# Central Banking and Monetary Policy

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Lecture 4

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# Outline

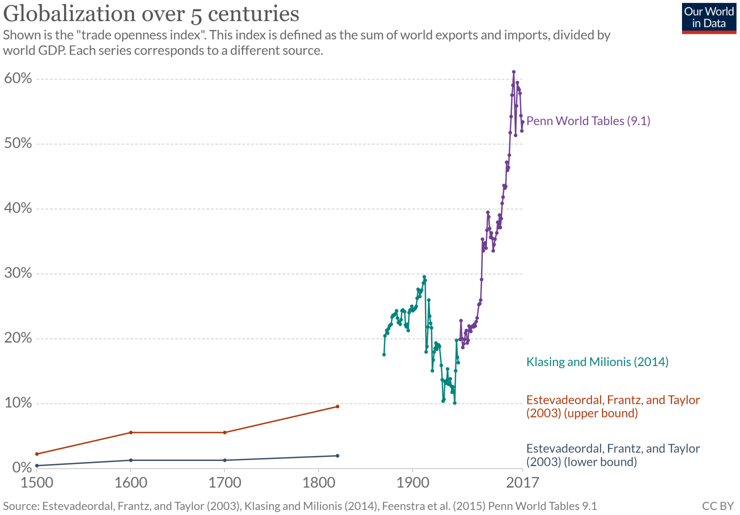
1) Globalisation
2) Financial Globalisation and Parity Conditions
3) Covered Interest Rate Parity
4) Offshore and Onshore Markets
5) Uncovered Interest Rate Parity
6) Carry Trade
7) Summary, Equilibrium, and Policy

# 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.

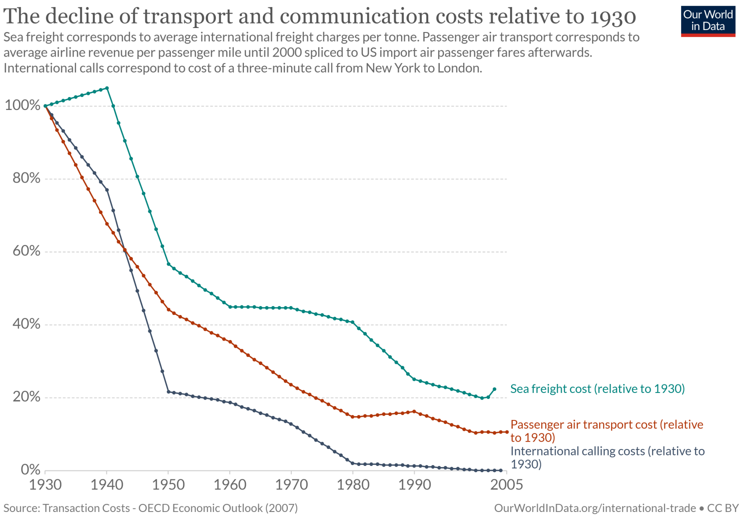
# The First Wave



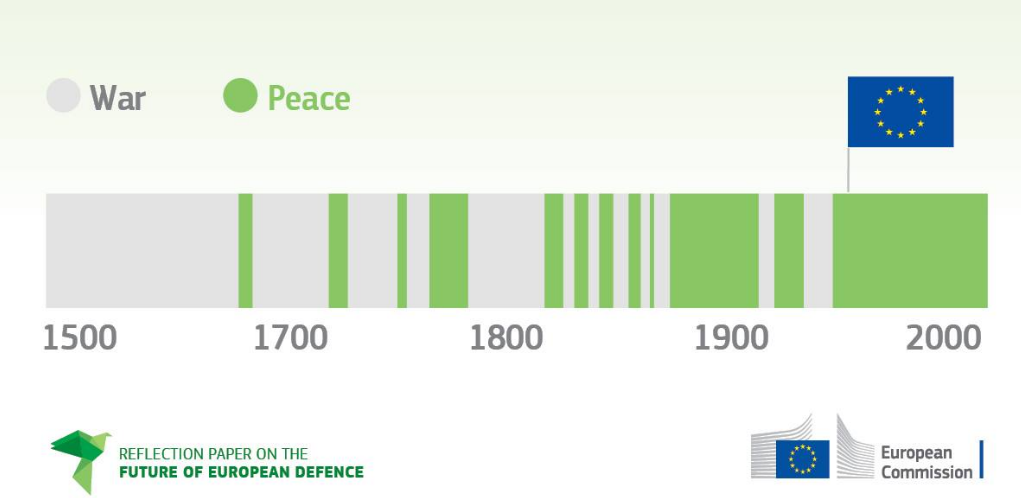
# Globalisation

- 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

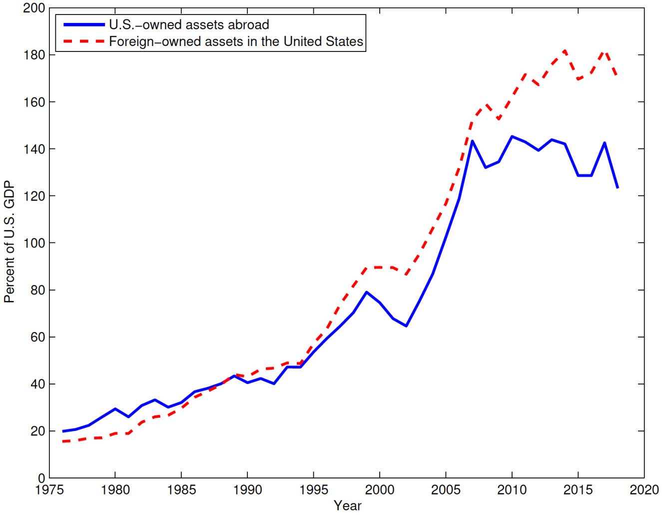


# Globalisation, Interdependence, and Peace




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

# US-Owned Assets Abroad and Foreign-Owned Assets in the US




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

# Financial Globalisation and Parity Conditions

# Financial globalisation and the exchange rate

Financial globalisation means that investors, banks, firms, and governments hold assets and liabilities across currencies and jurisdictions.

Let

$$A_t^* = \text{foreign-currency assets}, \qquad L_t^* = \text{foreign-currency liabilities}.$$

The domestic-currency value of the foreign-currency balance sheet is

$$S_t A_t^* - S_t L_t^* = S_t(A_t^* - L_t^*),$$

where $S_t$ is the domestic-currency price of foreign currency.

A depreciation of the domestic currency raises $S_t$. It therefore changes not only trade prices, but also the value of foreign-currency assets and liabilities.

Foreign exchange markets are mainly over-the-counter markets. Contracts such as forwards and swaps are central because they allow investors to hedge currency risk and transform funding across currencies.

# Notation for currency returns

Throughout the lecture,

$$S_t = \text{spot exchange rate}$$

measured as domestic currency per unit of foreign currency.

$$s_t = \log S_t, \qquad F_t = \text{forward exchange rate}, \qquad f_t = \log F_t.$$

A rise in $S_t$, or equivalently in $s_t$, is a depreciation of the domestic currency.

The forward premium on the foreign currency is

$$fp_t = f_t - s_t.$$

Domestic and foreign nominal interest rates are

$$i_t, \qquad i_t^*.$$

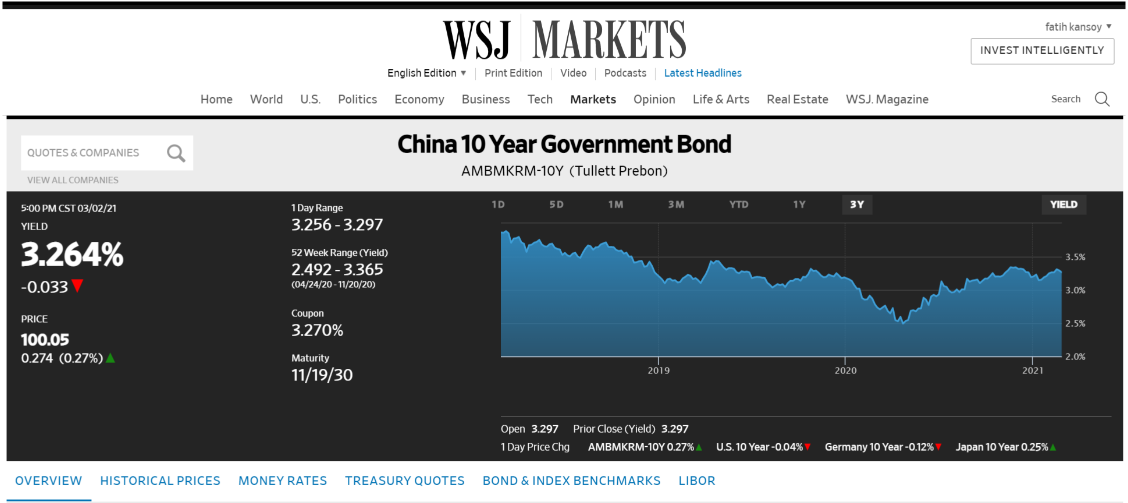
The star denotes the foreign-currency asset. The maturity of the interest rates and the forward contract is assumed to be the same.

# 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



# Interest Rate Return: US 2021

# Interest Rate Return: China 2025

# Interest Rate Return: China 2025

# 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).

# Covered foreign investment

A domestic investor can invest one unit of domestic currency at home,

$$1 \longrightarrow 1 + i_t.$$

Alternatively, the investor can buy foreign currency, invest abroad, and convert the proceeds back into domestic currency.

$$1 \longrightarrow \frac{1}{S_t} \longrightarrow \frac{1 + i_t^*}{S_t} \longrightarrow \frac{S_{t+1}}{S_t}(1 + i_t^*).$$

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Without hedging, the return depends on $S_{t+1}$, which is unknown at time $t$.

A forward contract replaces the uncertain $S_{t+1}$ with the known forward rate $F_t$,

$$\frac{S_{t+1}}{S_t}(1 + i_t^*) \quad \longrightarrow \quad \frac{F_t}{S_t}(1 + i_t^*).$$

The foreign investment is then covered against exchange-rate risk.

# The exact covered parity condition

Covered interest parity equates the domestic return with the covered foreign return,

$$\boxed{1 + i_t = \frac{F_t}{S_t}(1 + i_t^*)}.$$

The expression compares two payoffs known at time $t$.

- $1 + i_t$ is the domestic gross return.
- $1 + i_t^*$ is the foreign gross return.
- $F_t / S_t$ converts the foreign payoff back into domestic currency using the forward contract.
- No expectation of $F_t$ enters the condition.
- Both sides are known at time $t$.

The condition is exact only when the contracts have the same maturity, the credit risk is comparable, market access is unrestricted, and transaction, collateral, and funding costs are negligible.

# The log form of covered parity

Starting from

$$1 + i_t = \frac{F_t}{S_t}(1 + i_t^*),$$

take logs,

$$\log(1 + i_t) = f_t - s_t + \log(1 + i_t^*).$$

Using the first-order approximation

$$\log(1 + x) = x - \frac{x^2}{2} + O(x^3) \approx x,$$

we obtain

$$i_t \approx f_t - s_t + i_t^*.$$

# The forward premium

The forward premium is

$$fp_t = f_t - s_t.$$

Under covered interest parity,

$$fp_t \approx i_t - i_t^*.$$

| **Interest rates** | **Forward premium** | **Interpretation** |
|---|---|---|
| $i_t > i_t^*$ | $fp_t > 0$ | Foreign currency is more expensive forward than spot. |
| $i_t < i_t^*$ | $fp_t < 0$ | Foreign currency is cheaper forward than spot. |
| $i_t = i_t^*$ | $fp_t = 0$ | Forward and spot rates coincide in log approximation. |

In covered parity, $fp_t$ is a relative funding price. It is not yet an expectation of future depreciation.

# Covered interest differentials

The exact covered interest differential is

$$D_t^{CIP} = (1 + i_t) - \frac{F_t}{S_t}(1 + i_t^*).$$

The log-linear version is

$$d_t^{CIP} = i_t - i_t^* - fp_t.$$

$$D_t^{CIP} = 0 \quad \text{or} \quad d_t^{CIP} = 0$$

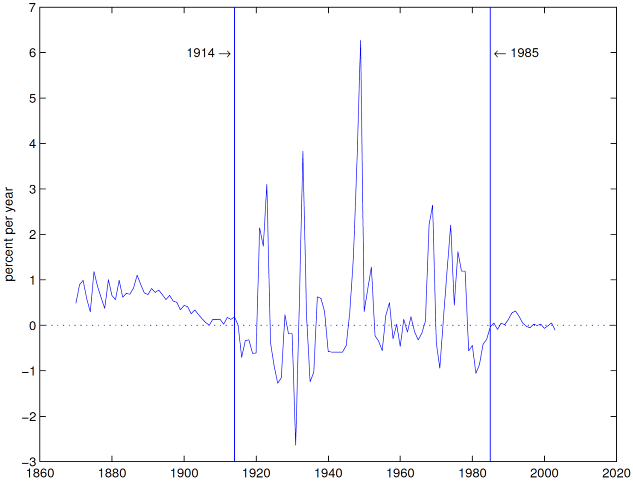
corresponds to covered interest parity.

If $d_t^{CIP} > 0$, the domestic money-market investment has the higher covered return. If $d_t^{CIP} < 0$, the foreign money-market investment has the higher covered return after forward hedging.

# 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

# 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

# So what?

- **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

# 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?

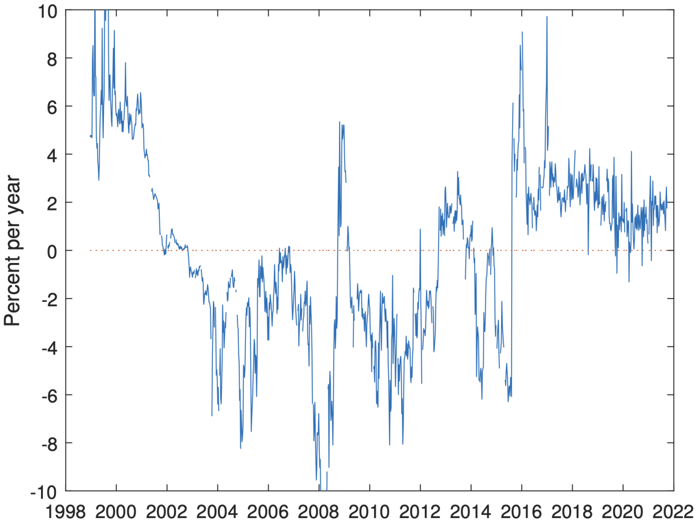
# Real World Example: China-US

- 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
- $\epsilon_t$: spot exchange rate (dollars per renminbi), and
- $F_t$: forward exchange rate (dollars per renminbi).

# Dollar-Renminbi Covered Interest Rate Differentials



# 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-≈2002 and post-≈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 ≈2003-2014.

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

# A numerical arbitrage calculation

Assume

$$i_t = 7\%, \qquad i_t^* = 3\%, \qquad S_t = 0.50, \qquad F_t = 0.51.$$

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Assume

$$i_t = 7\%, \qquad i_t^* = 3\%, \qquad S_t = 0.50, \qquad F_t = 0.51.$$

The domestic gross return is

$$1 + i_t = 1.07.$$

The covered foreign gross return is

$$\frac{F_t}{S_t}(1 + i_t^*) = \frac{0.51}{0.50}(1.03) = 1.0506.$$

Therefore

$$D_t^{CIP} = 1.07 - 1.0506 = 0.0194.$$

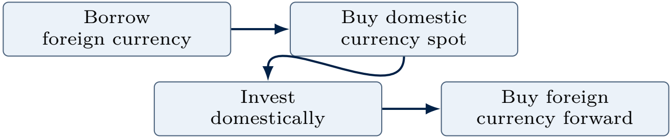
The domestic covered return is higher by 1.94 percentage points.

# Arbitrage positions in the example

The domestic covered return is higher:

$$1 + i_t = 1.07 \quad > \quad \frac{F_t}{S_t}(1 + i_t^*) = 1.0506.$$

So the arbitrage trader borrows foreign currency and locks in the return from moving into domestic currency:




Use cheap foreign funding, buy the high-return domestic asset, and use the forward contract to remove exchange-rate risk.

# Cash flows from the covered arbitrage

Borrow one unit of foreign currency. The future foreign-currency liability is

$$1 + i_t^* = 1.03.$$

| Action | Domestic-currency value at maturity |
|---|---|
| Convert into domestic currency and invest | $S_t(1 + i_t) = 0.50(1.07) = 0.5350$ |
| Buy foreign currency forward to repay loan | $F_t(1 + i_t^*) = 0.51(1.03) = 0.5253$ |
| Covered profit | $0.5350 - 0.5253 = 0.0097$ |

Equivalently,

$$S_t(1 + i_t) - F_t(1 + i_t^*) = 0.0097.$$

# Market pressure from covered arbitrage

In the previous example, arbitrage generates the following market pressures.

Borrow foreign currency $\Rightarrow$ foreign money-market rate rises.

Buy domestic currency spot $\Rightarrow$ $S_t$ falls.

Invest domestically $\Rightarrow$ $i_t$ falls.

Buy foreign currency forward $\Rightarrow$ $F_t$ rises.

These forces reduce

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

until the covered return differential is eliminated, unless a friction prevents arbitrage capital from operating at scale.

# Costs of covered arbitrage

Covered arbitrage is mechanically riskless only in the frictionless benchmark. In modern markets it uses scarce institutional inputs.

| **Input** | **Economic role** |
|---|---|
| Funding access | The arbitrageur must borrow at the relevant money-market rate. |
| Collateral | The forward or swap position may require margin or collateral. |
| Balance sheet | Dealer balance sheets are constrained by leverage, capital, and liquidity regulation. |
| Counterparty lines | Large trades require credit limits and settlement capacity. |
| Market access | Capital controls or segmented markets can prevent arbitrage across venues. |

A compact representation is

$$d_t^{CIP} = \lambda_t^{funding} + \lambda_t^{collateral} + \lambda_t^{balance\ sheet} + \lambda_t^{segmentation}.$$

# Cross currency basis

Under covered parity, the forward premium should equal the interest-rate differential:

$$\underbrace{fp_t}_{\text{observed forward premium}} \approx \underbrace{i_t - i_t^*}_{\text{CIP benchmark}} .$$

The cross-currency basis is the wedge between the two:

$$\boxed{d_t^{CIP} = i_t - i_t^* - fp_t}$$

| **Case** | **Meaning** |
|---|---|
| $d_t^{CIP} = 0$ | The forward price only reflects the interest-rate differential. |
| $d_t^{CIP} \neq 0$ | The forward price also reflects funding frictions, balance-sheet costs, collateral constraints, or market segmentation. |

Economically, the basis is the market price of transforming funding in one currency into funding in another through FX swaps.

# March 2020 dollar funding stress

**What happened**

- COVID panic created a global dash for dollars.
- Non-US banks, firms, and funds needed dollars for funding, margin calls, and precautionary liquidity.
- Private dealer balance sheets did not expand elastically enough.

**Why FX swaps mattered**

- An FX swap combines a spot exchange with a forward reversal.
- For many non-US institutions, it is the marginal way to borrow dollars synthetically.

$$i_t^{\$,swap} \uparrow \quad \Rightarrow \quad \text{dollar funding is scarce.}$$

Dollar demand rises → Dealer capacity is tight → FX swap dollars become expensive → Cross-currency basis widens

The forward price is not only a hedge price. In stress periods, it is also a price of dollar balance-sheet capacity.

# Connect to the real world

**Financial Times**

- Global funding squeeze forces dollar higher
- Fed expands dollar swap lines with central banks
- What makes this global dollar crunch different?
- Heavy take-up of Fed swaps eases strains on dollar

**Wall Street Journal**

- Dollar Surges as Investors Seek Shelter From Market Disruption
- Coronavirus Heightens Risk of Emerging-Market Defaults
- Fed Launches New Lending Facility for Foreign Central Banks
- Dollar Funding Strains Ease in International Markets

# Offshore and Onshore Markets

# 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 ($i_t^{on}$): Interest on dollar deposits in New York
  - Offshore rate ($i_t^{off}$): Interest on dollar deposits in London
- Offshore-onshore differential:

$$\text{Offshore-Onshore Differential} = i_t^{off} - i_t^{on} \tag{1}$$

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

# Same currency across different locations

Covered parity compares returns across *different currencies*. Offshore and onshore comparisons often compare returns in the *same currency* across different locations.

An onshore dollar deposit is a dollar deposit inside the United States. An offshore dollar deposit is a dollar deposit outside the United States.

$$i_t^{on} = \text{onshore interest rate on a dollar claim}, \qquad i_t^{off} = \text{offshore interest rate on a dollar claim.}$$

If the claims have the same currency, maturity, credit risk, liquidity, tax treatment, and legal protection, unrestricted arbitrage implies

$$i_t^{off} = i_t^{on}.$$

The comparison removes exchange-rate risk from the start. Any persistent wedge must come from institutional differences between the two markets.

# The offshore interest differential

The offshore onshore differential is

$$x_t^{off-on} = i_t^{off} - i_t^{on}.$$

$$x_t^{off-on} = 0$$

is the same-currency parity benchmark.

| **Differential** | **Economic meaning** |
|---|---|
| $x_t^{off-on} > 0$ | Offshore funding is more expensive, or offshore claims require compensation for lower safety, lower liquidity, or weaker access to central bank support. |
| $x_t^{off-on} < 0$ | Offshore funding is cheaper, often because offshore markets escape some domestic regulations or because demand for offshore lending is weak. |
| $x_t^{off-on} \approx 0$ | The two markets are highly integrated after adjusting for risk, maturity, and institutional differences. |

This differential is a direct measure of financial segmentation because no currency conversion is involved.

# Eurodollars and offshore dollar funding

A Eurodollar is a US dollar deposit outside the United States. The name refers to the offshore location, not to the euro currency.

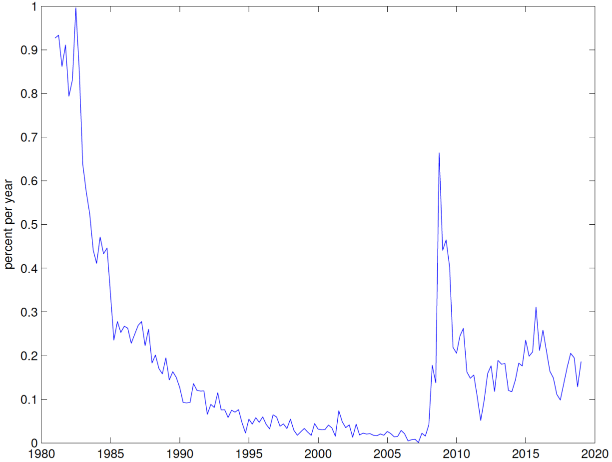
The Eurodollar market became important because it allowed dollar intermediation outside the domestic US regulatory perimeter.

$$\text{US dollar} \longrightarrow \text{London bank balance sheet} \longrightarrow \text{non-US borrower or investor.}$$

Historically, offshore dollar markets developed around regulatory arbitrage, international trade finance, and the need for dollar liquidity outside the United States.

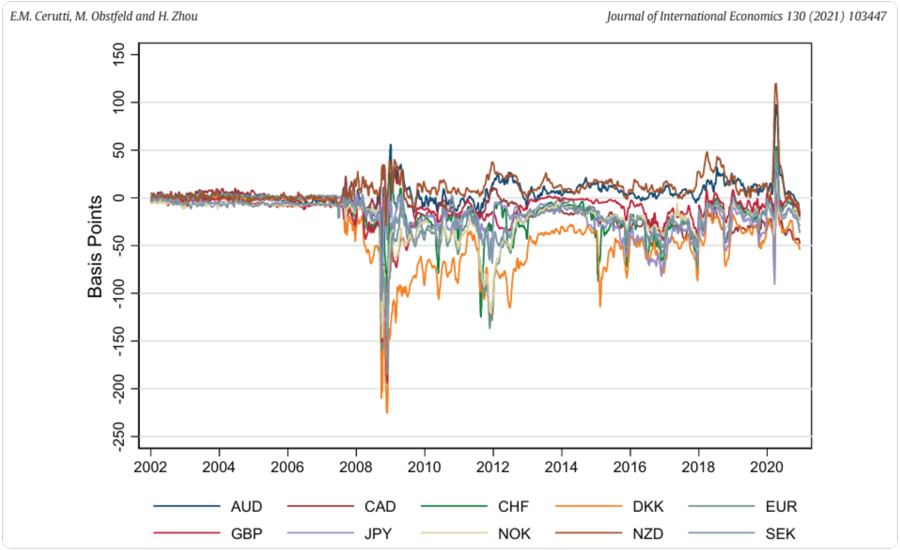
The modern offshore dollar system is larger than a deposit market. It includes dollar deposits, loans, repurchase agreements, commercial paper, foreign-exchange swaps, derivatives, and collateralised funding chains.

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

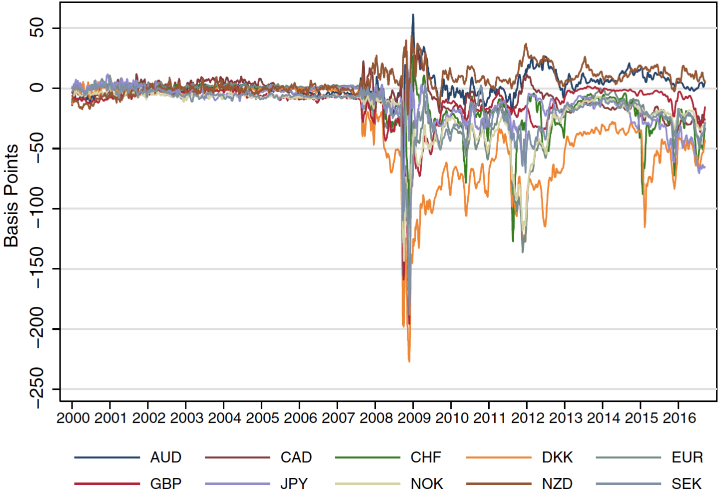



From *International Macroeconomics* by Stephanie Schmitt-Grohe, Martin Uribe and Michael Woodford

# Interest Rate Differentials: US and G10

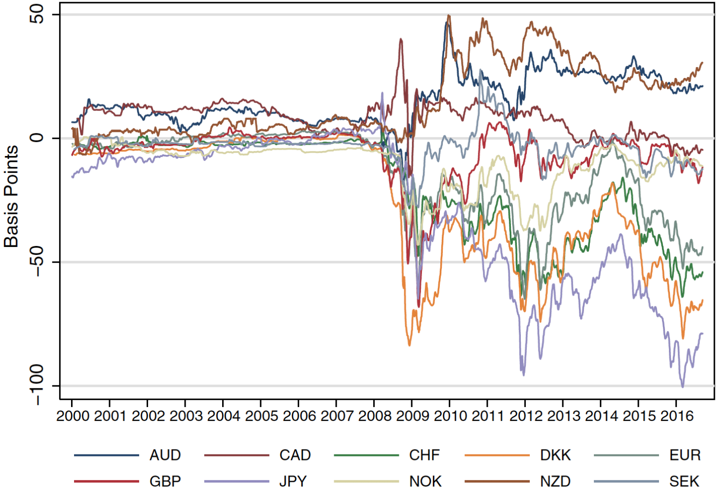


# CIP Violations after the Financial Crisis- Short-term Libor-based




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

# Uncovered foreign investment

A domestic investor can invest at home,

$$1 \longrightarrow 1 + i_t.$$

Alternatively, the investor can buy foreign currency, invest abroad, and convert the proceeds back at the future spot exchange rate,

$$1 \longrightarrow \frac{1}{S_t} \longrightarrow \frac{1 + i_t^*}{S_t} \longrightarrow \frac{S_{t+1}}{S_t}(1 + i_t^*).$$

The foreign investment is now uncovered because $S_{t+1}$ is unknown at time $t$.

The domestic-currency return on the foreign investment is

$$R_{t+1}^* = (1 + i_t^*)\frac{S_{t+1}}{S_t}.$$

This is a risky return. It combines the foreign interest rate with the future exchange-rate change.

# The uncovered parity condition

Uncovered interest rate parity imposes equality of expected returns,

$$1 + i_t = (1 + i_t^*) E_t \left( \frac{S_{t+1}}{S_t} \right).$$

The condition is not a no-arbitrage restriction in the same sense as covered parity. It requires assumptions about expectations and risk premia.

A useful interpretation is

$$\text{higher foreign interest rate} \quad \Rightarrow \quad \text{expected foreign-currency depreciation.}$$

If $i_t^* > i_t$, then the foreign currency must be expected to lose value against the domestic currency for the uncovered expected return to be equalised.

# Log approximation and expected depreciation

Using

$$s_t = \log S_t, \qquad \Delta s_{t+1} = s_{t+1} - s_t,$$

and the approximation $\log(1+x) \approx x$, the uncovered parity condition becomes

$$E_t(\Delta s_{t+1}) \approx i_t - i_t^*.$$

Since $S_t$ is domestic currency per unit of foreign currency,

$$\Delta s_{t+1} > 0$$

means depreciation of the domestic currency.

Thus

$$i_t > i_t^* \quad \Rightarrow \quad E_t(\Delta s_{t+1}) > 0.$$

A domestic interest-rate advantage is offset by expected domestic depreciation.

# UIP and currency excess returns

A domestic investor compares a domestic money-market position with an unhedged foreign money-market position.

$$r = \text{log return}, \qquad r^{\text{ex}} = \text{log excess return}.$$

$$\begin{aligned} \text{Domestic asset} &: \quad r_t = \log(1 + i_t) \approx i_t, \\ \text{Foreign asset} &: \quad r^*_{t+1} \approx i^*_t + \Delta s_{t+1}. \end{aligned}$$

The log excess return on the foreign position is therefore

$$\underbrace{r^{*,\text{ex}}_{t+1}}_{\text{foreign excess return}} = r^*_{t+1} - r_t \approx \underbrace{i^*_t - i_t}_{\text{interest differential}} + \underbrace{\Delta s_{t+1}}_{\text{exchange-rate return}}.$$

## UIP benchmark

$$E_t(\Delta s_{t+1}) \approx i_t - i^*_t \iff E_t(r^{*,\text{ex}}_{t+1}) \approx 0.$$

Here $i_t$ is only the domestic money-market interest rate. The foreign position's total return is $i^*_t$ plus the exchange-rate return.

# Covered parity and forward unbiasedness

Covered parity gives: $fp_t = f_t - s_t \approx i_t - i_t^*.$

Uncovered parity gives: $E_t(\Delta s_{t+1}) \approx i_t - i_t^*.$

Combining the two: $E_t(\Delta s_{t+1}) \approx fp_t.$

Equivalently: $E_t(s_{t+1}) \approx f_t.$

The forward rate is an unbiased predictor of the future spot rate only under the joint conditions of covered parity, uncovered parity, and rational expectations.

A rejection of forward unbiasedness does not by itself reveal whether the source is risk premia, expectations, market segmentation, or measurement.

# The Fama regression

The standard empirical regression is

$$\Delta s_{t+1} = \alpha + \beta f p_t + u_{t+1},$$

where

$$f p_t = f_t - s_t.$$

Under UIP,

$$E_t(\Delta s_{t+1}) = f p_t.$$

Under rational expectations,

$$E_t(u_{t+1}) = 0.$$

Taking conditional expectations of the regression gives

$$E_t(\Delta s_{t+1}) = \alpha + \beta f p_t.$$

Therefore, for all values of $f p_t$,

$$\boxed{\alpha = 0, \qquad \beta = 1.}$$

# Interpreting the Fama coefficient

The slope coefficient measures how realised depreciation responds to the forward premium.

$$\beta = 1$$

means that a higher forward premium is followed by depreciation in exactly the amount predicted by UIP.

$$0 < \beta < 1$$

means that depreciation occurs, but less than UIP predicts.

$$\beta = 0$$

means that the forward premium does not forecast depreciation.

$$\beta < 0$$

means that the currency tends to move in the opposite direction from the UIP prediction.

The negative coefficient is the strongest form of the forward premium puzzle.

# Sterling-Dollar Illustration

Suppose sterling is the domestic currency and the dollar is the foreign currency. The exchange rate is quoted as pounds per dollar.

$$s_t = \log(\text{pounds per dollar}).$$

A rise in $s_t$ is a sterling depreciation against the dollar.

The estimated regression is

$$\Delta s_{t+1} = 0.001 - 0.65 fp_t + u_{t+1}.$$

UIP predicts

$$\alpha = 0, \qquad \beta = 1.$$

The estimate rejects the UIP benchmark. The intercept is positive, and the slope is negative rather than one.

If $fp_t$ rises by one percentage point, predicted sterling depreciation falls by approximately 0.65 percentage points. The exchange-rate movement is opposite to the UIP prediction.

# The forward premium puzzle

Under covered parity,

$$fp_t \approx i_t - i_t^*.$$

A positive forward premium corresponds to a higher domestic interest rate.

UIP predicts

$$fp_t > 0 \quad \Rightarrow \quad E_t(\Delta s_{t+1}) > 0.$$

The domestic currency should depreciate enough to offset the domestic interest-rate advantage.

The forward premium puzzle is the empirical tendency for high-interest-rate currencies to depreciate less than UIP predicts, and in many samples to appreciate.

This is not a covered arbitrage failure. It is a statement about uncovered currency risk and expected excess returns.

# A two-state model for currency risk

Consider an uncovered currency position with excess return

$$r_{t+1}^{*,\mathrm{ex}} = \Delta s_{t+1} - fp_t.$$

Suppose the return has two possible states.

| **State** | **Return** | **Economic interpretation** |
|---|---|---|
| Normal state | $r^N > 0$ | Interest-rate advantage is earned and the exchange rate is stable. |
| Stress state | $r^S < 0$ | Funding currency appreciates, volatility rises, and the position loses. |

If the probability of the stress state is $p$, then

$$E_t(r_{t+1}^{*,\mathrm{ex}}) = (1-p)r^N + pr^S.$$

A positive average return does not imply arbitrage. The relevant issue is whether losses occur in states where liquidity and wealth are especially valuable.

# Currency premia without additional machinery

Define the expected currency excess return as

$$\rho_t^{FX} = E_t(r_{t+1}^{*,\mathrm{ex}}).$$

Using

$$r_{t+1}^{*,\mathrm{ex}} = \Delta s_{t+1} - fp_t,$$

we obtain

$$\rho_t^{FX} = E_t(\Delta s_{t+1}) - fp_t.$$

Hence

$$E_t(\Delta s_{t+1}) = fp_t + \rho_t^{FX}.$$

UIP is the special case

$$\rho_t^{FX} = 0.$$

When $\rho_t^{FX} \neq 0$, the interest differential is not fully offset by expected depreciation. The uncovered position then carries an expected return.

# From UIP to carry trade

A foreign-currency position earns

$$r^{*,\mathrm{ex}}_{t+1} = i^*_t - i_t + \Delta s_{t+1}.$$

Using covered parity,

$$fp_t = f_t - s_t \approx i_t - i^*_t,$$

so

$$r^{*,\mathrm{ex}}_{t+1} = \Delta s_{t+1} - fp_t.$$

If the foreign interest rate is higher,

$$i^*_t > i_t,$$

then

$$fp_t < 0.$$

UIP requires

$$E_t(\Delta s_{t+1}) = fp_t.$$

The foreign currency must be expected to depreciate enough to remove the interest-rate advantage.

Carry trade profits arise when this depreciation is too small, absent, or reversed.

# Carry Trade

# Carry trade mechanics

A carry trade borrows in a low-interest-rate currency and invests in a high-interest-rate currency.

The position is uncovered. The investor earns the interest-rate differential but remains exposed to the future spot exchange rate.

For a domestic investor holding a foreign-currency asset,

$$r^{*,\mathrm{ex}}_{t+1} = i^*_t - i_t + \Delta s_{t+1}.$$

The first component is the yield advantage.

$$i^*_t - i_t.$$

The second component is the currency gain or loss.

$$\Delta s_{t+1}.$$

A carry trade is therefore a joint position in interest rates and exchange rates. It is not a covered arbitrage.

# Carry trade as a portfolio strategy

Empirical work usually studies carry through currency portfolios rather than a single bilateral exchange rate.

At each date $t$, currencies are sorted by their interest differentials,

$$i_t^j - i_t^0,$$

where $0$ is the base currency and $j$ indexes foreign currencies.

A simple carry portfolio is

$$HML_t^{FX} = r_t^{\text{High,ex}} - r_t^{\text{Low,ex}}.$$

The portfolio is long high-interest-rate currencies and short low-interest-rate currencies.

This construction reduces the influence of idiosyncratic bilateral shocks and focuses on the common return to bearing carry risk.

# Fama regression and carry returns

The Fama regression is

$$\Delta s_{t+1} = \alpha + \beta f p_t + u_{t+1}.$$

Since

$$r^{*,\mathrm{ex}}_{t+1} = \Delta s_{t+1} - f p_t,$$

the implied excess return is

$$r^{*,\mathrm{ex}}_{t+1} = \alpha + (\beta - 1) f p_t + u_{t+1}.$$

Taking conditional expectations,

$$E_t(r^{*,\mathrm{ex}}_{t+1}) = \alpha + (\beta - 1) f p_t.$$

Under UIP,

$$\alpha = 0, \qquad \beta = 1, \qquad E_t(r^{*,\mathrm{ex}}_{t+1}) = 0.$$

When $\beta < 1$, the forward premium predicts expected currency excess returns. When $\beta < 0$, the prediction is especially strong.

# Sterling dollar carry interpretation

Let sterling be the domestic currency and the dollar the foreign currency,

$$s_t = \log(\text{pounds per dollar}).$$

A rise in $s_t$ is sterling depreciation and dollar appreciation.

Suppose the estimated relationship is

$$\Delta s_{t+1} = 0.001 - 0.65 fp_t + u_{t+1}.$$

The dollar excess return is

$$r_{t+1}^{\$,\mathrm{ex}} = \Delta s_{t+1} - fp_t.$$

Substituting the estimated equation,

$$r_{t+1}^{\$,\mathrm{ex}} = 0.001 - 1.65 fp_t + u_{t+1}.$$

If the dollar interest rate exceeds the sterling interest rate, then

$$fp_t < 0.$$

The estimated equation then implies a positive expected excess return on the dollar position.

# The risk profile of carry

| | |
|---|---|
| **Normal periods** | Interest-rate differentials accrue gradually. Volatility is low. Positions become attractive to leveraged investors. |
| **Transition** | A monetary-policy surprise, risk-off shock, or funding shock changes expected returns and risk limits. |
| **Stress periods** | Funding currencies appreciate, high-yield currencies fall, margin constraints bind, and positions are reduced. |
| **Return distribution** | Positive average returns can coexist with negative skewness and large drawdowns. |

The central risk is not ordinary exchange-rate volatility alone. It is the tendency for carry positions to lose money when funding liquidity and risk appetite deteriorate together.

# A carry unwind

A typical carry unwind has the following sequence.

$$\text{funding currency begins to appreciate}$$
$$\Downarrow$$
$$\text{leveraged carry positions lose money}$$
$$\Downarrow$$
$$\text{risk limits and margin constraints force position reduction}$$
$$\Downarrow$$
$$\text{investors buy back the funding currency}$$
$$\Downarrow$$
$$\text{the funding currency appreciates further}$$

This mechanism helps explain why carry losses can be sudden and nonlinear. The initial shock may be modest, but the adjustment is amplified when positions are crowded.

# 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

# 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

# Equilibrium and Policy

# Exchange rates with a currency premium

From

$$\rho_t^{FX} = E_t(\Delta s_{t+1}) - fp_t,$$

we have

$$E_t(\Delta s_{t+1}) = fp_t + \rho_t^{FX}.$$

Since

$$E_t(\Delta s_{t+1}) = E_t(s_{t+1}) - s_t,$$

the spot exchange rate satisfies

$$s_t = E_t(s_{t+1}) - fp_t - \rho_t^{FX}.$$

Using covered parity,

$$fp_t \approx i_t - i_t^*,$$

so

$$s_t = E_t(s_{t+1}) + i_t^* - i_t - \rho_t^{FX}.$$

The current exchange rate depends on expected future value, the interest differential, and the premium required to hold currency risk.

# A compact equilibrium representation

The FX premium clears the market for currency risk:

$$\rho_t^{FX} = \Phi\left(\underbrace{I_t^{FX}}_{\text{FX demand imbalance}}, \underbrace{B_t^{FX}}_{\text{balance-sheet capacity}}\right),$$

$$\frac{\partial \Phi}{\partial I_t^{FX}} > 0, \qquad \frac{\partial \Phi}{\partial B_t^{FX}} < 0.$$

| | |
|---|---|
| $I_t^{FX}$ | Net one-sided pressure to hold foreign-currency risk after natural offsetting. Examples: dollar debt repayment, import demand for dollars, global funds buying dollar assets. |
| $B_t^{FX}$ | Capacity of dealers, banks, hedge funds, and asset managers to take the other side. It falls when funding is scarce, volatility rises, margins increase, or risk limits bind. |

$$I_t^{FX} \uparrow \quad \text{or} \quad B_t^{FX} \downarrow \quad \Rightarrow \quad \rho_t^{FX} \uparrow.$$

A larger premium is needed to persuade someone to absorb the unwanted currency exposure. This connects carry premia, dollar funding stress, and balance-sheet constraints.

# Policy and market wedges

| Observed wedge | Likely mechanism | Relevant policy margin |
|---|---|---|
| Cross-currency basis widens | Dollar funding scarcity and dealer balance-sheet limits | Swap lines, repo facilities, liquidity operations |
| Offshore onshore gap widens | Segmentation, capital controls, and liquidity management | Intervention, fixing policy, liquidity supply |
| Carry trade unwinds | Leverage, volatility, and funding-currency appreciation | Market functioning, communication, liquidity backstops |
| UIP premium rises | Risk compensation, credibility risk, and limited participation | Monetary credibility, reserves, macroprudential tools |
| Dollar appreciation tightens conditions | Dollar funding demand and safe-haven flows | Domestic credit policy, swap-line access, reserves |

Policy analysis begins by identifying the relevant wedge. The instrument must address the constraint that prices the wedge.

# Core equations

### Parity conditions

$$\text{CIP:} \quad 1 + i_t = \frac{F_t}{S_t}(1 + i_t^*)$$

$$\text{Fwd premium:} \quad fp_t = f_t - s_t \approx i_t - i_t^*$$

$$\text{UIP:} \quad E_t(\Delta s_{t+1}) \approx i_t - i_t^*$$

$$\text{Fwd unbiased:} \quad E_t(s_{t+1}) \approx f_t$$

Here $s_t = \log S_t$, $f_t = \log F_t$, and $fp_t = f_t - s_t$.

### Empirical and return equations

$$\text{Fama:} \quad \Delta s_{t+1} = \alpha + \beta fp_t + u_{t+1}$$

$$\text{Excess ret.:} \quad r_{t+1}^{*,\text{ex}} = \Delta s_{t+1} - fp_t$$

$$\text{FX premium:} \quad \rho_t^{FX} = E_t(r_{t+1}^{*,\text{ex}})$$

# Main conceptual distinctions

| Distinction | Economic meaning |
|---|---|
| CIP and UIP | CIP compares known covered payoffs. UIP compares expected uncovered payoffs. |
| Forward premium in CIP | The forward premium equalises covered returns. |
| Forward premium in UIP | The forward premium is tested as a predictor of future depreciation. |
| CIP deviation | A covered funding, collateral, balance-sheet, or segmentation wedge. |
| UIP deviation | An expected-return, risk-premium, or expectation-error wedge. |
| Carry return | A portfolio exposure to the UIP wedge. |
| Forward premium puzzle | High-interest-rate currencies depreciate too little, or appreciate, relative to UIP. |
| Equilibrium view | Currency premia clear markets when risk-bearing capacity is limited. |

# The full argument

Financial globalisation creates large cross-currency positions.

Covered parity explains how forward markets price hedged currency returns.

Offshore and onshore markets show how legal location, access, and liquidity create segmentation.

Uncovered parity links interest differentials to expected depreciation.

The Fama regression tests whether the forward premium predicts depreciation as UIP requires.

Carry trade turns the UIP deviation into a portfolio return.

Equilibrium analysis asks who holds the currency risk and what premium is required for market clearing.

The central message is that parity deviations are prices of risk, funding, balance-sheet capacity, market access, and policy credibility.

# Selected readings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