International Monetary Economics

Georg Stadtmann

Introduction

Chapter 14
Exchange Rates and the Foreign Exchange Market: An Asset Approach

Outline

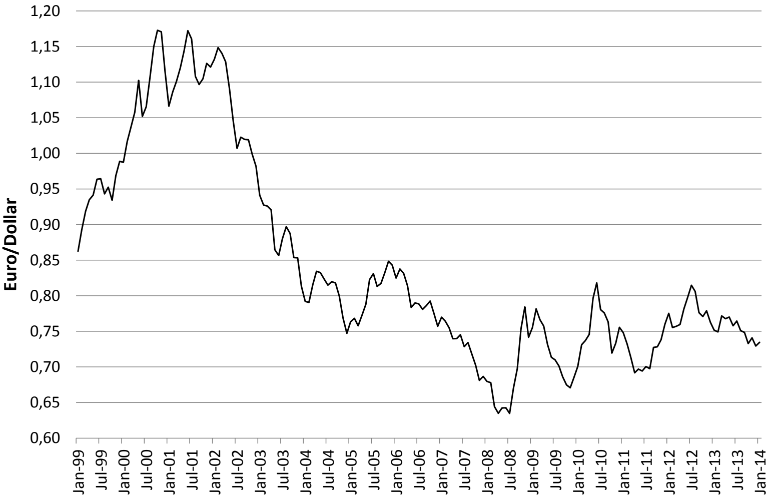
- 14.1 Direct and indirect quote, appreciation and depreciation
- 14.2 Forward rates and hedging
- 14.3 Covered interest rate parity (CIP)
- 14.4 Uncovered interest rate parity (UIP)
- 14.5 The UIP-model of the foreign exchange market

Learning objectives

After you worked through this chapter, you should be able

- to compute the degree of depreciation and appreciation,
- to distinguish the terms spot rate and forward rate,
- to explain, to derive and to apply the concepts of CIP and UIP,

Spot Exchange Rate



Source: Pacific exchange rate service: `http://fx.sauder.ubc.ca/`

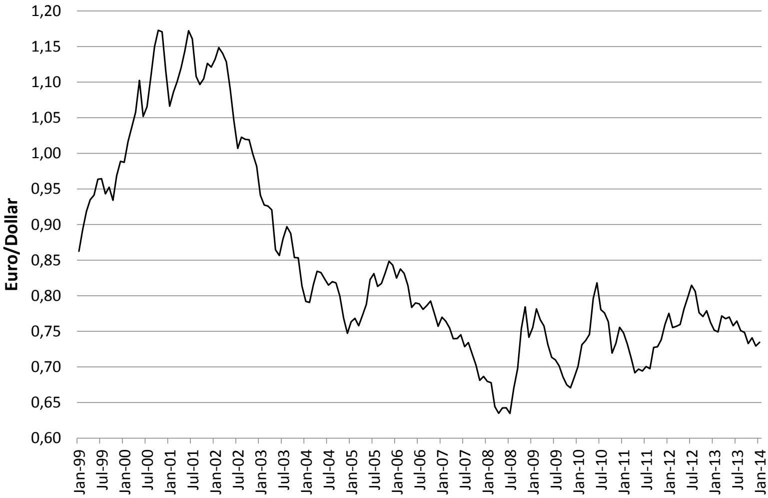
Case study: Exchange rate exposure

- A company produces in Germany and its cost structure is to 100 % in EUR (wages, rents, interest).
- Cost per unit: 100 EUR.
- The company will break even, when the price of the good is at least $p = 100$ EUR.
- The company sells its products completely on the German market.

How does a change in the exchange rate from $E_t = 1.10$ EUR/USD $\Rightarrow E_{t+1} = 0.75$ EUR/USD influence the business model of the company?

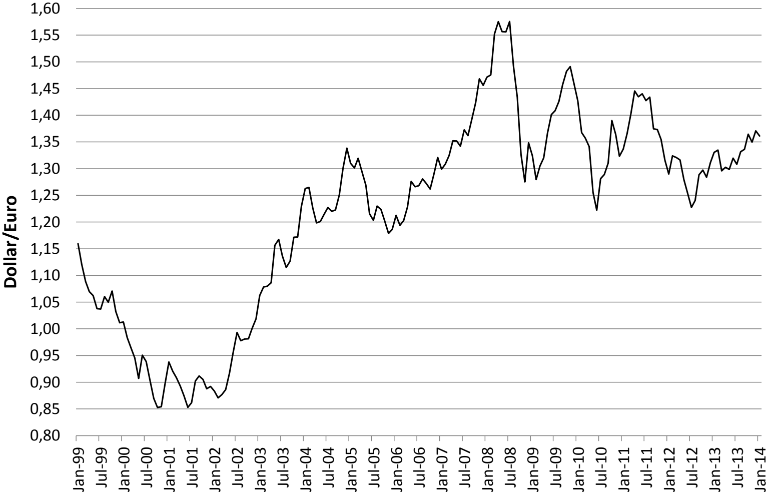
- An American competitor produces in the US and the cost structure is to 100 % in USD.
- Cost per unit: 100 USD.
- 1. Scenario: 100 USD $\cdot$ 1.10 EUR/USD = 110 EUR
- 2. Scenario: 100 USD $\cdot$ 0.75 EUR/USD = 75 EUR

Spot Exchange Rate



Source: Pacific exchange rate service: `http://fx.sauder.ubc.ca/`

Spot Exchange Rate



Source: Pacific exchange rate service: `http://fx.sauder.ubc.ca/`

Direct versus indirect quote

Two possible ways of exchange rate notation

$$\boxed{E_{€}^{\$} = \frac{1}{E_{\$}^{€}}}$$

Purchasing power of one unit domestic currency:

- How many dollars do I get for 1 €?
- $\rightarrow$ indirect quote $\qquad E_{€}^{\$} = 1.25\$/€$

Price of the foreign currency:

- How much is a dollar?
- $\rightarrow$ direct quote $\qquad E_{\$}^{€} = 0.80€/\$$

Depreciation versus appreciation

Scenario at time t:	1.00 €/\$
Scenario at time $t+1$:	1.25 €/\$

1. Question:

- Has the Euro appreciated or depreciated?
- Has the Dollar appreciated or depreciated?

2. Question:

- By how much has the Euro depreciated/the Dollar appreciated?

Depreciation versus appreciation

Scenario in t:	1.00 €/$
Scenario in $t+1$:	1.25 €/$

The apple market example:

1 apple costs 1.00 € :	1.00€/apple
1 apple costs 1.25 € :	1.25€/apple

The apple price increases by 25 %!

$\Rightarrow$ Dollar appreciates by 25 %!

Degree of depreciation of the euro

Scenario in t:	1.00 €/$	$\rightarrow$	1.00 $/€
Scenario in $t+1$:	1.25 €/$	$\rightarrow$	0.80 $/€

$$\boxed{\frac{0.8-1}{1} = -0.2}$$

Euro depreciates only by 20 %!

Conclusion: A currency can never depreciate by more than 100 %!

Outline

Case study: Forward rate and hedging: A starter

- An European exporter has sold a product to the US.
- He expects a payment of 150,000 \$ after one year.
- Currently the spot rate is at 0.7 €/\$ and the forward at 0.7105 €/\$
- European interest rate: 5 % p. a., USA: 3.448 % p. a.
- In case that exchange rate is constant:

$$150,000 \ \$ \cdot 0.7 \ €/\$ = 105,000 \ €$$

Risk: Appreciation of the Euro

- Exporter expects an appreciation of the Euro 0.6 €/\$

$$150,000 \text{ \$} \cdot 0.6 \text{ €/\$} = 90,000 \text{ €}$$

How can the exporter get rid of the exchange rate risk?

First option: Hedging with forward rate

- He uses the 1-year forward rate! $\rightarrow$ 0.7105 €/$
- Exporter sells 150,000 $ with a forward contract to a bank.

$$150,000 \text{ \$} \cdot 0.7105 \text{ €/\$} = 106,575 \text{ €}$$

Hedging with forward rate: Structure of the deal

Today:

- Signing of a contract that exporter delivers 150,000 \$ after one year.
- Bank agrees to exchange the amount at a fixed rate of 0.7105 €/\$
- and to credit 106,575 € in one year.

In 1 year:

- Exporter delivers 150,000 \$ to the bank.
- Bank credits 106,575 € to the account of the exporter.

Why is $F > E$?

- Exporter gets 106,575 € when he uses the forward contract.
- Compared to 105,000 € when he could exchange at the spot exchange rate.

- What is the reason for this?
- Why is the forward rate (0.7105 €/$) lager as the current spot rate (0.70 €/$)?

Second option: Hedging with interest rates

Today:

1. Exporter takes a US-Dollar loan.
2. Exporter exchanges Dollar at the current spot rate in Euro.
3. Exporter takes the Euros and puts it on an interest bearing Euro account.

In 1 year:

1. Exporter receives 150,000 $ from the American importer and pays back loan & interest.
2. Exporter closes his European account and takes face value and interest out of the account.

Second option: Structure of the deal

Step 1: Computation of the Dollar loan

- In one year the exporter has 150,000 $ to pay back the loan as well as the interest.
- Loan has to be smaller than 150,000 $.

$$\text{Loan: } \frac{150,000 \text{ \$}}{1.03448} \approx 145,000 \text{ \$}$$

Step 2: Spot transaction

- Exchange of 145,000 $ at the current spot rate of 0.7 €/$

$$145,000 \text{ \$} \cdot 0.7 \text{ €/\$} = 101,500 \text{ €}$$

Interest rate differential determines relationship between F & E!

Step 3: Euro account

- Interest bearing Euro account: Euro interest rate 5 % p. a.

$$101,500 \text{ €} \cdot 1.05 = 106,575 \text{ €}$$

Euro amount of the 1^{st} alternative is the same as with the 2^{nd} alternative!

The most important factor that influences the forward rate is the interest rate differential between Euroland and the US!

Outline

- 14.1 Direct and indirect quote, appreciation and depreciation
- 14.2 Forward rates and hedging
- 14.3 Covered interest rate parity (CIP)
- 14.4 Uncovered interest rate parity (UIP)
- 14.5 The UIP-model of the foreign exchange market

Domestic (European) investment alternative

- Investor can invest 1 € for 1 year
- Investment alternatives: Euroland or US
- After one year and domestic investment, one gets:

$$\boxed{\text{Euroland} = 1 \cdot (1 + R)}$$

After one year, investor gets

- his initial investment of 1 € as well as
- the interest income (R).

Foreign (US) investment alternative

Assumption:

- Investor uses the forward rate to hedge against the exchange rate risk.

$$\boxed{\text{Abroad} = \frac{1 \cdot F \cdot (1 + R^*)}{E}}$$

- Step 1: Convert 1 € in at the current spot rate in $1/E$ USD.
- Step 2: Invest $1/E$ USD at the foreign interest rate R^*.
- Step 3: Convert initial investment and interest back into EUR by using the forward rate (F).

Arbitrage equil.: domestic = foreign investment

$$1 + R = \frac{F \cdot (1 + R^*)}{E} \tag{1}$$

- Divide by $1 + R^*$

$$\frac{1 + R}{1 + R^*} = \frac{F}{E} \tag{2}$$

- Subtract 1 from both sides of equation (2):

$$\frac{1 + R}{1 + R^*} - \frac{1 + R^*}{1 + R^*} = \frac{F}{E} - \frac{E}{E} \tag{3}$$

$$\frac{1 + R - 1 - R^*}{1 + R^*} = \frac{F - E}{E} \quad \Rightarrow \quad \frac{R - R^*}{1 + R^*} = \frac{F - E}{E} \tag{4}$$

Covered interest rate parity

$$(4) \quad \frac{R - R^*}{1 + R^*} = \frac{F - E}{E}$$

$$(4') \quad R - R^* = \frac{F - E}{E} + \frac{F - E}{E} R^*$$

Copeland: p. 88/92: Consider the final term. It is the product of two rates: the rate of interest and the relative difference between the forward and the spot rate. Unless we are dealing with a case of a very rapid deterioration in a currency (in a hyperinflation, for example) this cross-product term is likely to be of the second order of smallness, and as such, can be ignored.

$$R - R^* = \frac{F - E}{E} \qquad (5)$$

Is Copeland right? $\rightarrow$ Numerical Example

$$(4') \quad R - R^* = \frac{F-E}{E} \quad + \quad \frac{F-E}{E} \cdot R^*$$

$$\frac{0.7105 - 0.7}{0.7} \cdot 0.03448 = 0.015 \cdot 0.03448 = 0.000517$$

Copeland: p. 88/92: Consider the final term. It is the product of two rates: the rate of interest and the relative difference between the forward and the spot rate. Unless we are dealing with a case of a very rapid deterioration in a currency (in a hyperinflation, for example) this cross-product term is likely to be of the second order of smallness, and as such, can be ignored.

Covered Interest Rate Parity (CIP)

$$(5) \quad R - R^* = \frac{F - E}{E}$$

or

$$(5') \quad R = R^* + \frac{F - E}{E}$$

Is derived by KOM in the appendix of chapter 14!

Outline

- 14.1 Direct and indirect quote, appreciation and depreciation
- 14.2 Forward rates and hedging
- 14.3 Covered interest rate parity (CIP)
- 14.4 Uncovered interest rate parity (UIP)
- 14.5 The UIP-model of the foreign exchange market

Uncovered interest rate parity (UIP)

- Same investment problem BUT: Investor does not hedge for the exchange rate risk.
- Investor does not use the forward rate.
- In period t investor has to form expectations with respect to the spot rate in period $t+1$: $E_{t+1}^{e_t}$

$$(6) \quad R_t - R_t^* = \frac{E_{t+1}^{e_t} - E_t}{E_t}$$

$$(6') \quad R_t = R_t^* + \frac{E_{t+1}^{e_t} - E_t}{E_t}$$

Does UIP hold?

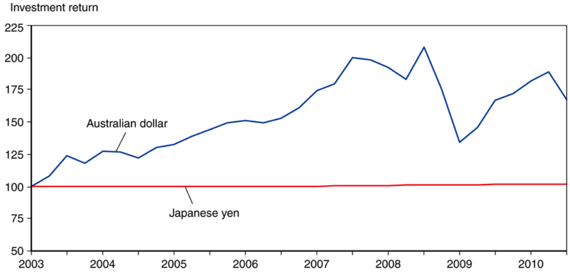
- Does the exchange rate develop according to the interest rate differential?
- How is $\frac{E_{t+1}-E_t}{E_t}$ related to $R_t - R_t^*$?

'Test' with empirical data:

- Domestic country Japan: $R = R^{YEN}$
- Foreign country Australia: $R^* = R^{AUS}$
- Exchange rate: $E = YEN/AUS$

Carry trades

Fig. 14-7: Cumulative Total Investment Return in Australian Dollar Compared to Japanese Yen, 2003-2010

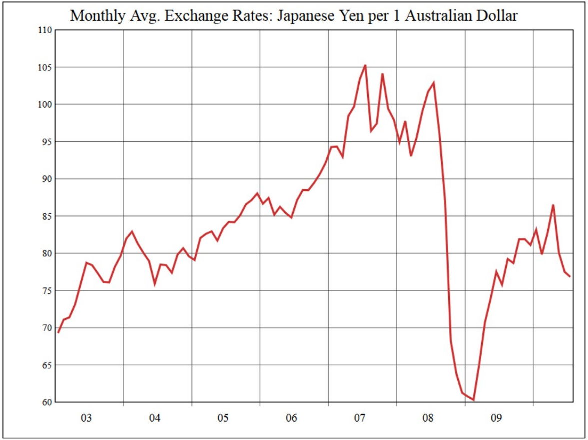


Source: Exchange rates and three-month treasury yields from Global Financial Data.

14-44

Exchange rate development: YEN/AUS

PACIFIC Exchange Rate Service



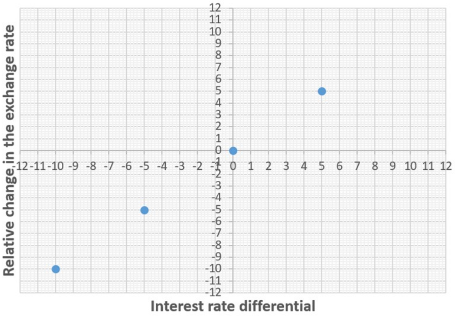
Time period shown in diagram: 1/Jan/2003 - 31/Jul/2010,

Testing UIP

Time	$R - R^*$	$\frac{E_{t+1}-E_t}{E_t}$
Jan 2003	-5 %	-5 %
Feb 2003	-10 %	-10 %
Mar 2003	0 %	0 %
Apr 2003	5 %	5 %

Testing UIP: Scatter diagram

R-R*	(E_t+1- E_t) / E_t
-5	-5
-10	-10
0	0
5	5



Testing UIP

$$\frac{E_{t+1} - E_t}{E_t} = \alpha + \beta \cdot (R_t - R_t^*) + \epsilon_{t+1} \tag{6}$$

2 pairs of Hypotheses:

- H_0: $\alpha = 0$ and H_a: $\alpha \neq 0$
- H_0: $\beta = 1$ and H_a: $\beta \neq 1$
- Hence, we want to perform a two sided test!

We want to test on a 95 % confidence level and assume that we have enough observations so that the normal distribution is the appropriate choice!

- $t_{critical} \approx 2$ (in case you want to be precise: 1.96)

Testing UIP

	Coeff.	SE	t-Stat	P-val.	Low95	Up95
Intercept	-0.0619	0.0364	-1.70	0.09	-0.13	0.01
$R_t^{YEN} - R_t^{AUS}$	-1.1283	0.6383	-1.77	0.08	-2.40	0.14

Interpretation confidence intervals

- Claimed value of $\alpha = 0$ is included in the 95 % confidence interval. We can NOT reject H_0.
- Claimed value of $\beta = +1$ is NOT included in the 95 % confidence interval. We have to reject H_0!

Conclusions

- Empirical evidence is NOT in line with UIP. Beta is estimated to be negative, but should be equal to 1!
- Beta is significantly different from 1 on a 95 % confidence interval.
- UIP does not hold.
- Interest rate differential not an unbiased / good predictor of the subsequent change in the exchange rate.

How to compute an estimated t-value (t_{est})

$$t_{est} = \frac{\text{estimated coefficient} - \text{claimed value}}{\text{standard error (SE)}} \tag{7}$$

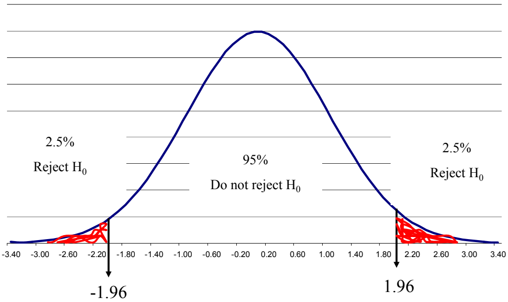
- We claimed (in the hypotheses) that alpha should be zero:

$$t_{est} = \frac{-0.0619 - 0}{0.0364} = -1.70 \tag{8}$$

- We claimed (in the hypotheses) that beta should be one:

$$t_{est} = \frac{-1.1283 - 1}{0.6383} = -3.33 \tag{9}$$

Interpretation t-values



Georg Stadtmann - Statistics - Slide No. 45

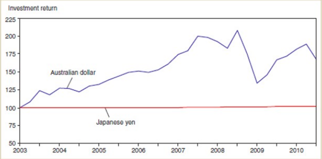


Figure 14-7

Cumulative Total Investment Return in Australian Dollar Compared to Japanese Yen, 2003–2010

The Australian dollar-yen carry trade has been profitable on average but is subject to sudden large reversals, as in 2008.

Source: Exchange rates and three-month treasury yields from Global Financial Data.

doubled his or her money in five and a half years. The carry trade is obviously a very risky business.

We can gain some insight into this pattern by imagining that investors expect a gradual 1 percent annual appreciation of the Australian dollar to occur with high probability (say, 90 percent) and a big 40 percent depreciation to occur with a 10 percent probability. Then the expected appreciation rate of the Australian dollar is:

$$\text{Expected appreciation} = (0.9) \times 1 - (0.1) \times 40 = -3.1 \text{ percent per year.}$$

The negative expected appreciation rate means that the yen is actually expected to appreciate *on average* against the Australian dollar. Moreover, the probability of a crash occurring in the first five years of the investment is only $1 - (0.9)^5 = 1 - 0.59 = 41$ percent, less than fifty-fifty.[9] The resulting pattern of cumulative returns could easily look much like the one shown in Figure 14-7. Calculations like these are suggestive, and although they are unlikely to explain the full magnitude of carry trade returns, researchers have found that investment currencies are particularly subject to abrupt crashes, and funding currencies to abrupt appreciations.[10]

[9] If crashes are independent events over time, the probability that a crash does *not* occur over five years is $(0.9)^5$. Therefore, the probability that a crash does occur in the five-year period is $1 - (0.9)^5$

[10] See Markus K. Brunnermeier, Stefan Nagel, and Lasse H. Pedersen, "Carry Trades and Currency Crashes," *NBER Macroeconomics Annual* 23 (2008), pp. 313–347. These findings are consistent with the apparently greater empirical success of the interest parity condition over relatively long periods, as documented by Menzie Chinn, "The (Partial) Rehabilitation of Interest Rate Parity in the Floating Rate Era: Longer Horizons, Alternative Expectations, and Emerging Markets," *Journal of International Money and Finance* 25 (February 2006), pp. 7–21.

Available online at www.sciencedirect.com

SCIENCE DIRECT

Journal of International Money and Finance 25 (2006) 7–21

Journal of International Money and Finance

www.elsevier.com/locate/econbase

The (partial) rehabilitation of interest rate parity in the floating rate era: Longer horizons, alternative expectations, and emerging markets

Menzie D. Chinn [a,b,*]

[a] *Robert M. La Follette School of Public Affairs and Department of Economics, University of Wisconsin, Madison, WI, USA*
[b] *NBER, Cambridge, MA, USA*

Chinn (2006), p. 9.

The combined assumptions of no risk premium in Eq. (3) (i.e. that UIP holds) and rational expectations is sometimes termed the "risk-neutral efficient-markets hypothesis" (RNEMH). In this case, the disturbance in Eq. (6) becomes simply the rational expectations' forecast error $\xi_{t,t+k}$, which by definition is orthogonal to all information known at time t, including the interest differential.

Unbiasedness is a weaker condition than RNEMH. All that is required is that any risk premium and/or non-rational expectations error be uncorrelated with the interest differential, while the RNEMH requires in addition that no other regressors known at time t have explanatory power.[3]

Estimates of Eq. (6) using values for k that range up to 1 year typically reject the unbiasedness restriction on the slope parameter. The survey by Froot and Thaler (1990), for instance, finds an average estimate for β of -0.88.[4]

Table 1 updates estimates of Eq. (6) for the period 1980Q1−2000Q4. The exchange rates of all six foreign countries were expressed in terms of U.S. dollars, and the 3-, 6-, and 12-month movements in exchange rates were regressed against differentials in euro currency yields of the corresponding maturity. Estimation using the 6- and 12-month horizon data at a quarterly frequency led to overlapping observations, inducing (under the rational expectations null hypothesis) moving average (MA) terms in the residuals. Instead of following Hansen and Hodrick

Froot/Thaler (1990), p. 182

A very large literature has tested the unbiasedness hypothesis and found that the coefficient β is reliably less than one. In fact, β is frequently estimated to be less than zero. The average coefficient across some 75 published estimates is -0.88 (Froot, 1990). A few are positive, but *not one is equal to or greater than the null hypothesis of* $\beta = 1$.

A coefficient of approximately minus one is difficult to explain. It implies that, for example, when U.S. interest rates exceed foreign rates by one percentage point, the dollar subsequently tends to appreciate at an annual rate of one percent. This is in contrast to the one percent depreciation dictated by the unbiasedness hypothesis.

Froot (1990): NBER 3247.

NBER WORKING PAPER SERIES

SHORT RATES AND EXPECTED ASSET RETURNS

Kenneth A. Froot

Chinn (2006), p. 10.

Table 1
Short-horizon estimates of β

$$\Delta s_{t,t+k} = \alpha + \beta(i_{t,k} - i^*_{t,k}) + \varepsilon_{t,t+k} \quad (6)$$

Currency	Maturity		
	3 mo.	6 mo.	12 mo.
Deutschemark	−0.809* (1.134)	−0.893*** (0.760)	−0.587*** (0.642)
Japanese yen	−2.887*** (0.997)	−2.926*** (0.777)	−2.627*** (0.747)
U.K. pound	−2.202*** (1.086)	−2.046*** (1.036)	−1.418*** (1.041)
French franc	−0.179 (0.904)	−0.154 (0.825)	−0.009 (0.853)
Italian lira	0.518 (0.606)	0.635 (0.670)	0.681 (0.770)
Canadian dollar	−0.477*** (0.513)	−0.572*** (0.419)	−0.610*** (0.557)
Constrained panel[a]	−0.757*** (0.374)	−0.761*** (0.345)	−0.536*** (0.369)

Notes: point estimates from the regression in Eq. (6) (serial correlation robust standard errors in parentheses, calculated assuming $2(k-1)$ moving average serial correlation, following Cochrane, 1991). Sample is 1980Q1–2000Q4. * (**)[***] Different from null of unity at 10%(5%)[1%] marginal significance level.
Source: Chinn and Meredith (2004).

[a] Fixed effects regression. Standard errors adjusted for serial correlation (assumes $k-1$ moving average serial correlation, cross averaging across currency pairs).

Outline

- 14.1 Direct and indirect quote, appreciation and depreciation
- 14.2 Forward rates and hedging
- 14.3 Covered interest rate parity (CIP)
- 14.4 Uncovered interest rate parity (UIP)
- 14.5 The UIP-model of the foreign exchange market

How to set up a model

1. Define the equilibrium conditions
2. Derive the slope of the curves
3. Determine equilibrium
4. Identify the shock: It is always an *exogenous* variable, which changes in the beginning!
5. Which curve shifts in which direction? Use the equations!
6. Shift the curves and determine new equilibrium.
7. Confirm graphical results by computing the multipliers.
8. Compare and conclude.

UIP-model: Equations

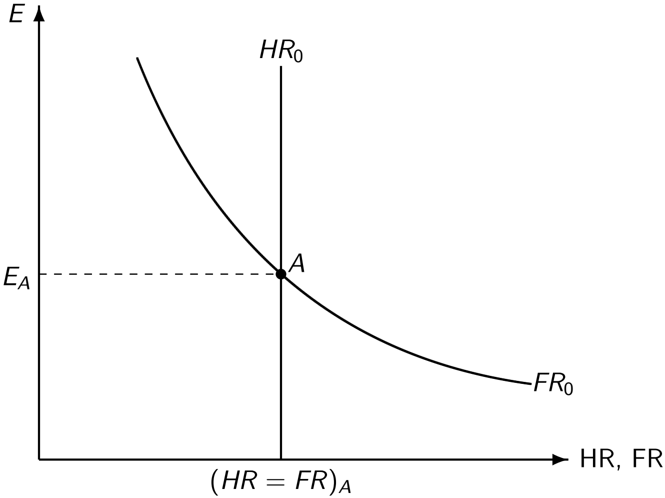
$$R_{\$} = R_{€} + \frac{E^e_{\$/€} - E_{\$/€}}{E_{\$/€}}$$

$$R = R^* + \frac{E^e - E}{E}$$

- Left hand side: Home Return (HR)
- Right hand side: Foreign Return (FR)

$$HR = FR$$

UIP-model: The diagram



The characteristics of the HR-curve

- One curve symbolizes the home return ($HR = R$) and hence, the left hand side of the equation.
- The HR-curve is a vertical line.

The characteristics of the FR-curve

$$R = R^* + \frac{E^e - E}{E} \tag{10}$$

- The second curve symbolizes the foreign return (FR) which is given by the right hand side of the equation (10).

$$FR = R^* + \frac{E^e - E}{E} \tag{11}$$

- Objective: Solve equation (11) for E!

$$FR - R^* = \frac{E^e}{E} - \frac{E}{E} \qquad \Rightarrow \qquad FR - R^* + 1 = \frac{E^e}{E}$$

$$E \cdot (FR - R^* + 1) = E^e \qquad \Rightarrow \qquad E = \frac{E^e}{FR - R^* + 1}$$

The characteristics of the FR-curve

$$E = \frac{E^e}{FR - R^* + 1}$$

$$\frac{dE}{dFR} = \frac{0 \cdot (FR - R^* + 1) - (1) \cdot E^e}{(FR - R^* + 1)^2} = -\frac{E^e}{(FR - R^* + 1)^2} < 0$$

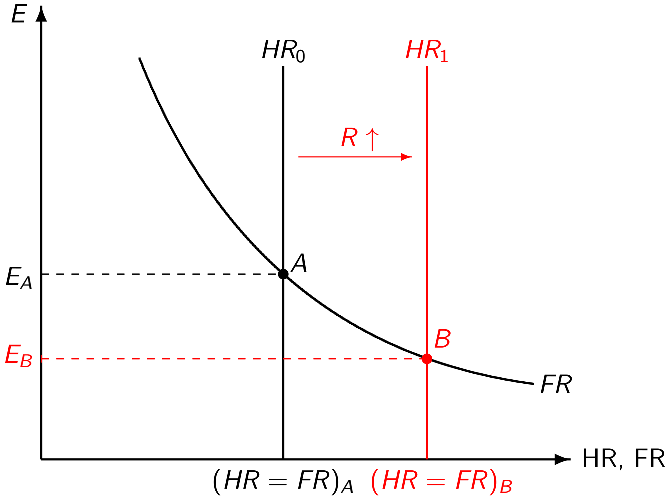
- The FR-curve has a negative slope.

$$\frac{d^2E}{dFR^2} = -\frac{0 \cdot (FR - R^* + 1)^2 - E^e \cdot (2) \cdot (FR - R^* + 1)}{(FR - R^* + 1)^4}$$

$$\frac{d^2E}{dFR^2} = \frac{2E^e}{(FR - R^* + 1)^3} > 0$$

- The FR-curve is convex.

UIP-model: Domestic interest rate increases



The endogenous variable of the UIP-model

- The UIP-model consists only out of 1 equation:

$$R = R^* + \frac{E^e}{E} - 1$$

- We can only determine 1 endogenous variable.
- Which one is endogenous?
- To perform a comparative static analysis, it makes sense to solve for the endogenous variable.

Solving for the endogenous variable

$$R = R^* + \frac{E^e}{E} - 1$$

Putting $R^* - 1$ on the LHS:

$$R - R^* + 1 = \frac{E^e}{E}$$

Solving for the current spot rate yields:

$$E = \frac{E^e}{R - R^* + 1}$$

Increase of the domestic interest rate ($R \uparrow$)

$$E = \frac{E^e}{R - R^* + 1}$$

Taking the differential with respect to R yields:

$$\frac{dE}{dR} = \frac{0 \cdot (R - R^* + 1) - (1) \cdot E^e}{(R - R^* + 1)^2} = -\frac{E^e}{(R - R^* + 1)^2} < 0$$

Negative sign indicates:

- If $R \uparrow$ than $E \downarrow$.
- If the domestic interest rate increases, the domestic currency appreciates.