In: Economics of Emerging Markets
Editor: Lado Beridze, pp.1-
ISBN 978-1-60021-850-7

Chapter 1

MEASUREMENT PROBLEMS IN GLOBAL FINANCIAL REPORTING: THE NEED FOR A STABLE COMPOSITE CURRENCY

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ABSTRACT

This paper extends previous work by Ijiri (1995) by proposing the use of a stable composite currency in global financial reporting. Ijiri argues that transnational corporations should report financial statements using a composite currency rather than individual home currencies to avoid currency-dependent results. We propose a composite currency comprised of national currencies of different countries that is stable in value over time. Consistent with Ijiri, transnational corporations would benefit from a stable benchmark for measuring accounting values.

Keywords: Composite currency; Stable aggregate currency; Global financial reporting; Foreign currency translation; Reporting currency; Exchange rates; Currency invariance

Work by Ijiri (1995) proposes the use of a composite currency in global financial reporting to resolve measurement problems inherent in local currencies. Ijiri demonstrates that for a transnational corporation (TNC), which typically invests in different countries, the currency of account should not be the national currency of a single country. In this regard, accounting information can vary considerably for different local currencies (e.g., U.S. dollars versus European euros) used to denominate prices, such that financial reports are currency

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dependent. Instead of using local currencies, he recommends denomination of prices in a composite currency comprised of a basket of national currencies to measure accounting information over time. More specifically, he proposes that currencies' amounts in the multiple-currency basket should be proportional to corresponding volumes of assets of a TNC in different countries. We will refer to this proportional currency-basket by using the abbreviation PIM (Proportional Ijiri Money). He further recommends that each TNC should develop its own specific PIM. As such, accountants would measure the values of goods and services using noncomparable units of account for different TNCs – for example, IBM-PIM, Toshiba-PIM, Siemens-PIM, etc.

In this paper we propose a simplified approach based on a basket of currencies that is relatively stable in value over time. We follow Hovanov, Kolari, and Sokolov (2004), who derive an optimal minimum-variance currency basket that can be considered a stable aggregate currency (hereafter *SAC*). In this regard, Hovanov et al. show that *SAC* is almost 40 times more stable in value that the U.S. dollar in the period 1981-1998.

Relevant to *SAC* as a unit of account, international accounting standards employ constant currency accounting to adjust income statement and balance sheet figures for changing currency values over time. Constant currency accounting assumes that the exchange rate at the end of an accounting period is the same as at the beginning of the period. Of course, comparing accounting data over time would be facilitated by denominating figures in a relatively constant money such as *SAC*. This *global approach* to constant currency accounting adjusts income statement and balance sheet data using *world money units* comprised of an optimal minimum-variance basket of international currencies. By contrast, current constant currency methods utilize a *local approach* that adjust data using *national currency units*. *SAC* solves the problem of choosing a local currency to denominate accounting data. As Ijiri points out, the application of different alternative base currencies creates ambiguity in time series observations of goods' and services' values. Transnational corporations with revenues and costs in multiple currencies need a composite currency that is global in nature. We believe that *SAC* can serve the role of common *numeraire* currency due to its extremely low volatility and construction from world currencies. Rather than a single world currency, we propose a numeraire currency comprised of national currencies of different countries. This proposal is consistent with work by Nobel Laureate Robert Mundell (2000a, 2000b, 2000c, 20001), who argues for the development of a common numeraire based on a currency basket containing the U.S. dollar, European euro, and Japanese yen. According to Mundell, denominating the values of goods and services in currency basket terms would increase the transparency and comparability of prices in international transactions.

In the next section we provide a simple accounting model of goods exchange. This model serves as a foundation for developing *SAC*. Subsequently, we compare the volatility of *PIM* versus *SAC* using historical exchange rates for the U.S. dollar (*USD*) and European euro (*EUR*).

A SIMPLE ACCOUNTING MODEL OF GOODS AND SERVICES

Here we review work by Kolari, Sokolov, Fedotov, and Hovanov (2001) concerning a simple accounting model of the real economy. A basic concept in our model is that all goods' values are in reality exchange rates. For example, when you purchase any good or service, the price indicates how much one unit costs per unit of a particular currency. Of course, goods can be traded for other goods, and currencies exchanged for other currencies. However, a basic problem in all of these exchange rates is that there is no stable benchmark to use as a starting point in setting all of their values. With no stable benchmark, we argue that accounting for goods and services values has measurement problems. In this section we provide a basic framework for accounting measurement.

Suppose that there is a fixed finite set of infinitely divisible goods (commodities, services, currencies, etc.) $G = \{g_1, ..., g_n\}$, with amount (quantity, volume) of i^{th} good being determined by a real number $q_i \geq 0$. In other words, any amount of i^{th} good may be represented in the form $q_i u_i$, where the positive real number q_i is the good's quantity, and the measurement unit u_i describes the quality of the good (Bridgman, 1931).

The amount q_i of any simple good g_i from the set G can be measured by a *scale of ratios* with a precision of a measurement unit $u_i = a_i u_i^{'}$, which is an increasing linear homogeneous transformation $q_i^{'} = a_i \cdot q_i$ (Abdel-Magid et al., 1986). It is important to keep in mind that these two real numbers q_i, and $q_i^{'}$ representing a fixed amount of simple good g_i on two corresponding numerical scales (e.g., U.S. dollars and European euros) are simple transformations of one another. Therefore, a researcher can manipulate their numerical data by choosing the most convenient measurement scale or measurement unit.

Any pair of goods g_i, g_j from the set $G = \{g_1, ..., g_n\}$ may be exchanged *directly* without the necessity of any medium of exchange in the form of another good or use of money. Moreover, this direct barter exchange of goods g_i, g_j, which are taken in any finite amounts $q_i > 0$, $q_j > 0$, is quantitatively defined by a positive *exchange coefficient* c_{ij}. The exchange coefficient gives the amount c_{ij} of good g_j that one can exchange for one unit u_i of good g_i, which can be written as the ratio $c_{ij} = q_j / q_i$ of exchangeable quantities q_i, q_j of corresponding goods g_i, g_j.

In the case when goods under exchange are currencies, the coefficient c_{ij} is the exchange rate between the i^{th} currency and the j^{th} currency. In other words, dimensional coefficient $c_{ij} \cdot u_j / u_i$ shows the price of one unit u_i of currency g_i represented in units u_j of currency g_j. The totality of all exchange coefficients c_{ij}, $i, j = 1, ..., n$ may be represented in the form of an exchange rate matrix $C = (c_{ij})$ with positive elements. The matrix $C=(c_{ij})$ is *transitive*, i.e., the relation $c_{ij}\cdot c_{jk}=c_{ik}$ takes place among every three elements c_{ij}, c_{jk}, c_{ik}, $i,j,k=1,...,n$ of the matrix (e.g., yen/dollar x dollar/euro = yen/euro). Trivial implications from transitivity of exchange matrix $C=(c_{ij})$ are *reflexivity* ($c_{ii}=1$, $i=1,...,n$), and *reciprocal symmetry* ($c_{ji}=1/c_{ij}$, or $c_{ij}\cdot c_{ji}=1$).

So far, our simple accounting model of goods and services can be summarized by the ordered set (G,U,C), where $G=(g_1,...,g_n\}$ is a fixed finite set of all simple goods under investigation, $U=\{u_1,...,u_n\}$ is a fixed set of measurement units for amounts of the corresponding goods, and $C=(c_{ij})$ is a fixed positive transitive matrix of exchange coefficients. Now consider the situation when an amount q_i of units u_i of i^{th} good is exchanged for an amount q_j of units u_j of j^{th} good. These goods can be set equal to one another by means of a fixed quantity of money, which Adam Smith (1976) referred to as the "value in exchange." This exchange of goods is an equivalence relation with reflexive, symmetric, and transitive binary properties (Kuratowski and Mostowski, 1967). We will write this relation for the pair of goods' amounts $q_i\,u_i$, $q_j\,u_j$ as $q_i[u_i]\equiv q_j[u_j]$. Next, assume that this value in exchange can be measured by a numerical scale represented by a fixed money denoted by the numerical function $Val(q;u)$ of a good's amount q (measured by the unit u). Thus, we have the *condition of exchangeability* defined as $q_i[u_i]\equiv q_j[u_j]$ if and only if $Val(q_i;u_i)=Val(q_j;u_j)$.

It is reasonable to suppose that $Val(q;u)$ is an additive and increasing function of q. From these conditions the explicit formula $Val(q;u)=q\cdot Val(1;u)$ for the value function may be derived (see Aczél, J. and J. Dhombres, 1989, chapter 2.1). One can treat the function $Val(q;u)$ as an indicator (index) of value in exchange of an amount qu of a good from the set $G=\{g_1,...,g_n\}$. When all goods under investigation are currencies, the function $Val(q;u)$ may be interpreted as an indicator (index) of exchange rate of a corresponding currency. Consequently, we can write:

$$\frac{Val(1;u_i)}{Val(1;u_j)}=\frac{q_j}{q_i}=c_{ij}, \tag{1}$$

which determines element c_{ij} of the exchange-matrix $C=(c_{ij})$, $i,j=1,...,n$. So, an observable proportion c_{ij} of two goods exchange may be treated as a ratio of two corresponding non-observable values in exchange $Val(1;u_i)$, $Val(1;u_j)$ of the goods' units. Such a theoretical interpretation of the empirical data c_{ij}, $i,j=1,...,n$ in terms of values of the function $Val(q;u)$ raises the question as to whether there exists a *one-argument* function

$Val(q;u)$, such that equation (1) holds for all exchange-coefficients treated as values of a *two-argument* function $c(i, j) = c_{ij}$, $i, j = 1,...,n$? In this regard, all elements of an exchange-matrix $C = (c_{ij})$ may be represented as corresponding ratios of values of a one-argument value-function $Val(q;u)$ if and only if the matrix is *transitive* (e.g., see Kolari et al., 2001), i.e., the relation $c_{ij} c_{jk} = c_{ik}$, $i, j, k = 1,...,n$ holds for every three elements c_{ij}, c_{jk}, c_{ik} of the matrix.

Now we can introduce estimations of value in exchange for units $u_1,...,u_n$ of goods under exchange. For example, elements of j^{th} column of the exchange matrix may be taken as the required estimations $Val_{ij} = c_{ij}$, $i = 1,...,n$. Setting $Val_{jj} = c_{jj} = 1$, the j^{th} good's unit u_j becomes a *unit of account* (i.e., numeraire, standard good, standard of value, etc.) in relation to which accounting values of all other goods and services are measured.

CONSTRUCTING STABLE INDICES OF VALUE

The fact that values in exchange Val_{ij}, $i = 1,...,n$ are dependent on the choice of a standard good g_j creates problems for comparing values when measured at different moments of time. For example, the value of any particular good in U.S. dollars differs over time from its value denominated in European euros or Japanese yen. The chosen base currency substantially changes the value of any good over time. To overcome this problem inherent in index Val_{ij}, Hovanov et al. (2004) provide a modified indicator of value in exchange, or *normalized value in exchange*

$$NVal_{ij} = \frac{Val_{ij}}{\sqrt[n]{\prod_{r=1}^{n} Val_{rj}}} = \frac{c_{ij}}{\sqrt[n]{\prod_{r=1}^{n} c_{rj}}} = \sqrt{\prod_{s=1}^{n} c_{is}} \quad (2)$$

.

The normalized index $NVal_{ij}$ of value in exchange of i^{th} good's unit u_i is represented in the form of a simple fraction, where numerator is equal to exchange coefficient c_{ij}, and the denominator equals the geometric mean of exchange coefficients $c_{1j},...,c_{nj}$ (i.e., elements of the j^{th} column of exchange-matrix $C = (c_{ij})$). This index may be represented in the form of geometric mean of exchange coefficients $c_{i1},...,c_{in}$ (i.e., elements of the i^{th} row of exchange-matrix $C = (c_{ij})$).

The most important property of $NVal_{ij}$ is its independence from the choice of a standard currency g_j: $NVal_{ij} = NVal_{ik}$ for all $j,k = 1,...,n$. Thus, it is invariant in relation to alternative choices of standard currencies. As an example, given the dollar value of a good, if we convert its value to euros or yen as the base currency, its value would be the same. In effect, we have converted dollars scaled in euros or scaled in yen to a single dollar scale. An analogy would be to create a formula that could convert temperature in Fahrenheit or centigrade to the some alternative temperature scale. Since normalized value in exchange $NVal_{ij}$ is independent of a standard currency g_j, we will use the notation $NVal_i = NVal_{ij}$.

$NVal_i$ can be used in empirical investigations of $c_{ij}(t)$, $i, j = 1,...,n$, $t = 1,...,T$, or currencies' rates of exchange. It is convenient to set this index equal to 1 at some initial point in time. In this regard, the normalized value in exchange of i^{th} currency at the moment t can be written as

$$NVal_i(t) = \frac{c_{ij}(t)}{\sqrt[n]{\prod_{r=1}^{n} c_{rj}(t)}} = \sqrt[n]{\prod_{s=1}^{n} c_{is}(t)} \;, \tag{3}$$

and the *reduced* (to the time t_0) normalized value in exchange is

$$RNVal_i(t/t_0) = \frac{NVal_i(t)}{NVal_i(t_0)} = \sqrt[n]{\prod_{s=1}^{n} \frac{c_{is}(t)}{c_{is}(t_0)}} \;, \tag{4}$$

where the time t_0 is set as the starting point by the researcher, i.e., $RNVal_i(t_0/t_0) = 1$ for all $i = 1,...,n$.

While $RNVal_i(t/t_0)$ provides a single value (for example) of a dollar-denominated good no matter what base currency is used (e.g., euros or yen), it will tend to have fairly large fluctuations over time due to changes in the dollar's value in world currency markets. As Adam Smith (1976, p. 48) observed, a commodity that substantially changes value over time should not be used to measure the value of other commodities. According to Davies (1996), many authors have sought a stable unit of account, including gold and silver money of mercantilists, labor of Smith and Ricardo, abstract labor of Marx, wage unit of Keynes, standard commodity and common labor of Sraffa, unit of consumption as well as ideal price in equilibrium between demand and supply of neo-classical economics, energy unit, etc. (e.g., see Bonar, 1909; Debreu, 1959; Sraffa, 1960; Georgescu-Roegen, 1976; and Passinetti, 1981). The basic problem is that we need a *measuring stick* (or unit of account) that does not change length (or dimension) over time. When measuring height, weight, speed, etc., we always assume that our measuring stick is constant over time. Unfortunately, even hard currencies of major industrial countries experience large swings in their currencies' values over time. For example, in the last eight years the European euro's value has fluctuated from about 0.80 dollars to over 1.40 dollars, which implies that it rose about 75 percent in this short period of time. If business, government, and nonprofit entities' activities were measured in euros or dollars, it is immediately obvious that it is unreasonable to suppose that their relative accounting valuations could change by one-half in just a few years![1]

In an effort to develop a stable money for measurement purposes, Hovanov et al. (2004) construct a minimum variance composite (basket) currency for a fixed market of goods and for a fixed period of time. This stable aggregate currency (*SAC*) is constructed from the national currencies of countries taken from a fixed set $G = \{g_1,..., g_n\}$ in fixed amounts $q_i > 0$, $i = 1,..., n$. An aggregate currency is determined by a vector $\bar{q} = (q_1,..., q_n)$ of the currencies' amounts (e.g., 1.00 dollar, 1.20 euros, and 100 yen with these amounts fixed over time). There are a number of well-known composite currencies which have been in practical use in the second part of the 20th century as numeraire – namely, the EUA (European Unit of Account) until 1979, ECU (European Currency Unit) from 1979 to 1999, SDR (Special Drawing Rights) of the International Monetary Fund since 1970, etc. (see Mussa et al., 1996).

We next turn to a mathematical solution that seeks an optimal, stable currency basket based on well-known diversification principles developed by Nobel Laureate Harry Markowitz (1952). For a fixed time t value in exchange $Val_j(\bar{q};t)$ of an aggregate currency $\bar{q} = (q_1,..., q_n)$ is defined by the formula

$$Val_j(\bar{q};t) = \sum_{i=1}^{n} q_i \, Val_{ij}(t) = \sum_{i=1}^{n} q_i c_{ij}(t) , \tag{5}$$

with value in exchange being measured in units u_j of currency g_j.[2] [2]Normalized index $NVal_j(\bar{q};t)$ of value in exchange of the aggregated currency is

$$NVal_j(\bar{q};t) = \frac{Val_j(\vec{q};t)}{\sqrt[n]{\prod_{r=1}^{n} c_{rj}(t)}} = \sum_{i=1}^{n} q_i \frac{Val_{ij}(t)}{\sqrt[n]{\prod_{r=1}^{n} c_{rj}(t)}} = \sum_{i=1}^{n} q_i \sqrt[n]{\prod_{r=1}^{n} c_{ir}(t)} = \sum_{i=1}^{n} q_i NVal_i(t)$$

6)

[1] Ijiri (1995) cites work by Abdel-Magid and Cheung (1986), Mehta and Thapa (1991), and Kirsch and Johnson (1991) to support the argument that comparing multinationals is difficult due to the use of different national or local currencies and frequent changes in functional currencies.

[2] Here we use only the simplest additive form of a composite good's (aggregated currency's) index of value. Interesting approaches to this fundamental problem of a composite good's (i.e., a set of commodities and services, a collection of currencies, a portfolio of securities, etc.) value estimation are available, for example, in works by Leontief (1936), Hicks (1939, Chapter II), Markowitz (1952), Sraffa (1960), Samuelson and Swamy (1974), and Sharpe (1995).

It is evident that normalized index $NVal_j(\overline{q};t)$ has the advantage that it does not depend on unit u_j of standard currency g_j, i.e., for all $j,k=1,...,n$ the equality $NVal_j(\overline{q};t) = NVal_k(\overline{q};t) = NVal(\overline{q};t)$ holds.

Similar to equation (4) above, it is convenient to reduce the value of the composite currency to the value 1.0 at the time t_0, or

$$RNVal(\overline{q};t/t_0) = \frac{NVal(\overline{q};t)}{NVal(\overline{q};t_0)} = \sum_{i=1}^{n} w_i RNVal_i(t) = RNVal(\overline{w};t/t_0), \qquad (7)$$

where weight-coefficient ("weight") w_i ($w_i \geq 0$, $w_1+...+w_n=1$) is determined by formula

$$w_i = \frac{q_i\, NVal_i(t_0)}{\sum_{r=1}^{n} q_r NVal_r(t_0)} = \frac{q_i\, Val_i(t_0)}{\sum_{r=1}^{n} q_r Val_r(t_0)} = \frac{q_i\, c_{ij}(t_0)}{\sum_{r=1}^{n} q_r c_{rj}(t_0)}. \qquad (8)$$

Definition (7) implies that $RNVal(\overline{q};t_0/t_0)=1$ for any aggregated currency $\overline{q}=(q_1,...,q_n)$.

We are now in a position to solve for an aggregated currency $\overline{q}=(q_1,...,q_n)$ with minimal volatility of the corresponding time series $RNVal(\overline{q};t) = RNVal(\overline{w};t)$, $\overline{w}=(w_1,...,w_n)$ for a fixed set of goods $G=\{g_1,...,g_n\}$, a fixed period of time $[1,T]=\{1,2,...,T\}$, and given time series $c_{ij}(t)$, $i,j=1,...,n$, $t=1,...,T$). Volatility of the time series can be measured by the sample variance

$$S^2(\overline{w}) = Var\big(RNVal(\overline{w};t)\big) = \frac{1}{T}\sum_{t=1}^{T}[RNVal(\overline{w};t) - ERNVal(\overline{w})]^2, \qquad (9)$$

where

$$E[RNVal(\overline{w})] = \frac{1}{T}\sum_{t=1}^{T} RNVal(\overline{w};t), \qquad (10)$$

is the mathematical expectation of time series $RNVal(\overline{w};t)$, $t=1,...,T$.[2]

Following Markowitz's diversification principles, the optimal weight-vector $\overline{w}^* = (w_1^*,...,w_n^*)$ minimizes variance $S^2(\overline{w}) = Var\big(RNVal(\overline{w};t)\big)$ under the constraints $w_i \geq 0,\ i=1,...,n,\ w_1+...+w_n=1$. Here the optimization problem involves minimizing quadratic form $S^2(\overline{w})$ given linear constraints, rather than the usual portfolio problem of minimizing variance conditional on the mean level. That is, we seek to solve for the global minimum point on Markowitz's efficient frontier. There exist many alternative numerical methods to solve this optimization problem. We use Solver.xla in MS Excel 7.0.

The aggregate stable currency with minimal variance $S^2(\overline{w}^*)$ is determined by the optimal weights $w_1^*,...,w_n^*$. The optimal amounts $q_1^*,...,q_n^*$ of the currencies, which are contained in the optimal currency basket, are proportional to corresponding optimal weight-coefficients $w_1^*,...,w_n^*$ and may be represented in the form $q_i^* = \mu \cdot w_i^* / c_{ij}(t_0)$, $i = 1,...,n$, where μ is an arbitrary positive constant (hereafter we utilize $\mu = 1$ as it provides the equality $Val(1\text{unit of } SAC; t_0) = Val(1\text{unit of currency } g_j; t_0)$) (Hovanov et al., 2004).

Thus, any vector $\overline{q} = (q_1,...,q_n)$ of the currencies' amounts, which are proportional to the components of optimal weight-vector $\overline{w}^* = (w_1^*,...,w_n^*)$, determines a required stable aggregate currency (*SAC*) with minimal variance $S^2(\overline{w}^*)$, which is associated with time series $RNVal(\overline{w}^*; t)$, $t = 1,...,T$. *SAC* provides a relatively constant *measuring stick* that we can use to reliably measure the values of goods and services without the problem of changing dimension as reflected by changes in national currency values over time.

A Comparison of *PIM* and *SAC* Volatility

In this section we compare the volatility of *SAC* and *PIM* (Proportional Ijiri Money). Similar to Ijiri's example, consider two transnational corporations X and Y in 2003 holding assets in Euro-zone countries and the U.S. More specifically, firm X has 160 million euros and 40 million dollars, and firm Y has 40 million euros and 160 million dollars. Using previous notation and expressing units in millions, this means that *X-PIM* should be determined by $\overline{q}_X = (160\,EUR, 40\,USD)$ with corresponding weight vector $\overline{w}_X = (80.56\%, 19.44\%)$, while *Y-PIM* is determined by $\overline{q}_Y = (40\,EUR, 160\,USD)$ with corresponding weight vector $\overline{w}_Y = (20.58\%, 79.42\%)$ (i.e., we have used equation (8) with $c_{12}(t_0) = 1.036\ USD/EUR$, $t_0 = 1$: January 1, 2003).

Comparative analyses of volatility are based on day-to-day exchange rates of currencies (EUR, USD) from January 1, 2003 to December 31, 2003. Data are gathered from the Pacific Exchange Rate Service (http://fx.sauder.ubc.ca/data.html). Two time series of reduced (to the time $t_0 = 1$: January 1, 2003) normalized indices of value in exchange were calculated, or $RNVal_i(t/1)$, $i = 1(EUR), 2(USD)$, $t = 1,...,250$. Solving for the minimum variance basket of euros and dollars, the optimal currency weights are $w^* = \{52.79\%\ EUR,\ 47.21\%\ USD\}$. Any basket containing euros and dollars in these proportions would be relatively stable over time (e.g., a basket containing 52.79 euros and

47.21 dollars). To compare the stability over time of this minimum variance basket to *PIM* currency baskets for firms X and Y, three time series of reduced normalized indices of value in exchange were calculated: $RNVal(SAC;t/1)$, $RNVal(X-PIM;t/1)$, $RNVal(Y-PIM;t/1)$, $t=1,...,T=1,...,251$, for SAC, *X-PIM,* and *Y-PIM,* respectively. Figure 1 illustrates these basket currencies' time series, in addition to the normalized values of the dollar and euro over time. It is obvious that *SAC* is much more stable over time than *X-PIM* , *Y-PIM* , *EUR*, and *USD.*

Next, sample standard deviations and sample coefficients of correlation for simple (EUR, USD) and aggregated (*SAC, X-PIM, Y-PIM*) currencies are calculated. Table 1 reports these results for the following five time series: $RNVal(SAC;t/1)$, $RNVal(X-PIM;t/1)$, $RNVal(Y-PIM;t/1)$, and $RNVal_i(t/1)$, $i=1,2$ for the dollar (*USD*) and euro (*EUR*). Here we see that *SAC* is more than 40 times more stable than *X-PIM,* and *Y-PIM* and more than 70 times more stable than *EUR*, and *USD* in our sample period. It is clear that *SAC* is far more stable in terms of smaller standard deviation than *X-PIM* and *Y-PIM*. Also, *SAC* is virtually uncorrelated with the simple currencies *EUR* and *USD*, which are contained in the *SAC* basket. We infer that composite currency *SAC* with demonstrated low volatility can be considered a *stable unit of account* not only for both X and Y transnational corporations but for any other *TNC*s holding assets in euros and dollars in 2003.

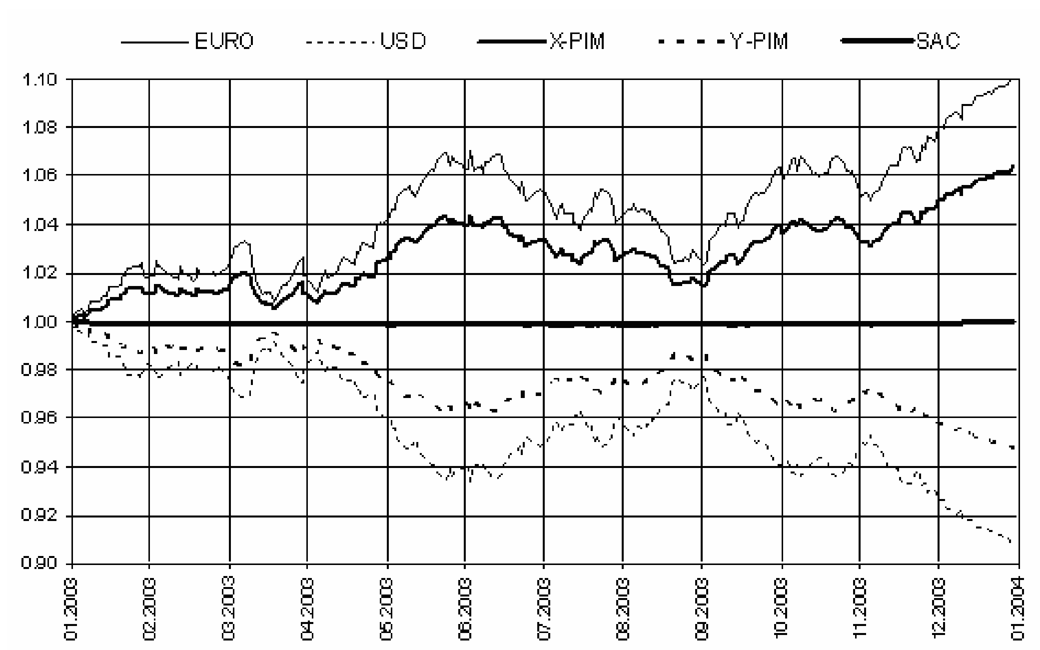

Figure 1. Values of reduced normalized indices of value in exchange of simple $RNVal_i(t/1)$, $i=1$ (EUR), 2 (USD) and aggregated $RNVal(X-PIM;t/1)$, $RNVal(Y-PIM;t/1)$, $RNVal(SAC;t/1)$ currencies in the sample period January 1, 2003 – December 31, 2003.

Table 1. Correlation coefficients and standard deviations of simple (*EUR, USD*) and aggregated (*X-PIM, Y-PIM, SAC*) currencies in the sample period January 1, 2003 – December 31, 2003

	EUR	*USD*	*X-PIM*	*Y-PIM*	*SAC*	*St. Dev.*
EUR	+1.00	-1.00	+1.00	-1.00	+0.01	0.0232
USD	-1.00	+1.00	-1.00	+1.00	+0.01	0.0212
X-PIM	+1.00	-1.00	+1.00	-1.00	+0.02	0.0146
Y-PIM	-1.00	+1.00	-1.00	+1.00	+0.02	0.0121
SAC	+0.01	+0.01	+0.02	+0.02	+1.00	0.0003

To check the stability of *SAC* outside the 2003 sample year, consider the asset structure of transnational corporation IBM in 2000 and 2001. Suppose that IBM holds its assets mainly in euros and dollars ($g_1 - EUR$, $g_2 - USD$). Let's assume that in 2000 IBM holds 43.139 billion euros and 45.21 billion dollars (see World Investment Report, 2002). In this case IBM-*PIM* should be determined by weight-vector $\overline{w} = (w_1, w_2)$ with almost equal components: $w_1 = 48.83\%$, $w_2 = 51.17\%$.

For the optimal basket *SAC* in the period January 1, 2000 to December 31, 2000, we use the optimal 2002 weights above, or $w^* = \{52.79\%\ EUR,\ 47.21\%\ USD\}$. Table 2 and Figure 2 show the results of the comparative analysis of simple (EUR , USD) and aggregated (SAC , $IBM - PIM$) currencies. As in the previous example, it is obvious that *SAC* is far more stable than IBM-*PIM* and is almost practically uncorrelated with the simple currencies (EUR , USD). Hence, *SAC* preserves its stability property in out-of-sample periods, which means that it is an appropriate metric for accounting values from year-to-year.

Finally, let's consider IBM's asset structure at 2001. Suppose it has changed to 32.8 billion euros and 55.513 billion dollars, which corresponds to IBM-*PIM* with weight-vector $w_1 = 37.14\%$, $w_2 = 62.86\%$. Again, two time series of reduced (to the moment $t_0 = 1$: January 1, 2001) normalized indices of value in exchange $RNVal_i(t/1)$, $i = 1,\ 2$, $t = 1,...,T = 1,...,251$, are calculated, and the optimal SAC basket $w^* = \{51.45\%\ EUR,\ 48.55\%\ USD\}$ is obtained.

Table 2. Correlation coefficients during the in-sample period January 1, 2000 – December 31, 2000 and standard deviations during the in-sample period January 1, 2000 – December 31, 2000 and out-of-sample period January 1, 2001 – December 31, 2001 of simple (*EUR, USD*) and aggregated (*IBM-PIM, SAC*) currencies

	EUR	*USD*	*IBM-PIM*	*SAC*	*St. Dev. (2000)*	*St. Dev. (2001)*
EUR	+1.00	-1.00	-0.98	+0.02	0.0259	0.0136
USD	-1.00	+1.00	+0.99	+0.01	0.0290	0.0157
IBM-PIM	-0.98	+0.99	+1.00	+0.18	0.0022	0.0011
SAC	+0.02	+0.01	+0.18	+1.00	0.0004	0.0002

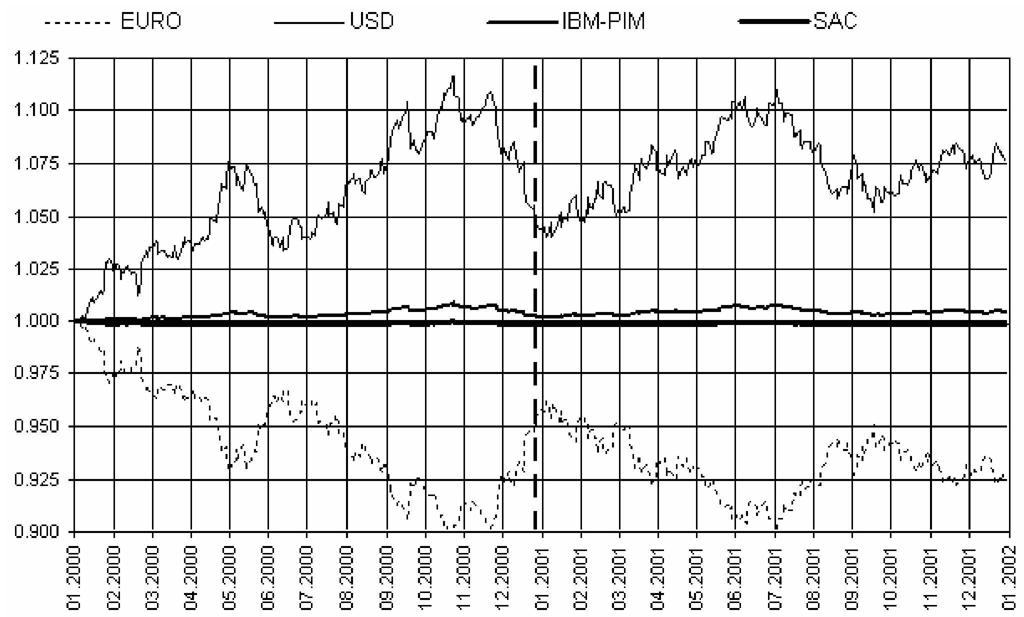

Figure 2. Values of reduced normalized indices of value in exchange of simple $RNVal_i(t/1)$, $i = 1\ (EUR),\ 2\ (USD)$ and aggregated $RNVal(IBM-PIM; t/1)$, $RNVal(SAC; t/1)$ currencies in the in-sample period January 1, 2000 – December 31, 2000 and out-of-sample period January 1, 2001 – December 31, 2001.

As shown in Table 3 and Figure 3, *SAC* is much less volatile than the euro and dollar as well as the aggregated currency IBM-*PIM* for in-sample and out-of-sample periods. Indeed, it changes little in value over time, which is not true for the proportional IBM multi-currency unit.

Table 3. Correlation coefficients during the in-sample period January 1, 2001 – December 31, 2001 and standard deviations during the in-sample period January 1, 2001 – December 31, 2001 and out-of-sample period January 1, 2002 – December 31, 2002 of simple (*EUR, USD*) and aggregated (*IBM-PIM, SAC*) currencies

	EUR	*USD*	*IBM-PIM*	*SAC*	*St. Dev.* (2001)	*St. Dev.* (2002)
EUR	+1.00	-1.00	-1.00	+0.01	0.0142	0.0280
USD	-1.00	+1.00	+1.00	+0.01	0.0150	0.0280
IBM-PIM	-1.00	+1.00	+1.00	+0.03	0.0042	0.0074
SAC	+0.01	+0.01	+0.03	+1.00	0.0001	0.0007

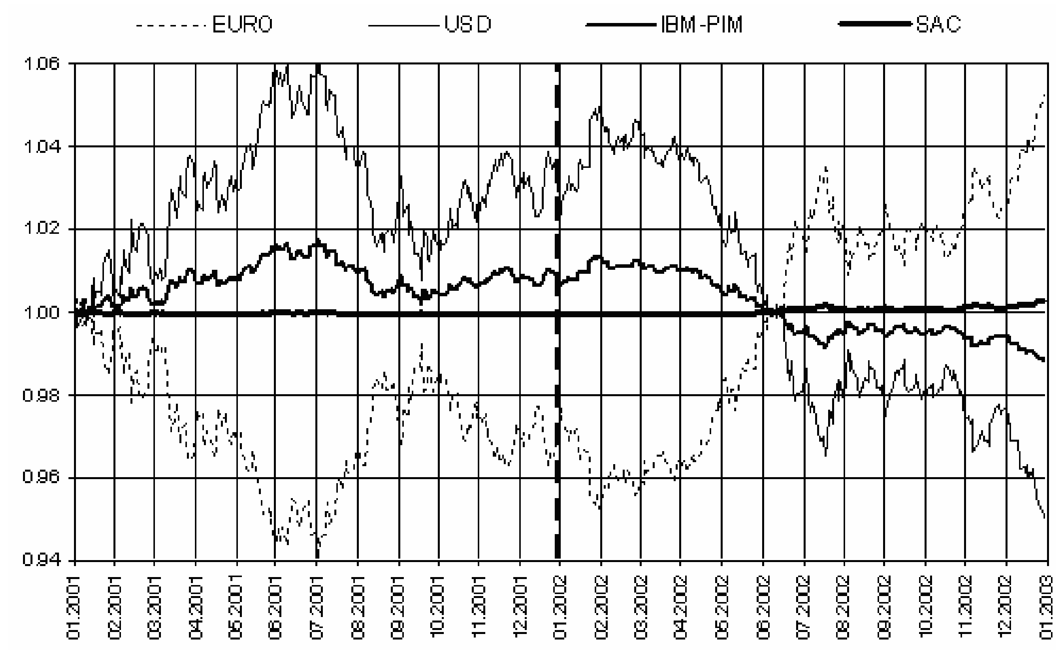

Figure 3. Values of reduced normalized indices of value in exchange of simple $RNVal_i(t/1)$, $i=1\ (EUR),\ 2\ (USD)$ and aggregated $RNVal(IBM-PIM;t/1)$, $RNVal(SAC;t/1)$ currencies in the in-sample period January 1, 2001 – December 31, 2001 and out-of-sample period January 1, 2002 – December 31, 2002.

PRACTICAL AND RESEARCH IMPLICATIONS OF STABLE COMPOSITE CURRENCIES

SAC's relative stability for in-sample and out-of-sample periods suggests that it is more stable unit of account than national or local currencies. Like any money, *SAC* could be used as a medium of exchange in actual transactions in that international businesses could arrange payments in this optimal currency basket. Also, *SAC* could be employed to denominate debt contracts and substantially reduce exchange rate risks associated with interest and principle payments that fluctuate with currency movements. While these potential applications of *SAC* are possible in the future, we believe that *SAC* has immediate relevance to accounting as a stable unit of account. How is it possible to know if a firm grew in size or profits from one period to the next if the measuring stick (e.g., the dollar or another national currency) is changing over time. Imagine measuring the growth of a person with a ruler that randomly changes in length over time. While this practice sounds absurd, we measure the value of assets, liabilities, revenues, costs, etc. with a measuring stick (e.g., the dollar and euro) that changes randomly in value over time. *SAC* mitigates this age-old problem of a stable numeraire by remaining relatively constant in value over time.

It is a simple process to convert accounting values denominated in national currencies to the optimal basket currency *SAC*. For example, using the optimal weights

$w^* = \{52.79\%\ EUR,\ 47.21\%\ USD\}$, we can compute on any day t the dollar/optimal currency basket exchange rate as USD/SAC_t = 0.5279 (USD/EUR_t) + 0.4721 (USD/USD = 1), where USD/EUR_t is the dollar/euro exchange rate on day t. By inverting this exchange rate to get SAC/USD_t, we can now easily convert values in *USD* to values denominated in *SAC*. Since *SAC* is a world money unit based on multiple national currencies, it provides a global, as opposed to local, approach to measuring the accounting values of goods and services. In the present paper we used the dollar and euro to construct *SAC*, but other major currencies (e.g., the British pound, Japanese yen, etc.) could readily be included in this optimal currency basket. In this regard, an empirical issue for future study is to explore different potential combinations of local currencies to find the most stable (minimum variance) composite currency.

Shiller (1993, 1998) argues that many common indices, such as consumer price indices, stock price indices, money stock measures, national income indices, etc., were initially theoretical concepts of interest to only a small group of researchers and specialists. However, over time they became accepted into everyday practice due to repeated usage and familiarity. According to Shiller, these indices are important because they have led to the development of new financial/economic information that is used by decision makers, government, and others. Analogously, the notion of denominating accounting values in composite currencies is a valuable indexation of financial data. Did a firm’s assets and profits grow because it increased its size or earnings or was it simply due to a change in the value of the currency used to denominate these accounting items? To abstract from movements in currency values and avoid currency-dependent financial reporting, not only transnational but all firms would benefit from using a stable composite currency to denominate accounting information. Consistent with Ijiri’s recommendation, in this way financial reporting could be harmonized across countries not only in terms of language and accounting standards but currency also.

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