}}{E_t} \right] = \frac{1 + i_t}{1 + i_t^*}$$

The Forward Premium & UIP's Core Prediction

- **UIP's Core Prediction:** Combining CIP and UIP, the forward rate (or forward premium) should reflect the market's expectation of the future spot rate:

$$\mathbb{E}_t\left[\frac{E_{t+1}}{E_t}\right] = \frac{F_t}{E_t}$$

  This means a forward premium on the foreign currency ($F_t/E_t > 1$) should signal an expected depreciation of the domestic currency ($\mathbb{E}_t[E_{t+1}/E_t] > 1$).

Mathematical Links: Interest Rates & Forward Premiums

From exact CIP:

$$\frac{1+i_t}{1+i_t^*} = \frac{F_t}{E_t}$$

Subtracting 1 from both sides yields an exact relationship for the percentage forward premium $FP_t = (F_t - E_t)/E_t$:

$$\frac{(1+i_t)-(1+i_t^*)}{1+i_t^*} = \frac{F_t - E_t}{E_t} \quad \Longrightarrow \quad \frac{i_t - i_t^*}{1+i_t^*} = FP_t$$

For small i_t^*, we can approximate $1 + i_t^* \approx 1$, leading to:

$$i_t - i_t^* \approx \frac{F_t - E_t}{E_t} = FP_t \tag{73}$$

Mathematical Links: Interest Rates & Forward Premiums

Alternatively, using logarithms (where $e_t = \ln(E_t)$, $f_t = \ln(F_t)$):

Taking the natural log of the exact CIP equation:

$$\ln(1 + i_t) - \ln(1 + i_t^*) = \ln(F_t) - \ln(E_t) = f_t - e_t$$

Using the approximation $\ln(1 + x) \approx x$ for small x:

$$i_t - i_t^* \approx f_t - e_t \tag{74}$$

The term $f_t - e_t$ is the log forward premium, which for small changes is

$$f_t - e_t = \ln(F_t / E_t) = \ln(1 + FP_t) \approx FP_t$$

Thus, both approximations suggest the interest rate differential is roughly equal to the forward premium:

$$i_t - i_t^* \approx FP_t \approx f_t - e_t$$

Testing UIP: The Fama Regression

UIP predicts that the current forward premium (or interest differential) should be an unbiased predictor of the future change in the exchange rate.

UIP Hypothesis (Log-linear form):

Let $\Delta e_{t+1} = \ln(E_{t+1}) - \ln(E_t)$ be the future log change in the spot rate, and $fp_t = \ln(F_t) - \ln(E_t)$ be the current log forward premium. UIP implies:

$$\mathbb{E}_t[\Delta e_{t+1}] = fp_t$$

(This uses the approximation $i_t - i_t^* \approx fp_t$ from the previous slide.)

The Fama (1984) Regression tests this relationship:

$$\Delta e_{t+1} = \alpha + \beta(fp_t) + \varepsilon_{t+1} \tag{75}$$

Or, using percentage changes and the percentage forward premium $FP_t = (F_t - E_t)/E_t$:

$$\frac{E_{t+1} - E_t}{E_t} = \alpha + \beta(FP_t) + \nu_{t+1} \tag{76}$$

Testing UIP: The Fama Regression

$$\frac{E_{t+1} - E_t}{E_t} = \alpha + \beta(FP_t) + \nu_{t+1}$$

Under the null hypothesis that UIP holds:

- $\alpha = 0$: No systematic forecast error; the forward premium is an unbiased predictor.
- $\beta = 1$: A 1% forward premium should lead to an expected 1% depreciation of the domestic currency.

The Empirical Finding: The Fama Puzzle

When the Fama regression is estimated across various currencies and time periods, the results consistently contradict UIP predictions.

Typical Empirical Findings (Fama, 1984, and numerous subsequent studies):

- The estimate for β is not only different from 1 but is often **less than zero**.
- A common finding is a β significantly negative (e.g., the average of -0.75 found by Burnside (2018)).
- The estimate for α is sometimes non-zero, suggesting a constant risk premium or systematic bias.

This systematic failure of UIP, specifically the negative β coefficient, is known as the **Fama Puzzle** or the **Forward Premium Puzzle**.

The Empirical Finding: The Fama Puzzle

Implication of a negative β (e.g., $\beta \approx -0.75$):

- If the domestic interest rate i_t is higher than the foreign rate i_t^* (so $fp_t > 0$, meaning the domestic currency is at a forward discount):
  - UIP predicts: The domestic currency should *depreciate* on average ($\mathbb{E}_t[\Delta e_{t+1}] > 0$).
  - Empirical finding ($\beta < 0$): The domestic currency tends to *appreciate* on average ($\mathbb{E}_t[\Delta e_{t+1}] < 0$).
- The forward premium has the *wrong sign* for predicting future exchange rate movements compared to the UIP hypothesis.

This result implies that high-interest-rate currencies do not depreciate as UIP suggests; they often tend to appreciate.

Interpreting the Puzzle & Its Implications

What does a negative β (e.g., $\beta \approx -0.75$) really mean?

- Suppose domestic interest rates are 1% higher than foreign rates ($i_t - i_t^* \approx fp_t = 0.01$).
  - **UIP Prediction ($\beta = 1$):** Domestic currency should depreciate by 1% on average. Expected net return from investing in domestic vs. foreign is zero (ignoring risk).
  - **Empirical Finding ($\beta = -0.75$):** Domestic currency is expected to *appreciate* by 0.75% on average ($\mathbb{E}_t[\Delta e_{t+1}] = \alpha + (-0.75) \times 0.01 \approx -0.0075$, assuming $\alpha \approx 0$).
- **Economic Significance:**

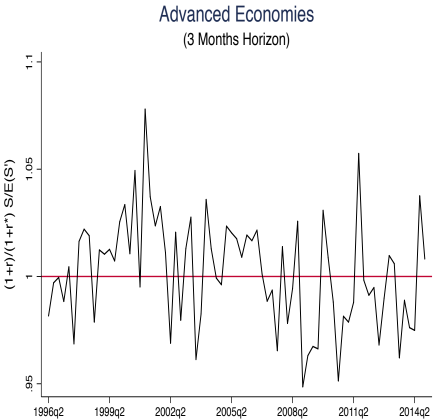
  Consider a currency with a 5% higher interest rate than another.
  - UIP: Expected depreciation of 5%.
  - Empirical: Expected appreciation of $0.75 \times 5\% = 3.75\%$.
  - This implies an expected excess return (unhedged) of roughly $5\%(\text{interest differential}) + 3.75\%(\text{expected appreciation}) = 8.75\%$ per year from investing in the high-interest-rate currency.

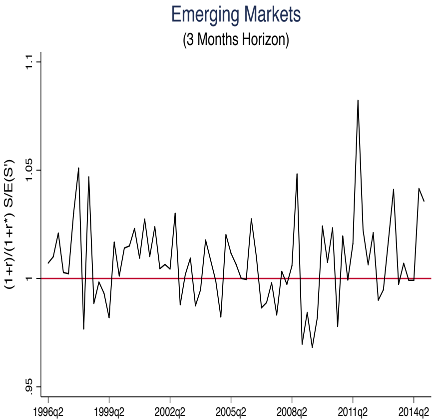
Interpreting the Puzzle & Its Implications

The Forward Premium Puzzle essentially means:

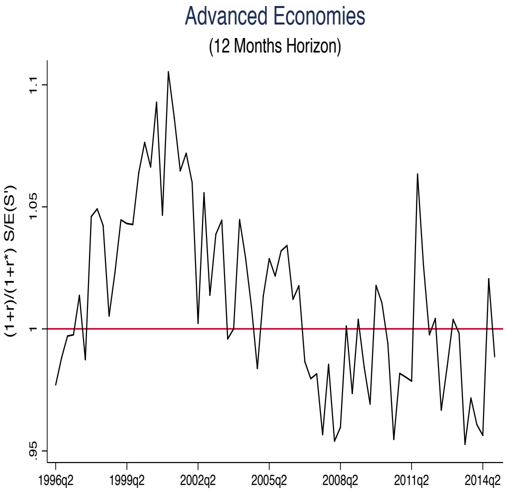
- High-interest-rate currencies tend to appreciate, while low-interest-rate currencies tend to depreciate (contrary to UIP).
- The forward exchange rate is a biased predictor of the future spot rate, and the bias is systematic.
- This pattern directly explains the profitability of **carry trades** (borrowing in low-interest-rate currencies and investing in high-interest-rate currencies without hedging).
- It remains one of the most significant and persistent anomalies in international finance.

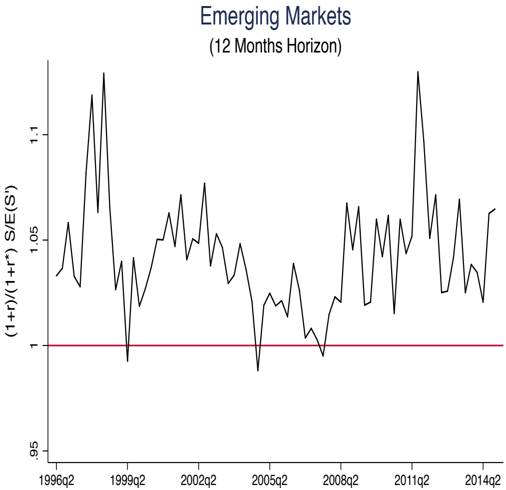
The UIP Deviations





The UIP Deviations





Explaining the Forward Premium Puzzle

Various explanations have been proposed:

1. **Time-varying risk premia**:
   * Risk premium varies systematically with interest rate differentials
   * Requires risk premium to be negatively correlated with forward premium
2. **Peso problems**:
   * Small probability of large exchange rate movements not captured in sample
   * Peso problem name from Mexican peso forward discount before 1976 devaluation
3. **Learning and expectation formation**:
   * Market participants don't have rational expectations
   * Slow learning about regime changes in monetary policy
4. **Market microstructure**:
   * Order flow and liquidity effects
   * Limits to arbitrage due to funding constraints
5. **Rare disasters**:
   * Premium for currencies that perform poorly in global catastrophes
   * Explains why high interest rate currencies earn excess returns

Summary

Key Concepts - CIP and Offshore-Onshore Differentials

- **Covered Interest Rate Parity (CIP):**
  - No-arbitrage condition: $(1 + i_t) = (1 + i_t^*)\frac{F_t}{E_t}$
  - Violations indicate impediments to capital mobility
  - Fundamental benchmark for financial integration
- **Historical Evidence (1870-2003):**
  - High integration pre-WWI and post-1985
  - Disintegration during 1914-1985
  - Financial globalisation not uniquely modern
- **Offshore-Onshore Differentials:**
  - Alternative measure avoiding exchange rate considerations
  - Similar historical pattern to covered interest rate differentials
  - Post-2008 regulatory environment created persistent but small differentials

Key Takeaways - UIP and Carry Trade

- **Uncovered Interest Rate Parity (UIP):**
  - Theoretical relationship: $1 + i_t = (1 + i_t^*)\mathbb{E}_t\left[\frac{E_{t+1}}{E_t}\right]$
  - Unlike CIP, UIP generally fails to hold theoretically and empirically
  - Failure due to risk premium: $F_1 - \mathbb{E}_1\{E_2\} = \frac{\text{Cov}_1(E_2, M_2)}{\mathbb{E}_1\{M_2\}}$

- **Carry Trade:**
  - Exploits UIP deviations by borrowing in low-interest and investing in high-interest currencies
  - Generates positive average returns with substantial crash risk
  - Characterized as "picking up nickels in front of steamrollers"

- **Forward Premium Puzzle:**
  - High-interest rate currencies tend to appreciate, not depreciate as UIP predicts
  - Empirical evidence: $b \approx -0.75$ in UIP regression tests
  - Represents one of the most robust anomalies in international finance

Theoretical vs. Empirical Results

Condition	Theoretical Prediction	Empirical Evidence
CIP	Holds	Holds (except during crises)
UIP	Generally fails	Strongly fails
$F_t = \mathbb{E}_t[E_{t+1}]$	Generally fails	Strongly fails

- Theory and evidence agree on:
  - CIP as an equilibrium condition
  - General failure of UIP
- The surprise in empirical evidence:
  - Not just that UIP fails
  - But that it fails in the opposite direction
  - High interest currencies tend to appreciate, not depreciate
- This suggests limitations in our understanding of:
  - Risk premium dynamics
  - Expectations formation
  - Market microstructure effects

Broader Implications

- **For financial market participants:**
  - UIP deviations create profit opportunities
  - But risks are easily underestimated
  - Requires sophisticated risk management approaches
- **For monetary policy:**
  - Exchange rate channel of monetary transmission works differently than simple models suggest
  - Interest rate increases may strengthen currency more than standard models predict
  - Complicates international policy coordination
- **For international macroeconomics:**
  - UIP failure challenges key building block of many open economy models
  - Greater importance of risk premia and financial frictions
  - Need for more sophisticated modeling of expectation formation