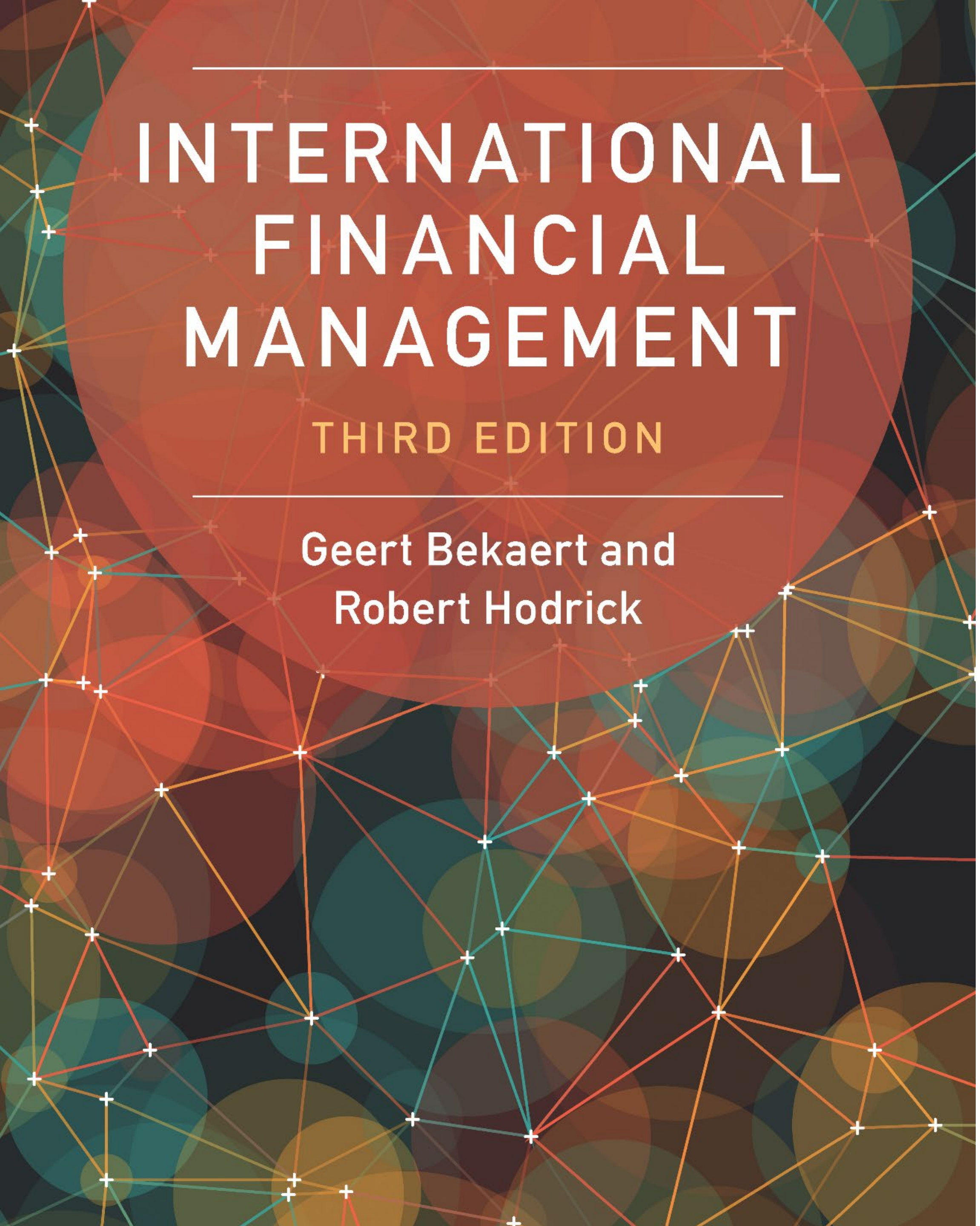


Chapter 20

Foreign Currency Futures and Options

20.1 The Basics of Futures Contracts

- Futures (versus forwards)
  - Allow individuals and firms to buy and sell specific amounts of foreign currency at an agreed-upon price determined on a given future day
  - Traded on an exchange (e.g., CME Group, NYSE Euronex's LIFFE CONNECT, and Tokyo Financial Exchange)
  - Standardized, smaller amounts (e.g., ¥12.5M, €125,000, C$100,000)
  - Fixed maturity dates
  - Credit risk
    - Futures brokerage firms register with the Commodity futures trading commission (CFTC) as a futures commission merchant (FCM)
    - Clearing member / clearinghouse

20.1 The Basics of Futures Contracts

- Margins
  - Credit risk is handled by setting up an account called a margin account, wherein they deposit an asset as collateral
    - The first asset is called the initial margin
    - Asset can be cash, US government obligations, securities listed on NYSE and American Stock Exchange, gold warehouse receipts or letters of credit
    - Depends on size of contract and variability of currency involved
    - Margin call – when the value of the margin account reaches the maintenance margin, the account must be brought back up to its initial value
- Marking to market – deposit of daily losses/profits
  - Maintenance margins
    - Minimum amount that must be kept in the account to guard against severe fluctuations in the futures prices (for CME, about $1,500 for USD/GBP and $4,500 for JPY/USD)

Exhibit 20.1 An Example of Marking to Market in the Futures Market

- Euro contract (€125,000)
  - On September 16, you "go long in December Euro"
    - In other words, you buy a Euro contract that is deliverable in December
  - Maintenance margin: $1500

Settle Price

$Contract\ Size \times \Delta F$

Initial Margin – for both buyer and seller

Exhibit 20.1 An example of marking to market in the futures market

Day	Futures price ($/€)	Change in futures price ($/€)	Gain or loss	Cumulative gain or loss	Margin account
t	1.3321	0	0		$2,000.00
t+1	1.3315	–$0.0006	–$75.00	–$75.00	$1,925.00
t+2	1.3304	–$0.0011	–$137.50	–$212.50	$1,787.50
t+3	1.3288	–$0.0016	–$200.00	–$412.50	$1,587.50
t+4	1.3264	–$0.0024	–$300.00	–$712.50	$2,000.00
t+5	1.3296	+$0.0032	+$400.00	–$312.50	$2,400.00
t+1	1.3301	+$0.0005	+$62.50	–$250.00	$2,462.50

Margin call

20.1 The Basics of Futures Contracts

- The pricing of futures contracts
  - The payoff on a forward contract:
    - $S(T) - F(t)$
    - where $S(T)$ is the future spot rate at maturity time T and $F(t)$ is the forward price at time t
  - The payoff on a futures contract
    - $f(T) - f(t)$
    - Where $f(T)$ is the futures price at maturity time T and $f(t)$ is the futures price at time t
  - Payoffs for futures can differ than those from forwards because the interest that is earned on future profits or that must be paid on future losses in a futures contract

Exhibit 20.2 Futures Quotes from August 5, 2015

Exhibit 20.2 Futures quotes from August 5, 2015

Contract size	JPY12,500,000			CAD100,000			GBP62,500			EUR125,000		
Exchange rate	USD per 100 JPY			USD per CAD			USD per GBP			USD per EUR		
Maturity	SEP	DEC	MAR	SEP	DEC	MAR	SEP	DEC	MAR	SEP	DEC	MAR
Open price	0.80435	0.80580	0.80475	0.7581	0.7575	0.7567	1.5562	1.5522	1.5517	1.0896	1.0913	1.0932
High price	0.80665	0.80780	0.80870	0.7625	0.7622	0.7614	1.5653	1.5634	1.5615	1.0948	1.0962	1.0960
Low price	0.80015	0.80015	0.80445	0.7556	0.7566	0.7567	1.5520	1.5515	1.5510	1.0852	1.0893	1.0893
Settle price	0.80100	0.80230	0.80470	0.758	0.7577	0.7579	1.5593	1.5584	1.5579	1.0901	1.0918	1.0941
Change in price	−0.00350	−0.00350	−0.00345	−0.0002	−0.0003	−0.0001	0.0030	0.0029	0.0029	0.0004	0.0004	0.0005
Open interest	250,419	2,038	92	163,438	5,543	887	168,379	791	32	360,882	6,137	666

Contract size	CHF125,00			AUD100,00			MXN500,000			EUR100,000		
Exchange rate	USD per CHF			USD per AUD			USD per 100,000 MXN			JPY per EUR		
Maturity	SEP	DEC	MAR	SEP	DEC	MAR	SEP	DEC	MAR	SEP	DEC	MAR
Open price	1.0237	1.0262	1.0297	0.7366	0.7325	0.7318	6120	6048	6005	135.47	....	....
High price	1.0259	1.0290	1.0314	0.7380	0.7341	0.7318	6142	6099	6005	136.22	....	....
Low price	1.0193	1.0231	1.0294	0.7318	0.7285	0.7269	6079	6038	6005	135.02	....	....
Settle price	1.0219	1.0254	1.0295	0.7331	0.7297	0.7266	6082	6038	6005	136.08	....	....
Change in price	−0.0010	−0.0010	−0.0011	−0.0037	−0.0036	−0.0037	−52	−52	−53	0.65	....	....
Open interest	36,944	431	19	167,683	695	17	138752	52321	7	7,667	....	....

20.2 Hedging Transaction Risk with Futures

- It is mid-February and Nancy Foods expects a receivable of €250,000 in one month
  - Will need 2 contracts (since contracts are €125,000)
  - Wants to receive \$ when the € weakens to protect against a loss in receivable
    - Thereby selling €
  - If contract delivery date coincides with receivable date, maturity is matched perfectly
  - Example:
    - February: Spot (\$1.24/€); Future (\$1.23/€)
    - March: Spot (\$1.35/€); Future (\$1.35/€); 30-day i(€) = 3% p.a.
    - Receivable in 30 days

20.2 Hedging Transaction Risk with Futures

- Value upon receipt of money (mid-March)
  - Sell receivable in spot market in March
    - $\$250{,}000 \times \$1.35/€ \;=\; \$337{,}500$
  - Loss on futures contract
    - $[(\$1.23/€) - (\$1.35/€)] \times €250{,}000 = -\$30{,}000$
  - Combination of CFs
    - $\$337{,}500 - \$30{,}000 = \$307{,}500$
  - Effective exchange rate
    - $\$307{,}500/€250{,}000 = \$1.23/€$

20.2 Hedging Transaction Risk with Futures

- Potential problems with a futures hedge
  - What if you need to hedge an odd amount?
  - What if the contract delivery date does not match your receivable/payable date?

20.3 Basics of Foreign Currency Option Contracts

- Gives the buyer the right but not the obligation to buy (call) or sell (put) a specific amount of foreign currency for domestic currency at a specific forex rate
  - Price is called the premium
  - Traded by money center banks and exchanges (e.g., NASDAQ, OMX, PHLX)
  - European vs. American options:
    - European options can only be exercised on maturity date; Americans can be exercised anytime (i.e., “early exercise” is permitted)
  - Strike / exercise price (“K”) – forex rate in the contract
  - Intrinsic value – revenue from exercising an option
    - In the money / out of the money / at-the-money
      - Call option: $max[S - K, 0]$
      - Put option: $max[K - S, 0]$

20.3 Basics of Foreign Currency Option Contracts Example: A Euro Call Option Against Dollars

- A particular euro call option offers the buyer the right (but not the obligation) to purchase €1M @ $1.20/€
  - If the price of the € > K, owner will exercise the option at expiration date
    - To exercise: the buyer pays $(\$1.20/€) \times €1M = \$1.2M$ to the seller and the seller delivers the €1M
  - The buyer can then turn around and sell the € on the spot market at a higher price!
  - For example, if the spot is $1.25/€, the revenue is:
    - $[(\$1.25/€) - (\$1.20/€)] \times €1M = \$50{,}000$
      - This is the intrinsic value of the option, not the profit
  - Buyer could therefore simply accept $50,000 from the seller if both parties prefer to do so

20.3 Basics of Foreign Currency Option Contracts Example: A Yen Put Option Against the Pound

- A particular yen put option offers the buyer the right (but not the obligation) to sell ¥100M @ £0.6494/¥100
  - If the price of the ¥100 < K, owner will exercise
    - To exercise: the buyer delivers ¥100M to the seller
      - The seller must pay $(£0.6494/¥100) \times ¥100M = £649{,}400$
  - For example, say the spot at exercise is £0.6000/¥100
    - The revenue then is:
      - $[(£0.6494/¥100) - (£0.6000/¥100)] \times ¥100M \ = \ £49{,}400$
        - Intrinsic value of option, not the profit
      - Buyer could therefore accept £49,400 from seller if both of the parties prefer to do so

20.3 Basics of Foreign Currency Option Contracts

- Options trading
  - Mostly traded by banks in the interbank market or the OTC market
    - Typically European convention in OTC market
    - CFs either exchanged or cash settlement
    - Considerable counterparty risk, managed by exposure limits
  - Currency options on the NASDAQ OMX PHLX
    - Mostly options on spot currencies vs U.S. Dollar
    - Expiration months:
      - March, June, September and December
      - Two nearest future months
    - Last trading day is the third Friday of expiring month
    - European-exercise type but settlement is in dollars
    - Options Clearing Corporation serves as clearinghouse

Exhibit 20.4 Prices of Options on Futures Contracts

Exhibit 20.4 Prices of options on futures contracts

Currency	Type	Maturity	Strike prices					
			7500	7550	7600	7650	7700	7750
		Sep	1.57	1.22	0.92	0.67	0.47	0.32
Canadian dollar	Calls	Dec	2.36	2.05	1.77	1.52	1.28	1.08
		Mar	2.83	2.54	2.26	2.00	1.77	1.55
CAD100,000		Sep	0.37	0.52	0.72	0.97	1.27	1.62
USD cents per CAD	Puts	Dec	1.18	1.38	1.59	1.84	2.10	2.40
		Mar	1.65	1.85	2.07	2.31	2.58	2.86
			1010	1015	1020	1025	1030	1035
		Sep	1.87	1.56	1.28	1.03	0.83	0.65
Swiss franc	Calls	Dec	3.01	2.73	2.48	2.24	2.02	1.81
		Mar	3.99	3.7	3.43	3.17	2.92	2.69
CHF125,000		Sep	0.68	0.87	1.09	1.34	1.64	1.96
USD cents per CHF	Puts	Dec	1.85	2.07	2.32	2.58	2.85	3.15
		Mar	2.42	2.63	2.85	3.09	3.34	3.61
			1080	1085	1090	1450	1460	1470
		Sep	1.96	1.66	1.39	1.15	0.94	0.76
Euro	Calls	Dec	3.70	3.39	3.09	2.81	2.54	2.29
		Mar	4.24	3.95	3.68	3.41	3.16	2.92
EUR125,000		Sep	0.95	1.15	1.38	1.64	1.93	2.92
USD cents per EUR	Puts	Dec	1.78	1.96	2.16	2.38	2.61	2.86
		Mar	2.83	3.04	3.27	3.50	3.75	4.01
			1545	1550	1555	1560	1565	1570
		Sep	2.27	1.94	1.65	1.38	1.15	0.94
British pound	Calls	Dec	3.59	3.30	3.02	2.76	2.51	2.28
		Mar	4.50	4.21	3.93	3.66	3.40	3.16
GBP62,500		Sep	0.02	0.02	0.01	0.02	0.13	1.45
USD cents per GBP	Puts	Dec	0.01	0.01	0.04	0.13	0.53	2.21
		Mar	0.16	0.33	0.64	1.22	2.33	4.32
			7950	8000	8050	8100	8150	8200
		Sep	1.11	0.82	0.58	0.40	0.27	0.18
Japanese yen	Calls	Dec	2.02	1.74	1.49	1.27	1.07	0.90
		Mar	2.72	2.44	2.18	1.93	1.71	1.51
JPY12,500,000		Sep	0.50	0.71	0.97	1.29	1.66	2.07
USD cents per 100 JPY	Puts	Dec	1.28	1.50	1.75	2.03	2.34	2.67
		Mar	1.78	2.00	2.24	2.49	2.77	3.07

20.3 Basics of Foreign Currency Option Contracts

- Currency options at the CME group
  - Contract sizes and expiration months follow those of futures contracts
  - Trading closes on Friday immediately preceding the third Wednesday of the contract month

20.3 Basics of Foreign Currency Option Contracts

- Exchange-listed currency warrants
  - Longer-maturity foreign currency options (> 1 year)
  - Issued by major corporations
  - Actively traded on exchanges such as the American Stock Exchange, London Stock Exchange, and Australian Stock Exchange
  - American-style option contracts
  - Issuers include AT&T, Deutsche Bank, Ford, Goldman Sachs
    - Not taking on currency risk – likely hedged in OTC market
    - Buying an option at wholesale price and selling at retail price
  - Allow retail investors and small corporations that are too small to participate in OTC market to purchase L/T currency options

20.4 The Use of Options in Risk Management

- A bidding situation at Bagwell Construction
  - U.S. company wants to bid on a building in Tokyo (in ¥)
  - Transaction risk since bid is in ¥
  - Cannot use forward hedge because if they do not win, it will be a liability
  - Option allows flexibility in case they do not win
- Using options to hedge transaction risk
  - Forward / futures contracts do not allow you to benefit from the "up" side
  - Allows a hedge but maintains the upside potential from favorable exchange rate changes

20.4 The Use of Options in Risk Management

- Pfimerc
  - Today is Friday, 1st October 2010
  - Receivable of £500,000 on Friday, 19th March 2011
    - S: $1.5834/£
    - 170-day F: $1.5805/£
    - $ 170-day interest rate: 0.20% p.a.
    - £ 34-day interest rate: 0.40% p.a.
    - Option data for March contracts in $/£:

Strike	Call Price	Put Price
158	0.0500	0.0481
159	0.0452	0.0533
160	0.0408	0.0589

20.4 The Use of Options in Risk Management

- How should Pfimerc hedge?
  - £ put option: right (but not obligation) to sell £ at a specific price if the value of the £ falls
  - In order to sell £500,000, Pfimerc must pay:
    - $£500{,}000 \times (\$0.0481/£) = \$24{,}050$
  - Exercise option if £ falls below \$1.58/£:
    - $£500{,}000 \times \frac{\$1.58}{£} = \$790{,}000$ if $S(t+170) \leq \$1.58/£$
  - Sell £ in spot market if £ is worth \$1.58 in 170 days:
    - $£500{,}000 \times S(t+170) > \$790{,}000$ if $S(t+170) > \$1.58/£$
  - Either way, cost of the put is:
    - $[\$24{,}050 \times (1 + (0.002 \times 170/360))] = \$24{,}073$
  - Minimum revenue is therefore:
    - $\$790{,}000 - \$24{,}073 = \$765{,}927$

20.4 The Use of Options in Risk Management

- Options as insurance contracts
  - Hedging foreign currency risk with forwards and options
  - Options as insurance contracts
    - As amount of coverage increases so does the cost (premium) to insure
  - Changing the quality of the insurance policy
    - Make ceiling on our cost of the foreign currency as low as possible

Exhibit 20.7 Hedging and Speculating Strategies

Exhibit 20.7 Hedging and speculating strategies

	Underlying transaction	
	Foreign currency receivable	Foreign currency payable
Forward hedge (or futures hedge)	Sell forward (Go short)	Buy forward (Go long)
Option hedge	Buy a put Establishes a revenue floor of $K-(1+i)P$	Buy a call Establishes a cost ceiling of $K+(1+i)C$
Option speculation	Sell a call Imposes a revenue ceiling of $K+(1+i)C$ but allows unlimited risk	Sell a put Imposes a liability floor of $K-(1+i)P$ but allows unlimited risk

20.4 The Use of Options in Risk Management

- Option valuation – Black and Scholes (1973)
  - The intrinsic value of an option
    - If the owner exercises it, will it make money (in / at / out of the money)?
  - The time value of an option
    - The part of the option's value that is attributed to the time left to expiry
    - Time value = Option price – intrinsic value
  - Increasing the exercise price (call)
    - Reduced the probability that the option will be exercised so it decreases the option's value

20.4 The Use of Options in Risk Management

- An increase in the variance
  - The distribution with the larger variance yields possibly larger payoffs so it increase the value of the option
- Increasing the time to expiration
  - American – increases uncertainty of spot rate at maturity so it increases the option's value
  - European – generally increases the option's value but it depends because in-the-money European options can lose value as time evolves

Exhibit 20.10 Different Probability Distributions of Future USD/EUR

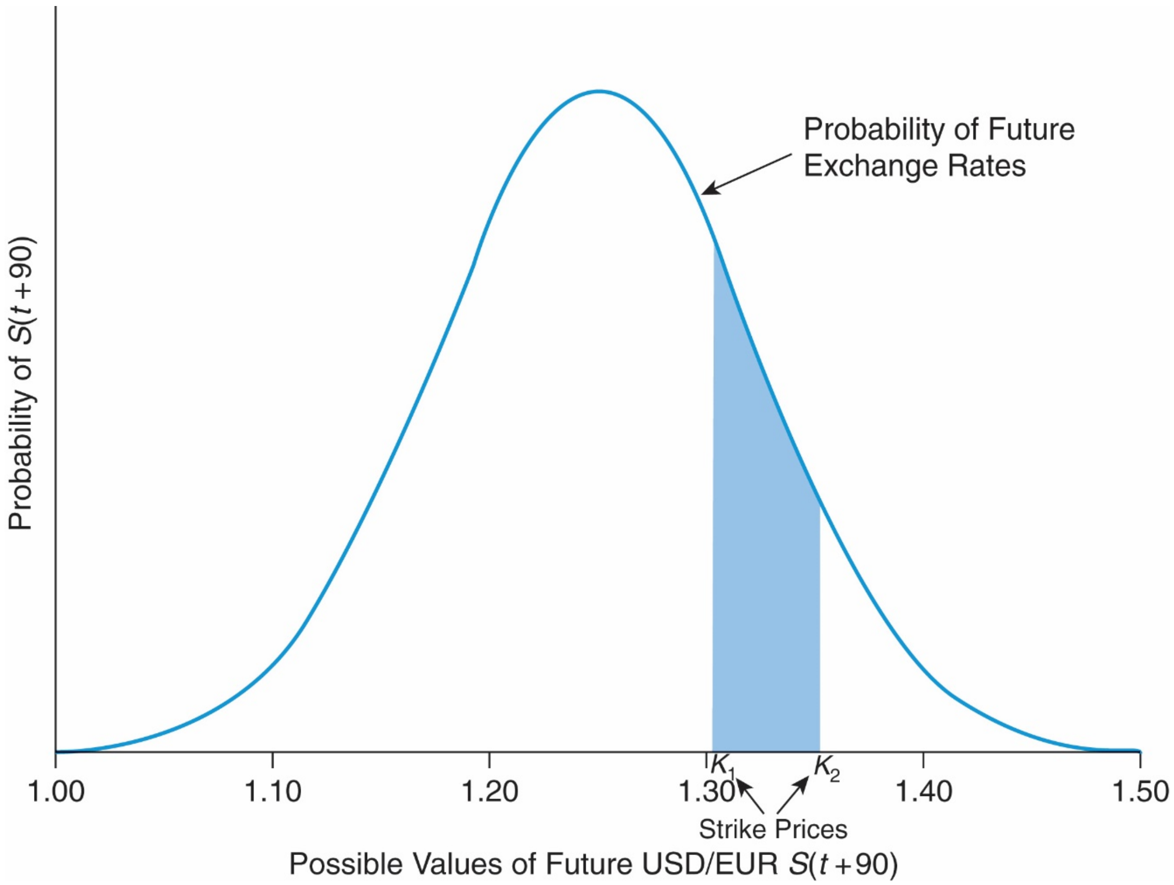
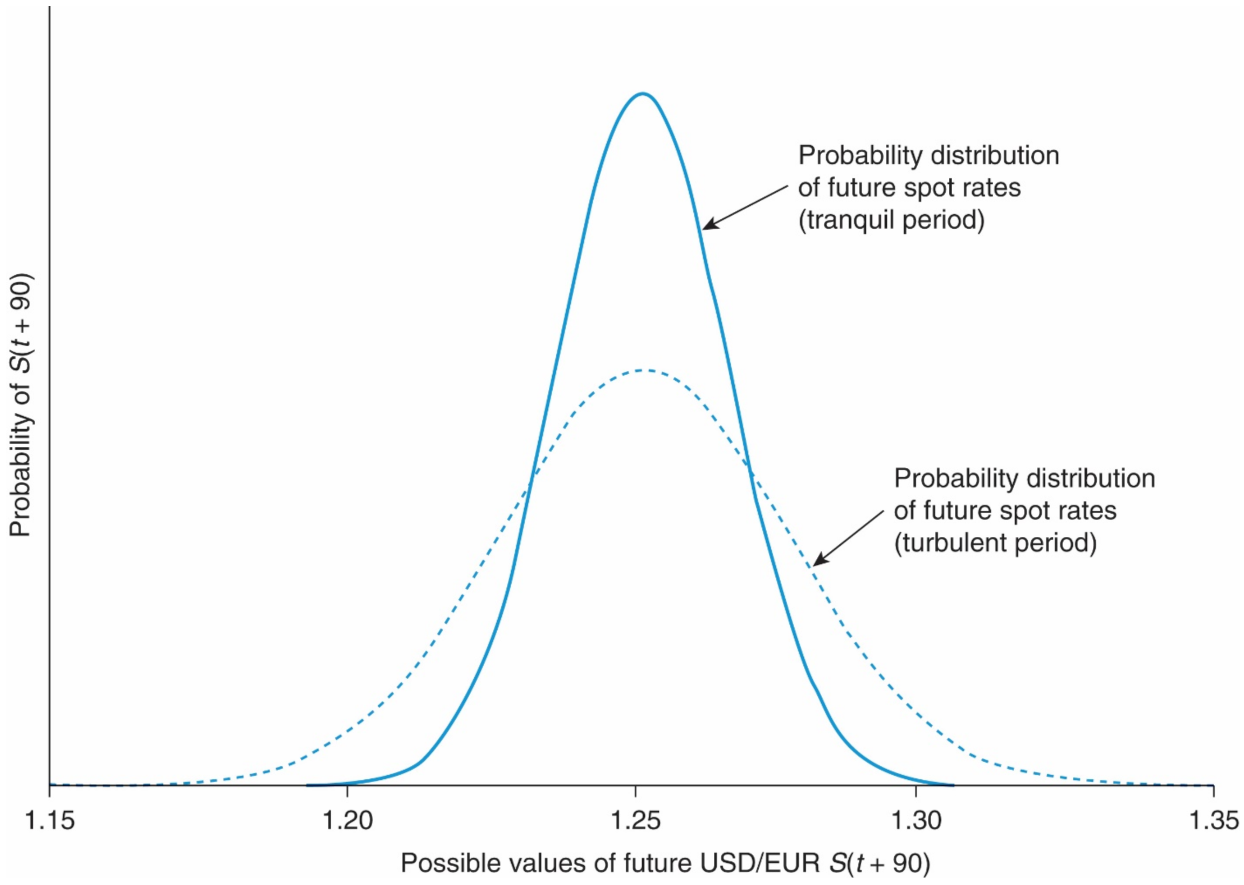


Exhibit 20.11 Different Probability Distributions of Future USD/EUR



20.5 Combinations of Options and Exotic Options

- Exotic options
  - Options with different payoff patterns than basic options
    - Range forward contract
      - Allows a company to specify a range of future spot rates over which the firm can sell or buy forex at the future spot rate
      - No money up front
    - Cylinder options
      - Allows buyers to specify a desired trading range and either pay money or potentially receive money up front for entering into the contracts
    - Both can be synthesized
      - Buying a call and selling a put (at a lower K)
      - For range forward contract:
        - K must be set such that $P(K_p) = C(K_c)$

20.5 Combinations of Options and Exotic Options

- Average-rate options (or “Asian” option)
  - Most common exotic option
  - Payoff is $max[0, \hat{S} - K]$
    - $\hat{S}$ defines the average forex rate between the initiation of the contract and the expiration date (source and time interval are agreed upon)
- Barrier options
  - Regular option with additional requirement that either activates or extinguishes the option if a barrier forex rate is reached
- Lookback options
  - Option that allows you to buy/sell at least/most expensive prices over a year (more expensive than regular options)
- Digital options (“binary” options)
  - Pays off principal if K is reached and 0 otherwise

An example of option pricing

- Suppose that we want to buy a call option that allows us to buy euros three months from now at a price of $1.14.
- Suppose there are only two possible values of the euro three months from now – either $1.16 or $1.13.
- Suppose the 3-month interest rate in the U.S. is 0.01 (not annualized), and in Europe is 0.005
- Suppose the current spot exchange rates is 1.15
- I am going to build a portfolio that replicates the payoffs to the option, and then figure out what that portfolio costs.

Replicating portfolio

- I will buy €X, and borrow \$Y. The idea is that I am going to find an X and Y that will give me a payoff equal to that of the call option that lets me buys euros for \$1.14
- This portfolio I buy today has a cost C given by $C = (\$1.15 \times €X) - \$Y$
- Now, if I bought the call option, it has two possible payoffs. Suppose the call option allows me to buy €100 at the price \$1.14.
  - If the spot price of euros in 3 months turns out to be \$1.13, the call option is worthless.
  - If the spot price of euros in 3 months is \$1.16, the value of the call option is

$$(\$1.16 - \$1.14) \times €100 = \$2.00$$

- Now we want to see what values of X and Y will give us payoff of \$2.00 when the spot exchange rate is \$1.16, and \$0 when the spot exchange rate is \$1.13

Pricing the option

- The value of my portfolio in one month is

  ($\$S \times €X)(1.02)$ - $\$Y(1.01)$, where S is the spot exchange rate in one month.
- We are looking for the values of X and Y that satisfy these two equations:

  $(\$1.13 \times €X)(1.005) - \$Y(1.01) = \$0$

  $(\$1.16 \times €X)(1.005) - \$Y(1.01) = \$2.00$
- These are two linear equations in two variables, X and Y, which we can solve
- We find €X = €66.335 and \$Y = \$74.59
- Then the cost today of the portfolio that has the same payoff as the option is
  - $C = (\$1.135 \times €X) - \$Y = (\$1.15 \times €66.335) - \$74.59 = \$1.695$
  - \$1.695 would be the price of the call option

Greater variance

- Suppose instead of \$1.13 and \$1.16 as possible future spot exchange rates, the possibilities had a greater variance but the same mean: \$1.12 and \$1.17
- The option's value when S = \$1.17 is (\$1.17 - \$1.14) × €100 = \$3.00
- We are looking for the values of X and Y that satisfy these two equations:

$$(\$1.12 \times €X)(1.005) - \$Y(1.01) = \$0$$

$$(\$1.17 \times €X)(1.005) - \$Y(1.01) = \$3.00$$

- These are two linear equations in two variables, X and Y, which we can solve
- We find €X = €59.70 and \$Y = \$66.53
- Then the cost today of the portfolio that has the same payoff as the option is
  - C = (\$1.135 × €X) - \$Y = (\$1.15 × €59.70) - \$66.53 = \$2.125
  - \$2.125 would be the price of the call option instead of \$1.695