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

Swap hedging of foreign exchange and interest rate risk

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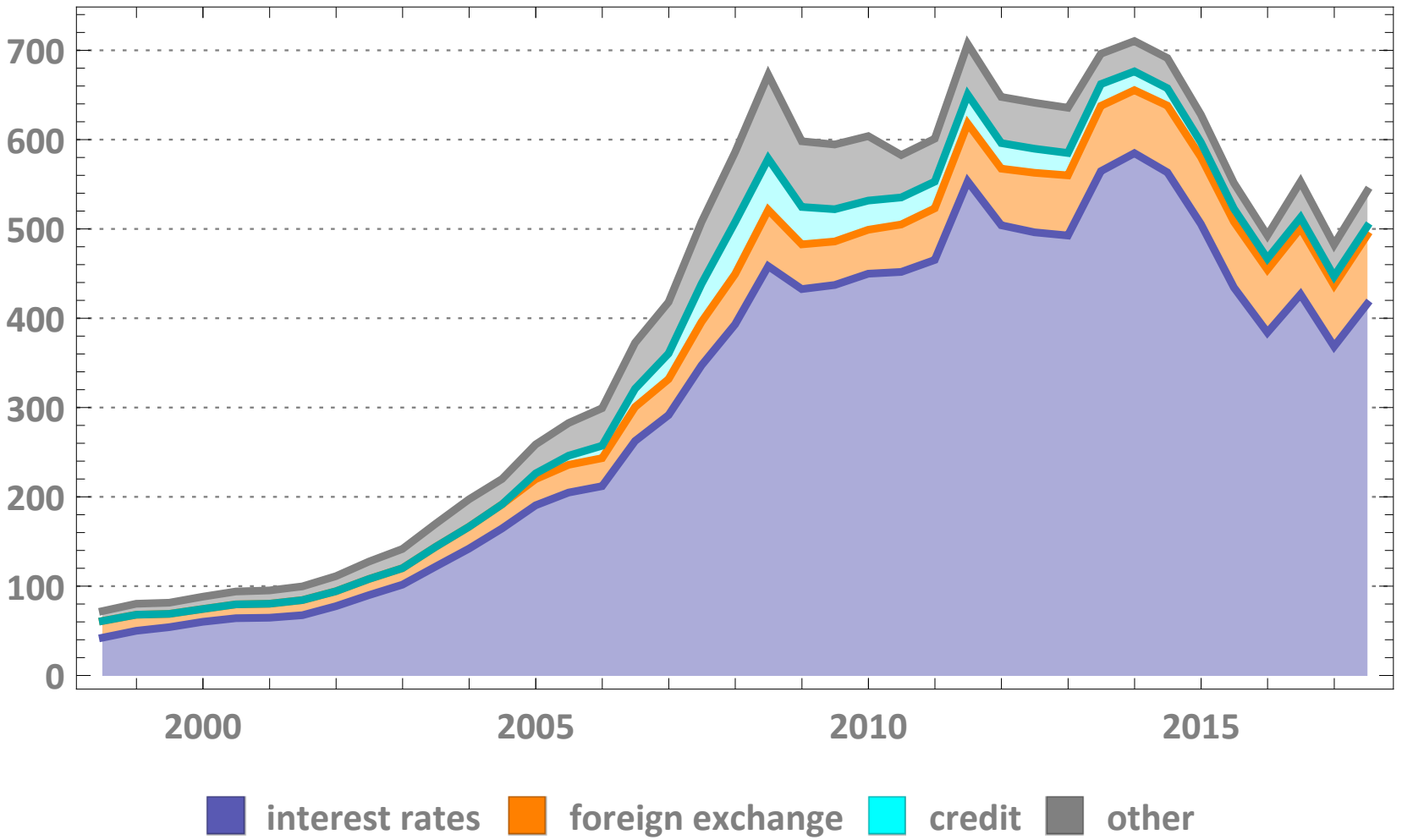
Issues in derivatives markets

- Largest **over-the-counter** (OTC) markets: interest-rate swaps, foreign-exchange forwards
- Measurement problem: size of market differs greatly depending on metric
  - **Notional amounts outstanding:** par value of existing contracts
  - $\leftrightarrow$ market value or NPV
  - Gross vs. net amount: many offsetting trades between pairs of counterparties
  - Efforts at **trade compression**
- Counterparty credit exposure
- Regulatory developments ($\rightarrow$central clearing)

OTC derivatives markets 1998–2017



Notional amounts outstanding, G10 countries including Switzerland, trillions of U.S. dollars, through H1 2017. *Source*: BIS, Semiannual OTC derivatives statistics, Table D5, `www.bis.org/statistics/derstats.htm`.

Swaps: definition and general structure

- A **swap** is a contract in which each counterparty agrees to make a series of payments, based on some observable fixed-income benchmark or index, to the other
  - Indexes are typically money market benchmarks, e.g. Libor
- Size of payments determined by a **notional principal amount** stipulated at outset
  - Notional principal amount itself may or may not be exchanged at start and end of swap
- Two counterparties make payments to one another at set times (quarterly,semi-annually, annually) until a set maturity date
- Generally done through a large bank (so $\exists$ two swaps), and governed by a standardized contract, the **ISDA Master Agreements**
  - Regulatory reform$\rightarrow$**mandatory clearing** replaces bilateral contracts

Major types of swaps

Foreign exchange swap: simultaneous spot purchase and future sale of one currency for another

Interest rate swap: counterparties exchange fixed-rate for floating-rate interest payments on an agreed principal

Currency swap: counterparties exchange interest payments on agreed principals in two different currencies

- **Cross-currency basis swap:** counterparties exchange fixed-rate for floating-rate interest payments on an agreed principal

Credit default swap: protection purchaser makes fixed payments to a seller in exchange for contingent payment if a reference entity defaults

Asset swap: portfolio consisting of a cash position in a bond and an interest rate swap

- E.g. long fixed-rate bond plus paying fixed rate in swap

Uses of foreign exchange and interest rate swaps

- Most businesses have regular cash flows related to financing, e.g.
  - Receivables from customers and payables to suppliers
  - Cash flows related to debt financing
  - Capital expenditures and returns on investments
  - Financial intermediaries' borrowing from providers of capital and lending to employers of capital
- Cash flows may be predictably and enduringly mismatched in some dimension that creates risk, e.g.
  - Import and export businesses: currency of inflows may not match that of outflows
  - Banks: funding costs related to short-term interest rates, while interest income related to longer-term rates
  - Multinational firms: funding advantage in home country, but investments abroad
- Swaps are a market mechanism for mitigating this problem
- Swaps can also be used to take on risk

Swap pricing

- Two counterparties to a swap make either

  Fixed payments or **leg** based on the current level of an index, or
  Floating payments or **leg** based on uncertain future realization of index or other uncertain future event, e.g. default
- Most swaps initiated **at-market:** regular payments equal to index, with no positive or negative spread
- Many swaps initiated with positive or negative spreads, esp.

  Credit spread: some counterparties pay positive or negative spread vis-à-vis index due to lower or higher credit quality than typical counterparty bank
  Basis: market segmentation leads to spread vis-à-vis index, e.g. higher USD borrowing costs for non-U.S. banks

Swap valuation

- For any swap, can compute **net present value** (NPV) of future payments

$$\text{NPV of swap} = \text{PV of fixed payments} - \text{PV of floating payments}$$

- NPV of a swap fluctuates over life of swap as market interest and foreign exchange rates fluctuate, while terms of swap remain fixed
- Absence of arbitrage$\Rightarrow$NPV of an at-market swap $= 0$ at initiation
  - A swap that has been in effect for some time may have a non-zero NPV

Overview of hedging instruments

Hedging instruments for interest rate risk

- Overview of interest rate swaps
- Interest rate swap example

Currency swaps

Structure and cash flows of interest rate swaps

- Describing **plain-vanilla interest rate swap**
- One party pays a fixed interest rate stipulated at outset, floating rate generally indexed to Libor
- Contract signed now, but each pair of payments made at end of a sequence of periods
- Size of payments determined by notional principal, but only interest cash flows, not principal itself, exchanged

Motivation and purpose of interest rate swaps

- Swap can be used to "transform" fixed into floating cash flows or vice versa
- Examples of motivation to **pay fixed** via swaps
  - Harder for some borrowers to issue long-term fixed-rate bonds, face **rollover** (interest-rate) **risk** on floating-rate loans
  - Commercial banks depend primarily on short-term funding, but extend long-term credit
- Example of motivation to **receive fixed** via swaps:
  - Institutional investors, e.g. pension funds, life insurance companies, must fund long-term fixed-rate commitments

Interest rate swap valuation

- If no credit risk or basis—at-market swap—arbitrage enforces equality of present values of swap's fixed and floating payments
  - Thereby enforcing zero NPV of interest rate swap at initiation
- **Par swap rate** is computed as the par coupon rate consistent with the spot or forward yield curve
  - Floating-rate bonds have to price at par
  - $\Rightarrow$Par swap rate is zero-NPV plain-vanilla swap fixed rate

Pricing an interest rate swap

- Spot curve can be used to calculate the coupon of a fixed-rate bond that prices at par

Zero-coupon rate assumptions				
Term	1 year	2 years	3 years	4 years
Spot rates	1.3250	1.7000	1.9250	2.0000
Forward rates		2.0764	2.3765	2.2253

  - $\rightarrow$Fixed rate in a swap against 1-year Libor "flat," i.e. at-market, no spread to Libor

- Using our rate assumptions, for \$100 par value bond:

$$100 = 100r\left(\frac{1}{1.01325} + \frac{1}{1.017^2} + \frac{1}{1.01925^3} + \frac{1}{1.02^4}\right) + \frac{100}{1.02^4}$$

  - $\rightarrow$Par swap rate $r = 0.0199252$ or 1.99252 percent
  - Par swap rate a weighted average of spot rates

Cash flows in the interest rate swap example

- Assume notional principal of 1 000 000
- Apart from credit risk, fixed flows are risk-free
- Cash flows that are uncertain at initiation in orange
  - Table gives one possible scenario for floating cash flows: future 1-year rates happen to equal today's forward interest rates
  - Increase in short-term rates would increase them and v.v.

Cash flows in interest-rate swap				
date	1 year	2 years	3 years	4 years
fixed	19 925.20	19 925.20	19 925.20	19 925.20
floating	13 250.00	20 763.90	23 764.90	22 253.30

Risk mitigation in the interest rate swap example

- Receiver of floating/payer of fixed protected against rise in short-term interest rates
  - Gains on swap offset business losses due to rise in rates
- Receiver of fixed/payer of floating protected against fall in long-term interest rates
  - Gains on swap offset business losses due to fall in rates

Structure and cash flows of currency swaps

- Similar to interest rate swaps:
  - Two counterparties make payments to one another at set times until a set maturity date
  - Contract signed now, but each pair of payments made at end of period
  - Generally done through a large bank, and governed by a standardized contract, but less standardization and far smaller transaction volumes than interest rate swaps
- Contrast to interest rate swaps:
  - *Both* parties may pay a fixed or both a floating interest rate
  - Counterparties' payments based on principal amounts *denominated in different currencies*
  - Principal amounts themselves are exchanged at the beginning and end of the swap
    - Exchange of principal at beginning and end at same exchange rate
    - Keeps it a simple exchange of notional amounts in two different currencies
  - Smaller transaction volumes

Floating and fixed indexes in currency swaps

Fixed-for-fixed currency swap: each party pays a distinct *fixed* interest rate stipulated at outset

- In an at-market swap, both fixed rates drawn from par swap rates

Floating-for-floating currency swap or **cross-currency basis swap:** each party pays a distinct *floating* interest rate stipulated at outset

- In an at-market swap, both floating rates equal to indexes, *if arbitrage among money and foreign exchange markets complete*

Fixed-for-floating currency swap: one party pays a fixed rate, while the other pays a floating rate

- The floating payments may be set at a spread above or below the index

Motivation and purpose of currency swaps

- Used to "transform" cash flows in one currency into another
- Participants may have better access to overseas capital markets in one currency while seeking to finance local business
- In addition to currency mismatch, there may be a mismatch of the "basis," e.g.
  - Interest payments based on MXN 28-day TIIE rate rather than 1-month USD Libor

Currency swap valuation

- Similarities to plain-vanilla interest rate and other swaps:
  - Arbitrage enforces zero NPV of at-market swap at initiation
  - Via covered interest-rate parity
- If each current and future cash flow in one currency is "covered" by buying it forward at today's spot forward exchange rates, then
  - NPV of the future cash flows is 0, discounted using the other currency's spot interest rate curve
  - The lower-rate borrower will have "given back" any funding rate advantage
- $\Rightarrow$Funding rate advantage bundled with currency risk

Motivation of the currency swap example

- How a market for fixed-for-fixed currency swaps might be made:
  - U.S.-domiciled clothing manufacturer wishes to establish factory in Turkey, but relatively disadvantaged in raising TRY funding: raises USD funding and swaps for TRY
  - Turkish firm seeks low-rate USD funding: raises TRY funding and swaps for USD
- Apart from transactions costs, borrowers of foreign currency can get closer to a highly-rated local borrower's cost
  - Simplifying assumption: each borrower pays the foreign currency's market par swap rate
- Fixed-for-fixed USD-TRY 4-year currency swap with annual payments, notional principal of 1 000 000
- Using interest rates computed from forward foreign exchange rates, TRY 4-year swap rate is 14.4668 percent

Cash flows in the currency swap example

- Turkish firm pays USD fixed; U.S. manufacturer pays TRY fixed
- Apart from credit risk, fixed flows are risk-free in local currency
- Cash flows that are uncertain at initiation in orange
  - Scenario based on realization of current forward exchange rates

Cash flows in currency swap				
	Turkish firm's cash flows		U.S.manufacturer's cash flows	
date	USD fixed	USD fixed in TRY	TRY fixed in USD	TRY fixed
today	1 000 000.00	3 750 000.00	1 000 000.00	3 750 000.00
1 year	-16 920.87	-66 541.33	-116 067.29	-456 434.62
2 years	-16 920.87	-69 883.20	-110 516.86	-456 434.62
3 years	-16 920.87	-73 478.88	-105 108.72	-456 434.62
4 years: interest	-16 920.87	-77 328.38	-99 876.29	-456 434.62
4 years: principal	-1 000 000.00	-4 570 000.00	-820 568.93	-3 750 000.00

Risk mitigation in the currency swap example

- "Outside the swap," at initiation
  - U.S. manufacturer borrows USD and uses TRY initial principal to fund investment
  - Turkish firm borrows TRY and exchanges USD initial principal for TRY to fund activities
- "Outside the swap," during the term of the swap
  - U.S. manufacturer repays TRY out of net revenue of local business
  - Turkish firm repays USD from TRY-denominated net revenue
- U.S. manufacturer *reduces* currency risk by matching currencies in which revenue, debt repayment denominated, but pays higher rate to borrow
  - TRY appreciation$\rightarrow$USD value of interest, principal repayments rises
  - No impact on solvency as long as TRY revenues meet projections
- Turkish firm has *increased* risk: now exposed to TRY depreciation
  - TRY revenues may fall short of requirements to meet USD obligation

Credit risks of swaps

- Since NPV fluctuates, at any point in time, either party may have a credit exposure to other
- **Counterparty** risk is credit risk emating from the credit exposure
- Differs in two key respects from credit exposure arising from len ding via loan, lease or security:
  - Credit exposure uncertain: driven by fluctuations in market prices, rather than having precisely predictable par value (plus accruals)
  - From standpoint of either counterparty, credit exposure may switch back and forth between positive or negative
- Often induces **wrong-way risk**: asset-price fluctuations that increase credit exposure also adversly affect counterparty credit
  - **Example**: foreign-exchange swap in which local bank pays dollars
- CDS or guarantee: **double default risk**, both underlying credit and counterparty must default to generate loss
- Managed/mitigated by monitoring, diversification of counterparties, limits, hedging via CDS, collateral, netting
  - Collateral, netting typically governed by ISDA Master Agreement

Credit Valuation Adjustment

- **Credit Valuation Adjustment** (CVA) is the difference between the market value of the derivatives contract and its market value if it were free of credit risk
  - Thus equal to expected loss due to counterparty default
  - Market value of counterparty risk, equal in principle to hedging cost
  - Net of collateral
- Required for fair-value hedge accounting and by Basel capital standards
  - If derivatives contract closed out without loss, CVA returned to P&L
  - Contra-asset account, similar to banks' ALL account
- CVA measured using estimates of exposure and credit risk parameters: default probability, recovery, etc.
  - Methods based on full simulation of future exposures and defaults
  - Simpler approaches based on current exposures