Chapter Objective:

This chapter examines several key international parity relationships, such as interest rate parity and purchasing power parity.
Chapter Outline

- Interest Rate Parity
  - Covered Interest Arbitrage
  - IRP and Exchange Rate Determination
  - Reasons for Deviations from IRP
- Purchasing Power Parity
- The Fisher Effects
- Forecasting Exchange Rates
Chapter Outline

- Interest Rate Parity
- Purchasing Power Parity
  - PPP Deviations and the Real Exchange Rate
  - Evidence on Purchasing Power Parity
- The Fisher Effects
- Forecasting Exchange Rates
Chapter Outline

- Interest Rate Parity
- Purchasing Power Parity
- The Fisher Effects
- Forecasting Exchange Rates
  - Efficient Market Approach
  - Fundamental Approach
  - Technical Approach
  - Performance of the Forecasters
Interest Rate Parity

- Interest Rate Parity Defined
- Covered Interest Arbitrage
- Interest Rate Parity & Exchange Rate Determination
- Reasons for Deviations from Interest Rate Parity

Interest Rate Parity Defined

- (Covered) IRP is an arbitrage condition.
- If IRP did not hold, then it would be possible for an astute trader to make unlimited amounts of money exploiting the arbitrage opportunity.
- Since we don’t typically observe persistent arbitrage conditions, we can safely assume that IRP holds.
  - Exception in periods of financial market stress? Why?
Consider alternative one year investments for $100,000:

1. Invest in the U.S. at \( i_S \). Future value = $100,000 \times (1 + i_S)

2. Trade your $ for £ at the spot rate, invest $100,000/S_{S/£} in Britain at \( i_E \) and get rid of any exchange rate risk by selling the future value of the British investment forward.

\[
\text{Future value} = 100,000 (1 + i_E) \times \frac{F_{S/£}}{S_{S/£}}
\]

Since these investments have the same risk, they must have the same future value (otherwise an arbitrage would exist)

\[
(1 + i_E) \times \frac{F_{S/£}}{S_{S/£}} = (1 + i_S)
\]

Since both of these investments have the same risk, they must have the same future value—otherwise an arbitrage would exist.
Interest Rate Parity

1. Trade $100,000 for £ at S

2. Invest £100,000 at $i_£$

3. One year later, trade £ for $ at F

Interest Rate Parity Defined

- The scale of the project is unimportant

\[
1,000 \times (1 + i_S) = \frac{1,000}{S_{S/£}} \times (1 + i_£) \times F_{S/£}
\]

\[
(1 + i_S) = \frac{F_{S/£}}{S_{S/£}} \times (1 + i_£)
\]
Interest Rate Parity Defined

Formally,

\[ \frac{F}{S}(1 + i_y) = (1 + i_S) \]

or if you prefer,

\[ \frac{1 + i_S}{1 + i_y} = \frac{F}{S} \]

IRP is sometimes *approximated* as

\[ i_S - i_y = \frac{F - S}{S} \]

Interest Rate Parity Carefully Defined

- Depending upon how you quote the exchange rate ($ per ¥ or ¥ per $) we have:

\[ \frac{1 + i_y}{1 + i_S} = \frac{F_{¥/$}{S_{¥/$}} \quad \text{or} \quad \frac{1 + i_S}{1 + i_y} = \frac{F_{$/¥}}{S_{$/¥}} \]
IRP and Covered Interest Arbitrage

If IRP failed to hold, an arbitrage would exist. It’s easiest to see this in the form of an example. Consider the following set of foreign and domestic interest rates and spot and forward exchange rates.

<table>
<thead>
<tr>
<th>Spot exchange rate</th>
<th>$S(£/£) = $1.25/£</th>
</tr>
</thead>
<tbody>
<tr>
<td>360-day forward rate</td>
<td>$F_{360}(S/£) = $1.20/£</td>
</tr>
<tr>
<td>U.S. discount rate</td>
<td>$i_s = 7.10%$</td>
</tr>
<tr>
<td>British discount rate</td>
<td>$i_f = 11.56%$</td>
</tr>
</tbody>
</table>

A trader with $1,000 to invest could invest in the U.S., in one year his investment will be worth $1,071 = $1,000 \times (1 + i_s) = $1,000 \times (1.071)$

Alternatively, this trader could exchange $1,000 for £800 at the prevailing spot rate, (note that £800 = $1,000 \div $1.25/£) invest £800 at $i_f = 11.56\%$ for one year to achieve £892.48. Translate £892.48 back into dollars at $F_{360}(S/£) = $1.20/£, the £892.48 will be exactly $1,071.$
Interest Rate Parity

1. Trade $100,000 for £800

2. Invest £800 at 11.56% = $892.48 for £ at $_{360}(£/£) = $1.20/£

3. One year later, trade £892.48 for $ at $_{360}(£/£) = $1.20/£

Interest Rate Parity & Exchange Rate Determination

According to IRP only one 360-day forward rate, $_{360}(£/£)$, can exist. It must be the case that

$F_{360}(£/£) = $1.20/£$

Why?

If, say, $F_{360}(£/£) \neq $1.20/£$, an astute trader could make money with one of the following strategies:
Arbitrage Strategy I

If $F_{360}($$/£) > $1.20/£

i. Borrow $1,000 at $t = 0$ at $i_S = 7.1\%$.

ii. Exchange $1,000$ for £800 at the prevailing spot rate, (note that £800 = $1,000÷$1.25/£) invest £800 at 11.56% ($i_E$) for one year to achieve £892.48

iii. Translate £892.48 back into dollars, if $F_{360}($$/£) > $1.20/£$, £892.48 will be more than enough to repay your dollar obligation of $1,071.

Arbitrage Strategy II

If $F_{360}($$/£) < $1.20/£

i. Borrow £800 at $t = 0$ at $i_E = 11.56\%$.

ii. Exchange £800 for $1,000$ at the prevailing spot rate, invest $1,000$ at 7.1% for one year to achieve $1,071.

iii. Translate $1,071$ back into pounds, if $F_{360}($$/£) < $1.20/£$, $1,071$ will be more than enough to repay your £ obligation of £892.48.
Reasons for Deviations from IRP

- **Transactions Costs**
  - The interest rate available to an arbitrageur for borrowing, \( i^b \), may exceed the rate he can lend at, \( i^l \).
  - There may be bid-ask spreads to overcome, \( F^b/S^a < F/S \).
  - Thus
  \[
  (F^b/S^a)(1 + i^a) - (1 + i^b) \leq 0
  \]

- **Capital Controls**
  - Governments sometimes restrict the import/export of currency by means of taxes or outright bans.

“Problems” with Covered IRP

- It is an arbitrage relation
  - What if we want to forecast future FX rates, or to explain past FX rate changes

- Where is inflation?
  - Shouldn’t inflation affect exchange rates?
  - If so, what is the connection with IRP?
    - For example, why did the dollar **depreciate** in March 2008 against the € despite news of an unexpected drop in US inflation and Eurozone inflation at a 14-year high?
Purchasing Power Parity

- Purchasing Power Parity and Exchange Rate Determination
  - Law of One Price
  - Absolute version of PPP
  - Relative version of PPP
    - The latter is the most frequently used (“default”) version

- PPP Deviations and the Real Exchange Rate
- Evidence on PPP
PPP and Exchange Rate Determination (“Law of One Price” Version of PPP)

● Absent transactions costs, goods should cost the same in any pair of countries: $P_S = P_E \cdot S(\$/\£)$, i.e.,

$$S(\$/\£) = \frac{P_S}{P_E}$$

● Example: if an ounce of gold costs $600 in the U.S. and £300 in the U.K., then the price of one pound in terms of dollars should be:

$$S(\$/\£) = \frac{P_S}{P_E} = \frac{600}{300} = \frac{2}{\£}$$

PPP and Exchange Rate Determination (“Absolute” Version of PPP)

● The exchange rate between two currencies should equal the ratio of the countries’ price levels:

$$S(\$/\£) = \frac{P_S}{P_E}$$

● For example, if the price of a “reference basket” is $300 in the U.S. and £150 in the U.K., then the price of 1£ in terms of the dollar should be:

$$S(\$/\£) = \frac{P_S}{P_E} = \frac{300}{150} = \frac{2}{\£}$$
PPP and Exchange Rate Determination
(“Relative” Version of PPP)

- Idea: “Relative PPP” states that the rate of change in the exchange rate, denoted $e$, should be equal to the differences between inflation rates (why?):

$$e = \frac{(s_{t+T} - s_t)}{s_t} = \frac{(\pi_S - \pi_E)}{(1 + \pi_E)} \approx \pi_S - \pi_E$$

- If U.S. inflation is $\pi_S = 5\%$ and U.K. inflation is $\pi_E = 8\%$, then the pound should depreciate by 2.78%, i.e., lose about 3% of its value in dollars

PPP Deviations and the Real Exchange Rate (RER Index)

Define the U.S. RER index $q = \frac{(1 + \pi_S)}{(1 + e)(1 + \pi_E)}$

If PPP holds, then $(1 + e) = \frac{(1 + \pi_S)}{(1 + \pi_E)}$ so $q = 1$.

If $q < 1$ competitiveness of domestic country (U.S.) improves; (Example: The Economist_07a)
If $q > 1$ competitiveness of domestic country (U.S.) worsens.
PPP Deviations and the Real Exchange Rate (RER Level)

The RER at time $t$ is, by definition, $s'_t = s_t$

The RER at time $t+T = s'_{t+T} = s_{t+T} \left[ \frac{(1+ \pi^*)}{(1+ \pi)} \right]$ 

If PPP holds, then $s_{t+T} = s_t \left[ \frac{(1+ \pi)}{(1+ \pi^*)} \right]$, so 

$s'_{t+T} = s_t \left[ \frac{(1+ \pi)}{(1+ \pi^*)} \right] \left[ \frac{(1+ \pi^*)}{(1+ \pi)} \right] = s_t = s'_t$

If $s'_{t+T} < s'_t$: U.S. competitiveness worsens.

If $s'_{t+T} > s'_t$: U.S. competitiveness improves.

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PPP Deviations and the Real Exchange Rate (RER Index)

Foreign country’s RER index $q^* = \frac{s'_{t+T}}{s'_t}$

If PPP holds, then $s'_{t+T} = s'_t$, so $q^* = 1$

$q^* < 1 \rightarrow$ foreign country’s competitiveness improves (and U.S. competitive position worsens);

$q^* > 1 \rightarrow$ foreign country’s competitiveness worsens (and U.S. competitiveness improves).
Question 2, PS#4.

The ¥/$ exchange rate moved from ¥105/1$ in March 1994 to ¥90/1$ in March 1995; during the same period, the U.S. consumer price index (CPI) rose from 130 to 133.6, and the corresponding Japanese index moved from 110 to 110.7;

What was the real appreciation of the ¥ during the relevant year (3-94 to 3-95)? Explain, intuitively and formally.

Question 2, PS#4: Intuitive Answer.

Intuitively, notice that 1$ buys in 3-95 about 14.3% (15/105) fewer ¥ than it did 1 year earlier, yet the inflation differential between the US and Japan was only 2.2% (133.6/130 - 110.7/110). Hence, the real depreciation of the $ must have been about 12% (14.3%-2.2%).

We can look at the same situation from the alternative point of view of the real appreciation of the Japanese ¥. In nominal terms, the ¥ appreciated against the $ by 16.7% (from 0.009524$/1¥ to 0.011111$/1¥), yet the inflation differential was only 2.2%. Hence, the real appreciation of the ¥ must have been about 14.5% (16.7%-2.2%).
PPP Deviations and the Real Exchange Rate (Example)

Question 2, PS#4: Formal Answer.

\[ s' \text{ (beginning of last year)} = s' \text{ (March 94)} = s' \text{ (t)} = 0.009524 \ $/¥ \]

\[ s' \text{ (beginning of this year)} = s' \text{ (March 95)} = s' \text{ (t+T)} \]

\[ s'_{t+T} = s'_{t+T} \left( \frac{1+\mu^*}{1+\mu} \right) = (0.0111111 \ $/1¥) \left( \frac{1.006}{1.028} \right) = 0.010873 \ $/¥ \]

Hence, the real appreciation of the ¥ is:

\[ \frac{s'(\text{beginning of this year})}{s'(\text{beginning of last year})} - 1 = \frac{s'_{t+T}}{s'_t} - 1 = \frac{0.010873}{0.009524} - 1 = 14.17 \% \]

Note: The difference between the formal (14.17%) and intuitive (14.5%) answers comes from discounting.

Evidence on PPP

- PPP probably doesn’t hold precisely in the real world for a variety of reasons.
  - Non-Tradables (NTG, NTGS):
    - Haircuts cost 10 times as much in OECD countries as in the developing world (Economist alternative? # of minutes to buy a Big Mac, 08-2009).
  - vs. Tradables (TGS):
    - Computer memory, on the other hand, is a standardized commodity that is actively traded across borders.
    - Even for such tradables, though, there may be deviations from PPP due to shipping costs, tariffs, quotas, etc.
- PPP-determined exchange rates still provide a valuable benchmark.
Evidence on PPP

- **Big Mac index**
  - *Law of One Price* in Practice
    - Examples: Big Mac parities for many countries *(Economist site)*
  - Empirical evidence
    - Country specificities:
      - Is the Big Mac really a commodity in India?
      - Are fast-food restaurants an everyday experience everywhere?
      - How much time does it take to buy a Big Mac?
    - How about a latte? Starbucks index, anyone?

- **Trade-weighted real exchange rate** *(Economist_07d)*

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The Fisher Effects
The Fisher Effects

- **Domestic Fisher effect**
  - Link between a country’s nominal int. rate and its inflation rate

- **International Fisher effect**
  - If FF is a reality in every country, what does it say about exchange rates

- Can the Fisher effects tell us anything
  - about when forward rates can help predict future spot rates?

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An increase (decrease) in the expected rate of inflation will cause a proportionate increase (decrease) in the interest rate in the country.

For the U.S., the Fisher effect is written as:

\[
1 + i_s = (1 + \rho_s)(1 + E[\pi_S]) = 1 + \rho_s + E[\pi_S] + \rho_s E[\pi_S]
\]

\[
i_s = \rho_s + E(\pi_S) + \rho_s E[\pi_S] \approx \rho_s + E[\pi_S]
\]

Where

- \( \rho_s \) is the equilibrium expected “real” U.S. interest rate
- \( E[\pi_S] \) is the expected rate of U.S. inflation
- \( i_s \) is the equilibrium expected nominal US int. rate
Expected Inflation

- The Fisher effect
  \[ i_s = \rho_s + (1 + \rho_s)E[\pi_s] \approx \rho_s + E[\pi_s] \]
- implies that the expected inflation rate is approximated as the difference between the nominal and real interest rates in each country, i.e.
  \[ E[\pi_s] = \frac{(i_s - \rho_s)}{(1 + \rho_s)} \approx i_s - \rho_s \]

International Fisher Effect

If the Fisher effect holds in the U.S.
  \[ i_s = (1 + \rho_s)(1 + E[\pi_s]) \approx \rho_s + E[\pi_s] \]
and if the Fisher effect holds in Japan,
  \[ i_y = (1 + \rho_y)(1 + E[\pi_y]) \approx \rho_y + E[\pi_y] \]
and if the real rates are the same in each country
  \( i.e. \ \rho_s = \rho_y \), then we get the International Fisher Effect:
  \[ E(e) = \frac{(i_s - i_y)}{(1 + i_y)} \approx i_s - i_y \]
International Fisher Effect

If the International Fisher Effect holds,

\[
E(e) = \frac{(i_S - i_F)}{(1 + i_F)}
\]

and “if” IRP also holds

\[
\frac{F - S}{S} = \frac{(i_S - i_F)}{(1 + i_F)}
\]

then “forward parity” holds:

\[
E(e) = \frac{F - S}{S}
\]
Approximate Equilibrium Exchange Rate Relationships

\[ E(\pi - \pi_{\$}) \approx IRP \approx PPP \approx FE \approx FRPPP \]

\[ (i_S - i_S) \approx UIRP \approx IRP \]

\[ F - S \approx FP \]

\[ E(\pi_S - \pi_{\$}) \approx FRPPP \]

The Exact Fisher Effects

- An increase (decrease) in the expected rate of inflation will cause a proportionate increase (decrease) in the interest rate in the country.

- For the U.S., the Fisher effect is written as:

\[ 1 + i_S = (1 + \rho_S) \times E(1 + \pi_S) \]

Where

- \( \rho_S \) is the equilibrium expected “real” U.S. interest rate
- \( E(\pi_S) \) is the expected rate of U.S. inflation
- \( i_S \) is the equilibrium expected nominal U.S. interest rate
International Fisher Effect

If the Fisher effect holds in the U.S.

\[ 1 + i_S = (1 + \rho_S) \times E(1 + \pi_S) \]

and the Fisher effect holds in Japan,

\[ 1 + i_Y = (1 + \rho_Y) \times E(1 + \pi_Y) \]

and if the real rates are the same in each country

\[ \rho_S = \rho_Y \]

then we get the International Fisher Effect:

\[ \frac{1 + i_Y}{1 + i_S} = \frac{E(1 + \pi_Y)}{E(1 + \pi_S)} \]

International Fisher Effect

If the International Fisher Effect holds,

\[ \frac{1 + i_Y}{1 + i_S} = \frac{E(1 + \pi_Y)}{E(1 + \pi_S)} \]

and “if” IRP also holds

\[ \frac{1 + i_Y}{1 + i_S} = \frac{F_{YS}}{S_{YS}} \]

then forward rate PPP holds:

\[ \frac{F_{YS}}{S_{YS}} = \frac{E(1 + \pi_Y)}{E(1 + \pi_S)} \]
Exact Equilibrium Exchange Rate Relationships

\[
\frac{1 + i_Y}{1 + i_S} \quad \text{IRP} \quad \frac{E(S_{Y/S})}{S_{Y/S}} \quad \text{IRP} \quad \frac{F_{Y/S}}{S_{Y/S}} \quad \text{FRPPP}
\]

\[
E(1 + \pi_Y) \quad \text{FE} \quad E(1 + \pi_S)
\]

\[
E(S_{Y/S}) \quad \text{IFE} \quad \text{FEP}
\]

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Forecasting Exchange Rates

- Efficient Markets Approach
- Fundamental Approach
- Technical Approach
- Performance of the Forecasts
**Efficient Markets Approach**

- Financial Markets are *efficient* if prices reflect all available and relevant information.
- If this is so, exchange rates will only change when new information arrives, thus:
  \[ S_t = E[S_{t+1}] \]
  and
  \[ F_t = E[S_{t+1} | I_t] \]
- Predicting exchange rates using the efficient markets approach is affordable – but is it good?

**Currency Carry Trade**

- If UIRP does not hold, then...
  - Currency carry trade
  - buy a currency with a high rate of interest and fund the purchase by borrowing a currency with low rates of interest, *without any hedging*.
- Carry trade profitable if the int. rate diff. exceeds the appreciation of the funding currency against the target currency.
- Risk?
Fundamental Approach

- Uses econometrics to develop models that use a variety of explanatory variables. Involves 3 steps:
  - step 1: Estimate the structural model
    - What variables should be included – macro, order flow?
  - step 2: Estimate future parameter values
    - Why is this any easier than forecasting the FX rate itself?
  - step 3: Use the model to develop forecasts
    - Why should past relations between variables hold in the future?
- Downside
  - In the short run at least, fundamental models seem not to work any better than the forward rate model or the random walk model.

Technical Approach

- Technical analysis looks for patterns in the past behavior of exchange rates.
- Clearly it is based upon the premise that history repeats itself.
- Thus it is at odds with the EMH
- Short-term vs. Long-term differences?
  - In the long run, fundamentals do matter
  - In the short run, trader prophecies may be self-fulfilling
Performance of the Forecasters

- Forecasting is difficult, especially with regard to the future.
  - Still, the evidence suggests that UIPR does pretty well at horizons of 5 to 10 years (*in contrast to short term*)
- As a whole, forecasters appear not to do a much better job of forecasting future exchange rates than does the forward rate
- The founder of *Forbes* Magazine once said: “You can make more money selling financial advice than following it”