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On the Foreign Exchange Neutralizer and Interest Rate Arbitrage Transaction

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Forward contracts in foreign exchange markets can be used to avoid foreign exchange risk, but they do not necessarily seem to be perfect hedging devices.

Recognizing these imperfections, in November 1982, Montreal Exchange of Canada and European Option Exchange of Amsterdam, Holland, and in December 1982, the Philadelphia Exchange of United States introduced the "Foreign Currency Option".

An investor who purchases this currency option does not have to exercise the forward contract if the foreign exchange rate at the expiration date is disadvantageous. Accordingly it seems to be a perfect hedging tool for investors and its use is expected to expand widely.

The Japan Economic Journal issue of April 15th, 1984, reported that the Bank of Tokyo had developed a similar contract called the "Forward Contract with Option" and had concluded its first such contract with C. ITOH CO., a major Japanese trading company.

This Paper will introduce the cancel option on forward contracts into the interest rate arbitrage transaction between two countries and derive the equilibrium price of the new contract.

I. A Forward Contract as a Hedging Tool against Foreign Exchange Risk and "Regret"

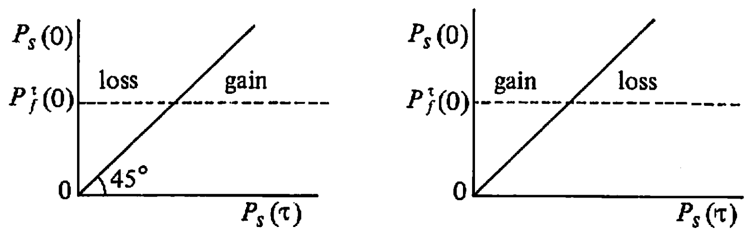
Forward contracts are traditional tools used to avoid foreign exchange risk. A forward contract is a promise to sell or buy at the current forward price for a fixed date on that date.

Indeed, a forward contract can be used to fix the amount which we will receive or pay, so it should be welcomed by business firms who wish to limit the risk of foreign exchange losses due to the fluctuation of foreign exchange rates and as a result be able to formulate more accurate budgets.

But, avoiding uncertainty by using forward contracts to fix our future commitments means that we have to give up any oppotunities for anticipated gains in the future as well. It definitely does not mean that we will not regret *ex post.* That is, we can not avoid opportunity losses from unanticipated favorable fluctuations of foreign exchange rates.

Suppose that $P_s(0)$ and $P_s(\tau)$ are the spot exchange rate (domestic units per foreign currency) at time 0 and τ respectively, and $P_f^{\tau}(0)$ is the forward rate at time

0 delivered at time τ. Let us consider the following trade. An investor buys foreign currency at the spot price at time 0 and sells it at the spot price at timer τ. If the value of the domestic currency declines, $P_s(\tau) > P_s(0)$, he receives a profit of $P_s(\tau) - P_s(0)$. On the contrary, if the value of it goes up, $P_s(\tau) < P_s(0)$, he suffers a loss of $P_s(\tau) - P_s(0)$. However, if he makes a forward contract at time 0 to sell foreign currency at time τ, he knows the outcome of the transaction at time τ independent of the future spot rate.



(a) forward contract to sell foreign exchange

(b) forward contract to buy foreign exchange

Fig. 1 Spot trading of foreign exchange.

But, as is indicated in Fig. 2, if $P_s(\tau) < P_f^{\tau}(0)$, he can avoid suffering the loss from spot-spot trading by making a forward contract to sell the foreign currency. On the contrary, if $P_s(\tau) > P_f^{\tau}(0)$, he also must give up an opportunity for a gain which he might get from spot-spot trading. In this case he will regret having made the forward contract. That is

(Si) If $P_s(\tau) < P_f^{\tau}(0)$, he receives the opportunity gain of $P_s(\tau) - P_f^{\tau}(0)$.

(Sii) If $P_s(\tau) > P_f^{\tau}(0)$, he suffers the opportunity loss of $P_s(\tau) - P_f^{\tau}(0)$.

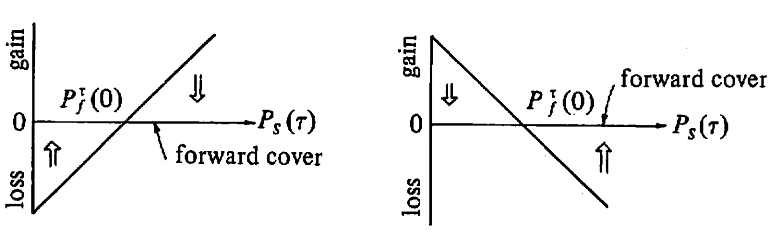
This is shown in Fig. 3 (a).

On the other hand, the result is the opposite in the case of a forward contract to buy foreign currency. That is,

(Bi) If $P_s(\tau) < P_f^{\tau}(0)$, he suffers the opportunity loss of $P_s(\tau) - P_f^{\tau}(0)$.

(Bii) If $P_s(\tau) > P_f^{\tau}(0)$, he receives the opportunity gain of $P_s(\tau) - P_f^{\tau}(0)$.

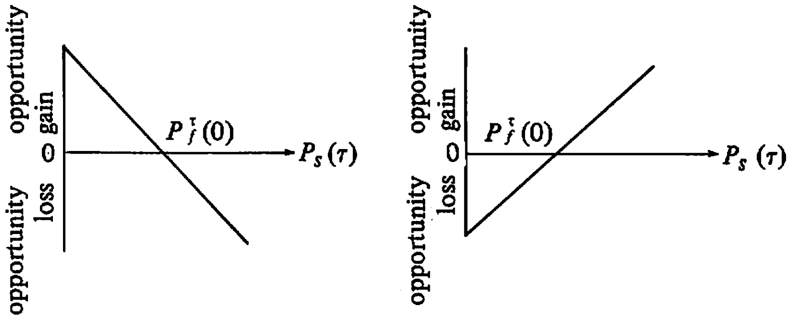
This is shown in Fig. 3 (b).



(a) spot-spot

(b) spot-forward

Fig. 2 Gains and losses.



(a) forward contract to sell foreign exchange

(b) forward contract to buy foreign exchange

Fig. 3 Opportunity gains and losses of forward cover.

II. Foreign Exchange Risk Neutralizer (FERN)

Now, let us assume investors can buy a cancel option on the exercise of the forward contract in addition to the forward contract. That is, cancel option is the right to break the promise to fulfill the forward contract. By doing so, he can eliminate the possibility of regreting *ex post* to have made such a contract. That is, in the case of a forward contract to sell foreign currency,

(Si) If $P_s(\tau) < P_f^\tau(0)$, he receives the opportunity gain of $P_s(\tau) - P_f^\tau(0)$.

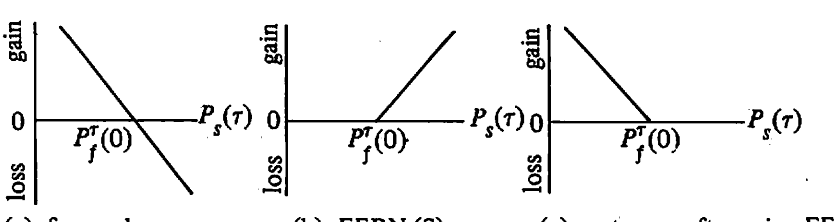
(Sii) If $P_s(\tau) > P_f^\tau(0)$, no loss is suffered.

In a similar manner, when he makes a forward contract to buy foreign currency,

(Bi) If $P_s(\tau) < P_f^\tau(0)$, no loss is suffered.

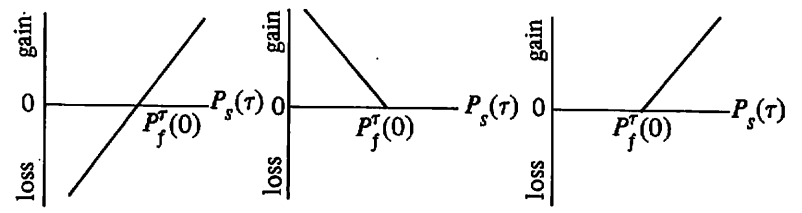
(Bii) If $P_s(\tau) > P_f^\tau(0)$, he receives the opportunity gain of $P_s(\tau) - P_f^\tau(0)$.

This cancel right is a type of insurance to eliminate the possibility of regreting *ex post.* Let us call it FERN (Foreign Exchange Risk Neutralizer). Fig. 4 (a) indicates the value of the cancel right in the case of a forward contract to sell, FERN (S). The value in the case of a forward contract to buy, FERN (B), is shown in Fig. 4 (b).



(a) forward cover (b) FERN (S) (c) outcome after using FERN

Fig. 4(a) Opportunity gains and losses using FERN (S).



(a) forward cover (b) FERN (B) (c) outcome after using FERN

Fig. 4(b) Opportunity gains and losses using FERN (B).

III. Assumptions

(1) The foreign exchange market

The foreign exchange market is frictionless, that is, there are no transaction costs or taxes. The market is competitive, that is, the spot and forward rates of foreign exchange are given for investors.

(2) A riskless security (domestic bond)

The rate of return on a domestic bond, R, is flat and given for investors. It is expressed as

$$dB/B = Rdt, \quad (1)$$

where B is the value of a domestic bond and its value at time 0, B (0), is equal to 1 in terms of the domestic currency.

(3) The spot rate of foreign exchange (domestic unit per foreign unit)

The spot rate of foreign exchange P_s follows such a stochastic process as

$$dP_s/P_s = \mu\, dt + \sigma\, dz \quad (2)$$

where μ is the instantaneous expected rate of return, σ is the instantaneous standard deviation and dz is the standard normal stochastic process.

(4) A risky security (foreign bond)

The rate of return on a foreign bond is R^*. Its level is flat and given for investors. It is written in terms of foreign currency as

$$dB^*/B^* = R^*dt, \quad (3)$$

where B^* is the value of a foreign bond and its value at time 0, B^* (0), is equal to 1 in terms of the foreign currency. But, because a domestic investor cannot avoid foreign exchange risk in terms of the domestic currency the rate of return for such an investor on the foreign bond follows a stochastic process such as

$$d\,(P_sB^*)/P_sB^* = (P_sdB^* + B^*dP_s)/P_sB^* = dB^*/B^* + dP_s/P_s$$
$$= (\mu + R^*)\,dt + \sigma dz. \quad (4)$$

According, because of foreign exchange risk a foreign bond is viewed as a risky security by domestic investors.

(5) Investor's preference
He is a pure financial-asset investor and risk-averter.

(6) Exercise of FERN
A investor can exercise FERN at the forward rate of $P_f^s(0)$ only at τ.

IV. "Regret" and the Interest Rate Arbitrage Transaction

Generally, the interest rate arbitrage transaction involving currencies of two countries is done for the purpose of earning profits, without taking on any foreign exchange risk by investing or raising funds advantageously. It may take many forms.

According to the interest rate parity theorem (IRPT), when investors engage in interest rate arbitrage using forward contracts the equilibrium spot-forward ratio can be written as

$$P_f^s(0)/P_s(0) = B(\tau)/B^*(\tau), \tag{5a}$$

where $B^*(\tau)$ and $B(\tau)$ are the value of principal and interest at time τ of foreign and domestic bonds respectively. They can be rewritten as

$$B^*(\tau) = B^*(0)\exp(R^*\tau), \qquad B(\tau) = B(0)\exp(R\tau),$$

so, the forward-spot ratio is

$$P_f^s(0)/P_s(0) = \exp[(R-R^*)\tau] \tag{5b}$$

But, covered transaction strategies employing forward contracts may cause investors to regret entering into the transactions. Let us consider this possibility to regret explicitly and examine the interest rate arbitrage transaction again. We will examine the case of an outflow of domestic funds to a foreign country, Strategy (S), and an inflow of foreign funds to domestic market, Strategy (B), in turn.

Strategy (S)

(1) In the domestic market, sell short $[1 + P_c(0)]X$ units of domestic bonds, a total domestic currency amount of $[(1 + P_c)BX]$, where $P_c(0)$ is the domestic currency price of FERN(S) at time 0,

(2) And change the funds received by short selling domestic bonds, $[1 + P_c(0)]\,B(0)X$, into foreign currency at the price of $P_s(0)$ and buy foreign bonds. At the same time, make a forward contract with cancel option to sell foreign currency.

The cost of raising funds for investors, C_s, is

$$C_s = [1 + P_c(0)]\,XB(\tau), \tag{6}$$

and the profits which they will be able to earn after τ periods by investing in foreign is

$$\begin{aligned}\Pi_s &= [X/P_s(0)]\,B^*(\tau)\,\mathrm{Max}\,[P_s(\tau), P_f^s(0)] \\ &= [X/P_s(0)]\,B^*(\tau)\{P_f^s(0) + \mathrm{Max}\,[P_s(\tau)-P_f^s(0), 0]\}.\end{aligned} \tag{7}$$

Accordingly, in equilibrium,

$$\{P_f^s(0) + \mathrm{Max}\,[P_s(\tau)-P_f^s(0), 0]\}/P_s(0) = [1 + P_c(0)]\,B(\tau)/B^*(\tau). \tag{8}$$

Comparing Eq. (5) with the above equation, $(1 + P_c)$ of the right hand side, RHS, and the second item of the left hand side, LHS, are different. The second item of LHS represents the value of FERN (S), and P_c represents its unit price. Both Eqs. (5) and (8) show the equilibrium relationship under uncertainty, so investors should prefer a forward contract with a cancel option to one without it if P_c is relatively low. As a result, P_c has to rise until they cannot enjoy excess profits by using a forward contract with a cancel option. That is, Eq. (8) is an equilibrium condition for determination of the price of FERN (S). Eq. (8) can be rewritten as

$$P_f^*(0)/P_s(0) - B(\tau)/B^*(\tau)$$
$$= -\text{Max}\,[P_s(\tau) - P_f^*(0), 0]/P_s(0) + P_c(0)\; B(\tau)/B^*(\tau). \quad (0)$$

When the market is in equilibrium and interest rate parity holds, RHS of Eq. (9) is equal to 0. So the equilibrium price of FERN (S) is

$$P_c(0) = \{\, \text{Max}\,[P_s(\tau) - P_f^*(0), 0]\,/\,P_s(0)\,\}\;\; B^*(\tau)/B(\tau), \qquad (10a)$$

similarly, its equilibrium price at τ is

$$P_c(0) = B^*(\tau)\,\text{Max}\,[P_s(\tau) - P_f^*(0), 0]/P_s(0) \qquad (10b)$$

Moreover, Eq. (10a) can be rewritten from the interest rate parity equation as

$$P_c(\tau) = \text{Max}\,[P_s(\tau) - P_f^*(0), 0]\,/\,P\;\;(0). \qquad (11)$$

Now, let us consider an interest rate arbitrage transaction using forward contracts with FERN (B).

Strategy (B)

(1) Sell short $[XB(0)/P_s(0)]$ units of foreign discount bonds in the foreign country.

(2) Change the foreign currency raised by short selling into domestic currency at P_s (0) in the spot exchange market, and make a forward contract with FERN (B).

(3) Buy X units of domestic bonds.

The cost of raising funds for investors, C_B, is

$$C_B = [XB(0)/P_s(0)]\; B^*(\tau)\,\text{Min}[P_s(\tau), P_f^*(0)]$$
$$= [X/P_s(0)]\; B^*(\tau)\;\; P_f^*(0) - \text{Max}\,[P_f^*(0) - P_s(\tau), 0]\;\; . \qquad (12)$$

On the other hand, the profit which they can earn after τ periods by investing in domestic bonds II_B is

$$\Pi_B = (1 - P_p)\,XB(\tau). \qquad (13)$$

Suppose that Pp is the price of FERN (B) per unit of domestic currency. In equilibrium, we have the following relationship.

$$\{\, P_f^*(0) - \text{Max}\,[P_f^*(0) - P_s(\tau), 0]\,\}\;/P_s(0) = (1 - Pp)B(\tau)/B^*(\tau) \qquad (14)$$

Comparing Eq. (5) with the above equation, Pp has to rise until investors cannot enjoy excess profits using a forward contract with FERN (B). That is, Eq. (14) is a necessary condition to determine the equilibrium price of FERN (B). Eq. (14) can be rewritten as

$$P_f^\tau(0)/P_s(0) - B(\tau)/B^*(\tau)$$
$$= \mathrm{Max}\,[P_f^\tau(0) - P_s(\tau), 0]/P_s(0) - P_P(0)\,B^*(\tau)/B(\tau). \qquad (15)$$

In the same manner, RHS of Eq. (15) is equal to 0, so the equilibrium price of FERN (B) is

$$P_P(0) = \{\mathrm{Max}\,[P_f^\tau(0) - P_s(\tau), 0]/P_s(0)\}\,B^*(\tau)/B(\tau) \qquad (16a)$$
$$= \mathrm{Max}\,[P_f^\tau(0) - P_s(\tau), 0]/P_f^\tau(0), \qquad (16b)$$

and its equilibrium price at time τ is

$$P_P(\tau) = B^*(\tau)\,\mathrm{Max}\,[P_f^\tau(0) - P_s(\tau), 0]/P_s(0). \qquad (16c)$$

Both Eqs. (10a) and (16a) include unknowns, Max $[P_s(\tau) - P_f^\tau(0), 0]$ and Max $[P_f^\tau(0) - P_s(\tau), 0]$ respectively. In the option pricing model (OPM),*[1] these unknowns are called a "call", and a "put" respectively. In the following section, we will derive the equilibrium price of FERN (S) at time 0 from OPM by using Eq. (10b) and (16c) as equilibrium conditions. In OPM, the option depicted in Fig. 4A (b) is a "call" and the option shown in Fig. 4B (b) is a "put".

V. The Price of FERN

The equilibrium price of FERN (S) is given by deriving the price of a call on a foreign bond denominated in foreign currency and whose exercise price is equal to the forward exchange rate. Similarly, the equilibrium price of FERN (B) is given by deriving the price of a put having the same characteristics. In order to derive the equilibrium price of FERN (S) and FERN (B), the following assumption has to be added.

Assumption (7) The price of FERN (a European option)

The price of FERN P_O is a function of the following variables; (1) the price of the underlying asset, that is, a foreign bond, P_sB^*; (2) time t; (3) the exercise price, that is, forward exchange rate P ; (4) the rate of return on a domestic bond R; (5) the rate of return on a foreign bond R^*; (6) the variance of the foreign exchange rate σ^2. Provided that P , R, R^*, σ^2 are given,

$$P_O = G(P_sB^*, t{:}\ R, R^*, P\ , \sigma) \qquad (17)$$

Such a contingent claim is called a European option on a foreign bond, which investors cannot exercise until the predetermined maturity date.

As the price of an underlying asset P_sB^* is subject to a diffusion process (assumption (4)) and the option price P_O is a function of the price of an underlying asset P_sB^* and time t, we can derive the following relationship from Ito's lemma*[2]

$$dP_O = G_s\,d(P_sB^*) + (1/2)\,G_{ss}\,[d(P_sB^*)]^2 + G_t\,dt. \qquad (18)$$

By substituting Eq. (4) into the above equation,

$$dP_O = [(1/2)\sigma^2 (P_sB^*)^2\, G_{ss} + (\mu + R^*)\,P_sB^*\,G_s + G_t]\;dt + \sigma\,(P_sB^*)\,G_s\,dz, \qquad (19)$$

where $G_s \equiv \partial G/\partial P_s$, $G_{ss} \equiv \partial^2 G_s/\partial P_s^2$.

As an option price, P_O is a function of the price of the underlying asset P_sB^*, so P_O is also subject to a similar stochastic process. Accordingly, P_O can be written as

$$dP_O = \mu_O P_O \, dt + \sigma_O P_O \, dz_O. \quad (20)$$

Comparing Eq. (19) with Eq. (20), the following relationship is derived.

$$\mu_O P_O = (1/2)\,\sigma^2 (P_s B^*)^2 G_{ss} + (\mu + R^*) P_s B^* G_s + G_t \quad (21a)$$

$$\sigma_O P_O = \sigma P_s B^* G_s \quad (21b)$$

$$dz_O = dz \quad (21c)$$

Let us consider a portfolio composed of three assets: (1) a domestic bond, (2) an underlying asset (a foreign bond) and (3) an option (FERN). Suppose that the weight of each asset in the portfolio is respectively W_0, W_1, W_2, and that the net investment amount is equal to 0, that is $W_0 + W_1 + W_2 = 0$. The return on such a portfolio dV is

$$dV = W_1 \left[(d(P_s B^*)/(P_s B^*) - R\, dt \right] + W_2 \left[(dP_O/P_O) - R\, dt \right]. \quad (22)$$

Substituting Eqs. (4) and (20) into the above equation, Eq. (22) can be rewritten as

$$dV = [W_1 (\mu + R^* - R) + W_2 (\mu_O - R)]\, dt + (W_1 \sigma + W_2 \sigma_O)\, dz \quad (23)$$

In equilibrium, it is impossible to make a profit with 0 net investment, so the following relationship holds.

$$W_1 \, (\mu + R^* - R) + W_2 (\mu_O - R) = 0 \quad (24)$$

Investors can form the following risk-neutral portfolio composed of the underlying asset and an option,

$$W_1 \sigma + W_2 \sigma_O = 0. \quad (25)$$

Because W_1, $W_2 \neq 0$, we can derive the following equilibrium condition,

$$(\mu + R^* - R)/\sigma = (\mu_O - R)/\sigma_O \quad (26)$$

The above equation corresponds to Eqs. (10) and (16). Rewriting RHS of Eq. (26) by substituting Eqs. (21a) and (21b),

$$(\mu + R^* - R)/\sigma = [(1/2)\sigma^2 (P_s B^*)\, G_{ss} + (\mu + R^*) P_s B^* G_s + Gt - RP_O] / \sigma P_s B^* G_s \quad (27)$$

We can derive a partial differential equation from the above equation.

$$(1/2)\,\sigma^2 \, (P_s B^*)^2 \, G_{ss} + R(P_s B^*) G_s + Gt - RP_o = 0 \quad (28)$$

From Eq. (10b), the value of a unit of FERN (S) at time τ, $P_c\,(\tau)$ is

$$P_c\,(\tau) = \text{Max}\,[P_s(\tau)\, B^*(\tau) - P_f^*(0)\, B^*(\tau), 0] / P_s(0), \quad (29a)$$

and, from Eq. (16c), the value of FERN (B) at time τ is

$$P_p\,(\tau) = \text{Max}\,[0, P_f^*(0)\, B^*(\tau) - P_s(\tau)\, B^*(\tau)] / P_s(0). \quad (29b)$$

The equilibrium price of FERN (S) at time 0, $P_c\,(0)$, can be derived by solving Eq. (28) under the initial condition that

$$G\,(P_s B^*, 0) = 0 \quad (30)$$

and using Eq. (29a),

$$P_c(0) = \quad P_s(0)\, B^*(\tau)\, N(d_1) - P \quad (0)[B^*(\tau)/B(\tau)]\; N(d_2) \quad / P_s(0).$$

By definition,

$$B^*(\tau) = B^*(0) \exp (R^* \tau) = \exp (R^* \tau)$$

and

$$B(\tau) = B(0)\exp(R\tau) = \exp(R\tau).$$

Thus,

$$P_c(0) = \exp(R^*\tau)N(d_1) - [P_f^{\tau}(0)/P_s(0)]\ \exp[-(R-R^*)\tau]\, N(d_2), \tag{31a}$$

provided that $N(d)$ follows a normal probability distribution function and

$$\begin{aligned} d_1 &= \{\ln[P_s(0)/P_f^{\tau}(0) + B(\tau)] + (1/2)\sigma^2\tau\}/\sigma\sqrt{\tau} \\ &= \{\ln[P_s(0)/P_f^{\tau}(0)] + [R + (1/2)\sigma^2]\tau\}/\sigma\sqrt{\tau} \\ d_2 &= d_1 - \sigma\sqrt{\tau}\ . \end{aligned}$$

Interest rate parity holds in equilibrium, so the above equation can be rewritten as,

$$P_c(0) = \exp(R^*\tau)N(d_1) - N(d_2) \tag{31b}$$
$$d_1 \equiv [R^* + (1/2)\sigma^2]\tau/\sigma\sqrt{\tau},\ d_2 \equiv d_1 - \sigma\sqrt{\tau}.$$

Next, from the following relationship,

$$\text{Max}[0, P_f^{\tau}(0) - P_s(\tau)] = \text{Max}[P_s(\tau) - P_f^{\tau}(0), 0] - [P_s(\tau) - P_f^{\tau}(0)] \tag{32}$$

the price of a put at time τ, $P_P(0)$, is

$$\begin{aligned} P_P(\tau) &= \text{Max}[0, P_f^{\tau}(0) - P_s(\tau)] \\ &= \text{Max}[P_s(\tau) - P_f^{\tau}(0), 0] - [P_s(\tau) - P_f^{\tau}(0)] \\ &= P_c(\tau) - [P_c(\tau) - P_f^{\tau}(0)]. \end{aligned} \tag{33}$$

Accordingly, we can derive the equilibrium price of FERN (B) by substituting Eq. (31a) into Eq. (33).

$$P_P(0) = -\exp(R^*\tau)\ N(-d_1) + [P_f^{\tau}(0)/P_s(0)]\ \exp[-(R-R^*)\tau]\ N(-d_2) \tag{34a}$$

In the same manner, the above equation can be rewritten from interest rate parity as follows.

$$P_P(0) = -\exp(R^*\tau)N(-d_1) + N(-d_2) \tag{34b}$$

Thus investors can avoid the possibility of regreting by paying the cost indicated by Eq. (31) when they make a forward contract to sell foreign currency, and by paying the cost of Eq. (34) when they make a forward contract to buy foreign currency.

VI. The Forward Exchange Rate and the Price of FERN

By differentiating Eq. (31) with respect to the forward exchange rate, we can derive the following equation.

$$\partial P_c(0)/\partial P_f^{\tau}(0) = -\exp[-(R-R^*)\tau]\ N(d_2) < 0 \tag{35}$$

In the same manner, the following relationship can be derived from Eq. (33).

$$\partial P_P(0)/\partial P_f^{\tau}(0) = \partial P_c/\partial P_f^{\tau}(0) + \exp[-(R-R^*)\tau] \tag{36}$$

Thus it can be said that the price of FERN (S) increases and that of FERN (B) decreases as the forward exchange rate increases. (see Fig. 5)

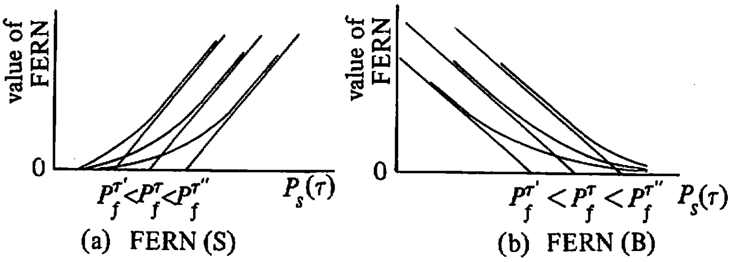


Fig. 5 Forward rate and the price of FERN.

Fig. 6 may help the reader to understand the above relationship. In Fig. 6 (a), the exercise price $P_f^{\tau}(0)$ is an unbiased estimator of a future spot exchange rate $P_s(\tau)$, that is,

$$P_f^{\tau}(0) = E\ [P_s(\tau)],$$

so the shadow area corresponding to the value of FERN (S) is equal to the other area of oblique line corresponding to that of FERN (B). In Fig. 6 (b), due to a lower exercise price is, the shadow area corresponding to FERN (S) is larger than that corresponding to FERN (B). That is, the value of FERN (S) is larger than that of FERN (B). On the other hand, Fig. 6 (c) shows that investors have to pay a relatively higher cost for FERN (B) because the forward exchange rate is higher.

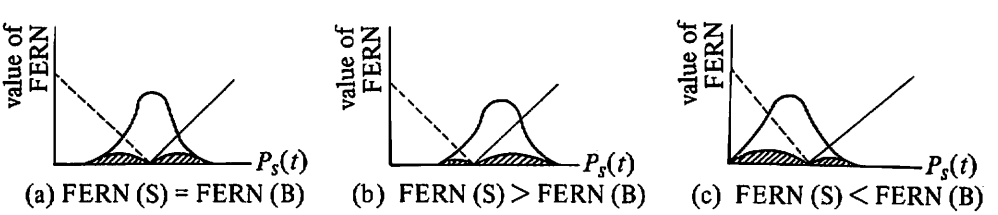


Fig. 6 Forward rate and the price of FERN.

VII. Concluding Remarks

Investors making forward contracts have to exercise at the fixed forward rate on maturity date independent of the realized future spot exchange rate. Accordingly they might regret if the future spot rate changes advantageously. Investors, if they are risk-averters, should hesitate to use forward contracts without any compensation for the risk of regret, in other words, without receiving a risk premium. However, we know that such "regret" can be eliminated by making use of FERN. In this paper, we considered interest arbitrage transactions using FERN and derived the market equilibrium conditions necessary to determine the price of FERN. Finally the equilibrium price of FERN was derived by using OPM.

In Japan, the Bank of Tokyo was the first bank to trade foreign currency options, and at present five banks are dealing in the currency options: Sumitomo Bank, Tokai Bank, Dai-ichi Kangyo Bank, Citi Bank N.A. (Tokyo) and the Bank of

America (Tokyo). Currency contracts are written only on the US dollar, and the trading volume is still low. The number of users of this option is also low. It is said that even the Bank of Tokyo has only about ten customers and the others have only one or two. Thus, although our banks have begun to deal in foreign currency options, they probably still dbout whether it will develop into a viable business.

I was interested in deriving an equation to price foreign currency options and also in how well such a equation could estimate the price of currently quoted option contracts. A comparison of option prices calculated by Eqs. (31) and (34) to price quotations from The Bank of Tokyo suggested that the obtained option prices are determined according to Eqs. (31) and (34). However, I cannot present a direct comparison, because the Bank of Tokyo would not permit reproduction of their option price table here.

Notes

1. See Black-Scholes (1973) and Merton (1973).
2. See appendix of Smith (1976).

References

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