Fluctuation of the Dollar and the Optimum Currency Composites for the Price of OPEC Oil

by

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Abstract

Since 1971, when the regime of the floating exchange rate system was adapted, the risk of the fluctuation of the exchange rate has increased. The purpose of this article is: (1) to design an optimization (minimization) variance function of a composite of major international currencies, with three constraint functions, (2) to use the quadratic programming method to find the weights of each of the currencies in the basket composites for the price of the OPEC oil.

Introduction

Since the establishment of the floating exchange rate system in the early 1970s and subsequently large variations in foreign exchange rates, international financial and business institutions have been exposed to exchange rate risks. This instability risk has represented a real economic cost that cannot be avoided. The variation of the value of a currency in terms of another one results in the variation of prices of imports and exports of those two corresponding countries. The problem is even more serious for those countries that rely heavily on one commodity export, as most of the members of OPEC do.

Because OPEC's oil is priced in terms of the United States dollar, the variation of the value of the dollar in terms of other currencies has brought about an instability in the price of OPEC oil in terms of other currencies. This instability results in instability in the terms of trade for OPEC members, especially for those members which are heavily dependent on imports from other industrialized nations.

One alternative for pricing a commodity in the world market is multiple currency pricing. However, the degree of stability of prices resulting from use of a multiple currency depends on the number and weighing of the currencies in the basket, as well as the structure of the trade partners of each country. If the exporters of commodities use a basket of currencies similar to the average composition of their imports, they would expect stability in the purchasing power of their commodity price for imported goods and services. For instance, at present, while the price of oil is denominated in dollars, any OPEC member that imports only from the United States would not have a problem of instability of purchasing power for its imports. If, on the other hand, an OPEC member does not import from the United States at all, but imports from other industrialized countries with high variations of their currencies via-a-vis the dollar, that OPEC member's revenue is subject to the highest variation in terms of its purchasing power.

The purpose of this article is to design three currency composites so that the risk of the variation of the value of that composite in terms of the U.S. dollar is minimal.[1] These currency baskets can be used for the price of commodities, such as oil, sugar, coffee, in the world market. Practical application of such a currency basket requires the agreements of both sellers and buyers of the commodity, unless there is a monopolist or monopsonistic cartel. In other words, the basket should be regarded as a part of the price package agreement, unless one party imposes its own terms, including the currency composite. A quadratic programming model, based on the Markowitz method, has been designed and the weights of currencies in each composite have been measured.

Quadratic Programming Model

Assuming the price of a commodity like oil is in terms of a basket of n currencies, the variance of the value of that basket, as a measure of risk, depends on the weights as well as the variance and covariance of the expected value of the currencies in the basket. Mathematically the variance of the value of the basket with n currencies can be measured as

$$\text{Var (Bkt)} = \sum_{i=1}^{n} \sum_{j=1}^{n} W_i \cdot W_j \cdot CV_{ij} \qquad (1)$$

where W represents the weights of each currency and CV represents the covariance of the expected vaue between two currencies i and j.[3]

The variance of the value of the basket is the meaure of the risk that we are trying to minimize. Therefore, the goal is to minimize the vaue of Var(Bkt).

Several constraint functions must be included in the above optimum function, as follows: First, the sum of the weights of the currencies in the basket must be equal to one. Thus, the first constraint function of the model for n currencies is

$$\sum_{i=1}^{n} W_i = W_1 + W_2 + W_3 + \ldots \ldots W_n = 1. \qquad (2)$$

As the second constraint it is assumed that the expected rate of return on the basket over time, i.e., the expected rate of change of the price of the commodity, to be constant. Thus mathematically, the second constraint function is

$$E\,(Bkt) = \sum_{i=1}^{n} E(E_i) \cdot W_i = 0, \qquad (3)$$

Where E(Bkt) is the expected rate of return on the basket as a whole and $E(E_i)$ is the expected rate of return of each currency over the time period.[4]

Third, the final constraint requirement in the model is that all the currency weights, Wi, be nonnegative.[5] That is,

$$W_1,\ W_2,\ W_3, \ldots W_i > 0. \qquad (4)$$

In the sum, the full model minimizes the objective function

$$Var(Bkt) = \sum_{i=1}^{n} \sum_{j=1}^{n} W_i \cdot W_j\ CV_ij, \qquad (5)$$

subject to the following constraints

$$\sum_{i=1}^{n} W_i = 1,$$

$$\sum_{i=1}^{n} E(E_1) \cdot W_i = d, \text{ and}$$

$$w_1,\ W_2,\ W_3, \ldots > 0.$$

Optimum Weights Results

Annual exchange rate data from 1970 to 1983 are used to measure the average rate of return as a proxy of the expected rate of return, E(Ei), the variance of the changes of the exchange rate of each currency, and the covariance between two currencies. Model (5) is used for three different composites of currencies to measure the optimum weight of each currency.[6] One basket has twelve currencies, the second has seven and the third has five currencies.

Twelve Currency Basket

The value of the mean, variance, and covariance, and covariance for twelve world major currencies are measured and shown in Tables 1 and 2. Employing model (5), and using the resulted variance and covariance data, the weights of each currency are calculated. The weight results for twelve currencies are shown in Table 3. The currencies listed in the table are those of the major industrial countries.

Table 1

Mean and Variance of the Annual Percentage Changes of the Exchange Rates for Twelve Currencies (1970-1983).*

NO	CURRENCY	MEAN	VARIANCE
1	Belgian franc	1.10	156.93
2	French franc	3.83	168.10
3	German mark	-2.33	109.19
4	Italian lira	7.42	147.42
5	Japanese yen	-2.39	79.85
6	Swiss franc	-4.42	107.01
7	British pound	6.95	1077.41
8	Canadian dollar	1.01	13.85
9	Denmark kroner	2.22	117.09
10	Swedish kroner	3.50	123.63
11	Netherlands guilder	-0.98	104.98
12	Australian dollar	-1.39	71.03

*Original source of data: International Monetary Fund. International Financial Statistics.

Table 2

Covariance Matrix of the Percentage Changes of the Rate of Return Between Exchange Rates (1970-1983)*

	1	2	3	4	5	6	7	8	9	10	11
2	153.5										
3	123.7	121.2									
4	129.4	138.2	109.7								
5	59.0	51.6	39.8	42.6							
6	110.2	114.7	94.8	89.4	48.1						
7	20.4	-57.2	29.0	-43.9	53.1	-21.6					
8	-5.1	-6.6	-3.7	-10.0	-10.3	37.0					
9	130.9	131.7	109.4	110.2	45.3	100.8	-9.0	-2.4			
10	126.7	131.0	94.4	102.4	30.8	77.2	-10.3	3.6	105.4		
11	121.4	122.1	105.0	106.9	35.8	95.0	5.0	-6.0	106.2	92.5	
12	-46.0	-54.2	-39.8	-40.3	-32.4	-35.2	-79.1	-6.4	-44.5	-52.2	-34.9

* 1 = Belgian franc 2 = French franc 3 = German mark 4 = Italian lira
5 = Japanese yen 6 = Swiss franc 7 = British pound 8 = Canadian dollar
9 = Denmark kroner 10 = Swedish kroner 11 = Neth. guilder 12 = Australian dollar

Table 3

Weights of Different Currency in a Currency Basket for OPEC with Different Rate of Return, d *

Currency:	1**	2	3	4	5	6	7	8	9
12 Currency Basket:	45.39	16.23	0.00	0.00	0.00	38.38	0.00	0.00	0.00
7 Currency Basket:	57.15	17.76	11.71	5.68	3.20	2.74	1.77	NI	Ni
5 Currency Basket:	59.52	17.28	12.37	7.48	NI	NI	3.36	NI	NI

* The sum of each row may not be equal to 100 because of rounding. NI indicates that the currency is not included in the basket.

** 1 = Canadian dollar 2 = Australian dollar 3 = Japanese yen
4 = Swiss franc 5 = German mark 6 = Swedish kroner
7 = Italian lira 8 = Netherlands guilder 9 = Denmark kroner

As the table indicates, the Canadian dollar, with the highest weight of 45.39 percent, dominates the basket. The Swedish kroner's weight is 38.38 percent, and the Australian dollar's weight is 16.2 percent. The weight of each of the other nine currencies is zero. It should be noted that only nine of the twelve currencies are shown in the table. The weight of each of the three currencies that are not shown (the Belgian franc, the British pound, the French franc) is also zero.

Seven Currency Basket

Since the weight of each of the nine currencies in the twelve currency basket is zero, and the Canadian dollar dominates the weight of the basket (45.39 percent), the weight of only seven currencies are measured and the other five currencies are eliminated. These seven currencies are shown in Table 3.

The elimination of the five currencies are based on two criteria: First, the relative importance of the currency in the world financial market and, second, the relative world demand for that currency. Employing these criteria, the Netherlands guilder and the Danish kroner are eliminated.

Second, as a test for the elimination of some other currencies the positive restriction of the weights, Wi, in the model (equation (4)) is dropped. By doing this we allowed the weights to attain either positive or negative signs. Then the currencies with negative weights, as nondesirable, are eliminated from the basket. As a result, the Belgian franc, the British pound, and the French franc with negative weights are eliminated.[7]

Again, model (5) is used to measure the weights of each of the seven currencies. In this basket the Canadian dollar, with a weight of 57.15 percent, dominates the basket even more than in the case of the twelve currency basket. The Australian dollar, with a weight of over 17 percent, is the second highest weight currency in the basket. The Japanese yen is third, the Swiss franc is fourth, the German mark is fifth, the Swedish kroner is sixth, and the Italian lira is seventh.

Five Currency Basket

Two currencies having small weights, the German mark and the Swedish kroner, are eliminated from the seven currency composite in order to assess the impact on the new weights. Accordingly, the Canadian dollar, the Japanese yen, and the Swiss franc each absorbs almost two percent of the weights. These results are shown in Table 3.

The Canadian dollar, with a weight of almost 60 percent, dominates the basket. The order of the dominance of the weights of the currencies is based on the combination of variance and covariance of the currencies in the basket. The three dominating currencies in all of the three baskets have the lowest variance among the twelve currencies (see Table 1).

Summary and Conclusions

Since the establishment of the floating exchange rate regime in 1971 the price of commodities, like the price of OPEC oil, in the international market has been subject to exchange rate risk. One way to minimize this single currency pricing risk is to employ a multiple currency pricing mechanism.

This study has designed and employed a guadratic programing model to measure the weights of currencies in three different currency baskets. These currency baskets can be used for the price of any commodity in the international market. The objective was to minimize the risk of instability of the value of the baskets subject to several constraints.

The weights for three different composites of currency baskets were measured. In each of the three baskets the Canadian dollar, with the lowest variance of the rate of change, attained the highest weight. The second and the third highest weighted currencies were the Australian dollar and the Japanese yen. The estimated weights of each of the other currencies were either zero or less than six percent.

The findings suggest that the inclusion of the more stable currencies (such as the Canadian dollar and the Australian dollar having the highest weights) could minimize the instability of the price of commodity in terms of other currencies.

In this study the 1970 to 1983 ex post annual exchange rate data were used for the measurement of the currency weights. To the extent that future exchange rates deviate from past trends, the estimated weights may not be optimum for future application.

Notes

1. The Special Drawing Rights, SDR, of the International Monetary Fund, IMF, is a currency basket with the following currencies and corresponding weights:

United States dollar	42 percent
Deutsch mark	19 percent
French franc	13 percent
Japanese yen	13 percent
Pound sterling	13 percent

The weights of these currencies are based on the importance of the dollar as a world currency and the volume of trade of each of those five currencies. The weights of the currencies in each of the baskets in this article are instead based on the minimization of the variations of the rate of change of each currency against the dollar. It should be noted also, that the price of oil should be paid in dollars, but be calculated on the basis of the currency basket.

2. To cure the problem of the weak dollar in the early seventies, OPEC negotiated with the multinational oil companies to adjust the oil price based on two different composites of currencies, called the Geneva I and the Geneva II baskets. See OPEC 1980(a) and 1980(b). For Markovitz method see Markovitz (1952).
3. The covariance between two variables measures the magnitude of the association of the two variables. For two currencies Ei and Ej ($i \neq j$) the covariance of the rate of return on these currencies is measured as

$$Cv_{i,j} = \sum_{i=1}^{n} \sum_{j=1}^{n} (DE_1 - \overline{DE}_i)(DE_j - \overline{DE}_j)/(n-1).$$

Where n is the number of observation, in this case 14. DE_i and DE_j are the annual rate of changes of ith and jth currencies in terms of the U.S. dollar respectively. If $i=j$, the measure is the variance. $\overline{DE}_i$ and $\overline{DE}_j$ are their corresponding mean.

4. The rate of change of the value of each of eight currencies in terms of the dollar is measured as $DE_i = (E_{i1} - E_{i0}) \times 100/E_{i0}$. Where E_{i1} and E_{i0} are the exchange rate of the currency for two different consecutive time periods (1970 to 1983). Therefore, the expected rate of return, or mean, of each currency can be calculated as

$$E(E_i) = \sum_{i=1}^{n} DE_i/14,$$

Where 14 is the number of years (i = 1970 to 1983).

5. Without this third constraint function, the value of some of the weights may be negative, which is not applicable for the currency basket purpose. The currency composite, with possible negative weight for some currencies, is applicable for investment. Those currencies with negative weights are the ones which are required to be sold short in the future market. See Shaaf (1986). However, for the price of

OPEC oil the weights of the currencies are required to be nonnegative.

6. Lemke-Howson's algorithm has been used to solve a complementary type problem. See Reklaitis, Revindran, and Ragsdell (1983).
7. This approach without the positive restriction on the weight has been used for the investment portfolio for OPEC. A negative weight for a currency in a portfolio suggests the sale of that currency short in the future market. See Shaaf (1986).

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