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HEDGED COST OF FUNDS AND INTEREST RATE ARBITRAGE

A central benefit of a globalized financial system is that corporations can seek capital outside their domestic markets. These foreign borrowings will, of course, be denominated in foreign currencies, which introduce a source of uncertainty into what might otherwise be a relatively certain stream of cash flows. In effect, currency fluctuations impact the cost of borrowing. For example, if a foreign currency appreciates, then a corporation will have to pay more in its domestic currency to meet the same foreign currency obligation.

Of course, opportunities to mitigate the currency risk associated with foreign borrowings are readily available. This note outlines the essential logic and calculations for hedged foreign borrowings and also describes how the resulting activities in the currency and money markets affect exchange rates and interest rates, respectively, in those markets.

Overview of Hedged Borrowing

If a firm borrows in another currency, the actual amount of domestic currency needed to make interest and principal payments will depend on the exchange rate at the time of payment. For this reason, it is incorrect to simply compare domestic and foreign effective interest rates to assess their relative cost. Consider the following information for Arbor Company, which can borrow for one year in either Norwegian krone (NOK) or U.S. dollars (USD).

Currency Market	
Spot USD/NOK	0.160
One-year future expected spot USD/NOK	0.156
Interest Rates (for one-year loans to Arbor Company)	
Dollar	6.75%
Krone	8.50%

Although krone borrowing may appear more expensive, this is not the case when we account for changes in the krone and dollar exchange rate. The krone is expected to depreciate (the expected future spot rate is lower than the current spot rate). If Arbor pays back the krone borrowing after the krone has depreciated, the effective cost of the loan would be lower.

We might ask, therefore, whether the expected change in the value of the krone is enough to make borrowing in krone a good idea. We can approximate the borrowing cost including expected currency effects by adding the expected change in the value of the krone to the interest rate. In this case, the expected change in the value of the krone is a 2.50% depreciation, calculated as (0.156 − 0.160) ÷ 0.160 = −2.50%, and Arbor would therefore expect to pay about 8.50% − 2.50% = 6.00%.[1] This is much lower than the U.S. rate; however, this simple calculation is just an approximation.[2] The best way to calculate the net cost is to map out the expected cash flows. In this case, let us assume Arbor borrows enough to net USD1,000,000 and agrees to pay principal and interest in one year. The cash flows are shown below.

	Dollar Cash Flow		Krone Cash Flow	Exchange Rate
Now:				
Borrow and convert (spot)	+1,000,000	←	+6,250,000	0.160 USD/NOK
One year:				
Convert (spot) and repay	−1,057,875	→	−6,781,250	0.156 USD/NOK
Implied interest rate	5.788%		8.50%	

The logic behind the cash flow diagram is the following: Arbor would have to borrow USD1,000,000 ÷ 0.160 = NOK6,250,000 to net USD1,000,000. At maturity in one year, Arbor will owe principal and interest of NOK6,250,000 (1 + 0.085) = NOK6,781,250. At the expected exchange rate, this implies an expected dollar payment of NOK6,781,250 × 0.156 USD/NOK = USD1,057,875. The implied effective interest rate is 5.788%—clearly cheaper than the U.S. loan. Since this rate is the effective rate at the expected future spot rate, it can be referred to as the *expected cost of funds*.

Hedged cost of funds

Though the expected cost of funds for a krone loan is lower than that of a dollar loan, the krone loan may not be preferred. The possibility of an exchange rate movement makes the 5.788% rate uncertain and not quite comparable to the certain 6.75% U.S. rate. This variability

[1] Depreciation and appreciation are calculated as the expected percentage change in a currency relative to the spot rate—the difference between the expected future spot rate and the current spot rate divided by the current spot rate. Forward premiums and discounts (discussed later in this note) are calculated the same way, but it is the difference between the forward rate and the spot rate reflected as a percentage.

[2] This is an approximation since the currency change and interest payments actually compound. Simply adding them is not quite correct. This is similar to nominal and real interest rates—we often state that the nominal rate is the real rate plus inflation, when the actual relation is $(1 + r) = (1 + a)(1 + i)$, where r, a, and i are the nominal interest rate, real interest rate, and inflation rate, respectively.

reduces the desirability of the loan. To mitigate the currency risk, Arbor can use a forward contract to lock in a rate for its repayment.[3]

Assume the same hypothetical borrowing, but instead of an uncertain 0.156 expected exchange rate, assume that Arbor can lock in an exchange rate in one year (a forward rate) of 0.158 USD/NOK. In this case, Arbor will pay NOK6,781,250 × 0.158 USD/NOK = USD1,071,438, which implies a borrowing rate of about 7.14%. The cash flows for this borrowing are shown below.

	Dollar Cash Flow		**Krone Cash Flow**	**Exchange Rate**
Now: *Borrow and convert (spot)*	+1,000,000	←	+6,250,000	0.160 USD/NOK
One year: *Convert (fwd) and repay*	−1,071,438	→	−6,781,250	0.158 USD/NOK
Implied interest rate	7.14%		8.50%	

In this case, the Krone loan is no longer attractive. Note that the 7.14% effective rate obtained with the forward contract is no longer subject to exchange rate risk. That risk has been hedged away with the forward contract. For this reason, the 7.14% rate is often referred to as the *hedged cost of funds*.[4]

To summarize, the actual cost of borrowing in a foreign currency will depend critically on exchange rates. Furthermore, a foreign currency borrowing, unlike domestic borrowing, will have an added uncertainty due to the risk that the realized exchange rate may differ from what was expected. This makes the comparison of borrowings very difficult. But the existence of forward markets to eliminate the risk of changing exchange rates allows an individual or a firm to generate known cash flows from international borrowings and therefore make valid comparisons.

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[3] A forward contract is a contract to exchange a given amount of one currency for a given amount of another currency at some point in the future. This contract effectively locks in a future exchange rate today. That exchange rate is the forward rate.

[4] Notice that the hedged cost of funds is composed of two elements: the foreign interest rate and the forward premium or discount implied by the forward rate. In the case where the firm borrows in a foreign currency at a rate r_f with principal and interest due in *one year* and a forward premium or discount on the *foreign* currency of p, the hedged cost of funds (domestic currency effective rate), r_h, can be calculated from the following relation: $(1 + r_f) \times (1 + p) = (1 + r_h)$. Notice the similarity to the nominal interest rate calculation in footnote 2. In our example, the krone is selling at $(0.158 - 0.160) \div 0.160 = -1.25\%$, a discount of 1.25%. Thus, after rearranging the above formula, the hedged cost of funds would be $(1 + 0.085)(1 - 0.0125) - 1 = 7.14\%$. Of course, this calculation is only valid for the most simple loan structure—principal and interest due in one year. By looking at the actual cash flows associated with any specific borrowing and the forward contracts needed to hedge the borrowing, we can calculate a hedged cost of funds for much more complicated borrowings.

In Arbor's case, the hedge cost of borrowing in krone was higher than the domestic rate, so between U.S. dollar borrowing and hedged krone borrowing, Arbor should strictly prefer the U.S. borrowing. This does *not*, however, rule out the unhedged krone borrowing. That expected cost was lower, and the company may accept the attendant risk in order to secure the lower rate. What drives the relative attractiveness of the unhedged borrowing, of course, is that the expected exchange rate in this example differs from the forward rate in a manner that favors krone borrowing—the expected rate implies a depreciation of 2.50%, whereas the krone is selling at only a 1.25% discount in the forward market [(0.158 − 0.160) / 0.160 = −1.25%].

Hedged cost of funds with multiple payments

If the required interest payments involve more than one payment, then a number of forward contracts will be needed, and the calculation of the hedged cost is more involved. Again, the approach to use in this case is to find the hedged stream of domestic payments using the forward rates and then calculate the effective interest rate for that stream of payments.

For example, assume that Arbor considered raising its $1 million with a two-year krone loan in which the firm paid accumulated interest and one-half the principal in one year and the remaining principal plus any accrued interest in two years. Assume further that this loan could be obtained at a rate of 9.25% (we increase the borrowing rate to reflect a yield curve that is likely to slope upward). The krone cash flows would be as follows: in one year 6,250,000 × 0.0925 + 6,250,000 ÷ 2 = NOK3,703,125; and in two years 6,250,000 ÷ 2 × 0.0925 + 6,250,000 ÷ 2 = NOK3,414,063. Assume that in addition to the USD0.158 per krone one-year forward rate, the firm also arranged a 0.154 forward rate in two years. We can find the dollar-denominated hedged cash flows and determine the effective (implied) interest rate on those cash flows. That will be the hedged cost of funds as shown below.

	Dollar Cash Flow		**Krone Cash Flow**	**Exchange Rate**
Now:				
Borrow and convert (spot)	+1,000,000	←	+6,250,000	0.160 USD/NOK
One year:				
Convert (fwd) and repay	−585,084	→	−3,703,125	0.158 USD/NOK
Two years:				
Convert (fwd) and repay	−525,766	→	−3,414,063	0.154 USD/NOK
Implied interest rate	7.44%		9.25%	

Notice that we calculate an implied rate for the borrowing (the internal rate of return of the cash flows) to find the hedged cost of funds. Notice also that the implied rate on the krone cash flow, as expected, is equal to the effective rate that was used to determine the cash flows. If

Arbor's U.S. borrowing alternative were, for example, 7.50% (once again, we acknowledge the effects of the yield curve), then the hedged Krone two-year loan would be preferred to a similar U.S. two-year loan.

Interest Rate Parity

Given the ease of international borrowing and ability to hedge currency movements in liquid currency markets as just described, there exists an implied link between currency markets and money markets. This link results from the possibility of arbitrage between the markets. In effect, there exists a set of transactions that provides riskless profits when the forward premium or discount on a currency does not offset the difference between the interest rates in the two countries. This set of transactions, called *covered interest arbitrage,* establishes a strong relation between interest rates and forward premiums or discounts.

Covered interest arbitrage profits exist when the forward market premium or discount does not offset the difference in interest rates. To see why this is the case, consider first that to mitigate exchange rate risk, one can use a forward contract to lock in a known change in exchange rates. If this is done, the net return from investing in a riskless security denominated in a foreign currency will be equal to the return on the investment plus the premium or discount on the currency. For the return on investments in different currencies to be equal, those currencies with higher returns on investments should be selling at a discount. In fact, the premium or discount should exactly offset the difference in returns.

Consider the market conditions show below. We have included here a forward rate that is *not* the same as the forward rate assumed earlier. Furthermore, the interest rates here are government security rates, not rates for a specific firm. To simplify our analysis, we will ignore transaction costs of all types, so one can either borrow or lend at the given interest rates and buy or sell at the given exchange rates.

Currency Market	
Spot USD/NOK	0.160
One year forward USD/NOK	0.157
Interest Rates (one-year riskless government securities)	
Dollar	3.50%
Krone	4.80%

Notice that the krone interest rate is 1.30% higher than the U.S. rate. Furthermore, the forward rate implies a krone discount of 1.875% [(0.157 − 0.160) ÷ 0.160 = −1.875%]. Since the discount is higher than the interest difference, the net cost of borrowing in krone [4.80% + (−1.875%) = 2.925%] will be lower than the return earned on dollars [3.50%]. This suggests profits might be available.[5] Covered interest arbitrage essentially locks in a cost of borrowing in one currency (acknowledging any currency effects) that is lower than the return that can be earned in another currency. The transactions are summarized below:

1. Borrow in one currency.
2. Transfer the borrowings on the spot market into another currency.
3. Invest the transferred funds in riskless securities.
4. Enter a forward contract to transfer the proceeds from the maturing investments back into the original currency.
5. When the investments mature, use the forward contract to transfer the funds, payoff the interest and principal on the borrowings, and pocket any excess.

Let us consider the possible profits that would be earned if an arbitrageur executed a covered interest arbitrage where the arbitrageur borrows NOK500,000. The resulting cash flows are shown below.

	Dollar Cash Flow		**Krone Cash Flow**	**Exchange Rate**
Now:				
Borrow and convert (spot)	+80,000	←	+500,000	0.160 USD/NOK
Invest in dollar security	−80,000			
	0			
One year:				
Obtain proceeds	+82,800			
Convert (fwd) and repay	−82,268	→	−524,000	0.157 USD/NOK
	532			

In these cash flows, the arbitrageur transferred back into NOK just enough to pay off the borrowing, an amount equal to NOK500,000 (1 + 0.048) = NOK524,000. The result of these transactions is a net profit of USD532. Notice that there is no risk associated with these cash flows since all the amounts are contracted at one point in time.

Though the amount is small, the lack of risk means large sums will be allocated to this arbitrage and the resulting transactions will generate pressures on the exchange and money markets. In particular, there would be borrowing in krone driving krone interest rates up,

[5] Comparing interest differences with the premium or discount only "suggests" profits since that comparison ignores the effect of the premium or discount on the interest earned. A more exact formula is provided subsequently, though even that formula only applies in the simple case where we consider single annual cash flows. In practice, there are also transaction costs, such as fees, bid/ask spreads, and differences in borrowing and lending rates. For these reasons, the best way to actually determine the existence of profits is to calculate the actual net profit from a given set of transactions.

investing in dollars driving dollar interest rates down, selling of the krone in the spot market driving its spot value down, buying of krone on the forward market driving its forward value upwards. The first two effects would increase the interest differences between dollar and krone and the latter two would decrease the discount on the krone.[6] These pressures will continue as long as profits from arbitrage exist.

The profits existed because the forward discount on the krone did not offset the difference in interest rates between the krone and the dollar. Conversely, when the forward premium or discount exactly offsets the interest differential, there is no incentive for to engage in arbitrage. This state of the markets is referred to as *interest rate parity*: the forward premium or discount between two currencies will offset the difference in interest rates between the two currencies.

The formula that expresses this relation can be derived directly from the covered interest arbitrage transactions. Let us assume one borrows an amount of foreign currency equal to B. Interest rate parity states that the amount one obtains by converting this amount at the spot rate (multiply B by s_0, where s_0 is the spot rate), investing the proceeds (multiply by $1 + r_d$, where r_d is the effective domestic currency interest rate from now to date t) and converting the matured investment back to the foreign currency at the forward rate (divide by f_t), must equal the same amount invested in the foreign money market (multiply B by $1 + r_f$ where r_f is the effective foreign currency interest rate from now to date t).[7] Setting the domestic and foreign cash flows equal and simplifying, in **Equation 1** we obtain:[8]

$$\frac{1+r_d}{1+r_f} = \frac{f_t}{s_0} \tag{1}$$

In our krone example one possible outcome consistent with parity is for the forward rate to move to 0.158 USD/NOK and the other rates to remain unchanged. This rate is the forward rate we assumed earlier in this note—a rate consistent with interest rate parity.

It should be clear that profitable arbitrage opportunities will be taken by any individual in a position to do so since wealth is guaranteed to increase. In fact, individuals will incur costs to find arbitrage opportunities so long as the costs are lower than the profits. Since arbitrage profits are riskless, there is no need to consider expectations of future events when establishing their

[6] The interest differential is 3.50% − 4.80% = −1.30%, which will increase in magnitude (become more negative) as dollar interest rates decline and krone rates increase. The premium or (in this case) discount, is (0.157 – 0.160) ÷ 0.160 = −1.875%, which will decrease in magnitude (become less negative) as the forward rate rises and the spot rate declines.

[7] Note that which currency is considered "domestic" and which "foreign" is implied by the exchange rate: the rates are assumed to express the foreign currency value in terms of the domestic currency. Also, it may seem more natural to think in terms of countries, rather than currencies; however, the markets upon which currencies and securities are traded can be located anywhere, and it is, in the end, the currency that matters.

[8] The steps just described state that $Bs_0(1 + r_d)\,(1/f_t) = B(1 + r_f)$, which simplifies to formula (4) after cancelling out the initial borrowing B and rearranging.

profitability. Hence, all traders will be in agreement as to the existence of arbitrage opportunities and will act in the same manner to realize profits. This will have a strong effect on global markets and makes arbitrage a powerful basis for describing relations between market variables.

Hedged Cost of Funds Calculated from Interest Rates

As a result of the tight link between currency markets and money markets that arises from arbitrage between these markets, forward rates can be directly inferred from interest rates. In fact, since one can actually construct a forward contract from sets of interest rate contracts, a schedule of interest rates over time essentially generates a set of forward rates over time.[9] With these forward rates, one can then construct a set of hedged future cash flows associated with any borrowing. These hedged cash flows finally can be used to calculate a hedged cost of borrowing.

We begin by recognizing how forward rates can be calculated for multiple periods from interest rates. To see this, first note that **Equation 1** can be rewritten as **Equation 2**:

$$f_t = s_0 \frac{1 + r_d}{1 + r_f} \tag{2}$$

In this formula, the interest rates are the effective rates from the current time to date *t*. For example, if one calculated a forward rate 30 days into the future, it would be a 30-day effective rate and could be obtained by taking annual yields to maturity and dividing by 12. In the case where date *t* is two years in the future, one could calculate the effective rate for two years by compounding the annual yields for two years.

Consider the interest rates shown below. These are the effective annual yields for borrowings that pay principal and interest at maturity. Thus the rate on a two-year bond is the annual effective rate from holding the bond for the two years (this should not be confused with the interest rate *in* the second year). Given the interest rates, we can calculate the implied forward rate assuming interest parity holds. Next to each implied forward rate, we show the calculation that would give the associated forward rate for the maturity of the bond. Note that the spot rate equals USD0.160 per krone, and that each currency has an upward-sloping yield curve and that we have rounded the forward rates to three decimals.

[9] The actual construction of synthetic forward rates from the interest rates is beyond the scope of this note. Suffice it to say that a set of money market contracts can yield a forward rate for a date determined by the maturity of the money market contracts.

Maturity	Interest Rate Dollar	Interest Rate Krone	Implied Forward	Calculation
1	3.50%	4.80%	0.158	$0.16 \times (1 + 0.0350) \div (1 + 0.0480)$
2	3.75%	5.75%	0.154	$0.16 \times (1 + 0.0375)^2 \div (1 + 0.0575)^2$
3	3.95%	6.55%	0.148	$0.16 \times (1 + 0.0395)^3 \div (1 + 0.0655)^3$
4	4.10%	7.22%	0.142	$0.16 \times (1 + 0.0410)^4 \div (1 + 0.0722)^4$
5	4.20%	7.45%	0.137	$0.16 \times (1 + 0.0420)^5 \div (1 + 0.0745)^5$

Please note again that the interest rates used in this context were not the borrowing rates for Arbor. Each company or borrower may face different interest rates depending on firm characteristics. In other words, interest rate parity applies at the macro level, not for each firm. In fact, if a firm were able to borrow at the rates used in this calculation, then it would never have a preference of borrowing in one currency over another since, by construction, those markets are in parity. The interest rates in this chart are used strictly to establish forward rates.

We can now extend this analysis to consider the hedged cost of borrowing $1 million for Arbor if the firm were to consider a five-year krone loan. In particular, if we assume Arbor borrowed in krone and agreed to pay 11% interest annually with principal due at maturity. The 11% rate, of course, reflects the relatively long term of the bond and the yield curve. The cash flows would be as shown below (implied rates from above).

Year	Implied Forward	Krone Cash Flows		Dollar Cash Flows	Calculation
0	0.160	+6,250,000	←	+1,000,000	1,000,000 ÷ 0.160 = 6,250,000
1	0.158	–687,500	→	–108,600	−687,500 × 0.158 = –108,600
2	0.154	–687,500	→	–105,900	−687,500 × 0.154 = –105,900
3	0.148	–687,500	→	–101,800	−687,500 × 0.148 = –101,800
4	0.142	–687,500	→	–97,600	−687,500 × 0.142 = –97,600
5	0.137	–6,937,500	→	–950,400	−6,937,500 × 0.137 = –950,400

The effective interest rate implied by the dollar-denominated cash flows is equal to 7.75%. Thus from interest rate data and the terms of the contract, we have calculated the hedged cost of funds. As before, this can be compared to an alternative domestic (dollar) borrowing.

Appendix

HEDGED COST OF FUNDS AND INTEREST RATE ARBITRAGE

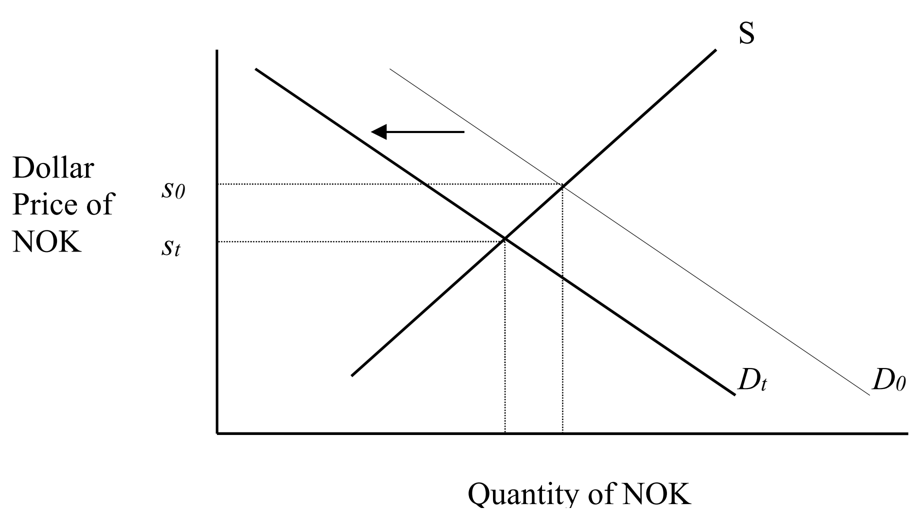
Currency Language and Calculations

Exchange Rates

The central importance of foreign exchange rates to international business decision making means a clear understanding of the determinants of those rates is vital. Before this topic can be explored, it is necessary to understand a few basic points regarding exchange rates.

Exchange rates are nothing more than prices of one currency in terms of another. For example, if the Norwegian krone (NOK) is quoted in U.S. dollars at 0.16 USD/NOK, one can buy a single NOK for 16 cents. In this sense it is like buying anything—an apple, a car, a ticket to a football game. An exchange rate is the price at which the demand for a currency is equal to its supply. Thus the basic logic that determines prices of goods can be applied to currencies. When any good becomes scarce, the supply is reduced and, if there is no change in demand, then the price will rise. Similarly, if the supply is held constant but there is a decrease in the demand, the price will decrease. Consider the supply and demand of the NOK as shown in **Figure 1**:

Figure 1. Supply and demand of the NOK.



If there were an unexpected decrease in the demand for krone between now (time *0*) and sometime in the future (time *t*), then the price of a krone would fall. This is shown in the figure above as a shift to the left in the demand curve from D_0 to D_t . Had the krone originally been worth USD0.160, its value would fall to, for example, USD0.158. In other words, the exchange rate quote would move from 0.160 USD/NOK to 0.158 USD/NOK.

Appendix (continued)

Exchange Rate Terminology

The *spot rate* is the rate at which a currency can be bought or sold for immediate delivery. The spot rate that might be expected at some future moment in time is the *future spot rate*. This future spot rate might very well differ from the current spot rate. We use the following terms to describe changes in the spot rate:

Appreciation:	*An increase in the value of a currency.*
Depreciation:	*A decrease in the value of a currency.*

Suppose, as shown in the diagram above, that the value of the krone were expected to decrease to 0.158 USD /NOK. We would say that the krone is expected to depreciate.[1] Since it is possible that the krone will simultaneously increase in value when measured by some other currency, we will usually be more specific and specify a particular currency against which the NOK is being compared. In this case, we would say the krone is expected to depreciate *relative to the dollar* or, equivalently, *in terms of the dollar*.

Now, let the dollars per krone spot exchange rate before the depreciation be denoted s_0 and let the dollars per krone exchange rate after the depreciation be denoted s_t and let t be one year later. Thus s_0 = 0.160 USD/NOK and s_t = 0.158 USD/NOK. To quantify this change, we might say the krone will depreciate by USD0.002. But that same depreciation would be more significant if the krone were selling at 0.10 USD/NOK and less significant if the krone were selling at 0.20 USD/NOK. For this reason, we usually express the change in percentage terms as shown in **Equation 3**:[2]

$$\text{Appreciation or depreciation of the krone} = \frac{s_t - s_0}{s_0} = \frac{\$0.158 - \$0.160}{\$0.160} = -1.25\% \qquad (3)$$

We have discussed the dollar and krone exchange rate in terms of dollars per krone. One could just as easily quote the dollar in terms of krone. Either quote is acceptable, though the most common convention is to quote nondomestic currencies in terms of domestic currencies (for example, to quote the euro in the United States as USD/EUR). To convert quotes from one form to the other, one simply takes the inverse. Thus to convert 0.160 USD/NOK to a quote on the USD in terms of the krone can be seen in **Equation 4**:

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[1] The terminology is also applicable in the past tense. For example, had we previously observed an increase in the value of the NOK, we would say the NOK had appreciated.

[2] Since the term "depreciation" implies a negative change, one might write "the krone is expected to depreciate by 1.25%." In contrast, if one were not to explicitly label the magnitude an appreciation or a depreciation, one would include the sign. Thus one might say "the value of the krone is expected to change by −1.25%" or "the krone will experience an appreciation or depreciation of −1.25%." What is confusing and should be avoided is to double the negative and say "the krone is expected to depreciate by −1.25%."

Appendix (continued)

$$\text{Krone per dollar quote} = \frac{1}{s_0} = \frac{1}{0.160} = 6.250\,\text{NOK/USD} \tag{4}$$

Similarly, the quote after the exchange rate move would be as follows in **Equation 5**:

$$\text{Krones per dollar quote} = \frac{1}{s_1} = \frac{1}{0.158} = 6.329\,\text{NOK/USD} \tag{5}$$

Notice that the value of the dollar (as expressed in krone) is expected to increase. This is as it should be—when the krone becomes relatively weaker (it costs less dollars to buy it), the dollar becomes relatively stronger. We can again express this change as a percentage change (**Equation 6**):

$$\text{Appreciation of the dollar} = \frac{1 \div s_1 - 1 \div s_0}{1 \div s_0} = \frac{6.329 - 6.250}{6.250} = 1.26\% \tag{6}$$

There are two things to notice about the above result. First, the change is positive, as we would expect if the dollar were to appreciate. Second, the percentage change in the value of the dollar is 1.26%, whereas the percentage change in the value of the krone is 1.25%. This difference, while small, is not due to rounding but to a different currency being used as the basis for the calculation.[3]

The existence of two ways to quote a currency relation and that the changes will be of opposite sign can be a source of confusion. Our strong recommendation is to pick a currency to be the focus of the discussion and have all quotes be quotes on that currency. For example, in this note, we consistently discuss the krone, and therefore, we provide quotes on the krone (in terms of dollars). The advantage of this approach is that one's intuition will always be correct—for example, when the krone depreciates the quote will fall.

Foreign Exchange Markets

The foreign exchange markets exist so that individuals, businesses, or public entities can exchange one currency for another in order to transfer purchasing power from one country to another. The transfer may be made to buy goods and services or to make financial investments. Exchange markets exist both for immediate exchange of currency or to enter contracts for future

[3] If we compare the numbers two and four, which differ by two, we might say that four is 100% larger than two, or we might say that two is 50% smaller than four.

Appendix (continued)

exchanges of currencies. The market for future delivery is called the *forward market*. A purchase on the forward market is often referred to as *purchasing a forward contract*. The quotes on these two markets need not be identical.[4]

As we saw, describing past or expected currency value changes in percentage terms helps scale the change so that the economic meaning of a change can be readily assessed. When that change is annualized, it can also be readily linked to capital market conditions (interest rates) and price levels (inflation rates). For these reasons, it is most useful to think of the forward rate in terms of the annualized percentage difference from the spot rate. This annualized percentage is the forward premium or discount (**Equation 7**):

$$\text{Forward premium or discount} = \frac{f_t - s_0}{s_0} \times \frac{12}{M} \tag{7}$$

Where s_0 is the spot rate now (time zero) and f_t is the forward rate for time t, which is M months in the future. The last term annualizes the percentage difference (note that there is no adjustment for compounding). When the percentage difference is positive, the currency is selling at a premium, and when it is negative, the currency is selling at a discount.

Let us assume a three-month forward contract on the krone is selling for 0.1592 USD/NOK. The premium or discount *on the krone* can be seen in **Equation 8**:

$$\frac{0.1592 - 0.1600}{0.1600} \times \frac{12}{3} = 2.00\% \text{ discount.} \tag{8}$$

We noted previously that a depreciation of a given currency relative to another is also an appreciation of the other currency relative to the given one. Similarly, if a given currency is selling at a discount to another, the other is selling at a premium relative to the given currency. Hence, in **Equation 9**, the forward discount or premium *on the dollar* is

$$\frac{1 \div 0.1592 - 1 \div 0.1600}{1 \div 0.1600} \times \frac{12}{3} = \frac{6.281 - 6.250}{6.250} \times \frac{12}{3} = 2.01\% \text{ premium.} \tag{9}$$

Once again, since a different currency has been used as the basis for the quote, the numerical value of the premium or discount will differ between the dollar and krone quotes. We strongly suggest, once again, picking one currency and having all the quotes be quotes on that currency.

[4] Forward contracts tend to be large negotiated contracts. One can obtain similar results for smaller quantities using futures contracts, where terms are specified in advance and the resulting contracts are traded, but the details of the futures markets are beyond the scope of this note.