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# Trades in commodities, financial assets, and currencies: A triangle of arbitrage, hedging and speculative designs☆

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ABSTRACT

This work brings three markets — (i) commodities (e.g., steel iron ores, electronic parts, oil), (ii) financial assets (such as various stocks, bonds, notes), and (iii) different currencies (like U.S. dollar, British pound, euro, yen and so on) and examines the scope of triple operations of arbitrage, hedging, and speculation. Trading of cross-listed cross-currency assets with arbitrage and hedging is already recorded and analyzed. Here one more dimension — cross-country trades in commodities are added, and speculation is juxtaposed too within one framework.


## 1. Introduction

The existing literature has waxed eloquent on the scope and validity of arbitrage in the foreign exchange market since the seminal papers by Frenkel and Levich (Frenkel & Levich, 1975; Frenkel & Levich, 1977), Deardorff (Deardorff, 1979) — all following the classic work of Aliber (Aliber, 1973) — and a few modifications in the 1980s. John Keynes (Keynes, 1923) should be noted for bringing many of the scholars in this line of research to begin with. Rhee and Chang (Rhee & Chang, 1992) have taken the issue to an upper notch by introducing intra-day currency trading in perfect foreign exchange market, and Blenman (Blenman, 1992) revised the paradigm by introducing market segmentation. Subsequently, Ghosh, in a series of papers (Ghosh, 1997a; Ghosh, 1997b; Ghosh, 1998), have changed the dimension and direction by introducing iterative arbitrage

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where intra-moment (as opposed to intra-day) operational strategies are put into play — all still only in foreign exchange market. Ghosh and Prakash (Ghosh & Prakash, 2001) have taken the issue by including speculative strategies on top of hedging-cum-arbitrage. Ghosh and Arize (Ghosh, 1999), and Clark and Ghosh (Clark & Ghosh, 2005) take the research a few steps further with the introduction of options. Ghosh and Ghosh (Ghosh & Ghosh, 2005) expand Ghosh-Arize analytical structure. Later, Ghosh, Ghosh and Bhatnagar (Ghosh et al., 2010) break away from arbitrage, hedging and speculation in currency-only environment, and examine the cross-listed cross-currency assets and currencies.

In this joint work, we plan to bring in commodity market in the fold, and restructure arbitrage and speculation covered by various derivative securities. The work is structurally theoretical, and verified with empirical data, collected from Reuters real-time data base, data stream, and other sources in almost all previous studies. Our hunch at this stage is that by integrating three markets on different trading platforms we will establish a new set of useful results and magnified profit potential for any investor — individual or firm. We will encounter some time-stamping of real data since there will be some gap between closing and opening of major markets such as Tokyo, Paris, Frankfurt, London, New York and Chicago. It may take painful efforts to secure data on the gap periods, and we know the difficulty. Yet, we have done it before, and we could successfully publish our results. Since we can do what we need to do to remain dominant in the field, we plan to pursue it rigorously.

## 2. Trades in commodities

Trades in commodities are abundantly explained and exposited in the existing literature within the so-called Heckscher–Ohlin–Samuelson model of international trade under general equilibrium in the symmetric structure of two factors (labor and capital), two commodities (exportable and importable) involving two countries (exporting and importing). Let us expand a bit to bring out four major results in that literature. Following Jones (Jones, 1965), consider that inelastically given primary factors, labor ($L$) and capital ($K$) produce exportable commodity ($X_1$)and importable commodity($X_2$), and the factor allocations are as follows:

$$a_{L1}X_1 + a_{L2}X_2 = L \tag{1}$$

$$a_{K1}X_1 + a_{K2}X_2 = K \tag{2}$$

and the dual of the full-employment equations, defined by Eqs. (1) and (2) — the so-called zero-profit conditions are expressed as follows:

$$a_{L1}w + a_{K1}r = P_1 \tag{3}$$

$$a_{L2}w + a_{K2}r = P_2 \tag{4}$$

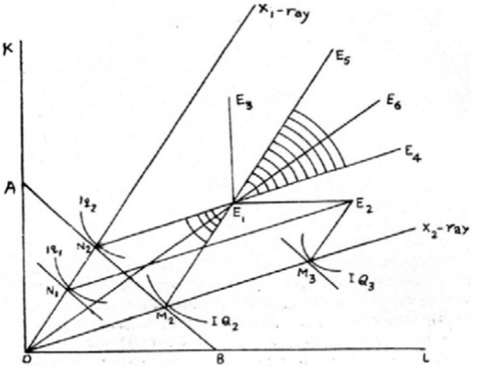


**Fig. 1.** Input change and output change: the relationship.

where $a_{ij}$ is the $i$-th factor to produce one unit of $j$-th commodity, $w$ and $r$ are wage and rental rates, respectively, and $P_i \quad (i=1,\ 2)$is the $i$-th commodity price. Logarithmic differentiation of expressions (1) and (2) yields the following:

$$\hat{X}_1 > \hat{K} > \hat{L} > \hat{X}_2 \tag{5A}$$

$$\hat{X}_1 = \hat{K} = \hat{L} = \hat{X}_2 \tag{5B}$$

$$\hat{X}_1 < \hat{K} < \hat{L} < \hat{X}_2 \tag{5C}$$

commodity where circumflex over a variable means the percentage change in the value of the variable, — that is, $\hat{X}_1$measures the percentage change in $X_1$, and so on provided $X_1$is relatively more capital intensive and $X_2$is relatively more labor-intensive ($\frac{a_{K1}}{a_{L1}} > \frac{a_{K2}}{a_{L2}}$). Expressions (5A) through (5C) are the generalized expressions of Rybczynski Theorem of factor growth (or decay) on output change. Fig. 1 exhibits output changes upon a change in primary factors of production, well-illustrated in Ghosh (Ghosh, 1984). It is shown that if the first commodity is relatively more capital-intensive, and if capita grows by, say, 5%, first good grows at more than 5% (say, 7%), and the second commodity will grow at the lowest rate (or decay). If $\hat{K} = 5\%,\ \ \hat{L} = 0$, then $\hat{X}_1 > 5\%,$ and $\hat{X}_2 < 0.$ This is precisely Rybczynski Theorem (Rybcznski, 1955).

Similarly, logarithmic differentiation of expressions (3) and (4) yields the following:

$$\hat{w} > \hat{P}_2 > \hat{P}_1 > \hat{r} \tag{6A}$$

$$\hat{w} = \hat{P}_2 = \hat{P}_1 = \hat{r} \tag{6B}$$

$$\hat{w} < \hat{P}_2 < \hat{P}_1 < \hat{r} \tag{6C}$$

This is the famous Stolper–Samuelson Theorem in generalized form (Stolper & Samuelson, 1941; Ghosh, 1984; Ghosh, 2015). Two other major theorems are Heckscher–Ohlin Theorem and Factor Price Equalization Theorem, which can be derived quite easily in any distortion-free international market, and in it capital-abundant country exports its product to the labor-abundant country that exports its labor-intensive good in exchange under condition of balance of trade (see Ghosh (Samuelson, 1953; Ghosh, 1984)).

The result is not that simple one in a multi-commodity world where there are many exporting countries (or corporations) and many importing countries (or companies). Several scholars like Paul Krugman have already noted that final exportable and importable goods go through intermediate input processing and sequencing. The U.S. corporation such as IBM buys parts such as several computer chips and electronic inputs from China, Taiwan, South Korea, soft wares from India and so on, and sells IBM computers to, say, Mexico, UK, etc. Now, if the final product, IBM computer, is the export commodity, it is really not the export good of the United States. It is the export good of all the countries combined and comingled. With that clarity in place, it is evident that commodity world offers the opportunities for arbitrage. Price discrimination, often practiced, also provides scope of arbitrage profits. Take a simple example where a country or a firm A purchases (imports) a commodity $f_1$ in the quantities $q_1 \ \ (1 \le \alpha_i \le \alpha_m$ from sources $\alpha_1,\ \ \alpha_2,\ \ \ldots\ldots,\ \ \alpha_m$ at prices $b_i \ \ (1 \le i \le m)$ and sells (exports) the amounts purchased from the aforesaid sources at higher prices $s_i \ \ (1 \le \gamma_i \le \gamma_m)$ in $\gamma_1,\ \ \gamma_2,\ \ \ldots\ldots,\ \ \gamma_m$ markets and makes the arbitrage profits. The same importer can do the same type of importing, say, good $f_2$, from one set of markets and exporting to another set of markets and makes arbitrage profits, and the practice may extend to other markets as well in the similar fashion. The profit the arbitrageur thus can make from the commodity markets (at the present time) is expressed as follows[1]:

$$\pi_{0(C)} = \sum_{j=1}^{n} \sum_{i=1}^{m} q_{ii}^{j} \left( b_{i\alpha_i}^{f_j} - s_{i\gamma_j}^{f_j} \right). \tag{7}$$

[1] Profit is made usually in 6 months or so after selling the purchased commodities at higher prices. However, profit amount can be ascertained, and discounting the profit amount, the arbitrageur can get the present value of the total profit.

Here $q_{ij}$ is the quantity of i-th good bought at the j-th market at price $b_{ij}^{f_i}$ and sold at price $s_{i\alpha_j}^{f_i}$ (where $s_{i\alpha_j}^{f_i} > b_{ij}^{f_i}$), and $q_{ij}^{f_i}$is the quantity. The preliminary estimate of commodity market arbitrage in 5 markets with 8 commodities, based on exploiting the price discrimination alone is 83 billion dollars. This can be further increased if the importing country or the importing firm buys raw materials for the final products with underlying arbitrage potentials. This aspect remains unexplored as of this moment by any research at any level. Since it involves a huge time and resources, we leave the issue highlighted and move onto to other arbitrage calculation by bringing in the asset markets and currency markets in an effort to integrate the total profit possibilities.

## 3. Asset markets

Cross-listed assets are a regular feature in most major stock exchanges. General Motors stock is not just traded in NYSE; it is in other stock exchanges world-wide. Many financial assets are traded simultaneously in different stock exchanges, and many of these exchanges operate in different countries with sovereign currencies. American Express, Wal-Mart, General Motors, General Electric, Boeing, Microsoft, McDonalds', Coca Cola are a few of the U.S. securities that trade in several overseas stock exchanges. For example, General Motors stocks are listed in New York Stock Exchange (NYSE), London Stock Exchange (LSE), Frankfurt Stock Exchange (DAK), Zurich Stock Exchange. In fact, cross-listed cross-currency stocks form the majority of Dow Jones Industrial securities. London (UK) is 5 h ahead of New York (USA), and Frankfurt (Germany) and Zurich (Switzerland) are 6 h ahead of New York. Once these price quotes are observed on intra-day basis, one may find the arbitrage opportunities that can be exploited by a hawk-eyed arbitrageur instantly. In this section, we attempt to formulate the arbitrage profits emanating from cross-listed cross-currency trading environment. As we all know, arbitrage profit is the result of any misaligned market quotations of the same asset in different securities markets. Initially, consider that there are n securities which are listed in two stock exchanges in two different countries with different currencies. For the sake of simplicity at this stage we assume away transaction costs, which can be factored in without any issue raised or difficulty met. Let the currencies of the country 1 and country 2 be $E_1$ and $E_2$, expressed in U.S. dollars, and the observed prices of stock $i$ be $P_{1i}$ and $P_{2i}$ in stock exchange 1 and stock exchange 2, respectively where $1 \le i \le n$. Then $E_1 P_{1i}$ and $E_2 P_{2i}$ are the dollarized values of the $i$-th stock in market 1 and market 2, respectively. If $E_1 P_{1i} \neq E_2 P_{2i}$, then there is a scope of arbitrage profit by buying the $i$-th stock in the market where its dollarized value is lower and selling it the market where its dollarized value is higher.

If the investor recognizes that at a given point of time $E_1 P_{1i} > E_2 P_{2i}$ for $i = 1, 2, \ldots$, m and $E_1 P_{1i} < E_2 P_{2i}$ for $i = $ m + 1, m + 2, …., n, then the arbitrage profits involving 2 markets ($\pi(2)$) for the investor must be measured by the following expression:

$$\pi(2) = \sum_{i=1}^{m} Q_i(E_1 P_{1i} - E_2 P_{2i}) - \sum_{i=m+1}^{n} Q_i(E_1 P_{1i} - E_2 P_{2i}) \tag{8}$$

where $Q_i$ is the number of securities bought or sold. The first part on the right-hand side of the expression (8) evidently signifies the selling of security $i$ in market 1 and buying the security in market 2 ($i = 1, 2, \ldots$, m), and the second part signifies the opposite for stock $i = $ m + 1, m + 2, …., n.

Instead of 2 markets if the number of markets for the arbitrageur is $\Gamma$, then the total profits can be much higher if profit opportunities are exploited properly, and the total value of profits is measured by:

$$\pi(\Gamma) = \sum_{j,k,j\neq k}^{h\subseteq\Gamma} \sum_{i=1}^{n_k} Q_i(E_1 P_{1i} - E_2 P_{2i}) - \sum_{j,k,j\neq k}^{h\subseteq\Gamma} \sum_{i=n_j+1}^{n_k} Q_i(E_1 P_{1i} - E_2 P_{2i})$$

$$i, j = 1, 2, , H; i \neq j, k = 1, 2, \ldots, H. \tag{9}$$

The result has originated in the work of Ghosh, Ghosh and Bhatnagar (Ghosh & Ghosh, 2005), and the numerical measure of profits under given parameters is given. Obviously, under different data-set the result will be different, and we are not computing the numerical value as the analysis is theoretical in structure. It should, however, be noted that since transactions in asset markets take a few days, the appropriate discounting is required to get the present value of $\pi(\Gamma)$to be $\pi_0(\Gamma) \equiv (1+T)^{-1}\pi(\Gamma)$ where $T$ refers to the settlement period. Here then asset market arbitrage profit in present value term is:

$$\pi_{0(A)} \equiv (1+T)^{-1}\pi(\Gamma) \equiv (1+T)^{-1}\left[\sum_{j,k,j\neq k}^{h\subseteq\Gamma}\sum_{i=1}^{n_k} Q_i(E_1P_{1i}-E_2P_{2i}) - \sum_{j,k,j\neq k}^{h\subseteq\Gamma}\sum_{i=n_i+1}^{n_k} Q_i(E_1P_{1i}-E_2P_{2i})\right].$$

## 4. Foreign exchange markets

Next, we move to foreign exchange markets and look at the covered arbitrage possibilities. It is well-documented in the literature that if the difference between interest rates of the domestic economy and of the foreign economy is as follows[2]:

$$r - r* \neq \left(\tfrac{F-S}{S}\right)(1+r*),$$

Arbitrage profits exist. Here $r$ is the domestic interest rate, $r^*$ is the foreign interest rate, $S$ and $F$ are the spot rate of exchange and forward rate of exchange of foreign currency in terms of domestic currency. If $r - r* < \left(\tfrac{F-S}{S}\right)(1+r*)$,arbitrageur converts home currency (US dollars, in this case) into foreign currency (say, British currency in this example), puts the pounds in the British bank in fixed deposit, and then sell the British pound amount with accrued interest earnings at forward exchange rate, and then take the profits without assuming any risk. The profit from first round of arbitrage can be measured by the following in present value term:

$$\pi_{1(0)} = W\beta \tag{11}$$

where W is the initial amount of investment capital and $\beta\,(\equiv (1+r)^{-1}[\tfrac{F}{S}(1+r*) - (1+r)]$is the rate of profit per dollar[4]. When this process is sequentially repeated before the quotes change values for z-th times and profits are added, cumulative profit level is defined by:

$$\pi_0^{**} = W\{(1+\beta)^z - 1\}. \tag{12}$$

If the arbitrageur puts in the discounted value of his first round of profit $W\beta$in his successive $z$ rounds of operations. Ghosh and Arize (2003) have pointed out that the profit maker should not be short-sighted to ignore profits of other rounds of iterative arbitrage, and if profits of other subsequent rounds are put in arbitrage process, then cumulative profits will be equal to:

$$\pi_0^{**} = W\{(1+\beta)^z - 1\}. \tag{13}$$

For computing total profit from foreign exchange market (interchangeably currency market) we choose to the measure in expression (13) and re-label it as

$$\pi_{0(F)} = W\{(1+\beta)^z - 1\} \tag{14}$$

[2] See Clark and Ghosh (Clark & Ghosh, 2005).

## 5. Total arbitrage profits with hedging by forward cover

Integration of commodity markets, financial asset markets and currency markets obviously yields on covered arbitrage the present value of profits as follows:

$$\pi_{0(C)} + \pi_{0(A)} + \pi_{0(F)} \equiv M = \sum_{j=1}^{n}\sum_{i=1}^{m} q_{ii}^{j}\left(b_{ii}^{f_j} - s_{i\alpha_j}^{f_j}\right) + (1+T)^{-1}\left[\sum_{j,k,j\neq k}^{h\subseteq\Gamma}\sum_{i=1}^{n_k} Q_i(E_1P_{1i} - E_2P_{2i}) - \sum_{j,k,j\neq k}^{h\subseteq\Gamma}\sum_{i=n_i+1}^{n_k} Q_i(E_1P_{1i} - E_2P_{2i})\right] + W\left\{(1+\beta)^z - 1\right\}. \quad (15)$$

Having estimated $\pi_{0(C)} = \$135{,}000{,}00$, $\pi_{0(A)} = \$102{,}000{,}000$, $\pi_{0(F)} = \$85{,}000{,}000$,and hence $M = \$322{,}000{,}000$, we can compute Table 1 (with the following data ($r = 0.0452$, $r^* = 0.0410$, $F = 1.6812$, $S = 1.6152$. Here then $\beta = 0.0367$. So, Table 1 is as follows:

**Table 1**
Measures of covered arbitrage profits.

| $i$ | β | $\{(1+\beta)^i - 1\}$ | $M\{(1+\beta)^i - 1\}$ |
|---|---|---|---|
| 1 | 0.0367 | 0.0367 | 11,817,400.00 |
| 2 | 0.0367 | 0.07474689 | 24,068,498.58 |
| 3 | 0.0367 | 0.114190101 | 36,769,212.48 |
| 4 | 0.0367 | 0.155080878 | 49,936,042.58 |
| 5 | 0.0367 | 0.197472346 | 63,586,095.34 |
| 6 | 0.0367 | 0.241419581 | 77,737,105.04 |
| 7 | 0.0367 | 0.286979679 | 92,407,456.79 |
| 8 | 0.0367 | 0.334211834 | 107,616,210.46 |
| 9 | 0.0367 | 0.383177408 | 123,383,125.38 |
| 10 | 0.0367 | 0.433940019 | 139,728,686.08 |
| 11 | 0.0367 | 0.486565618 | 156,674,128.86 |
| 12 | 0.0367 | 0.541122576 | 174,241,469.39 |
| 13 | 0.0367 | 0.597681774 | 192,453,531.32 |
| 14 | 0.0367 | 0.656316695 | 211,333,975.92 |
| 15 | 0.0367 | 0.717103518 | 230,907,332.83 |
| 16 | 0.0367 | 0.780121217 | 251,199,031.95 |
| 17 | 0.0367 | 0.845451666 | 272,235,436.42 |
| 18 | 0.0367 | 0.913179742 | 294,043,876.94 |
| 19 | 0.0367 | 0.983393439 | 316,652,687.22 |
| 20 | 0.0367 | 1.056183978 | 340,091,240.84 |
| 21 | 0.0367 | 1.13164593 | 364,389,989.38 |
| 22 | 0.0367 | 1.209877335 | 389,580,501.99 |
| 23 | 0.0367 | 1.290979834 | 415,695,506.41 |
| 24 | 0.0367 | 1.375058793 | 442,768,931.50 |
| 25 | 0.0367 | 1.462223451 | 470,835,951.28 |
| 26 | 0.0367 | 1.552587052 | 499,933,030.70 |
| 27 | 0.0367 | 1.646266997 | 530,097,972.92 |
| 28 | 0.0367 | 1.743384995 | 561,369,968.53 |
| 29 | 0.0367 | 1.844067225 | 593,789,646.37 |
| 30 | 0.0367 | 1.948444492 | 627,399,126.40 |
| • | | | |
| • | | | |
| • | | | |
| 45 | 0.0367 | 4.06278441 | 1,308,216,580.03 |
| 46 | 0.0367 | 4.248588598 | 1,368,045,528.51 |
| 47 | 0.0367 | 4.441211799 | 1,430,070,199.41 |
| 48 | 0.0367 | 4.640904272 | 1,494,371,175.73 |
| 49 | 0.0367 | 4.847925459 | 1,561,031,997.88 |
| 50 | 0.0367 | 5.062544324 | 1,630,139,272.20 |

Look at, for instance, row 10 in Table 1. The iterative arbitrage profit is $139,728,686.08, and on row 20 the amount is $340,091,240.84, and on row 50, the cumulative arbitrage profit is $1,630,139,272.20. This is the power of covered arbitrage, that is, arbitrage with appropriate hedging.

## 6. Covered arbitrage with options

Thus far, hedging is done with forward cover. Here in this section we bring out put and call options, and try to use them appropriately. Before we do that, let us consider $X_p$, $X_c$ as exercise prices of put option and call option, and $\rho_p$ and $\rho_c$as put premium and call premium, respectively. With these notations, it is easy now to ascertain the arbitrage profit ($\mu_1$) as

$$\mu_{0(p)} = M(1+r)^{-1}\left\{\frac{X_p}{S}(1+r*)-(1+r)\left(\frac{\rho_p}{S}(1+r*)+1\right)\right\}, \tag{16}$$

and the cumulative profit on z-th iterations successively is measured by:

$$\mu^*_{0(p)} = M(1+r)^{-1}\left\{\frac{X_p}{S}(1+r*)-(1+r)\left(\frac{\rho_p}{S}(1+r*)+1\right)\right\}\left[\frac{(1-\omega)^z}{(1-\omega)}\right] \tag{17}$$

where $(1+r)^{-1}\{\frac{X_p}{S}(1+r*)-(1+r)(\frac{\rho_p}{S}(1+r*)+1)\}$. If (16) is negative, the arbitrage takes the reverse course, the arbitrageur starts off with the foreign currency, converts into home currency and the process is exactly repeated in the reverse fashion and the call premium is used to generate initial arbitrage profit and then the iterations are done sequentially.

## 7. Speculation with arbitrage and hedging

### *7.1. Speculation with forward and spot contracts*

Speculation is assumption of risk by choice. Literature is sporadic, and yet extensive enough on different facets of this act of trading (see (Jones, 1965; Dalal, 1979; Krugman et al., 2011), Neihans, 1984; Samuelson, 1953; Tsiang, 1973 Sweeney, 1991; Tsiang, 1959; Stolper and Samuelson, 1941; Surajas and Sweeney, 1992; Sweeney, 1986; Sweeney, 1991; Tsiang, 1959, 1973). Given spot rate of exchange ($S$), forward rate of exchange ($F$) and put and call options' exercise prices ($X_p$) and ($X_c$), a speculating trader can take an open position on future spot rate of exchange ($\tilde{S}$) which is unknown at this moment with or without hedging by having already forward cover or options cover or none at all. It is easy to assess that if:

$(\tilde{S} > F)$,

the speculator must buy a forward contract, and sell the domestic currency at the future spot rate. An example may clarify it better. Assume that $F = 2.15$ (meaning £1 = \$2.15) and $\tilde{S} = 4.15$, he should British pound at forward rate and sell it at future spot rate, and the total profit is $(\tilde{S} - F)A_F$ where $A_F$is the contract size in British pound. If the contract size $A_F$ = £2,000,000, then total profit of the speculator will be $(\tilde{S} - F)A_F = (4.15 - 2.15) \times 2,000,000 = 4,000,000.\ 15)$. It is a case of forward speculation. If he buys the foreign current at the current spot rate, his total profit must be equal to $[\tilde{S} - \frac{S(1+r)}{(1+r*)}] \times A_S$ since he needs now to the discounted value of £1 and let that dollar value grow to $S(1+r)$. One should now immediately conclude that if $(\tilde{S} < F)$, he should sell forward contract. And if $(\tilde{S} = F)$, forward speculation yield zero profits. Similarly, if $[\tilde{S} < \frac{S(1+r)}{(1+r*)}]$, speculator should buy foreign currency spot and make a total profit of $[\frac{S(1+r)}{(1+r*)} - \tilde{S}] \times A_S$. When $[\frac{S(1+r)}{(1+r*)} = \tilde{S}]$, spot speculation yields zero profits.

### *7.2. Speculation with option contracts*

Here we bring the picture out where hedging device is option contract. Consider again the earlier scenarios on the exchange rates, and take now the put option premium, $\rho_p = 0.0041$, and the exercise price is

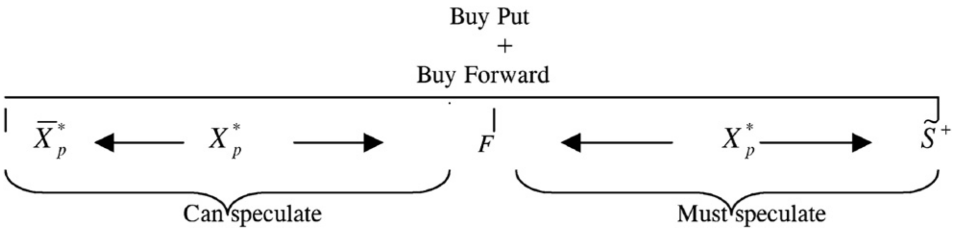


**Fig. 2.** Speculative choices with put option and forward contract.

$X_p$ =1.6825. Assume furthermore that its expiration time match the maturity of the forward contract. The effective exercise price of the put option is then $X_p^* = \$1.6825 - \$0.0041 = \$1.6784$, she should purchase British pound forward and a put option if his expected future spot rate is \$1.6840. When $X_p^* \geq F$, speculation cannot be loss-creating with forward and put purchase. If probability of the exercise of the put option is equal to the speculator's expected spot rate of exchange, then speculation is profit-bearing, and the expected profit is

$$E(\mu_A) = \xi_1 \left(X_p^* - F\right) + (1 - \xi_1)\left(\tilde{S} - F\right) \tag{18}$$

where $\mu_A$ measures total profit when put contract size is $A$ (say, equal to £100,000), and $\xi_1$ is the probability of exercising put option. From these situations it is easy to ascertain the ranges where the speculator may speculate and must speculate. Fig. 2 portrays the ranges with simultaneous purchases of forward and put, and the figure depicts the ranges of long call and short forward. In Fig. 2, if $X_p^*$ lies between $\bar{X}_p^*$ and $F$, speculator can make profit potentially, and if $X_p^*$ lies between $F$ and $\tilde{S}^+$, he definitely makes profit through speculation. Fig. 3 is now self-explaining.

Next, we must take speculative design a bit further. Kenen (Kenen, 1965), Dalal (Dalal, 1979), Ghosh and Prakash (Ghosh & Prakash, 2001) have given a good research result on speculation. Following that literature, we extend the speculation along with arbitrage and hedging — the triangle all these operations — to estimate the impact for market trader operating in the markets — commodities, financial assets and currencies.

Here, we iterate the ($z$-1)th rounds of arbitrage profit and get to the following expression of profit ($\Pi_z^s$) on the $z$-th round:

$$\Pi_z^s = \Psi(1 + \rho)^z. \tag{19}$$

Here $\Psi \equiv M\{[\frac{\tilde{S}}{S}](1 + r*)\}$, and the total profit on the $z$-th round with arbitrage and hedging till ($z$-1)th rounds is measured by:

$$\frac{M}{S}\Psi(1 + \rho)^z. \tag{20}$$

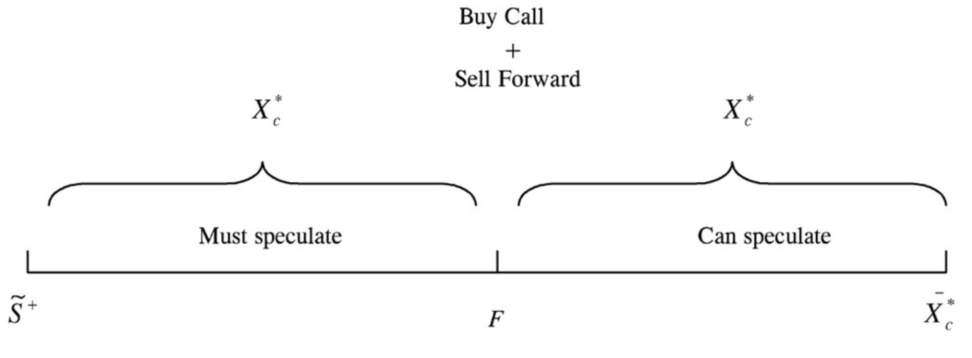


**Fig. 3.** Speculative choices with call option and forward contract.

## 8. Conclusion

It is a study on triple plays in the triangle of markets: commodities, financial assets, and currencies. Most of the existing literature is in the currency market or on asset market or commodity market singularly. Here we extend that partial view, and bring out arbitrage, hedging and speculation in the integrated structure of commodity market, asset market and currency market. Some of the inputs are estimated (as in the profit measure of covered arbitrage in commodities), but the results are clear and evident enough. If commodity market arbitrage is added to the asset market arbitrage with hedging, and the added profits are churned through foreign exchange trading, the compounded profits will be well magnified. Here in do not end with covered arbitrage; we bring in covered speculation as well. It is indeed the trinity of market strategies and operation.

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