AcF305:

International Financial and Risk Management

Week 3

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Outline of Lecture 3

- Essential reading: Chapter 4 of Sercu (2009).
- Topics:
  - **Forward rates**: What are forward rates? How are they quoted? How do I find the settlement date? What does ‘forward premium’ or ‘discount’ mean?
  - **Relation between FX and money markets**: How can one shift money between countries and over time? Are some ways better than others?
  - **Covered interest parity**: Is there a relation between spot and forward rates? How is it determined? What enforces this relationship?
  - **Market value of a forward contract**: How do I value an outstanding forward contract? What is its value at (a) inception and (b) maturity? How is the value of forward rates related to certainty equivalents? And, first of all, what are certainty equivalents?

Forward Rates I

- *Assume:* Perfect capital markets (will be relaxed in later lectures).
  - No transaction costs, taxes or default risk, agents act as price takers.
- *Definition:* Forward contracts stipulate the number and price (in HC) of FC units that are bought and sold (until here: like spot contracts) at some point in the future (unlike spot: not 2 days from now).
  - **Recall**: A contract set up at t for delivery/payment at T is denoted by $F_{t,T}$.
- Forward contracts represent a binding obligation and participants cannot walk away.
- Forward contracts are over-the-counter products – similar to the currency contracts we trade in spot markets.

Forward Rates I

- How do we determine settlement date? – Day where transaction happens

  - Find spot settlement date: add 2 days to today, check if working day (*wd*). If not, move forward to next *wd*.
  - Add *n* # of months, for an n-Forward contract and check if *wd*. If not, move forward to next *wd*. If this falls outside of month, move backward to next *wd*.
  - *Example:* today = 31/01/2012, time-to-maturity = 90 days. Then the settlement date is: 30/04/2012.

- Quoting conventions:
  - **Outright/Forward rate**: HC price of the FC that needs to be paid in the future.
  - **Swap rate**: Difference between HC price of the FC that needs to be paid in the future and HC price that would need to be paid now.

Forward Rates II

- An example from the *Globe and Mail* newspaper:

	(Outright)		(Swap rates) Premium or discount, in cents	
	CAD per USD	USD per CAD	CAD per USD	USD per CAD
U.S. Canada spot	1.3211	0.7569		
1monthforward	1.3218	0.7565	+0.07	–0.05
2 months forward	1.3224	0.7562	+0.13	–0.07
3 months forward	1.3229	0.7559	+0.18	–0.10

- Origin of the term “swap rate” is the swap contract:
  - Buy an asset now (at the spot rate) and sell it in the future (at the forward rate) to facilitate a portfolio investment in a foreign country.
  - Swap rate: Undiscounted profit from this strategy (sell – buy price).
- More terminology:
  - If swap > 0, then FC trades at a premium (in the example: the U.S. dollar becomes more expensive over time).
  - If swap < 0, then FC trades at a discount (in the example: the Canadian dollar becomes cheaper over time).

Interest Rates

- Interest rates are quoted using different approaches:
  1. **Simple**: Linear extrapolation = if time period doubles, then interest doubles.
     Relation to effective return: $1 + r_{t,T} = 1 + (T-t) * [\text{simple interest rate}]$
  2. **Compound interest**: Interest is re-invested *m* times per year = interest increases more than linearly.
     Relation to effective return: $1 + r_{t,T} = (1+[\text{quoted interest rate} / m])^{(T-t)m}$
  3. **Continuous compounding**: Interest is re-invested at every instant = interest increases even more rapidly than in the 2nd case.
     Relation to effective return: $1 + r_{t,T} = e^{\text{quoted interest rate}(T-t)}$
- In this course, we will not spend too much time talking about these methods. In our case, the interest rate will normally be quoted as an effective return. However, sometimes interest rates can be presented in "per-annum" (p.a.) terms. If that's the case, we make a linear extrapolation to compute the effective rate (e.g., 7% p.a. interest rate ➔ 7/12% effective rate of a 1-month deposit)

FX and Money Markets – Some Parables

- Foreign exchange markets:

  - **Spot contracts**: You give the bank an amount of HC for receipt of FC, settlement: normally 2 days.
    → As a result, this is like an exchange of cheques (which are settled in 2 days): you write a cheque to the bank over the amount of HC and the bank writes you a cheque over the amount of FC.

  - **Forward contracts**: You give the bank an amount of HC for receipt of FC, settlement: at some point in the future.
    → As a result, this is like an exchange of promissory notes (PN): bank A writes a PN to bank B (promises the amount of HC in the future). Thus, bank B writes a PN to bank A (promises the amount of FC in the future).

FX and Money Markets – Some Parables

- Money markets:

  - **Deposit**: You give the bank an amount of HC now and receive another (higher) amount of HC at some point in the future.
    → As a result, this is like an exchange of a cheque and a PN: you write a cheque to the bank over the amount of HC and the bank writes you a PN which promises you the other amount of HC at the point in the future.

  - **Loan**: The bank gives you an amount of HC now and receives from you another higher amount of HC at some point in the future.
    → As a result, this is again like an exchange of a cheque and a PN.

Joint Trading in FX and Money Markets

- *Example:* An investor from Chile wants to make a risk-free 4-year money market investment of CLP 100k in Norway. What does she need to do?
  - *Assume:* S_t = CLP/NOK 100, $F_{t,T}$ = CLP/NOK 110, $r_{t,T} = 21\%$, $r^*_{t,T} = 10\%$

1. Convert CLP 100k into NOK at spot rate:

$$\underbrace{\text{CLP 100,000}}_{\text{investment}} * \underbrace{(1 / \text{CLP/NOK } 100)}_{1/S_t} = \underbrace{\text{NOK 1,000}}_{\text{converted amount}}$$

2. Invest the converted amount at Norwegian bank at effective interest rate:

$$\underbrace{\text{NOK 1,000}}_{\text{converted amount}} * \underbrace{(1.10)}_{\text{effective rate}} = \underbrace{\text{NOK 1,100}}_{\text{investment output}}$$

3. Convert investment output back into CLP at forward rate:

$$\underbrace{\text{NOK 1,100}}_{\text{investment output}} * \underbrace{(\text{CLP/NOK } 110)}_{F_{t,T}} = \underbrace{\text{CLP 121,000}}_{\text{investment output in HC}}$$

Spot/Forward/Money Market Diagram: Example

$$
\begin{tikzcd}
\boxed{HC_t = 100,000} \arrow[r, "\times 1/100"] & \boxed{FC_t = 1,000} \arrow[d, "\times 1.10"] \\
\boxed{HC_T = 121,000} & \boxed{FC_T = 1,100} \arrow[l, "\times 110"]
\end{tikzcd}
$$

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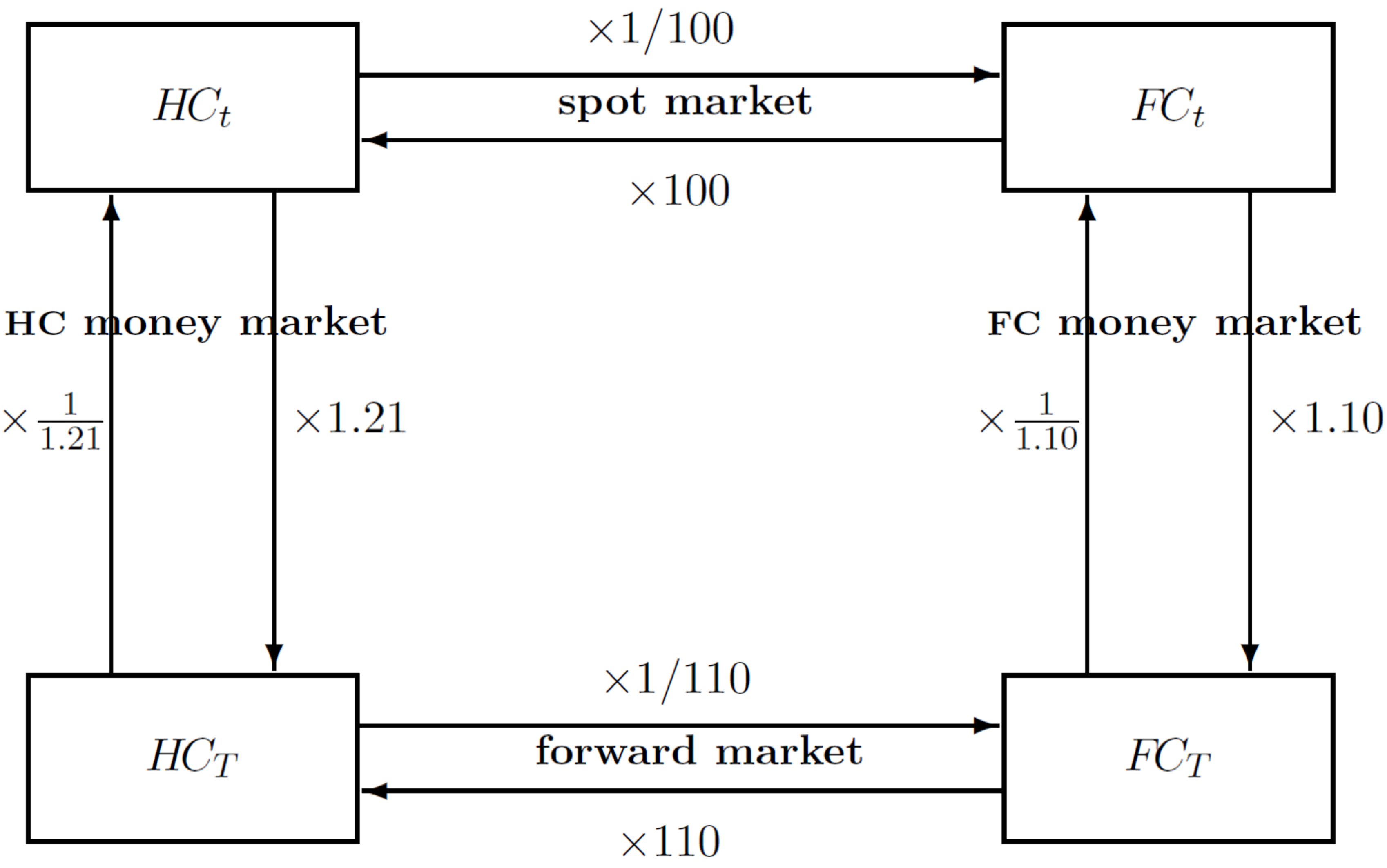
Spot/Forward/Money Market Diagram: General



Spot/Forward/Money Market Diagram: Insights

- Usage of the diagram:
  1. Identification of starting position: This is where your money would be if the money and/or FX markets were not used.
  2. Identification of ending position: This is the location of the money after the money and/or FX markets have been used.
  3. Determine the route. Multiply the starting sum by all multiplicative factors along the way.
- *Example:* Customer A will pay seller B 1,000 units of FC at point in time T. However, B wants the money immediately in his HC.
  - Starting position is the lower-right box (FC_T). The desired ending position is the upper-left box (HC_t). Route: B decides to borrow against his foreign currency income and then convert at the spot rate.
  - End outcome: $FC\,1{,}000 * \frac{1}{1+r^{*}_{t,T}} * S_t$

Spot/Forward/Money Market Diagram: Insights

- **Note**: There are always two routes to achieve a desired ending position, i.e. B could have also converted into HC at the forward rate and then borrowed against this amount of home currency.

- The outcome of these two routes will **always be the same** as long as we assume that capital markets are perfect. Why? Next slide

Covered Interest Parity I

- The relations between the money and FX markets allow one to derive an important arbitrage condition: covered interest parity (CIP).

- This is a condition under which the relation between interest, spot and forward currency rates of two countries are in equilibrium.

- If the covered interest parity holds, there is not possibility for arbitrage opportunities between money and foreign exchange markets.

Covered Interest Parity I

- *Assume:* Agent A owns one unit of HC at time *t* and wants to convert this into FC, also at time t.
  - **Direct strategy**: Convert HC → FC through spot rate:
    Outcome = $1/S_t$
  - **Indirect strategy**: Lend HC at domestic risk-free rate, convert proceeds into FC using a forward contract and borrow against FC proceeds.
    Outcome = $(1 + r_{t,T}) * [1/F_{t,T}] * [1/(1 + r^*_{t,T})]$

- If outcomes were different, then there would be an arbitrage opportunity.
  - *Example:* If profits(S1) < profits(S2), then sell $1/S_t$ units of foreign currency for one unit of HC and invest this into indirect strategy.
  - This transaction would be repeated until outcomes are equalized.
- As a result: $1/S_t = (1 + r_{t,T}) * [1/F_{t,T}] * [1/(1 + r^*_{t,T})]$

$$F_{t,T} = S_t * \frac{1 + r_{t,T}}{1 + r^*_{t,T}}$$

Covered Interest Parity II

- **Shopping around**: If CIP holds, then an economic agent can never gain from shopping around → each trip will have the same outcome.
  - In the real-world with market imperfections (transaction costs, taxes, etc.), shopping around can create value.
- **Causality**: CIP does not imply causality.
  - While $F_{t,T}$ is the left hand side variable in the CIP formula, this does not say that it is the dependent (endogenous) variable. We could have written CIP as:

$$S_t = F_{t,T} * \frac{1+r^*_{t,T}}{1+r_{t,T}}$$

- **Relation to swap rate**: Sign of swap rate determined by interest rate differential (home minus foreign interest rate).

$$[swap\ rate]_{t,T} \equiv F_{t,T} - S_t = S_t\left[\frac{1+r_{t,T}}{1+r^*_{t,T}} - 1\right] = S_t\left[\frac{1+r_{t,T}}{1+r^*_{t,T}} - \frac{1+r^*_{t,T}}{1+r^*_{t,T}}\right] = S_t\left[\frac{r_{t,T} - r^*_{t,T}}{1+r^*_{t,T}}\right]$$

$$\approx S_t\left[r_{t,T} - r^*_{t,T}\right]$$

Intuition: If foreign country has higher interest rate than home country, its currency must trade at a discount. Otherwise, profit on currency investment and higher profit on money market investment.

Market Value of a Forward Contract I

- **Forward contract**: Agreement to buy or sell an underlying at a future date.
- **Market value**: Price at which an outstanding (initiated in the past, $t_0 <$ today (t), at the *past* forward rate) forward can be bought and sold.
- Why important? (1) early settlement, (2) default and (3) "mark to market" book value of forward in firms' accounting statements.
- **Note**: t_0 (time contract was initiated) $< t$ (now) $< T$ (delivery date).
- Valuation can be done, if we interpret outstanding forward contract as portfolio of two promissory notes (PNs):
  - 1st PN (written by agent): Deliver $F_{t0,T}$ units of HC to bank.
  - 2nd PN (written by bank): Deliver one unit of FC to agent.
- Computation of PV of portfolio:
  - 1st PN: Value of $F_{t0,T}$ units of HC as of today (t): $\dfrac{F_{t_0,T}}{1+r_{t,T}}$
  - 2nd PN: Value of 1 unit of FC as of today in HC:

$$\underbrace{\frac{1}{1+r^*_{t,T}}}_{\text{discount FC}} * \underbrace{S_t}_{\text{translate into HC}}$$

Market Value of a Forward Contract II

- Putting it all together (keeping in mind that 1st PN is a liability):

$$MV_{F_{t0,T}} = \underbrace{\frac{1}{1+r^*_{t,T}} * S_t}_{2^{nd}\ \text{PN}} - \underbrace{\frac{F_{t_0,T}}{1+r_{t,T}}}_{1^{st}\ \text{PN}}$$

- Using CIP, this can be rewritten in its standard form:

$$MV_{F_{t0,T}} = \frac{F_{t,T} - F_{t_0,T}}{1+r_{t,T}}$$

- *Intuition:* Assume that $F_{t0,T}$ = 115 and $F_{t,T}$ = 110.
  - Market value is negative (110−115 discounted). Why?
  - Compared to the new forward price ($F_{t,T}$), the old forward contract overpays. At the new rate, you can buy FC for a cheaper price at T.
  - Loss (or gain) can be 'locked in'. Sell one unit of FC at $F_{t,T}$. Then:

	HC flows at T	FC flows at T
old contract: buy at $F_{t_0,T}$=115	–115	1
new contract: sell at $F_{t_0,T}$=110	110	–1
net flow	–5	0

Market Value of a Forward Contract: Special Cases

- Value of forward contract **at maturity** (also, see next slide):

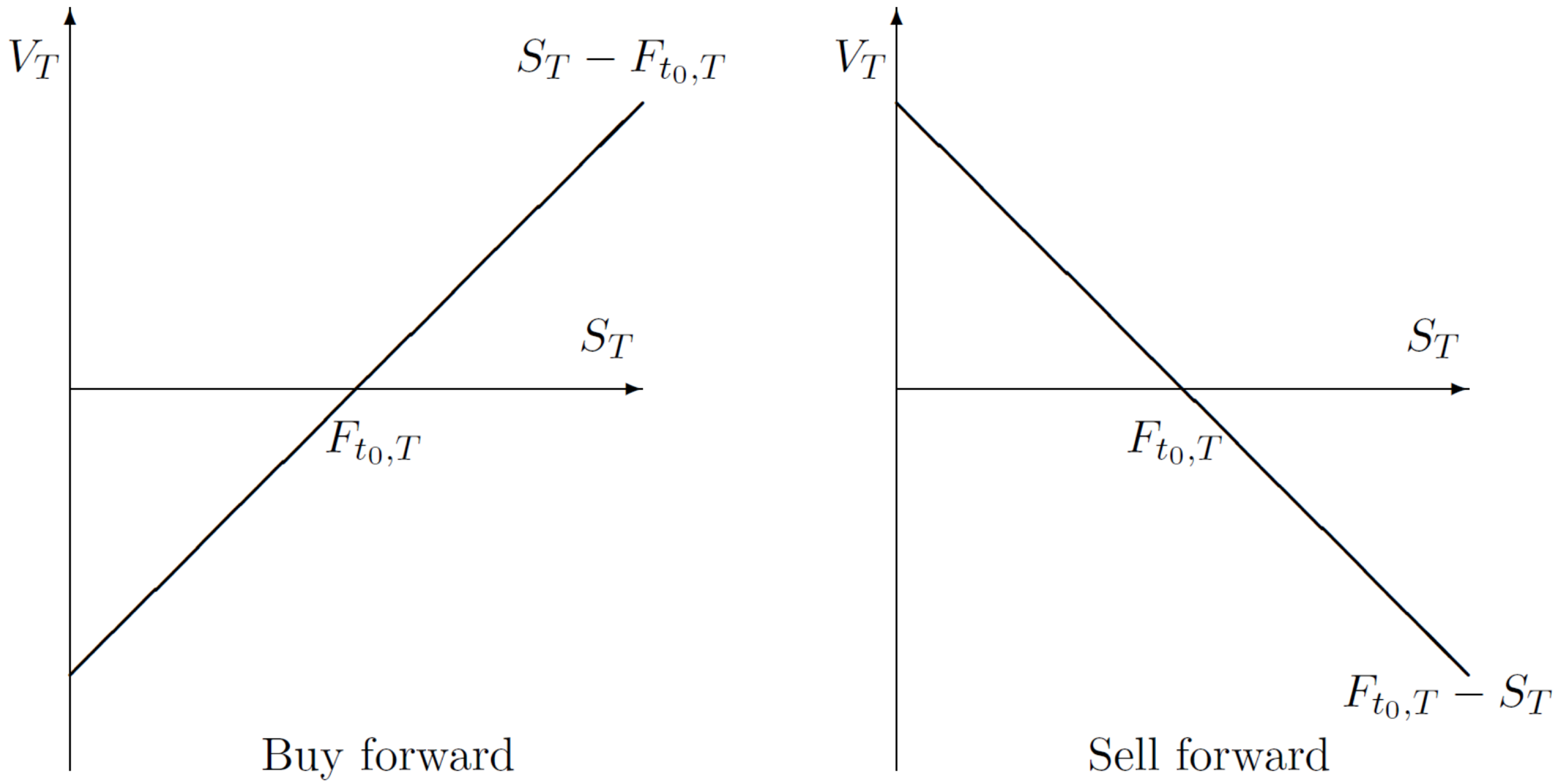
$$MV_{F_{t0,T}} = \frac{F_{T,T} - F_{t_0,T}}{1 + r_{T,T}} = S_T - F_{t_0,T}$$

- From this, the usefulness of a forward contract for hedging can be seen:
  - An agent has to pay one unit of FC at time T (value at T: $\tilde{S}_T$, unknown at t).
  - To hedge this exposure, the agent decides to buy one forward contract maturing at time T (value at T: $\tilde{S}_T - F_{t_0,T}$, unknown at t).
  - Combined value at T: $\tilde{S}_T - F_{t_0,T} - \tilde{S}_T = -F_{t_0,T}$, **known at t**.
- Value of forward contract **at inception** (t=t_0):

$$MV_{F_{t0,T}} = \frac{F_{t_0,T} - F_{t_0,T}}{1 + r_{t,T}} = 0$$

- At inception, the value must be equal to zero, as a forward contract can always be replicated through money and FX markets.

Market Value of a Forward Contract: Graphs



Certainty Equivalents I

- The ‘zero value at inception’ property leads to another nice insight:
  - At the outset, it means that the market values one unit of FC and $F_{t,T}$ units of HC at time T equally ↔ both amounts must have same PV, i.e.
    $$PV_t(FC\,1) = PV_t(HC\,F_{t,T})$$
  - Having 1 unit of FC at T is equivalent to having S_T units of HC at T, i.e.
    $$PV_t(HC\,\tilde{S}_T) = PV_t(HC\,F_{t,T})$$
    or suppressing the currency denominations:
    $$PV_t(\tilde{S}_T) = PV_t(F_{t,T})$$
- In terms of HC, the LHS is uncertain, while the RHS is a risk-free, known number.

- The market is thus equally happy to obtain (1) a sure gain of $F_{t,T}$ units of HC or (2) a lottery promising the risky amount of $\tilde{S}_T$ units of HC.
  → We say: $F_{t,T}$ is the *certainty equivalent* of $\tilde{S}_T$, the amount of HC that makes one equally happy as having the lottery, and write:
  $$CEQ_t(\tilde{S}_T) = F_{t,T}$$

Certainty Equivalents II

- When individuals are averse to risk, then the certainty equivalent will always be below the expectation of the lottery $E[\tilde{S}_T]$; i.e. Market participant assign higher probabilities to bad states.
- This means: Individuals must be compensated for taking on risk. The risky option must pay off more on *average* than the sure payoff. Otherwise, risk-averse agents would not regard it as equally valuable.
- It is a very difficult task to determine how the market adjusts for risk (i.e. what the functional form of $CEQ_t(\tilde{S}_T)$ is):
  - The Capital Asset Pricing Model (CAPM) conjectures that the risk premium depends on the market beta, i.e.
    $$E[\tilde{S}_T / S_t] - r_{t,T} = \beta_{\tilde{S}_T / S_t} E[r_{t,T}^{mkt} - r_{t,T}]$$
  - In this case, one can simply discount $E[\tilde{S}_T]$ at *r* plus the risk premium.
- As a result of these considerations, the forward rate can be used to value outstanding FC assets or liabilities.

Certainty Equivalent III (summary)

- **A forward rate is thus the risk-adjusted expected value of a spot rate**
  - **This is the certainty equivalent of future spot rates**

- Simplifying risk-adjusted expectations:
  - Think of a lottery based on a coin toss
    - Gain 100 dollars if coin toss is tails
    - Lose 75 dollars if coin toss is heads
    - Expected value is 0.5*100 + 0.5*(-75) = 12.5 dollars

- Even though expected value of lottery is $ 12.5, you may be willing to pay only $ 0, because you adjust that expectation by the pain of losing $ 75 in one of the scenarios.

Certainty Equivalent III (summary)

- Example: You have a job in New York. To get to New York, you need to fly. This job will give you \$ 10,000. What is the expected payoff from this trip?
  - E(Payoff) = \$ 10,000 x Prob(Plane no crash) + \$ 0xProb(Plane crash)
    = \$ 10,000 x 1 + \$ 0 x 0 = **\$ 10,000**

- Now, you are very risk averse, therefore, you use subjective probabilities (Your own probabilities!)
  - E(Payoff) = \$ 10,000 x Prob(Plane no crash) + \$ 0xProb(Plane crash)
    = \$ 10,000 x 0.95 + \$ 0 x 0.05 = **\$ 9,500**

- Certainty equivalents are simply **risk-adjusted expectations**.

The carry trade

- The carry trade is an investment strategy undertaken by FX trader
- This strategy buys currencies where the interest rates are high, and shorts currencies where the interest rates are low
- If the covered interest party holds, this strategy **should not** give any benefit
- Why?
- Consider the following situation
  - A Trader borrows from country X currency X and with the borrowed amount buys from country Y some currency Y (i.e. shorts currency X and with the proceeds buys currency Y)
  - The covered interest parity says that high interest currencies tend to depreciate. Why? Remember $E^N[S_{t+1}] = F_{t,t+1}$ – Think of $E^N[S_{t+1}]$ as the CEQ
  - Therefore, investing in high interest currencies by shorting low interest currencies should not give any benefit

The carry trade II: Empirical findings

- Empirical analysis shows that this is not the case. High interest currencies tend to appreciate (at least in the short run), rather than depreciate as predicted by the covered interest parity

- What are the statistics of this strategy?

Carry trade III: Results across different asset classes

"Carry", by R. Koijen, T. Moskowitz, L. Pedersen and E. Vrugt. JFE

Asset class	Strategy	Mean	Stdev	Skewness	Kurtosis	Sharpe ratio
Global equities	Carry2-13	4.50	10.31	0.16	3.69	0.44
	Carry1-12	5.90	10.12	0.22	3.73	0.58
Fixed income 10Y global (level)	Carry2-13	3.42	7.00	0.29	6.02	0.49
	Carry1-12	3.11	6.81	-0.11	4.59	0.46
Fixed income 10Y−2Y global (slope)	Carry2-13	0.17	0.65	-0.08	6.13	0.26
	Carry1-12	0.24	0.67	-0.11	6.26	0.35
US Treasuries (maturity)	Carry2-13	0.46	0.60	0.42	7.59	0.77
	Carry1-12	0.47	0.60	0.27	8.33	0.78
Commodities	Carry2-13	11.06	19.20	-0.90	6.29	0.58
	Carry1-12	12.69	19.40	-0.82	5.70	0.65
Currencies	Carry2-13	4.03	7.72	-0.97	6.04	0.52
	Carry1-12	4.25	7.71	-0.96	6.08	0.55
Credit	Carry2-13	0.26	0.58	-0.10	22.53	0.45
	Carry1-12	0.27	0.58	-0.07	21.20	0.46
Options calls	Carry2-13	67.06	148.93	-1.76	8.94	0.45
	Carry1-12	42.62	158.81	-1.95	8.71	0.27
Options puts	Carry2-13	122.01	87.59	-1.02	7.47	1.39
	Carry1-12	136.13	89.37	-1.22	7.98	1.52
All asset classes (global carry factor)	Carry2-13	6.19	5.65	-0.21	6.20	1.10
	Carry1-12	6.54	5.84	-0.15	6.23	1.12

Summary, Homework and Additional Reading

- **In this lecture**, we dealt with:
  - Forward rates.
  - Relation between FX and money markets.
  - Covered interest parity.
  - Market value of a forward contract: Pricing through portfolio replication, special cases, certainty equivalents.
- **At home**, you will need to cover:
  - Hedging relevancy; implications for spot values.
- **Tutorial**: exercises 2-4 only.
- **Additional reading**:
  - Froot, K.A. and Thaler, R.H. (1990), "Anomalies: Foreign Exchange", *Journal of Economic Perspectives* 4(3), 179-192.
  - Green, P. (1992), "Is Currency Trading Profitable? Exploiting Deviations from Uncovered Interest Parity", *Financial Analysts Journal* 48(4), 82-86.