Figure 4.4 **Selected Foreign Exchange Rates**

CROSS RATES

	Canadian dollar	U.S. dollar	British pound	German mark	Japanese yen	Swiss franc	French franc	Dutch guilder	Italian lira
Canada dollar	—	1.3797	2.1289	0.8735	0.013610	1.0362	0.2550	0.7777	0.000875
U.S. dollar	0.7248	—	1.5430	0.6331	0.009864	0.7510	0.1848	0.5637	0.000634
British pound	0.4697	0.6481	—	0.4103	0.006393	0.4867	0.1198	0.3653	0.000411
German mark	1.1448	1.5795	2.4372	—	0.015581	1.1863	0.2919	0.8903	0.001002
Japanese yen	73.48	101.37	156.42	64.18	—	76.14	18.74	57.14	0.064291
Swiss franc	0.9651	1.3315	2.0545	0.8430	0.013135	—	0.2461	0.7505	0.000844
French franc	3.9216	5.4106	8.3486	3.4255	0.053373	4.0635	—	3.0498	0.003431
Dutch guilder	1.2858	1.7741	2.7374	1.1232	0.017500	1.3324	0.3279	—	0.001125
Italian lira	1142.86	1576.80	2433.03	998.29	15.554286	1184.23	291.43	888.80	—

Mid-market rates in Toronto at noon, Aug. 8, 1994. Prepared by the Bank of Montreal Treasury Group.

		$1 U.S. in Cdn.$ =	$1 Cdn. in U.S.$ =
U.S./Canada spot		1.3797	0.7248
1 month forward		1.3808	0.7242
2 months forward		1.3818	0.7237
3 months forward		1.3827	0.7232
6 months forward		1.3862	0.7214
12 months forward		1.3973	0.7157
3 years forward		1.4457	0.6917
5 years forward		1.4917	0.6704
7 years forward		1.5622	0.6401
10 years forward		1.6547	0.6043
Canadian dollar	High	1.3083	0.7644
in 1994:	Low	1.3990	0.7148
	Average	1.3712	0.7293

Country	Currency	Cdn. $ per unit	U.S. $ per unit
Britain	Pound	2.1289	1.5430
1 month forward		2.1294	1.5421
2 months forward		2.1297	1.5412
3 months forward		2.1297	1.5402
6 months forward		2.1320	1.5380
12 months forward		2.1385	1.5304
Germany	Mark	0.8735	0.6331
1 month forward		0.8739	0.6329
3 months forward		0.8751	0.6329
6 months forward		0.8787	0.6339
12 months forward		0.8891	0.6363
Japan	Yen	0.013610	0.009864
1 month forward		0.013650	0.009886
3 months forward		0.013728	0.009928
6 months forward		0.013873	0.010008
12 months forward		0.014211	0.010170
Algeria	Dinar	0.0436	0.0316
Antigua, Grenada and St. Lucia	E.C.Dollar	0.5119	0.3711
Argentina	Peso	1.38205	1.00170
Australia	Dollar	1.0213	0.7402
Austria	Schilling	0.12403	0.08990
Bahamas	Dollar	1.3797	1.0000
Barbados	Dollar	0.6933	0.5025
Belgium	Franc	0.04245	0.03077
Bermuda	Dollar	1.3797	1.0000
Brazil	Real	1.509519	1.094092
Bulgaria	Lev	0.0258	0.0187
Chile	Peso	0.003281	0.002378
China	Renminbi	0.1604	0.1162
Cyprus	Pound	2.8744	2.0833
Czech Rep	Koruna	0.0490	0.0355
Denmark	Krone	0.2220	0.1609
Egypt	Pound	0.4076	0.2954
Fiji	Dollar	0.9548	0.6920
Finland	Markka	0.2662	0.1929
France	Franc	0.2550	0.1848
Greece	Drachma	0.00578	0.00419
Hong Kong	Dollar	0.1786	0.1294
Hungary	Forint	0.01258	0.00912
Iceland	Krona	0.01972	0.01429
India	Rupee	0.04397	0.03187
Indonesia	Rupiah	0.000636	0.000461
Ireland	Punt	2.1068	1.5270
Israel	N Shekel	0.4531	0.3284
Italy	Lira	0.000875	0.000634
Jamaica	Dollar	0.04415	0.03200
Jordan	Dinar	1.9852	1.4388
Lebanon	Pound	0.000824	0.000597
Luxembourg	Franc	0.04245	0.03077
Malaysia	Ringgit	0.5346	0.3874
Mexico	N Peso	0.4074	0.2953
Netherlands	Guilder	0.7777	0.5637
New Zealand	Dollar	0.8340	0.6045
Norway	Krone	0.1999	0.1449
Pakistan	Rupee	0.04519	0.03275
Philippines	Peso	0.05276	0.03824
Poland	Zloty	0.0000603	0.0000437
Portugal	Escudo	0.00859	0.00623
Romania	Leu	0.0008	0.0006
Russia	Ruble	0.000661	0.000479
Saudi Arabia	Riyal	0.3679	0.2667
Singapore	Dollar	0.9164	0.6642
Slovakia	Koruna	0.0437	0.0317
South Africa	Rand	0.3821	0.2770
South Korea	Won	0.001719	0.001246
Spain	Peseta	0.01062	0.00770
Sudan	Dinar	0.0445	0.0322
Sweden	Krona	0.1787	0.1295
Switzerland	Franc	1.0362	0.7510
Taiwan	Dollar	0.0524	0.0380
Thailand	Baht	0.0553	0.0401
Trinidad, Tobago	Dollar	0.2475	0.1794
Turkey	Lira	0.0000441	0.0000320
Venezuela	Bolivar	0.00812	0.00589
Zambia	Kwacha	0.002090	0.001515
European Currency Unit		1.5701	1.2105
Special Drawing Right		1.9950	1.4460

The U.S. dollar closed at $1.3772 in terms of Canadian funds, down $0.0095 from Friday. The pound sterling closed at $2.1201, down $0.0182.

In New York, the Canadian dollar closed up $0.0050 at $0.7261 in terms of U.S. funds. The pound sterling was down $0.0026 to $1.5394.

Source: Globe and Mail, Monday, August 8, 1994.

Solution to Yamada's Stylized Arbitrages

a) Yamada can make an arbitrage profit by doing a ***long (DM)*** covered interest arbitrage. The arbitrage is short because it involves borrowing in US and investing in DM. This arbitrage involves the following sequence of transactions which will all be executed at 9:10 am Singapore time:

Borrow $5,000,000 for three months. In three months time, the amount owing on this borrowing will be: ($5 mil)(1 + (.09/4)) = $5,112,500

Exchange the $5 mil. at the spot exchange rate to get ($5 mil)(1.82) = 9.1 mil DM.

Invest the 9.1 mil. DM for three months. In three months time, the investment will mature to a value: (9.1 mil)(1 + (.05/4)) = 9,213,750 DM

Sell the maturing value of the DM investment for US dollars using a three month forward exchange contract. At the quoted forward exchange rate of 1.8, the DM investment will produce (9,213,750/1.8) = $5,118,750

In three months time, the DM investment will mature and the proceeds delivered on the forward exchange contract. The proceeds of the forward contract will be used to settle the maturing three month loan producing an arbitrage profit of $5,118,750 - $5,112,500 = $6250.

b) If the US interest rate is 10%, instead of 9%, then the cost of the US$ borrowing would be (5 mil)(1 + (.1/4)) = $5,125,000. Because this exceeds the covered return which could be received on the DM investment, the short arbitrage would not be profitable. However, in the absence of transactions costs, it would now be possible to do the **l*ong*** arbitrage, which would involve borrowing in DM and investing in the US. In this case the profit would be $5,125,000 - $5,118,750 = $6250.

c) The presence of a $7000 transaction cost would prevent either the long or the short arbitrage from being executed. This illustrates the point that covered interest arbitrage only provides upper and lower boundaries on the available combinations of interest rates and exchange rates that are consistent with absence of arbitrage at a specific point in time.

NOTE: In actual practice, the presence of transaction costs dictates that the spot and forward transactions will combined into one transaction, a foreign exchange swap.

The basics of the arbitrage trading strategy can be illustrated by considering a stylized cash-and-carry arbitrage trade between US dollars and a foreign currency for 1 year securities. If the covered foreign interest rate ***exceeds*** the rate on a comparable US security, the trade described in Figure 4.5 can be executed at $t=0$. Assuming perfect capital markets, this trade will generate an arbitrage profit by assumption because the amount received on the covered foreign investment will be more than the cost of the US dollar borrowing.

Figure 4.5: **Short Covered Interest Arbitrage Trade**

At $t=0$

US asset	**Exchange Market**	**Foreign (Canadian) asset**
Borrow $\$Q$ for 1 year at $r(0,1)$	Buy $\$Q/S(0)$ Canadian dollars, spot	Invest $\$Q/S(0)$ for 1 year at $r^*(0,1)$
	Sell $(\$Q/S(0))(1+r^*(0,1))$ Canadian dollars forward at $F(0,1)$	

At $t=1$ Use the funds from the maturing foreign asset to settle the forward exchange position by paying the foreign currency and receiving US dollars. Use these dollars to settle the US dollar loan.

where: $F(0,1)$ = the 1 year forward exchange rate in US direct terms; $S(0)$ = the spot exchange rate in US direct terms; $r(0,1)$ = the domestic (US) interest rate on a 1 year zero coupon security (quoted on a 365 day basis); $r^*(0,1)$ = the foreign (Canadian) one year interest rate (quoted on a 365 day basis).

To see how the series of transactions in Figure 4.5 translates into an arbitrage profit function, consider that the fully covered value of the foreign asset at maturity is $F(0,1)\{\$Q/S(0)\}(1+r^*)$ while the amount to be repaid at maturity of the loan is $\$Q\ (1+r)$. This produces the arbitrage profit function associated with the ***short arbitrage:***

$$\pi_s(0) = F(0,1)\{\$Q/S(0)\}(1+r^*) - Q\ (1+r) \leq 0$$

The ≤ 0 condition is required for absence of arbitrage.

To this point, much of the discussion of arbitrage transactions has assumed perfect markets. This assumption permits the profit functions for both the short and long arbitrages to be combined to produce an equality relationship involving forward and spot prices. When markets are not assumed to be perfect, as is the case in actual markets, then the short and long arbitrage conditions provide upper and lower boundaries on the futures or forward price. To see how this occurs, relax the assumption that lending and borrowing rates are equal by letting y and y^* denote the interest rates applicable to the ***long covered interest arbitrage trade*** done using covered Canadian borrowing to finance a US asset position. A sequence of transactions similar to those in Figure 4.5 produces the arbitrage profit function:

$$\pi_L(0) = Q\ (1+y) - F(0,1)\{\$Q/S(0)\}(1+y^*) \leq 0$$

In this case $y = y(0,1)$ is a lending rate and $y^* = y^*(0,1)$ is a borrowing rate, while for the short arbitrage r is a borrowing rate and r^* is a lending rate.

Manipulating the long arbitrage condition gives:

$$F(0,1) \geq \{(1+y)/(1+y^*)\}\ S(0)$$