Chapter 7

Arbitrage and Hedging with Forward Forward Contracts in Interest Rates

INTRODUCTION

In this chapter, we discuss arbitrage and hedging, but the hedging instruments used here are forward contracts in interest rates. As noted in earlier chapters, the interest rate parity and discussions on arbitrage in foreign exchange market have been existing in literature for a long period. Ever since the classic treatment of the issue by Keynes (1923), several attempts have been made to reexamine and reinterpret this subject. All existing works, as it appears, revolve around the covered interest rate parity involving spot and forward contracts in currency exchange rates, with domestic and foreign interest rates matching the maturity of the chosen forward contract. It has been pointed out that in the absence of interest rate parity where transaction costs do not exist, an investor can make profits from appropriate currency market transactions without assuming any risk. Frenkel and Levich (1975, 1977), Deardorff (1979), and later a host of researchers (see, for instance, Blenman, 1991; Ghosh, 1994, 1997; and many others[1]) have discussed the feasibility of arbitrage profits or the absence thereof with and without transaction costs. That literature has been recognized duly for the proper setting of this work in relation to its discussion of arbitrage. An attempt is thus made here to open up a new branch in which a new interest rate parity can be derived, and, more importantly, it brings out the conditions where covered arbitrage can profitably arise in the market in which forward contract on interest rate exists in this age of financial engineering. In the section titled "The Analytical Structure: A New Parity and Covered Arbitrage," the analytical framework that provides another version of interest rate parity is introduced, then the scope for covered arbitrage profits for an investor is explored. In the section "The Parity and Covered Arbitrage with Transaction Costs," the framework to cover the case of transaction costs is brought out, and the condition for arbitrage profits is enunciated. In section "Compounding of Covered Arbitrage Profits," the possibility of compounding profit levels in the event that profits are feasible in the first instance under the initial scenario is thrown into relief. In the last section, concluding remarks are offered regarding the possibility of extending the work under other scenarios.

THE ANALYTICAL STRUCTURE: A NEW PARITY AND COVERED ARBITRAGE

In this section, a time line is drawn for an investor with a menu of available choices that he can use in his design of investment strategies. First, assume that the investor, at the present, has the quotations on the spot rate of exchange S_0, three-month forward rate of exchange F_{01}, and three-month domestic and foreign rates of interest r_{01}, r^*_{01}, respectively. He also has six-month quotations on all of those rates: F_{02}, r_{02}, and r^*_{02}. In this situation, with a three-month and a six-month data set, the investor must check if the interest rate parity exists for both maturity levels (that is, for three and six months). If the interest rate parity exists for, say, a three-month situation, but it fails to exist for a six-month period, or vice versa, it is obvious that the investor will engage in covered arbitrage in the situation that admits of deviation from parity. If, however, both the three-month and six-month quotations provide the scope for arbitrage opportunity, the investor should get involved with the case that yields the higher rate of return. So far, the case is simple with these two sets of quotations. But, in financial markets where new instruments have already entered in the form of forward contracts (forward rate agreements FRAs on interest rates), the investment design may become a bit more sophisticated.

Consider forward contracts on interest rates, and examine their impact on interest rate parity and the absence thereof in an effort to measure arbitrage profits and profit multipliers. Before going further, it is first useful to explain what a forward contract on interest rate is. A forward contract is one that fixes an interest rate at that present time for a deposit or a loan starting at a future date, say, three months from that given day and expiring at a further future date, say, six months from that day.[2] Therefore, a three to six month forward contract on interest rate is immediately established between the investor and the bank, and the terms of the contract are binding to both parties. Since these contracts are currently available in financial markets, one may encounter the scenarios defined by the following time line:

In Figure 7.1, the left end of the time line represents the present time (or today), the midpoint shows the period of three months from that day, and

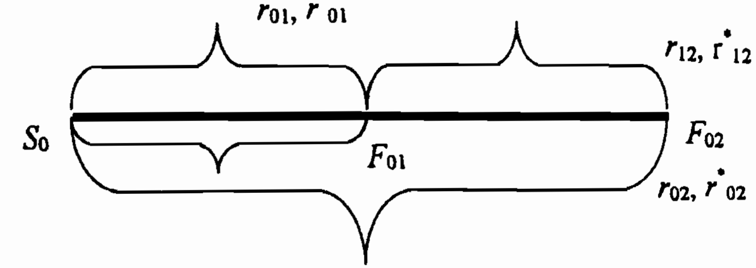

Figure 7.1 Arbitrage with forward contracts in interest rates and forward exchange rates

the right end shows the period of six months from that day. S_0 is the currently quoted spot rate of exchange of, say, £1 in terms of U.S. dollars (S_0 = \$/£1), F_{01}, and F_{02}, the forward rates of exchange for three-month and six-month maturities. r_{01} and r_{02} are three-month and six-month interest rates in the domestic market. Similarly, r^*_{01}, and r^*_{02} are foreign market interest rates for three and six months, respectively. Now, let r_{12}, and r^*_{12} be three- to six-month domestic and foreign forward interest rates, which an investor can lock into immediately. The whole spectrum of quotations now available for our investor is then exhibited as follows:

S_0 = the spot rate of exchange of one British pound in terms of U.S. dollars;

F_{01} = three-month forward rate of exchange of one British pound in terms of U.S. dollars;

F_{02} = six-month forward rate of exchange of one British pound in terms of U.S. dollars;

r_{01} = three-month interest rate in domestic U.S. money market;

r^*_{01} = three-month interest rate in foreign money market;

r_{02} = six-month interest rate in domestic money market;

r^*_{02} = six-month interest rate in foreign money market;

r_{12} = three-month forward interest rate in domestic money market, effective three months from the present day, but the contract can be made immediately;

r^*_{12} = three-month forward interest rate in foreign British money market, effective three months from the present day, but the contract can be made immediately.

Under the given menu of market data, the question is: can the investor make arbitrage profits? In this chapter, the answer to this question is given, along with a general conclusion about the conditions in which risk-free profit opportunities exists and the condition in which they do not.

Given the market situations with the quotations presented, the investor has a number of opportunities to consider. Since all the possible scenarios cannot be depicted for the paucity of space, and since all possible scenarios are not economically meaningful, we will consider a few alternatives. In the framework of this analysis, other scenarios can be easily worked out. Consider that our investor has all the information on his computer screen—real-time and on-line. He can borrow, say, M dollars from his bank at r_{01} for three months or at r_{02} for six months. He may then exchange M dollars at the spot rate for British pounds, invest the pound amount either at r^*_{01} or at r^*_{02}, and sell the amount $(M/S_0)(1 + r^*_{01})$ at the three-month forward rate or sell the amount $(M/S_0)(1 + r^*_{02})$ at the six-month forward rate. He can get the dollar amount $(M/S_0)(1 + r^*_{01})\cdot F_{01}$ or $(M/S_0)(1 + r^*_{02})\cdot F_{02}$, depending upon the initial choice of maturity. The arbitrage profit levels from three-month and six-month maturities must then be as follows, respectively:

$$\pi_{01} = M\left[\frac{F_{01}}{S_0}(1+r^*_{01})-(1+r_{01})\right] \tag{7.1}$$

$$\pi_{02} = M\left[\frac{F_{02}}{S_0}(1+r^*_{02})-(1+r_{02})\right] \tag{7.2}$$

From equation 7.1 we get that if:

$$\frac{F_{01}}{S_0}(1+r^*_{01})-(1+r_{01})=0,$$

the interest rate parity exists for three-month maturity whereby we have:

$$r_{01}-r^*_{01}=\left(\frac{F_{01}-S_0}{S_0}\right)(1+r^*_{01}). \tag{7.3}$$

Similarly, from equation 7.2, in the situation of interest rate parity, one can get:

$$r_{02}-r^*_{02}=\left(\frac{F_{02}-S_0}{S_0}\right)(1+r^*_{02}). \tag{7.4}$$

These are the expressions of interest rate parity long known in existing literature. In the event of inequality between the left-hand and the right-hand sides in equation 7.3 and/or equation 7.4, the investor has the scope for

risk-free profit opportunity via what is popularly called *covered arbitrage*. If the left-hand side of equations 7.3 or 7.4 is greater than the right-hand side, the investor should borrow from the home market and invest in the foreign market. In an opposite situation, an opposite strategy must be used—that is, borrowing from the foreign market and investing in the home market will yield positive profits to the investor who is not exposed to risk. To make these statements more comprehensible, take equation 7.3 and assume that $r_{01} = 10\%$, $r^*_{01} = 9.5\%$, $S_0 = 2$, and $F_{01} = 2.15$. In this case, note that we have the following situation $(r_{01} - r^*_{01}) < (F_{01}-S_0)/S_0)(1+r^*_{01})$ (as, with this data, one can easily find that $(0.10-0.095) < (2.15-2.00/2.00)(1+0.095)$. Under this situation, if the investor borrows \$1,000,000 at 10 percent from a domestic bank, and he exchanges his borrowed \$1,000,000 at the spot rate \$2.00 = £1, he gets £500,000, which invested in the British market at 9.5 percent yields £500,000H1.095 = £547,500. This amount of pound sterling is sold forward at 2.15 to bring the U.S. dollar amount to the tune of \$1,177,125, from which the investor must subtract the borrowed amount and the total interest accrued on it (\$1,000,000H1.1 = \$1,100,000). Note now that the investor finally ends up with the net amount of \$77,125 as the fruits of his interim financial transactions.

Next, consider the following alternatives: (a) the investor exchanges his M dollars in the spot market, invests the converted amount in the foreign market for six months in this instance, sells the newly created amount in the forward market, and subtracts from there the original principal and the accrued interest; (b) he first borrows M dollars for three months (not six months), and at the same time enters into a three- to six-month forward contract with a bank to put his amount $(M/S_0)(1 + r^*_{01})$ (three months from present day) in deposit at r^*_{12} for the next three months, which at the end of six months from that day then becomes $(M/S_0)(1 + r^*_{01})(1 + r^*_{12})F_{02}$ upon the forward sale of the foreign currency amount. The profit level in this instance then must be:

$$\pi_{0.1,2} = M\left[\frac{F_{02}}{S_0}(1+r^*_{01})(1+r^*_{12})-(1+r_{01})(1+r_{12})\right]. \tag{7.5}$$

Compare equations 7.2 and 7.5, and in the event of $\pi_{0.2} = \pi_{0.1,2}$, we have a new interest rate parity, which can be expressed as follows:

$$\begin{aligned}&[(1+r_{01})(1+r_{12})-(1+r^*_{01})(1+r^*_{12})-(r_{02}+r^*_{02})]\\ &=\left(\frac{F_{02}-S_0}{S_0}\right)[(1+r^*_{01})(1+r^*_{12})-(1+r^*_{02})].\end{aligned} \tag{7.6}$$

This is the new interest rate parity. If there is no rollover with forward contracts on interest rates, the original interest rate parity, which is defined by the following expression:

$$(r_{02} - r^*_{02}) = \left(\frac{F_{02} - S_0}{S_0}\right)(1 + r^*_{02})(1.1^*) \tag{7.7}$$

is once again smoothly rehabilitated.[3] Note that under the pure expectation hypothesis of the term structure on interest rates (which holds in equilibrium), one can observe the following relations:

$$(1 + r_{01})(1 + r_{12}) = (1 + r_{02}), \text{ and } (1 + r^*_{01})(1 + r^*_{12}) = (1 + r^*_{02}),$$

which means that parity holds and arbitrage profits do not arise. But in reality, market has a centripetal move toward equilibrium at any point of time, but it is not in equilibrium *necessarily* at every point in time, hence parity does not take place, and thus, 1^{**} becomes meaningful at many times. Grabbe correctly notes, "It is tempting to equate the implied forward rate $f(t + n, T - n)$ [that is, in our example, r_{12}] with the expected short-term interest rate that will prevail at time $t + n$ [that is, in our case, for three- to six-months from now]. The expectations theory should be considered a purely empirical proposition in the same way that the speculative efficiency hypothesis is a purely empirical proposition" (1991, p. 266).[4] If liquidity preference or market segmentation theory can precisely bring out the relations $(1 + r_{01})(1 + r_{12}) = (1 + r_{02})$, and $(1 + r^*_{01})(1 + r^*_{12}) = (1 + r^*_{02})$, then 1^* holds, and arbitrage profits become nonexistent. In this situation, it is useless to discuss further on 1^{**} (as 1^* and 1^{**} cannot hold simultaneously). Since one cannot theoretically establish that 1^* always holds (see Grabbe, 1991), and empirical evidence for the absence of parity does often exist, 1^{**} is a significant situation to work on and profit possibilities should be meaningfully explored.

Now, consider the following scenario:

$$\begin{aligned} &[(1+r_{01})(1+r_{12}) - (1+r^*_{01})(1+r^*_{12}) - (r_{02} - r^*_{02})] \\ &\neq \left(\frac{F_{02} - S_0}{S_0}\right)[(1+r^*_{01})(1+r^*_{12}) - (1+r^*_{02})]. \end{aligned} \tag{7.8}$$

If the left-hand side of equation 7.8 is greater than the right-hand side, then it is evident that the investor should borrow from the home market at r_{01} and invest in the foreign market at r_{01}^* for the first three months, then rollover for the next three months with a currently available three- to six-month forward contracts on interest rates instead of taking a straight six-month position. If the left-hand side is less than the right-hand side, the investor should borrow from the foreign market, invest in the home economy, and take the opposite position in terms of the choice of investment horizon.

THE PARITY AND COVERED ARBITRAGE WITH TRANSACTION COSTS

In the previous section, the discussion is about the absence of transaction costs in both foreign exchange markets and in money markets. In this section, we move away from the assumption that there are no transaction costs and introduce those costs for the investor the way they appear. In the original conceptual environment postulated by Frenkel and Levich (1977) and Deardorff (1979), transaction costs are proportional. Recently, Rhee and Chang (1992), Ghosh (1991, 1994), Blenmann (1991, 1992, 1996), and Blenman and Thatcher (1995, 1997) have introduced *ask* and *bid* quotations that essentially capture foreign exchange transaction costs and *lend* and *borrow* rates of interest that capture those costs in money market operations. First, let us introduce the modified notations as follows:

S_0^A = spot *ask* rate of exchange of one British pound in terms of U.S. dollars;

S_0^B = spot *bid* rate of exchange of one British pound in terms of U.S. dollars;

F_{01}^A = three-month forward *ask* rate of exchange of one British pound in terms of U.S. dollars;

F_{01}^B = three-month forward *bid* rate of exchange of one British pound in terms of U.S. dollars;

F_{02}^B = six-month forward *bid* rate of exchange of one British pound in terms of U.S. dollars;

F_{02}^A = six-month forward *ask* rate of exchange of one British pound in terms of U.S. dollars;

$r_{0i(L)}$ = i-month *lend* rate of interest in domestic money market (i = 3, 6);

$r^*_{0i(L)}$ = i-month *lend* rate of interest in foreign money market (i = 3, 6);

$r_{0i(B)}$ = i-month *borrow* rate of interest in domestic money market (i = 3, 6);

$r^*_{0i(B)}$ = i-month *borrow* rate of interest in foreign money market (i = 3, 6);

$r_{12(V)}$ = three- to six-month forward interest rate in domestic money market, effective three months from the given day, but the contract can be made that given day (V = *lend* (L) or *borrow* (B));

$r^*_{12(V)}$ = three- to six-month forward interest rate in foreign (British) money market, effective three months from the given day, but the contract can be made that given day (V = *lending* (L) or *borrowing* (B)).

With these notations with which we capture transaction costs, we present π_{01}, π_{02}, and $\pi_{0.1,2}$, defined by equations 7.9, 7.10, and 7.11, modified as π^T_{01}, π^T_{02}, and $\pi^T_{0.1,2}$, respectively as follows:

$$\pi^T_{01} = M\left[\frac{F^A_{01}}{S^B_0}(1 + r^*_{01(L)}) - (1 + r_{01(B)})\right] \tag{7.9}$$

$$\pi_{02}^{T} = M\left[\frac{F_{02}^{A}}{S_0^B}(1+r_{02(L)}^{*}) - (1+r_{02(B)})\right] \tag{7.10}$$

$$\pi_{0.1,2}^{T} = M\left[\frac{F_{02}^{A}}{S_0^B}(1+r_{01(L)}^{*})(1+r_{12(L)}^{*}) - (1+r_{01(B)})(1+r_{12(B)})\right]. \tag{7.11}$$

From the equality of equations 7.10 and 7.11, one can easily establish the following parity statement:

$$\begin{aligned}&[(1+r_{01(B)})(1+r_{12(B)}) - (1+r_{01(L)}^{*})(1+r_{12(L)}^{*}) - (r_{02(B)} - r_{02(B)}^{*})]\\ &= \left(\frac{F_{02}^{A} - S_0^B}{S_0^B}\right)[(1+r_{01(L)}^{*})(1+r_{12(L)}^{*}) - (1+r_{02(L)}^{*})].\end{aligned} \tag{7.12}$$

In the event of the inequality between these two sides of equation 7.12, the opportunity for arbitrage profit arises and persistence of that profitable scenario exists. In the subsequent section, we explore this possibility.

COMPOUNDING OF COVERED ARBITRAGE PROFITS

In the previous sections, we have delineated the conditions under which covered arbitrage profits can exist. It is now time to examine the possibility of compounding the original profits made in the arbitrage operation by exploiting the initial absence of parity. Consider the possibility:

$$\pi_{0.1,2}^{T} = M\left[\frac{F_{02}^{A}}{S_0^B}(1+r_{01(L)}^{*})(1+r_{12(L)}^{*}) - (1+r_{01(B)})(1+r_{12(B)})\right] > 0. \tag{7.13}$$

That means the investor, at the given day, first borrows M dollars for three months (not six months) at $r_{01}{}^{(B)}$ and at the same time enters into a three- to six-month forward contract with that or any other bank for the rate $r_{12(B)}$ to put his amount $M/S_0^B(1 + r_{01(L)}^{*})$ in deposit at $r_{12(L)}^{*}$ three months from that day for the next three months, which at the end of six months from that day then becomes $M/S_0^B(1 + r_{01(L)}^{*})(1 + r_{12(L)}^{*})F_{02}^{A}$ upon the forward sale of the foreign currency amount. The present value of this amount of profit is obviously:

$$\pi_{0.1,2(0)}^{T(1)} \equiv \frac{\pi_{0.1,2}^{T}}{(1+r_{01(B)})(1+r_{12(B)})}.$$

Since this profit is made by the investor on the first opportunity, we designate it as the first round by assigning 1 as the superscript—that is, by modifying the notation suitably as $\pi_{0.1,2(0)}^{T(1)}$. By plugging in this profit level along with the original amount of M dollars, by putting in $(M + \pi_{0.1,2(0)}^{T(1)})$ dollar amount in, the same way as he did put in his initial amount of M dollars, the investor can make the following amount from the second replica of his play:

$$\pi_{0.1,2(0)}^{T(2)} = M\alpha^{T}(\alpha^{T}+2)^{2-1},$$

and from his nth round of play after putting in all previous levels of profits—by plugging in $M + \Sigma_{i=1}^{n-1}\pi_{0.1,2(0)}^{T(1)}$, he gets the following amount of profits:

$$\pi_{0.1,2(0)}^{T(n)} = M\alpha^{T}(\alpha^{T}+2)^{n-1},$$

$$\text{where } \alpha^{T} = \left[\frac{\left[\frac{F_{02}^{A}}{S_0^B}(1+r_{01(L)}^{*})(1+r_{12(L)}^{*}) - (1+r_{01(B)})(1+r_{12(B)})\right]}{(1+r_{01(B)})(1+r_{12(B)})}\right].$$

It is a matter of simple verification that on the very first round of arbitrage play, the investor's level of profit can be shown to be equal to $\pi_{0.1,2(0)}^{T(1)} = M\alpha^T(\alpha^T + 2)^{1-1} = M\alpha^T$. It is now evident that $(\alpha^T + 2)^{i-1}$ is the multiplier of the initial covered arbitrage profit on the ith round ($i = 1, 2, 3, \ldots, n$). Next, the summation of $\pi_{0.1,2(0)}^{T(1)}$ over first n iterations measures the cumulative profits on first n successive plays in the market with the data frozen over the period of iterations, and this cumulative profit is then defined as follows:

$$\pi_0^{T^*} = M\alpha^{T}\left[\frac{1-(\alpha^{T}+2)^{n}}{1-(\alpha^{T}+2)}\right].$$

Similar results in other possible scenarios can be easily derived, but it will not be of profitable use to time or space to continue.

CONCLUDING REMARKS

Many interesting extensions of these results can be made by way of introducing other features with this trading strategy in this framework, but the most fruitful exercise in this context has to do with some useful empirical work along these lines. Since this paper is grounded on theoretical structure, we keep it the way it is. And empirical studies along this work are left for future attempts. We must make some concluding observations, however, on the microstatics and macrodynamics of the market in the context of this research.

It is fundamental reality that if arbitrage opportunity exists in the marketplace, it will soon disappear by the dynamics of competition. In that sense it may be questionable if the second, the third, and the nth round of arbitrage activities of our investor can ever take place. A careful reflection on this point is absolutely essential, and upon that reflection and comprehension of market forces, one should realize a few points. First of all, if an investor finds that an arbitrage opportunity exists, he ascertains profits *instantly* for all the n rounds of arbitrage. The market data are same for round 1 and round n within 20 seconds or 2 minutes at which quotes do not change from the investor's screen. His first and his nth executions take place *almost* at the very same instant with programmed trading, the two rounds differing only by the amounts of arbitrage funds. In the first round the amount is M dollars and in the nth round the amount will be $M + \Sigma_{i=1}^{n-1} \pi^{T(i)}{}_{0.1,2(0)}$, and the time involved in these n successive rounds may be less than a second with digitized signatures of approval by the bank(s) in the middle of today's technology and speed. The moment the market data are factored in, and $\pi_{0.1,2}$ ($\neq 0$) is ascertained, one computes $\pi^1_{0.1,2(0)}$, $\pi^2_{0.1,2(0)}$, $\pi^3_{0.1,2(0)}$, ..., $\pi^n{}_{0.1,2(0)}$, and so on. If the investor can exploit the market one time via arbitrage, he can exploit the same market several times because the moment is *virtually* frozen and the data for market exploitation remain the same. Note the investor is a micro-agent operating in the marketplace in which even the speediest adjustment cannot deprive him of the opportunity to take advantage of the market misalignment. We know for sure that arbitrage exists in the market, and many players subsist on it. Therefore, arbitrage and iterations thereof are the valid plays in the market. One should also note that in the trillion-dollar market, a million or even a few billions by a micro-agent may not throw the market into any state of concussion. However, if a large number of participants act at the same moment, there may be an execution jam, and nobody is likely to take any profits out of arbitrage. In a situation of multiple players, the macrodynamics of the market set in and force arbitragers into a zero-profit condition. One more point should be made then. Since too many iterations are involved in this investment strategy, one should realize that before any iteration is executed, some quotes may change. So to guard against this possibility appropriate limit orders should be put in with each iteration of covered arbitrage, and that should guarantee nonnegative profit conditions in the repeated arbitrage acts.

Market dynamics and market efficiency are of paramount significance. Clinton (1976) and Dornbusch (1976) highlight and examine some of these concerns quite efficiently. One should note that in a frozen (static) moment, no adjustment is possible, and micro-level arbitrage is certainly an exploitable opportunity.

At this point, a few more issues should be addressed as well. One may wonder why an investor who sees an arbitrage opportunity will start off with \$1 million instead of hundreds of millions or billions. The answer is simple. If the investor has \$1 million as the maximum amount available to him, he has to begin only with that much money. M dollars, in our paradigm, is the maximum available initial fund. Of course, if the investor has more, he will initiate his moves with more funds. The issue here is not what the optimal amount of initial investment funds for arbitrage should be; the issue is: if an initial amount—be it M or Z dollars—is available for arbitrage, what amount of money can potentially be generated out of that initial situation? Two other issues should be brought to limelight in this context. One may argue that since profits out of the first round of arbitrage are obtained only at the end of six months from the given day, how is this investor getting funds for the second, the third, and other rounds of market plays? Note here that π_1 is the guaranteed amount of money made by the investor without taking any risk, and any bank should recognize this amount the investor makes at the end of six months. If this is common knowledge by the investor as well as the bank, it is equally recognizable that this investor has $\pi_{1(0)}$ / $\pi_1/1 + r$ now—and it is his equity position that he can legitimately utilize (probably with a prior discussion with his banker). Next, it is worth noting, particularly against the backdrop of the common belief that markets are so well aligned that scope for arbitrage in reality is nonexistent, that in the currency market one can almost always find arbitrage opportunity. Note that although the spot rate and forward rate are *usually* defined at a point of time, and corresponding to those defined quotes a set of domestic and foreign interest rates will yield $\pi_{0.1,2} = 0$, one can always find another set of interest rates from the available spectrum of interest rates, which generates $\pi_{0.1.2}$? 0. That clearly signifies that arbitrage opportunity is a viable and feasible strategy in the foreign exchange market more often than not. Additionally, it should be pointed out that one who watches real-time data could also easily recognize that quotations on spot and forward rates by different banks and/or dealers are not always the same at that instant. So on that front one may also find the scope for arbitrage. Finally, we should note that if one round of arbitrage act is undertaken, it may also appear that arbitrage profit is negligible. In that sense one can conclude that arbitrage opportunity is virtually nonexistent. But the replication of the same strategy over and over does not make arbitrage profits insignificant in reality at all.

NOTES

1. See other studies cited in the references at the end of this work.
2. The existing literature on this new instrument is almost nonexistent. Forward contracts on interest rates are a variant of forward rate agreements (FRAs) on

interest rates, which appear to have better vintage. This instrument is still only in the arsenal of practitioners in banking institutions. However, one may review Sercu and Uppal (1995, pp. 290–294).

3. Take equation (7.6). $[(1+r_{01})(1+r_{12})-(1+r^*_{01})(1+r^*_{12})-(r_{02}+r^*_{02})]$

$$=\left(\frac{F_{02}-S_0}{S_0}\right)[(1+r^*_{01})(1+r^*_{12})-(1+r^*_{02})],$$

and decompose it as follows:

$$\frac{r_{02}-r^*_{02}}{1+r^*_{02}}=\left(\frac{F_{02}-S_0}{S_0}\right)\left[1-\frac{(1+r^*_{01})(1+r^*_{12}}{(1+r^*_{02})}\right]$$
$$+\frac{(1+r_{01})(1+r_{12})-(1+r^*_{01})(1+r^*_{12})}{(1+r^*_{02})}$$

whence:

$$\frac{r_{02}-r^*_{02}}{1+r^*_{02}}=\left(\frac{F_{02}-S_0}{S_0}\right)-$$
$$\left(\frac{F_{02}-S_0}{S_0}\right)\left[1-\frac{(1+r^*_{01})(1+r^*_{12}}{(1+r^*_{02})}\right]+\frac{(1+r_{01})(1+r_{12})-(1+r^*_{01})(1+r^*_{12})}{(1+r^*_{02})}$$

If pure expectations theory holds in both home and domestic economies—that is, $(1 + r_{01})(1 + r_{12}) = (1 + r_{02})$, and $(1 + r^*_{01})(1 + r^*_{12}) = (1 + r^*_{02})$, then (7.6) reduces to the following:

$$\frac{r_{02}-r^*_{02}}{1+r^*_{02}}=\left(\frac{F_{02}-S_0}{S_0}\right)-\left(\frac{F_{02}-S_0}{S_0}\right)+\frac{(1+r_{01})(1+r_{12})-(1+r^*_{01})(1+r^*_{12})}{(1+r^*_{02})}$$

The whole expression then reduces to: interest rate parity—deviation from interest rate parity. Since deviation from interest rate parity is zero in this case, interest rate parity theory holds.

4. Here we discuss the contextual relevance of the term structure of interest. It should be noted that if the relations $(1 + r_{01})(1 + r_{12}) = (1 + r_{02})$, and $(1 + r^*_{01})(1 + r^*_{12}) = (1 + r^*_{02})$ hold, scope for arbitrage profits does not exist. Empirically one often finds the following: $(1 + r_{01})(1 + r_{12})$? $(1 + r_{02})$, and $(1 + r^*_{01})(1 + r^*_{12})$? $(1 + r^*_{02})$. See Grabbe [1991] on this issue.

REFERENCES

Aliber, R.G. (1973). "The Interest Rate Parity Theorem: A Reinterpretation," *Journal of Political Economy*, 81 (6), 1451–1459.

Blenman, L.P. (1991). "A Model of Covered Interest Arbitrage under Market Segmentation," *Journal of Money, Credit, and Banking*, 23 (4), no. 706–717.

———. (1992). "The Interest Rate Parity: Seven Expressions: A Reply," *Financial Management*, 21 (3), 10–11.

———. (1996). "Contemporaneous, Non-contemporaneous Currency Exchanges and Arbitrage Activity," *The International Journal of Finance*, 8 (1), 15–32.

Blenman, L.P., and J.S. Thatcher. (1995). "Arbitrage Opportunities in Currency and Credit Markets: New Evidence," *The International Journal of Finance*, 7 (1), 1123–1145.

———. (1997). "Arbitrageur Heterogeneity, Investor Horizon and Arbitrage Opportunities: An Empirical Investigation," *Financial Review*, 32.

Callier, P. (1981). "One-Way Arbitrage, Foreign Exchange and Securities Markets: A Note," *Journal of Finance*, 36 (5), 1177–1186.

Clinton, K. (1976). "Spot Rates, Forward Rates and Exchange Market Efficiency," *Journal of Financial Economics*, 5 (1), 55–65.

———. (1988). "Transaction Costs and Covered Interest Arbitrage: Theory and Evidence," *Journal of Political Economy*, 96 (2), 358–370.

Deardorff, A.V. (1979). "One-Way Arbitrage and Its Implications for the Foreign Exchange Markets," *Journal of Political Economy*, 87 (2), 351–364.

Dornbusch, R. (1976). "Expectations and Exchange Rate Dynamics," *Journal of Political Economy*, 84 (6), 1161–1176.

Frenkel, J.A., and R.M. Levich. (1975). "Covered Interest Arbitrage: Unexploited Profits?" *Journal of Political Economy*, 83 (2), 325–338.

———. (1977). "Transaction Costs and Interest Arbitrage: Tranquil Versus Turbulent Periods," *Journal of Political Economy*, 85 (6), 1209–1226.

Ghosh, D.K. (1991). "The Interest Rate Parity: Seven Expressions," *Financial Management*, 20 (4), 8–9.

———. (1994). "The Interest Rate Parity, Covered Interest Arbitrage and Speculation under Market Imperfection." In D.K. Ghosh and E. Oritz (Eds.), *Changing Environment of International Financial Markets: Issues and Analysis* (pp. 69–79). London: Macmillan.

———. (1997). "Naked and Covered Speculation in the Foreign Exchange Market." In D.K. Ghosh and E. Oritz (Eds.), *The Global Structure of Financial Markets* (pp. 119–143). London: Routledge.

Giddy, I.H. (1976). "Why It Doesn't Pay to Make a Habit of Forward Hedging," *Euromoney*, December, 96–100.

Grabbe, J.O. (1991). *International Financial Markets* (2nd ed.). New York: Elsevier Science.

Keynes, J.M. (1923). *A Tract on Monetary Reform*. London: Macmillan.

McCormick, F. (1979). "Covered Interest Arbitrage: Unexploited Profits?—Comment," *Journal of Political Economy*, 87 (2), 411–417.

Rhee, S.G., and R.P. Chang. (1992). "Intra-day Arbitrage Opportunities in Foreign Exchange and Eurocurrency Markets," *Journal of Finance*, 47 (1), 363–379.

Roll, R.W., and B. Solnik. (1979). "On Some Parity Conditions Frequently Encountered in International Finance," *Journal of Macroeconomics*, 1.

Sercu, P., and R. Uppal. (1995). *International Financial Markets and the Firm*. Cincinnati, OH: South-Western College.

Taylor, M.P. (1989). "Covered Interest Arbitrage and Market Turbulence," *The Economic Journal*, 99 (396), 376–391.