GLOBAL EDITION

# FUNDAMENTALS OF FUTURES AND OPTIONS MARKETS

Ninth Edition

John C. Hull

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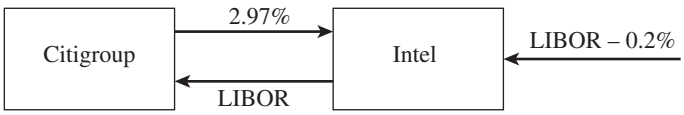


**Figure 7.6** Intel uses the swap in Figure 7.3 to convert a floating-rate investment into a fixed-rate investment

These three sets of cash flows net out to an interest rate inflow of 2.77%. Thus, one possible use of the swap for Intel is to transform an asset earning LIBOR minus 20 basis points into an asset earning 2.77%.

## Organization of Trading

As discussed in Sections 1.3 and 2.5, following the credit crisis of 2008 there was an international agreement that standard swaps, where appropriate, be traded on electronic platforms and cleared through central counterparties (CCPs). The swaps are then treated like futures contracts in that initial and variation margin is posted by both sides.[2]

Most countries have made progress implementing the international agreement. For example, in the United States there is now a rule requiring that standard swap transactions between financial institutions be executed on electronic platforms, known as swap execution facilities, and be cleared through a CCP. This rule does not apply when one of the parties to a swap agreement is an end user, whose main activity is not financial and who is using swaps to hedge or mitigate commercial risk.[3] In the examples in Figures 7.1 and 7.3, Apple and Intel are nonfinancial companies. Assuming they are using the swaps to mitigate risk, the trades could be entered into directly with Citigroup and cleared bilaterally.

Occasionally a financial institution may be lucky enough to enter into offsetting trades with two different nonfinancial companies (such as Apple and Intel) at about the same time. Usually, however, when it enters into a trade such as that in Figure 7.1, it must manage its risk by entering into the opposite trade with another financial institution. The trade with the other financial institution will be executed on an electronic platform and cleared through a CCP. The financial institution could then be in the position where the trade with the nonfinancial company is uncollateralized (with no initial or variation margin being posted) while the offsetting trade is fully collateralized (with both initial and variation margin being posted).

Note that in Figure 7.1 Citigroup received 3% in a three-year swap, whereas in Figure 7.3 it pays 2.97%. Citigroup is a market maker in interest rate swaps. The example indicates that it has built a three-basis-point spread into the rates at which it transacts. This spread is to compensate it for its overheads and for potential losses in the event of a default by a counterparty.

Table 7.3 shows the full set of quotes for plain vanilla U.S. dollar swaps that might be made by a market maker such as Citigroup.[4] The bid–offer spread is three to four

[2] However, they differ from futures contracts in that there is no daily settlement.

[3] The rule does apply to insurance companies and pension plans when they use swaps to mitigate risks.

[4] The standard swap in the United States is one where fixed payments made every six months are exchanged for floating LIBOR payments made every three months. For ease of exposition, we assumed that fixed and floating payments are exchanged every six months in Table 7.1.

**Table 7.3** Bid and offer fixed rates in the swap market for a swap where payments are exchanged semiannually (percent per annum)

| *Maturity* (*years*) | *Bid* | *Offer* | *Swap rate* |
|---|---|---|---|
| 2 | 2.55 | 2.58 | 2.565 |
| 3 | 2.97 | 3.00 | 2.985 |
| 4 | 3.15 | 3.19 | 3.170 |
| 5 | 3.26 | 3.30 | 3.280 |
| 7 | 3.40 | 3.44 | 3.420 |
| 10 | 3.48 | 3.52 | 3.500 |

basis points. The average of the bid and offer fixed rates is known as the *swap rate.* This is shown in the final column of Table 7.3.

## 7.2 DAY COUNT ISSUES

We discussed day count conventions in Section 6.1. The day count conventions affect payments on a swap, and some of the numbers calculated in the examples we have given do not exactly reflect these day count conventions. Consider, for example, the six-month LIBOR payments in Table 7.1. Because it is a money market rate, six-month LIBOR is quoted on an actual/360 basis. The first floating payment in Table 7.1, based on the LIBOR rate of 2.2%, is shown as $1.10 million. Because there are 184 days between March 8, 2016, and September 8, 2016, it should be

$$100 \times 0.022 \times \frac{184}{360} = \$1.1244 \text{ million}$$

In general, a LIBOR-based floating-rate cash flow on a swap payment date is calculated as $L\,Rn/360$, where $L$ is the principal, $R$ is the relevant LIBOR rate, and $n$ is the number of days in the accrual period.

The fixed rate that is paid in a swap transaction is similarly quoted with a particular day count basis being specified. As a result, the fixed payments may not be exactly equal on each payment date. The fixed rate is usually quoted as actual/365 or 30/360. It is not therefore directly comparable with LIBOR because it applies to a full year. To make the rates comparable, either the six-month LIBOR rate must be multiplied by 365/360 or the fixed rate must be multiplied by 360/365.

For ease of exposition, we will ignore day count issues in our valuations of swaps in this chapter.

## 7.3 CONFIRMATIONS

When swaps are traded bilaterally a legal agreement, known as a confirmation, is signed by representatives of the two parties. The drafting of confirmations has been facilitated by the work of the International Swaps and Derivatives Association (ISDA) in New York. This organization has produced a number of Master Agreements that consist of clauses defining in some detail the payments required by the two sides, what happens in

**Business Snapshot 7.1** Extract from hypothetical swap confirmation

| | |
|---|---|
| Trade date | 1-March-2016 |
| Effective date | 8-March-2016 |
| Business day convention (all dates) | Following business day |
| Holiday calendar | U.S. |
| Termination date | 8-March-2019 |
| *Fixed amounts* | |
| Fixed-rate payer | Apple Inc. |
| Fixed-rate notional principal | USD 100 million |
| Fixed rate | 3.0% per annum |
| Fixed-rate day count convention | Actual/365 |
| Fixed-rate payment dates | Each 8-March and 8-September commencing 8-September, 2016, up to and including 8-March, 2019 |
| *Floating amounts* | |
| Floating-rate payer | Citigroup Inc. |
| Floating-rate notional principal | USD 100 million |
| Floating rate | USD 6-month LIBOR |
| Floating-rate day count convention | Actual/360 |
| Floating-rate payment dates | Each 8-March and 8-September commencing 8-September, 2016, up to and including 8-March, 2019 |

the event of default by either side, collateral requirements (if any), and so on. Business Snapshot 7.1 shows a possible extract from the confirmation for the swap between Apple and the Citigroup in Figure 7.1. Almost certainly, the full confirmation would state that the provisions of an ISDA Master Agreement apply to the contract.

The confirmation specifies that the following business day convention is to be used and that the U.S. calendar determines which days are business days and which days are holidays. This means that, if a payment date falls on a weekend or a U.S. holiday, the payment is made on the next business day.[5] September 8, 2018, is a Saturday. The fifth exchange of payments is therefore on Monday September 10, 2018.

## 7.4 THE COMPARATIVE-ADVANTAGE ARGUMENT

An explanation commonly put forward to explain the popularity of swaps concerns comparative advantages. In this context, a comparative advantage is advantage that leads to company being treated more favorably in one debt market than in another debt market. Consider the use of an interest rate swap to transform a liability. Some companies, it is argued, have a comparative advantage when borrowing in fixed-rate

[5] Another business day convention that is sometimes specified is the *modified following* business day convention, which is the same as the following business day convention except that when the next business day falls in a different month from the specified day, the payment is made on the immediately preceding business day. *Preceding* and *modified preceding* business day conventions are defined analogously.

markets, whereas other companies have a comparative advantage when borrowing in floating-rate markets. To obtain a new loan, it makes sense for a company to go to the market where it has a comparative advantage. As a result, the company may borrow fixed when it wants floating, or borrow floating when it wants fixed. The swap is used to transform a fixed-rate loan into a floating-rate loan, and vice versa.

## Illustration

Suppose that two companies, AAACorp and BBBCorp, both wish to borrow $10 million for five years and have been offered the rates shown in Table 7.4. AAACorp has a AAA credit rating; BBBCorp has a BBB credit rating.[6] We assume that BBBCorp wants to borrow at a fixed rate of interest, whereas AAACorp wants to borrow at a floating rate of interest linked to six-month LIBOR. Since BBBCorp has a worse credit rating than AAACorp, it pays a higher rate of interest in both fixed and floating markets.

A key feature of the rates offered to AAACorp and BBBCorp is that the difference between the two fixed rates is greater than the difference between the two floating rates. BBBCorp pays 1.2% more than AAACorp in fixed-rate markets and only 0.7% more than AAACorp in floating-rate markets. BBBCorp appears to have a comparative advantage in floating-rate markets, whereas AAACorp appears to have a comparative advantage in fixed-rate markets.[7] It is this apparent anomaly that can lead to a swap being negotiated. AAACorp borrows fixed-rate funds at 4% per annum. BBBCorp borrows floating-rate funds at LIBOR plus 0.6% per annum. They then enter into a swap agreement to ensure that AAACorp ends up with floating-rate funds and BBBCorp ends up with fixed-rate funds.

To understand how the swap might work, we first assume (somewhat unrealistically) that AAACorp and BBBCorp get in touch with each other directly. The sort of swap they might negotiate is shown in Figure 7.7. AAACorp agrees to pay BBBCorp interest at six-month LIBOR on $10 million. In return, BBBCorp agrees to pay AAACorp interest at a fixed rate of 4.35% per annum on $10 million.

AAACorp has three sets of interest rate cash flows:

1. It pays 4% per annum to outside lenders.
2. It receives 4.35% per annum from BBBCorp.
3. It pays LIBOR to BBBCorp.

**Table 7.4** Borrowing rates that provide a basis for the comparative-advantage argument

| | *Fixed* | *Floating* |
|---|---|---|
| AAACorp | 4.0% | 6-month LIBOR − 0.1% |
| BBBCorp | 5.2% | 6-month LIBOR + 0.6% |

[6] The credit ratings assigned to companies by S&P and Fitch (in order of decreasing creditworthiness) are AAA, AA, A, BBB, BB, B, and CCC. The corresponding ratings assigned by Moody's are Aaa, Aa, A, Baa, Ba, B, and Caa, respectively.

[7] Note that BBBCorp's comparative advantage in floating-rate markets does not imply that BBBCorp pays less than AAACorp in this market. It means that the extra amount that BBBCorp pays over the amount paid by AAACorp is less in this market. One of my students summarized the situation as follows: "AAACorp pays more less in fixed-rate markets; BBBCorp pays less more in floating-rate markets."

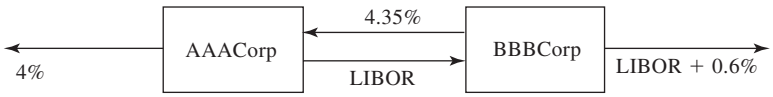


**Figure 7.7** Swap agreement between AAACorp and BBBCorp when rates in Table 7.4 apply

The net effect of the three cash flows is that AAACorp pays LIBOR minus 0.35% per annum. This is 0.25% per annum less than it would pay if it went directly to floating-rate markets.

BBBCorp also has three sets of interest rate cash flows:

1. It pays LIBOR + 0.6% per annum to outside lenders.
2. It receives LIBOR from AAACorp.
3. It pays 4.35% per annum to AAACorp.

The net effect of the three cash flows is that BBBCorp pays 4.95% per annum. This is 0.25% per annum less than it would pay if it went directly to fixed-rate markets.

In this example, the swap has been structured so that the net gain to both sides is the same, 0.25%. This need not be the case. However, the total apparent gain from this type of interest rate swap arrangement is always $a - b$, where $a$ is the difference between the interest rates facing the two companies in fixed-rate markets, and $b$ is the difference between the interest rates facing the two companies in floating-rate markets. In this case, $a = 1.2\%$ and $b = 0.7\%$, so that the total gain is 0.5%.

If the transaction between AAACorp and BBBCorp were brokered by a financial institution, an arrangement such as that shown in Figure 7.8 might result. In this case, AAACorp ends up borrowing at LIBOR − 0.33%, BBBCorp ends up borrowing at 4.97%, and the financial institution earns a spread of four basis points per year. The gain to AAACorp is 0.23%; the gain to BBBCorp is 0.23%; and the gain to the financial institution is 0.04%. The total gain to all three parties is 0.5% as before.

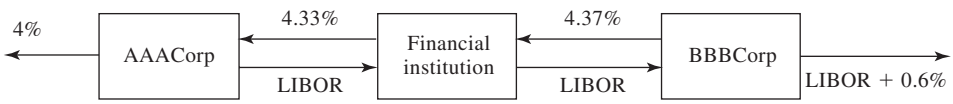


**Figure 7.8** Swap agreement between AAACorp and BBBCorp when rates in Table 7.4 apply and swap is brokered by a financial institution

## Criticism of the Comparative-Advantage Argument

The comparative-advantage argument we have just outlined for explaining the attractiveness of interest rate swaps is open to question. Why in Table 7.4 should the spreads between the rates offered to AAACorp and BBBCorp be different in fixed and floating markets? Now that the interest rate swap market has been in existence for a long time, we might reasonably expect these types of differences to have been arbitraged away.

The reason that spread differentials appear to exist is due to the nature of the contracts available to companies in fixed and floating markets. The 4.0% and 5.2% rates available to AAACorp and BBBCorp in fixed-rate markets are five-year rates (for example, the rates at which the companies can issue five-year fixed-rate bonds). The

LIBOR − 0.1% and LIBOR + 0.6% rates available to AAACorp and BBBCorp in floating-rate markets are six-month rates. In the floating-rate market, the lender usually has the opportunity to review the spread above LIBOR every time rates are reset. (In our example, rates are reset semiannually.) If the creditworthiness of AAACorp or BBBCorp has declined, the lender has the option of increasing the spread over LIBOR that is charged. In extreme circumstances, the lender can refuse to continue the loan. The providers of fixed-rate financing do not have the option to change the terms of the loan in this way.[8]

The spreads between the rates offered to AAACorp and BBBCorp are a reflection of the extent to which BBBCorp is more likely to default than AAACorp. During the next six months, there is very little chance that either AAACorp or BBBCorp will default. As we look further ahead, default statistics show that on average the probability of a default by a company with a BBB credit rating increases faster than the probability of a default by a company with a AAA credit rating. This is why the spread between the five-year rates is greater than the spread between the six-month rates.

After negotiating a floating-rate loan at LIBOR + 0.6% and entering into the swap shown in Figure 7.8, BBBCorp appears to obtain a fixed-rate loan at 4.97%. The arguments just presented show that this is not really the case. In practice, the rate paid is 4.97% only if BBBCorp can continue to borrow floating-rate funds at a spread of 0.6% over LIBOR. If, for example, the credit rating of BBBCorp declines so that the floating-rate loan is rolled over at LIBOR + 1.6%, the rate paid by BBBCorp increases to 5.97%. The market expects that BBBCorp's spread over six-month LIBOR will on average rise during the swap's life. BBBCorp's expected average borrowing rate when it enters into the swap is therefore greater than 4.97%.

The swap in Figure 7.8 locks in LIBOR − 0.33% for AAACorp for the whole of the next five years, not just for the next six months. This appears to be a good deal for AAACorp. The downside is that it is bearing the risk of a default by the financial institution. If it borrowed floating-rate funds in the usual way, it would not be bearing this risk.

## 7.5 VALUATION OF INTEREST RATE SWAPS

We now move on to discuss the valuation of interest rate swaps. An interest rate swap is worth close to zero when it is first initiated. After it has been in existence for some time, its value may be positive or negative.

Each exchange of payments in an interest rate swap is a forward rate agreement (FRA) where interest at a predetermined fixed rate is exchanged for interest at the LIBOR floating rate. Consider, for example, the swap between Apple and Citigroup in Figure 7.1. The swap is a three-year deal entered into on March 8, 2016, with semiannual payments. The first exchange of payments is known at the time the swap is negotiated. The other five exchanges can be regarded as FRAs. The exchange on March 8, 2017, is an FRA where interest at 3% is exchanged for interest at the six-month LIBOR rate observed in the market on September 8, 2016; the exchange on

[8] If the floating-rate loans are structured so that the spread over LIBOR is guaranteed in advance regardless of changes in credit rating, there is in practice little or no comparative advantage.