Lecture notes on risk management, public policy, and the financial system

Foreign exchange risk

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Foreign exchange risk

- Behavior of foreign exchange rates
- Exchange rate volatility

Foreign exchange and interest rates

Defining foreign exchange risk

- **Foreign exchange rate** or **currency risk:** risk of loss from fluctuations in foreign exchange rates
- Includes risk of
  - **Economic risks:** potential losses on assets, liabilities, and future cash flows denominated in foreign currencies
  - **Translation risk:** accounting losses for firms with foreign subsidiaries/revenues
- **Appreciation** (**depreciation**) of a foreign currency: rise (fall) of its price in home/local currency units

  Long positions in foreign currency are exposed to appreciation of the home currency/depreciation of foreign currency
    - E.g. investments in foreign assets

  Short positions in foreign currency are exposed to depreciation of the home currency/appreciation of foreign currency
    - E.g. future payment obligation for imported goods, repayment of loan in foreign currency

Foreign exchange market efficiency

- Exchange rates similar to other asset markets in displaying rough market efficiency,
- Exchange rates determined—at least in long term—by fundamentals
  - E.g. changes in relative price levels, trade balances, money supply growth
- Exchange rates more unpredictable in short term
  - Exchange rate forecasts based on fundamentals data no more accurate than random-walk forecast
  - Extremely difficult to construct predictably successful trading system
- Indicates relevant information largely impounded in current market-clearing exchange rates
- Need to borrow foreign currency a particular obstacle to efficiency in exchange markets
  - Market segmentation→**cross-currency basis**

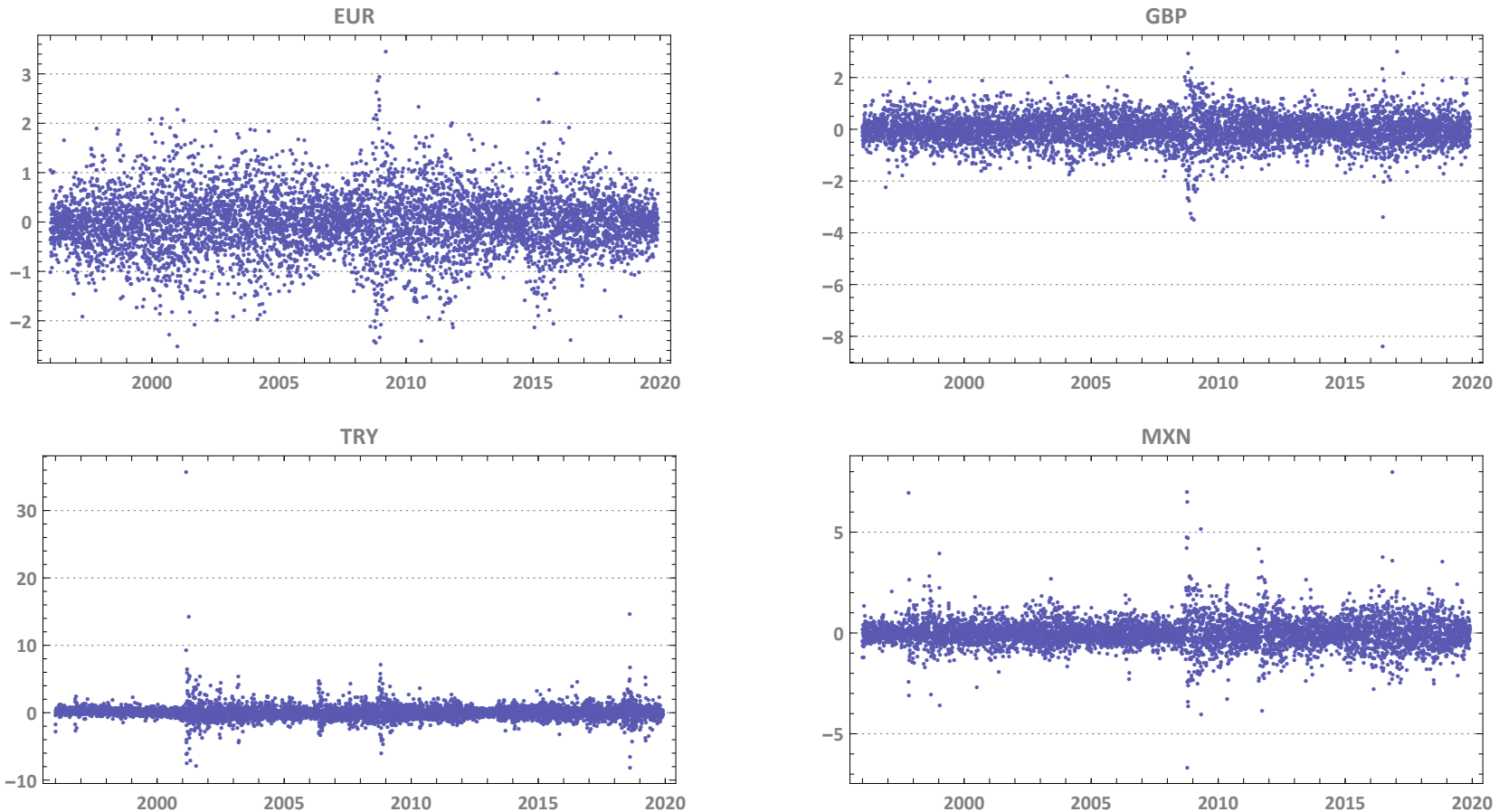
Time variation of exchange rates

- Exchange rate **returns**—percent changes in rates—a measure of fluctuations
- (→)**Volatility**—extent to which exchange rates fluctuate over time—a measure of foreign exchange risk
- Volatility itself changes dramatically over time
- **Volatility regimes** or **clustering:** relatively calm—low volatility—periods are succeeded by relatively volatile periods
  - Both calm and volatile periods are persistent, but end eventually

Extreme exchange rate returns and volatility

- **Fat** or **heavy tails**: surprisingly, even shockingly high-magnitude returns recurrent
- Many episodes of extreme volatility associated with abandonment of **fixed** or **pegged** exchange rate systems
- Exchange rate returns typically **skewed**: extreme returns tend to be in a particular direction, either appreciation or depreciation
  - Largest-magnitude changes in emerging-market crosses against major currencies (USD, EUR, GBP, JPY, CHF) generally depreciations
- Extremely high volatility associated with **currency crises**

Volatility in emerging markets exchange rates



Daily returns in percent of the euro (EUR), British pound (GBP), Turkish lira (TRY), and Mexican peso (MXN) against USD, 02Jan1996 to 02Jan2019. EUR and GBP are conventionally stated as USD price per currency unit, so positive returns represent *appreciation* against USD; TRY and MXN are conventionally stated as the currency price of US$1, so positive returns represent *depreciation* against USD. *Source*: Bloomberg L.P.

Foreign exchange risk

Foreign exchange and interest rates

- Integration of foreign exchange and money markets
- Open and closed interest-rate parity
- Constructing an implied interest-rate term structure from forwards
- Interest rates and currency risk
- Open interest rate parity

Foreign exchange markets connect money markets

- Foreign exchange hedging instruments closely integrated with local money markets
- Currency investments generally embedded in foreign money market, debt, equity, or other investments
  - Held in positive-yield form rather than in foreign cash
- Primarily via **forward foreign exchange** markets
  - Over-the-counter markets with standard times to maturity
  - Available for very many currency pairs through commercial banks
  - **Foreign exchange futures:** fixed maturity dates, settlement via futures exchanges
- Money markets or forward foreign exchange transactions can be used to take foreign exchange positions
- $\Rightarrow$Relationship between interest rates and forward exchange rates

Foreign exchange forward instruments

Forward foreign exchange transaction: contract for delivery of foreign currency at a future date

- Buy currency at **forward foreign exchange rate** set today
- But take delivery at future **settlement** date
- Also called **outright forward** transactions
- Very similar to currency futures contracts
  - Differences in how counterparties trade, clear and exchange collateral, determination of maturity dates

Spot foreign exchange transaction: contract for immediate delivery of foreign currency

- Equivalent to forward contract with zero time to settlement

Foreign exchange swap: contract pairing spot and forward foreign exchange transactions

- Occasionally pairs forward transactions with different settlement dates

Foreign exchange premiums

- **Forward foreign exchange premium** or **discount:** difference between spot and forward exchange rates
- Forward FX rates and premiums generally expressed in **forward points**—number of currency units (times standard multiple)
  - The τ-year forward premium is

$$\frac{F_{t,\tau}}{S_t} - 1$$

  - $S_t, F_{t,\tau}$: spot, τ-year forward rates (local price of foreign currency)
  - τ-year forward points are $F_{t,\tau} - S_t$ (times some power of 10, e.g. 100 or 10 000)
- **Example:**
  - Spot GBP-USD rate (USD price of £1) is \$1.30
  - 3-month forward outright rate \$1.3060
  - Forward premium is 60 points (multiple is 100 for GBP-USD)
  - GBP deliverable 3 months hence is

$$\frac{1.3060}{1.30} - 1 = 0.004615$$

    or 0.46 percent costlier in USD than spot

Forward markets and currency positioning

- Money market investments economically equivalent to long forward position
  - Operating in money markets:
    - Now: borrow—or deploy own capital—in USD, convert to foreign currency, and lend locally at short term
    - In a few weeks or months: redeem local loan/deposit, convert back to USD
  - Operating in forward markets:
    - Now: buy FX forward
    - In a few weeks or months: take delivery, convert back to USD
- USD money market rate an explicit cost if borrowing, an opportunity cost if deploying own capital
- Emerging markets generally have better-developed, more liquid forward foreign exchange than money markets

Forward exchange and money market arbitrage

- Forward exchange rates: range of maturities
  - Overnight to a few years, depending on currency and state of development of market
- Spot and forward exchange rates of different maturities match up with term structure of interest rates in both currencies
  - Enforced by arbitrage
  - But arbitrage doesn't always work well ($\rightarrow$basis)
- Forward foreign exchange sometimes more liquid than money market
  - May be representative out to maturities of several years
- Not merely informational: liquid forward market can effectively facilitate local borrowing/lending

Open and closed positions

- **Open** or **uncovered** currency positions are exposed to exchange rate risk
- Forward foreign exchange position is an *open* currency position
  - Take delivery of currency in future and sell at then-prevailing spot rate
  - Profitable if realized appreciation of foreign currency exceeds forward premium
- Long (short) forward position can also be used to hedge or cover or **close** a short (long) foreign exchange position
- Foreign exchange swap is a *closed* position
  - Currency bought or sold in advance at known forward foreign exchange rate

Closed and open interest-rate parity

How can we explain persistent differentials between equivalent—tenor, credit risk, etc.—short-term interest rates in different currencies?

Covered or **closed interest-rate parity:** equal to forward FX premium

- Equality between cost of funding an FX position through money markets and via FX swaps
- Enforced by low-risk arbitrage
- All constituents of the arbitrage are observable

Uncovered or **open interest rate parity:** equal to expected appreciation or depreciation of one currency against another

- Refers to open or uncovered positions in which the currency exposure has not been hedged or sold forward
- "Enforced" only by risky "arbitrage"

Covered interest-rate arbitrage

- Local currency is "priced to depreciate" by forward premium $\frac{F_{t,\tau}}{S_t} - 1$ in τ years
- Differential between local ($r_{t,\tau}$) and foreign ($r^*_{t,\tau}$) τ-year money market rates at annual rate is

$$\frac{1 + r_{t,\tau}}{1 + r^*_{t,\tau}} - 1 \approx r_{t,\tau} - r^*_{t,\tau}$$

- τ-year interest rate differential must equal forward premium

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

- Arbitrage consists of two sets of transactions, now and in future
  - Requires access to money markets in both currencies
- Now: borrow in local money market, convert to foreign exchange, invest in foreign money market, sell future proceeds forward
  - No net cash flow
- Future: complete forward sale and return borrowed local currency
  - No net cash flow only if arbitrage is working perfectly

Covered interest-rate arbitrage: example

- Suppose $\tau = \frac{3}{12}$, i.e. 3 months, $S_t = 1.3000$, U.S. and U.K. money market rates $r_{t,\tau} = 0.0275$, $r^*_{t,\tau} = 0.01$
- Arbitrage then enforces 3-month forward FX rate close to \$1.30567:

$$F_{t,\tau} = S_t \frac{1 + \tau r_{t,\tau}}{1 + \tau r^*_{t,\tau}} = 1.3000 \frac{1 + \frac{3}{12}0.0275}{1 + \frac{3}{12}0.01} = 1.3000 \times 1.00436$$

  - Forward premium is 0.00436 (0.436 percent) or 56.7 forward points
- Arbitrage opportunity if forward rate is higher than \$1.30567 (GBP dear, USD cheap)
  - Buy USD forward
  - Borrow \$1.30 at 2.75 percent, owe \$1.30894 in 3 months
  - Buy £1 and deposit at 1 percent, receive £1.0025 in 3 months
  - $1.30567 = 1.30894 \times 1.0025 \Rightarrow$if $F_{t,\tau} > 1.30567$, deliver £1.0025 for more than \$1.30894

Covered interest rate parity: example

- Foreign exchange forward often more liquid and accessible than local money markets
- Use forwards to infer equivalent of a local money market curve
  - In emerging markets with less-liquid money markets, forward-implied interest rate data more reliable
- **Example** of Turkish lira (USD-TRY): assume price and rates are:

spot exchange rate	3.7500	TRY per USD
1-year TRY interest rate	11.5926	percent
1-year USD interest rate	1.3250	percent

- Then the 1-year TRY forward rate should equal

$$3.7500 \frac{1.115926}{1.03250} = 4.1300,$$

or expressed in forward points (multiple is 10 000 for USD-TRY) as

$$10\,000 \times (4.1300 - 3.7500) = 3800$$

- Works both ways: 1-year forward points and USD interest rate$\Rightarrow$TRY interest rate

Deriving an interest rate curve

- TRY curve based on USD rates and TRY forwards
- Observe USD Libor/swap curve and TRY forward points
- Infer USD-TRY forward exchange and TRY money market rates
- Forward interest rates in the table have one year to maturity and the settlement date indicated by the column heading

Rate assumptions for the examples				
Maturing in	1 year	2 years	3 years	4 years
USD spot interest rates	1.3250	1.7000	1.9250	2.0000
USD forward 1-year interest rates	1.3250	2.0764	2.3765	2.2253
USD-TRY forward points	3800	8200	13200	18800
USD-TRY forward exchange rates	4.1300	4.5700	5.0700	5.6300
TRY spot interest rates	11.5926	12.2699	12.7041	12.9066
TRY forward 1-year interest rates	11.5926	12.9514	13.5774	13.5165

Interest rates in percent

Higher interest rates in emerging markets

- Emerging markets generally have significantly higher interest rates than advanced market economies
- Mirrored (through not always exactly) in forward foreign exchange rates expressing USD appreciation
- Higher interest rates in emerging markets also mean hedging generally costly
  - Sell currency positions forward at rates reflecting USD appreciation

The risks of open currency positions

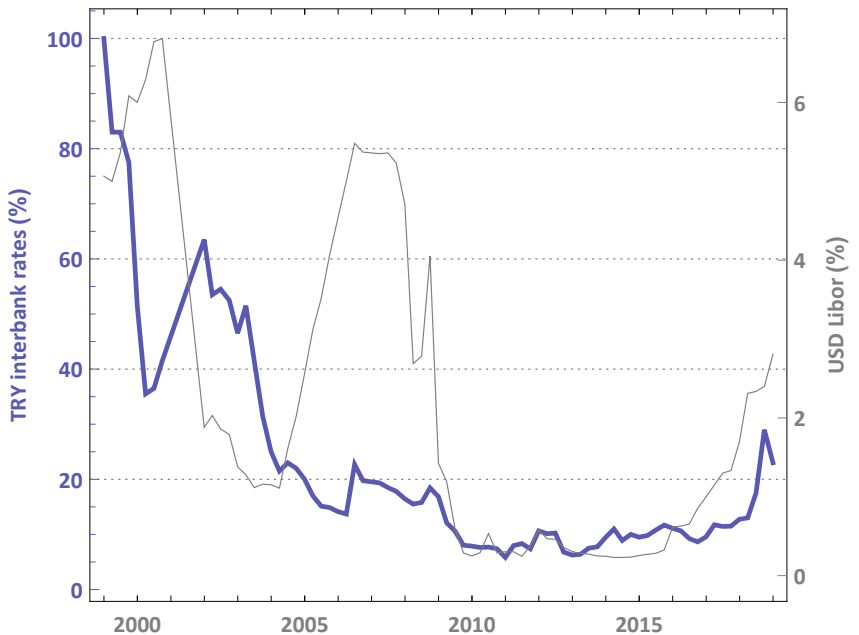
- Lending in emerging markets funded in major currency→long uncovered emerging markets currency position against USD
- Foreign exchange fluctuations a major source of risk
  - Lending profitable if and only if interest rate differential exceeds any FX depreciation—USD appreciation—over the investment term
  - But profit reduced—or even turns to loss—if currency depreciates
- Spread between local and USD money market rate (the **carry**) a finite buffer against foreign exchange losses
  - If USD appreciation exactly equal to spread, lender breaks even
  - Equivalently: if USD appreciates so that future spot rate exactly equal to forward, lender breaks even
  - And equivalently: break even if growth in local currency money market balances keeps pace with rising price of USD

Currency carry trades

- Higher emerging-markets interest rates the motivation for FX **currency carry trade**
- Similar to lending in emerging markets, but shorter-term and via simple market instruments
  - Carry trade essentially an unhedged short-term loan in local currency
  - Provides straightforward illustration of risks in lending abroad by USD-based investors without currency hedge
- Carry trade an open position
  - Remains at risk until closed out via sale of currency at uncertain future spot rate
- Foreign exchange fluctuations by far the greatest source of risk in carry trade

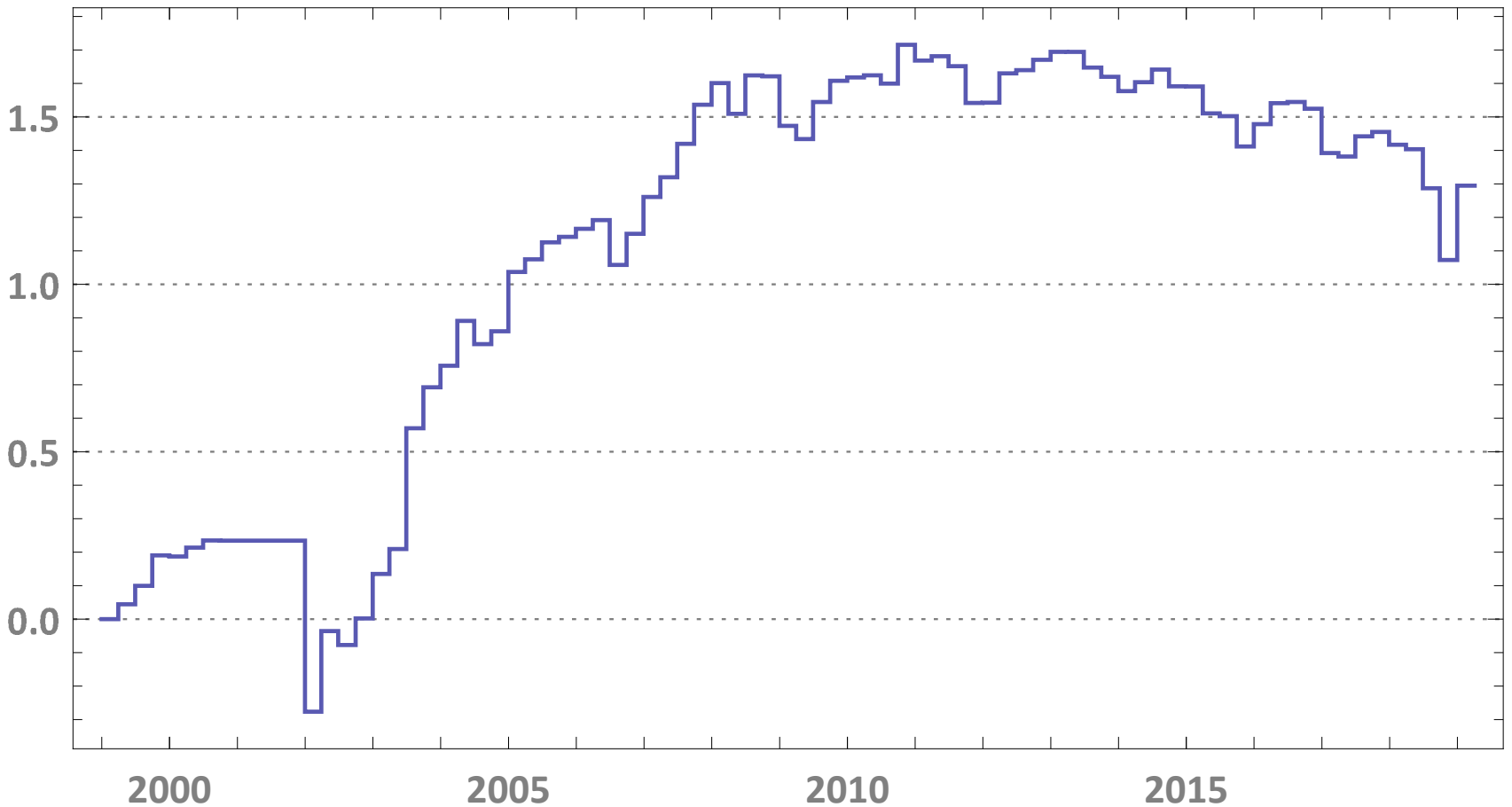
Turkish lira foreign exchange and interest rates

Turkish lira (TRY) spot rates (Turkish lira per U.S. dollar), quarter-end from Q4 1998 to Q4 2018. *Source*: Bloomberg L.P.



3-month Turkish lira interbank and U.S. dollar ICE Libor rates, quarter-end from Q4 2001 to Q4 2018. *Source*: Bloomberg L.P.

Cumulative returns on USD-TRY carry strategy



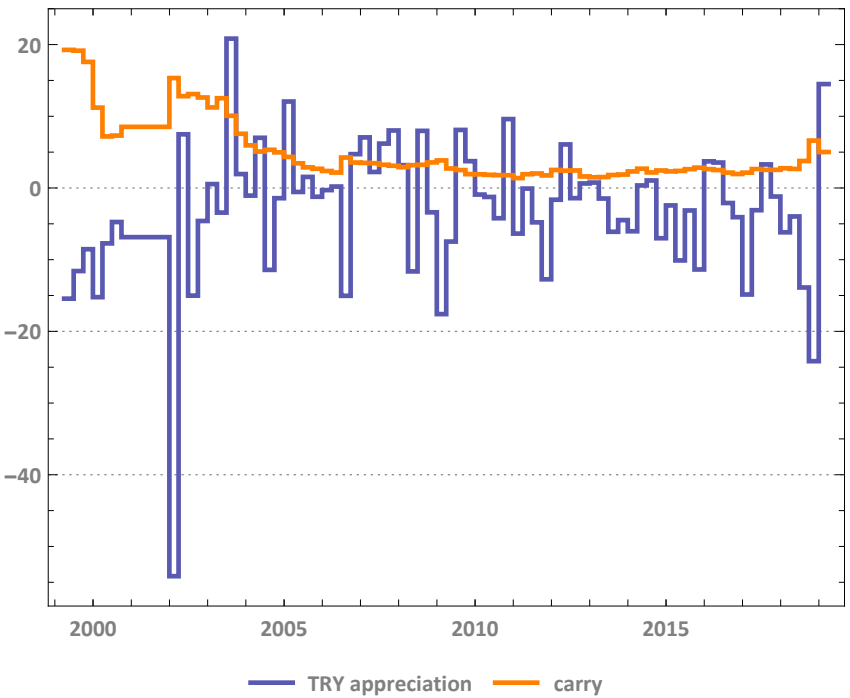
Cumulative net returns in USD of strategy of buying \$1 equivalent of TRY and investing in TRY 3-month money market, quarterly, Q4 1998 to Q4 2018. *Data source*: Bloomberg L.P.

Currency risk and hedging

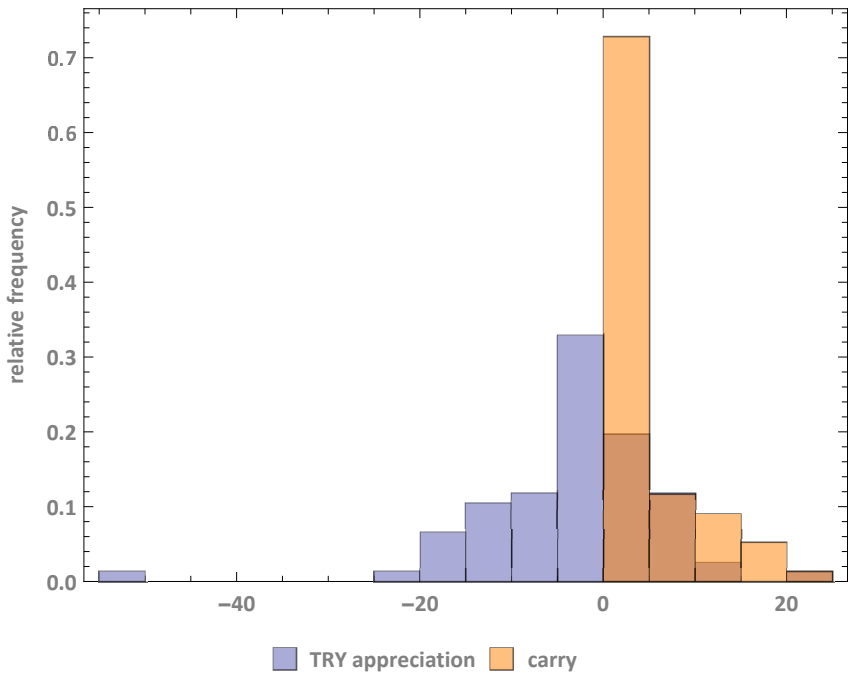
- Exchange rate losses can be very large compared to interest rate differentials
- Interest rate gains generally outweigh exchange rate losses over time, but losses can be sudden and very large
  - Exchange rates have *skewed* distributions: largest-magnitude changes are sudden USD appreciations
  - Exchange rates have *heavy-tailed* distribution: also many substantial USD depreciations, adding to carry gains
- Interest rate differentials generally positive and relatively non-volatile
- Durations are short$\rightarrow$interest rate fluctuations generally
  - Have small valuation impact
  - Primarily influence carry, potential future profitability

Turkish lira foreign exchange and interest rate risks

Decomposition of carry returns into carry (interest-rate differential) and currency changes

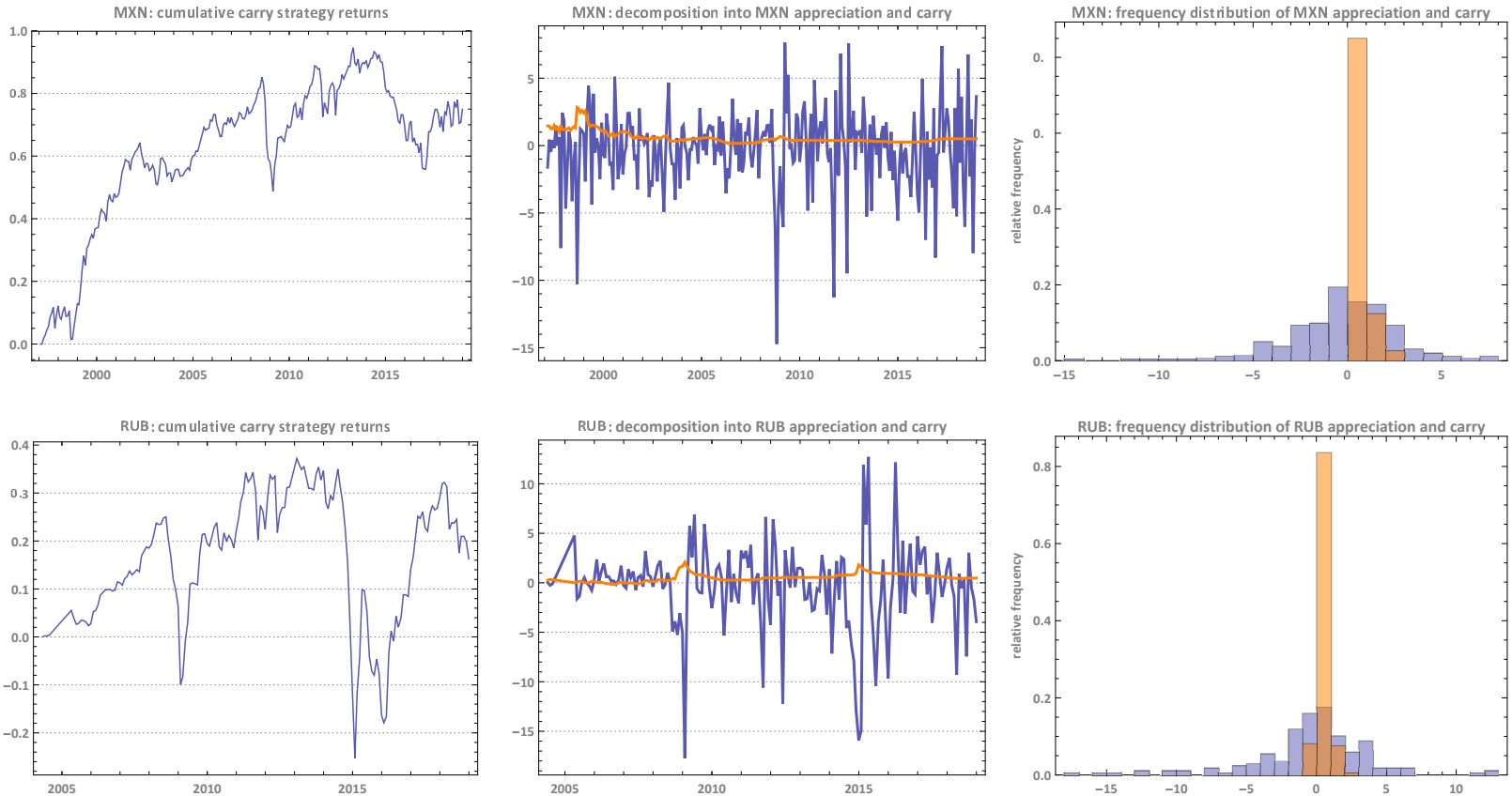


Frequency distributions of carry (interest-rate differential) and currency changes



Interest-rate differentials at a quarterly rate; quarterly arithmetic exchange rate returns. Exchange rates are in foreign currency units per USD, so negitive returns reflect USD appreciation and losses to the carry strategy. Percent, Q4 1998 to Q4 2018. *Data source*: Bloomberg L.P.

Mexican peso and Russian ruble carry strategy



Left: cumulative returns of carry strategy; center: decomposition into carry and currency changes; right: distributions of carry and currency changes. Top: USD-MXN, using 1-month Mexican MXN deposit (28-day TIIE interbank) rate, month-end 31Jan1997 to 31Dec2018; bottom: USD-RUB, using 1-month National Foreign Exchange Association (NFEA) MosPrime Rate (Moscow Prime Offered Rate), month-end 31Jan2001 to 31Dec2018, and 1-month U.S. dollar ICE Libor rates. *Data source*: Bloomberg L.P.

Open interest rate parity puzzle

- Open interest rate parity does not hold, in fact exchange rate movements often move in opposite direction
  - Future changes in the exchange rate should offset interest-rate differential
  - But instead *amplify* rather than offset interest-rate differential
- If it held, carry trade could not be profitable
- Considered anomalous and often referred to as **uncovered interest rate parity puzzle**
  - Excess return likely compensates for currency risk
  - High interest rates and costly hedging go hand-in-hand with foreign exchange volatility
- Leads to interpretation of forward premium as measure of expected ap-/depreciation
  - Expected appreciation unobservable and views may differ

Risk and the uncovered parity puzzle

- Over longer time periods, such investments often profitable, i.e. reap **excess return** over borrowing or risk-free rate
- Investing in higher-yielding currencies leaves you exposed to currency risk, but earn **risk premium** to compensate
- Hedging cost can be viewed as "payment" of a risk premium to holders of open positions for bearing risk
- Relationship to foreign-exchange volatility
  - Carry trade most profitable during low-volatility periods
  - Onset of high-volatility period forces closing of carry positions
- "**Peso problem**:" depreciation may occur in very infrequent but very large spasms
  - May be large contributor to risk premium

Risk and uncovered parity in emerging markets

- Failure of uncovered parity/profitability of carry trade most pronounced for major currency pairs
  - Higher-yielding major currencies appreciate rather than depreciate relative to lower-yielding with surprising frequency
- Emerging market interest rate differentials can be quite wide, but more reliably associated with eventual depreciation
  - Eventually, if not in the full measure of the interest rate differentials
  - And highly uncertain timing, even when volatility is high