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Effects of Volatile Asset Prices on Balance of Payments and International Investment Position Data

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Abstract

This paper aims at clarifying, with the help of a simple formal model and numerical examples, several aspects of the relationship between international investment position (IIP) and balance of payments (BOP) statistics. Exact and approximated relations are compared to analyze the estimation accuracy of the most popular data model used to reconcile BOP transaction statistics with IIP and external debt stock statistics, and discuss (a) how such accuracy is affected by volatile asset prices and transactions and (b) how net errors and omissions are related to the model in question. Numerical examples based on equity prices and exchange rates actually observed in the 1990s suggest that the bias might have been especially large for estimates based on less detailed financial information. Serious consideration should be therefore given by national compilers to make use of more detailed financial information in compiling BOP and IIP statistics.

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I. Introduction

Volatile asset prices and exchange rates influenced profoundly the behavior of economic agents in the last two decades. They also affected, in various ways, the body of statistical information used by agents and policymakers to form their expectations and base their actions thereupon—in particular, the balance of payments (BOP) and international investment position (IIP) statistics.

Data on financial transactions (flows) and positions (stocks) capture different economic aspects of a country's external relations.[1] Stocks describe the status of an economy at a given point in time. In particular, marked-to-market positions allow domestic and foreign creditors to measure their current wealth and provide domestic and foreign issuers with a current indication of their creditworthiness. For this reason, stocks are an important state variable in models designed to assess the sustainability of countries' external imbalances (Milesi-Ferretti and Razin, 1996). Flows describe the effective behavior of international investors in a certain period of time, as expressed by deliberate changes in the ownership of financial claims. The difference between changes in stocks and transactions (so-called *reconciliation adjustments*) is more than a bare residual; it reflects, *inter alia*, the influence of variations in asset prices and exchange rates and therefore measures the extent to which international investors are affected by financial and currency crises of partner countries. Reconciliation adjustments are therefore very relevant, for two reasons. First, they are part of the data validation process through which national compilers can "explain" how IIP and BOP statistics are related and show that the two sets of data have been cross-checked and their accuracy verified. Second, such adjustments provide the analyst with a means to assess the *ex post* exposure of a country to valuation changes on both the asset and liability sides.[2]

The availability of annual IIP statistics is expected to increase in the next future, because this type of information has been included in the prescribed data categories for countries subscribing to the IMF *Special Data Dissemination Standard* (SDDS).[3] As soon as more information is made available to the general public, problems of interpretation are also likely

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[1] As indicated by existing international standards, financial transactions should be valued at *market prices*. Market prices reflect the present economic value placed by market participants on the relevant financial instruments; they need not be the "equilibrium" ones (i.e., those at which markets are cleared) and must be recognized by both parties to the transaction. Market prices provide a common basis for valuing the whole complex of transactions occurring in a given reference period. The same valuation principle applies to end-period positions, which describe the status of an economy at a given point of time. According to this approach, stocks would be valued at "marginal" prices and exchange rates, i.e. those observed for the last transaction, or prevailing at the end of the reference period.

[2] Ex post adjustments reflect changes in asset prices and exchange rates that have actually occurred in historical time. An *ex ante* exposure to changes in asset prices (including those of national currencies) can be determined on the basis of assumptions on future levels of such variables, as well as of current position data attributed by instrument and currency.

[3] Several advanced countries are also planning to release higher-frequency (mainly quarterly) data on financial positions.

to increase. Indeed, as shown by a cursory look at historical data, total reconciliation adjustments have been generally large and volatile in the 1980s and 1990s, on both the asset and liability sides and for various categories of financial claims (**Chart 1**). Besides, adjustments on the asset side were generally different from those on the liability side; as a result, ***net IIPs could not be obviously predicted by the evolution of current account balances***.[4] What caused such wide and erratic differences? Were they determined by changes in prices or in exchange rates? Or by a change in the benchmark used for compiling data on positions, so that a break occurred in the stock series? As is clear, a reconciliation between stock and flow data would be crucial to answer all such questions.

This paper aims at clarifying, with the help of a simple formal model and numerical examples, several aspects of the relationship between BOP and IIP data.[5] The complexity of a full-fledged reconciliation between flow and stock data is illustrated in section II, with the help of *exact* relations defined in a discrete time setting. These latter are then compared with approximated formulas: in particular, with those most popularly used in the fields of BOP, IIP, and external debt statistics (defined as the *IMF model* because they have been recommended by the Fund in various methodological publications). The IMF model is employed to show: (a) how positions can be estimated using flow data and viceversa; (b) how the effects of price and exchange rate changes can be identified separately; and (c) how, and in which sense, independent measures of stocks and flows can be cross-checked and validated. Analytical expressions are also derived to assess the estimation accuracy of the IMF model and discuss (a) how such accuracy is affected by volatile asset prices and transactions[6] and (b) how net errors and omissions of the balance of payments are related to this approximated stock-flow relation. All such points are illustrated by numerical examples in section III.

The model and numerical examples considered in this paper are targeted to ***portfolio investment***. Portfolio investment is a particularly important category of financial flows and stocks, which pertains to marketable instruments whose prices fluctuate more widely than those of other financial instruments. In addition, portfolio investment flows are regarded as more volatile than many other financial flows (such as direct investment). In any event,the analysis also applies to other types of financial flows and stocks, such as loans. Section IV concludes.

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[4] More accurately, by the combined balances of the current account and the capital account. On the assumption of zero errors and omissions, such combined balances coincide with the overall balance of a country's transactions on external assets and liabilities.

[5] The paper offers a unified treatment and an expansion of themes discussed in the *Balance of Payments Compilation Guide* and in the *Coordinated Portfolio Investment Survey Guide*. See IMF (1995), para.732-743 and 778-783, and IMF (1996), Appendix VIII, pp.155-158.

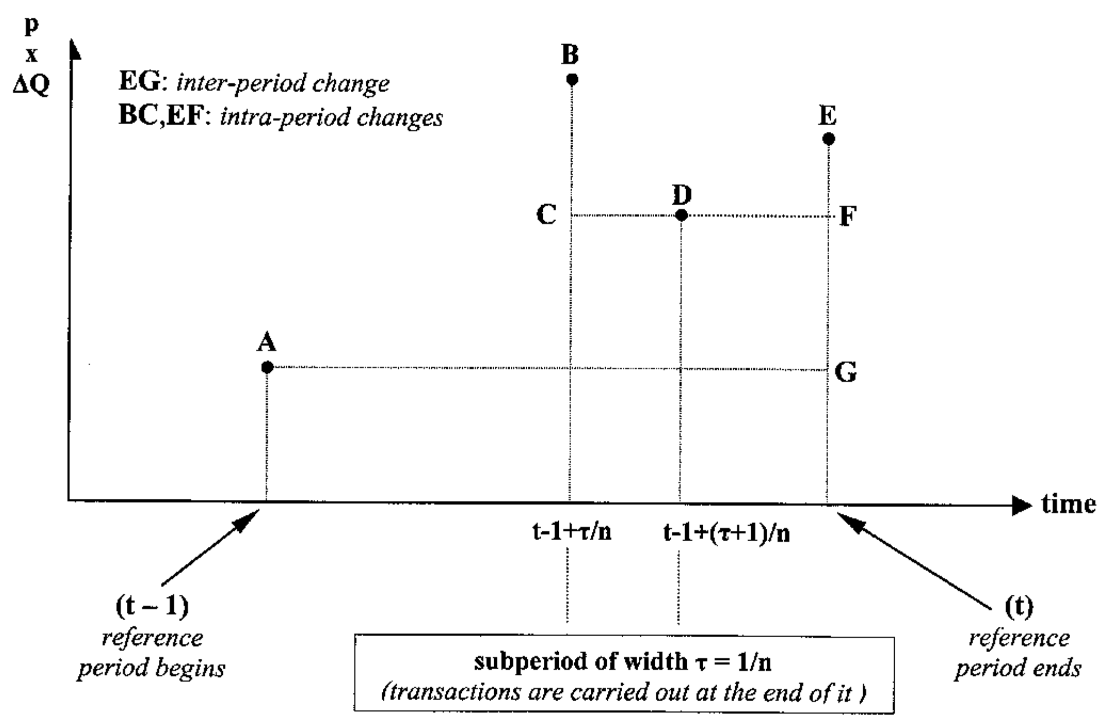
[6] Volatility is defined here as the observed dispersion of a variable around a certain central value (a period-end level or a mean), and is measured by the standard deviation of logarithmic changes in the values of such a variable.

II. Reconciliation of Stocks and Flows

A. The stock-flow arithmetic: a formulation in discrete time

In this section we consider the stock-flow arithmetic for a *single security*; aggregation issues will be discussed in the next section, with the help of numerical examples. The security in question is issued by a nonresident (resident) debtor and held by a resident (nonresident) investor, and therefore represents part of the external assets (liabilities) of the economy for which the BOP and IIP statements are compiled. The security is traded at a market price p and is denominated in some original currency. All values are expressed in terms of domestic currency, i.e., the currency of the resident investor (issuer); the relevant exchange rate is denoted with x (domestic currency per unit of foreign currency). A quantity Q of this instrument is held at each point in time; it may vary as a result of *outright transactions* (i.e., changes of ownership with or without a *quid pro quo*), or *non-transaction changes* such as cancellations, write-offs, reclassifications due to debt-equity swaps, and so forth. Transaction-related changes in Q (or *transactions*, for short) will be denoted with ΔQ^T; all other changes with ΔQ^N.

A reference period of unit length is chosen, going from time $t-1$ to time t. The reference period is further divided into n intervals of equal length ($1/n$); without loss of generality, transactions are assumed to occur *at the end* of such intervals. *Inter-period* changes in p, x, and Q are defined as those changes occurred between $t-1$ and t; *intra-period* changes as those occurred within the reference period (see **Figure** below).



Net balance of payments flows (*F*) are defined as the algebraic sum of all transactions occurred in the reference period; such transactions are valued at "instantaneous" prices and exchange rates, i.e., those prevailing when they are made. *Gross turnover* (*GT*) is defined as the value of all gross purchases and sales of securities:

$$(1) \qquad F_t = \sum_{\tau=1}^{n} \Delta Q^{T}_{t-1+\tau/n}\, x_{t-1+\tau/n}\, p_{t-1+\tau/n}$$

$$(2) \qquad GT_t = \sum_{\tau=1}^{n} \left(\Delta Q^{T(+)}_{t-1+\tau/n} + \Delta Q^{T(-)}_{t-1+\tau/n}\right) x_{t-1+\tau/n}\, p_{t-1+\tau/n}$$

where $\Delta Q^{T(+)}_{t-1+\tau/n}$ and $\Delta Q^{T(-)}_{t-1+\tau/n}$ represent transactions of a positive (purchases) and negative (sales) sign, respectively. The *value of the stock* held at time *t* (*K*) can be obtained either directly, as $Q_t x_t p_t$, or recursively, i.e., by adding transaction and non-transaction changes to the previous period holdings and valuing the resulting quantity at period-end prices and exchange rates:

$$(3) \qquad K_t \equiv Q_t\, x_t\, p_t = \left(Q_{t-1} + \sum_{\tau=1}^{n} \Delta Q^{T}_{t-1+\tau/n} + \sum_{\tau=1}^{n} \Delta Q^{N}_{t-1+\tau/n}\right) x_t\, p_t.$$

Total *reconciliation adjustments* (*ADJ*) are obtained residually, as the difference between changes in stocks and BOP flows (see equation 4 below). They can be further divided into three components: *exchange rate*, *price*, and *other* adjustments. The first two adjustments can be computed on the basis of equation (4), by keeping *p* (or *x*) constant and letting *x* (or *p*) vary from their actual levels to those prevailing at the end of the reference period (i.e., at time *t*). Other adjustments are essentially imputable to non-transaction changes in *Q*: they are identified easily as the last term on the right-hand side of equation (4).[7]

$$\begin{aligned}(4) \qquad ADJ_t &= (K_t - K_{t-1}) - F_t \\ &= Q_{t-1}\,(x_t\, p_t - x_{t-1}\, p_{t-1}) + \sum_{\tau=1}^{n} \Delta Q^{T}_{t-1+\tau/n}\,(x_t\, p_t - x_{t-1+\tau/n}\, p_{t-1+\tau/n}) + \sum_{\tau=1}^{n} \Delta Q^{N}_{t-1+\tau/n}\, x_t\, p_t\end{aligned}$$

$$(4a) \qquad ADJ_t^{price} = Q_{t-1}\,(p_t - p_{t-1})\, x_{t-1} + \sum_{\tau=1}^{n} \Delta Q^{T}_{t-1+\tau/n}\,(p_t - p_{t-1+\tau/n})\, x_{t-1}$$

$$(4b) \qquad ADJ_t^{xrate} = Q_{t-1}\,(x_t - x_{t-1})\, p_{t-1} + \sum_{\tau=1}^{n} \Delta Q^{T}_{t-1+\tau/n}\,(x_t - x_{t-1+\tau/n})\, p_{t-1}$$

$$(4c) \qquad ADJ_t^{other} = \sum_{\tau=1}^{n} \Delta Q^{N}_{t-1+\tau/n}\, x_t\, p_t$$

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[7] It should be noted that equations (4a)-(4c) do not add up to (4): $ADJ^{res} = ADJ_t - ADJ_t^{xrate} - ADJ_t^{price} - ADJ_t^{other} = Q_{t-1}(x_t - x_{t-1})(p_t - p_{t-1}) + \Sigma_\tau \Delta Q^{T}_{t-1+\tau/n}\,[x_t\,(p_t - p_{t-1}) - x_{t-1}\,(p_t - p_{t-1+\tau/n}) + x_{t-1+\tau/n}\,(p_{t-1+\tau/n} - p_{t-1})]$. This residual represents the *compound effect* of changes in *p* and *x*, and cannot be further divided into "price" and "exchange rate" elements. It will be zero only when either *x* or *p* is constant.

Price and exchange rate adjustments depend on both inter- and intra-period changes in the relevant variables. Inter-period changes are indicated by the first term on the right-hand side of equations (4a) and (4b), and affect *ADJ* in a simple way. In particular, *ADJ* will grow (fall) when x and p increase (decrease): in other terms, ***an inter-period depreciation (appreciation) of the domestic currency will render ΔK greater (smaller) than what expected on the basis of BOP flows only; the same will happen when market prices grow (decrease).*** The influence of intra-period changes is more complex, since x and p may vary in either direction and are weighted by the whole sequence of transactions occurred in the period. "Intra-period" effects will be of secondary importance only when net transactions are small compared with the initial stock.

B. A simplified stock-flow model

"Exact" equations are difficult to implement in statistical practice because they require knowledge of the whole sequence of intra-period prices, exchange rates, and transactions: such information may not be readily available to individual respondents, let alone national compilers. Some simplifying assumptions or models are therefore needed to facilitate empirical applications. (Non-transaction adjustments are assumed to be nil throughout the rest of this paper; such an assumption is made for the sake of simplicity and can be dropped easily.)

In what follows we examine the *data model most widely employed* in the field of BOP, IIP, and External Debt statistics; this is referred to as the ***IMF model*** since it was recommended in various methodological publications prepared by the Fund.[8] The IMF model can be used for a variety of purposes: calculating flows on the basis of stock data; calculating stocks with flow data; or "validating" both sets of data. The first two variants are particularly useful when *only one* of these variables is measured directly; the third when *both* variables are measured, using either the same source or different sources or samples (in which case it is necessary to check on whether reported data on stocks and flows are mutually consistent). The IMF model was originally employed in the area of external debt and banking statistics, to derive net flows from stock data:[9]

$$(5) \qquad \hat{F}_t = K_t\left(\frac{\bar{x}_t}{x_t}\frac{\bar{p}_t}{p_t}\right) - K_{t-1}\left(\frac{\bar{x}_t}{x_{t-1}}\frac{\bar{p}_t}{p_{t-1}}\right) = (Q_t - Q_{t-1})\ \bar{x}_t\,\bar{p}_t$$

where $\hat{F}_t$ is an *estimate* of net flows and barred variables represent period averages. This is the familiar equation for the so-called *banking flows at constant exchange rates*, where changes

[8] See IMF (1995), paras.732-743 and 778-783, and IMF (1996), Appendix VIII, pp.155-158. Other international agencies contributed to some of such publications, namely: the Bank of International Settlements (BIS), the Organization for Economic Cooperation and Development (OECD), and the World Bank. See IMF *et al.* (1988) and IMF *et al.* (1994).

[9] See IMF *et al.* (1988, , pp. 36-7, pp. 47-8, and p. 52) and IMF *et al.* (1994, p. 27).

in assets or liabilities are valued at constant (period-average) exchange rates.[10] It can also be used to solve the "dual" problem, i.e. deriving stocks from flows. To this end, F_t and K_{t-1} should be treated as exogenous and equation (5) solved for K_t:

$$(6) \qquad \hat{K}_t = K_{t-1} \frac{x_t}{x_{t-1}} \frac{p_t}{p_{t-1}} + F_t \left(\frac{x_t}{\bar{x}_t} \frac{p_t}{\bar{p}_t}\right)$$

where $\hat{K}_t$ is an *estimate* of the stock held at time *t*. Equations (5-6) are the analog to (1) and (3), respectively; they differ from these latter equations in that intra-period prices and exchange rates are replaced by their period *averages*.[11] The IMF model offers a conveniently simplified stock-flow relationship, as well as more manageable formulas for reconciliation adjustments:[12]

$$(7) \qquad ADJ_t = K_{t-1} \left(\frac{x_t}{x_{t-1}} \frac{p_t}{p_{t-1}} - 1\right) + F_t \left(\frac{x_t}{\bar{x}_t} \frac{p_t}{\bar{p}_t} - 1\right)$$

$$(7a) \qquad ADJ_t^{price} = K_{t-1} \left(\frac{p_t}{p_{t-1}} - 1\right) + F_t \left(\frac{p_t}{\bar{p}_t} - 1\right)$$

$$(7b) \qquad ADJ_t^{xrate} = K_{t-1} \left(\frac{x_t}{x_{t-1}} - 1\right) + F_t \left(\frac{x_t}{\bar{x}_t} - 1\right).$$

The reconciliation between stocks and flows is summarized in **Table 1**, separately for "exact" and "simplified" measures (similar tables are normally employed by national

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[10] BIS statistics on banking flows are only adjusted for changes in exchange rates, not for those in financial asset prices. This is essentially so because of historical reasons; in particular, because banking assets and liabilities mostly consisted in nontaxable instruments in the 1980s.

[11] BIS statistics on banking flows are obtained from position changes valued at *end-of-period (not average)* exchange rates (see IMF *et al.*, 1994, p. 27 and p. 64): $\hat{F}_t = (Q_t - Q_{t-1})\, x_t p_t = K_t - K_{t-1} (x_t p_t)/(x_{t-1} p_{t-1})$. The "dual" of this equation is $\hat{K}_t = K_{t-1} (x_t p_t)/(x_{t-1} p_{t-1}) + F_t$: in other terms, *unadjusted* flows would be used if such an equation were employed to estimate *K*. As is clear, this is not the method recommended by the IMF.

[12] Interestingly, the "compound effect" discussed earlier would not disappear: $ADJ_t^{res} = ADJ_t - ADJ_t^{xrate} - ADJ_t^{price} - ADJ_t^{oth} = K_{t-1} \frac{(x_t - x_{t-1})(p_t - p_{t-1})}{x_{t-1}\, p_{t-1}} + F_t \frac{(x_t - \bar{x}_t)(p_t - \bar{p}_t)}{\bar{x}_t\, \bar{p}_t}$. In IMF (1995, 1996) it is suggested that ADJ^{xrate} be computed first, and ADJ^{price} obtained residually as $ADJ - ADJ^{xrate}$: in this way, the residual would be included in ADJ^{price}. Alternatively, ADJ^{xrate} could be obtained after computing *ADJ* and ADJ^{price}, in which case the compound effect would be included in ADJ^{xrate}. As is clear, whether the two methods yield the same results depends on the size of ADJ^{res}. This issue arises only for securities denominated in foreign currency (more in general, in a currency that is different from the one used for compiling the BOP and IIP statements) and is therefore more likely to prevail on the asset side. In practice, such residuals are likely to be negligible (see the numerical examples in section III).

compilers to collect and/or compile and/or publish statistical information on financial flows and stocks).

A particularly relevant application of the IMF model is the estimation of position data, through equation (6). This equation can be used under different circumstances, namely: (a) in the presence of actual stock information, to cross-check and validate both stock and flows statistics; or (b) to estimate positions in the absence of any information on stocks, e.g., when stock data are collected at a lesser frequency than flow data, or when stock benchmarks are available at long and irregular intervals, or when this information is not available altogether. This procedure is widely used to compile data *actually released to the general public*; it also gained some popularity among individual researchers, which tried to obviate the lack of relevant stock information for various developing countries (Sinn, 1990, Rider, 1994, Lane and Milesi-Ferretti, 1999, and Kraay *et al.*, 2000).

The most commonly used stock estimators in the 1980s were those based on ***unadjusted*** flows and stocks (i.e., valued at historical prices and exchange rates; see Kennedy, 1980). The IMF estimators are based on ***adjusted*** magnitudes, valued at period-end prices and exchange rates. This class of estimators comprises those based on ***variable (shifting) benchmarks*** and those based on ***fixed (time-invariant) benchmarks***. The basic difference between variable- and fixed-benchmark estimators is the width of the estimation period. In the first case, end-of-period stocks are estimated on the basis of current flows and the *actual value* of previous-period stocks; in practice, variable-benchmark estimators provide one-period-ahead estimates that can be used to cross-check stock and flow data collected at the same frequency. On the other hand, fixed benchmark estimators provide estimates for the stock prevailing at the end of more-than-one-period ahead and can therefore be used in the absence of actual stock information. In particular, they are obtained by applying iteratively the same formula used for variable-benchmark estimators, where the actual value of previous-period stock is replaced with an *estimate* based on previous flows and stocks. Fixed-benchmark estimators are further distinguished as to whether the relevant flows are adjusted with factors relating to the corresponding *individual* periods, or factors relating to *cumulated* periods. The related formulas for adjusted and unadjusted estimators are shown in **Table 2.**[13]

Adjusted estimators can be constructed at different levels of detail, in particular:

- On a ***security-by security basis*** (i.e., by applying the IMF formulas to *individual* securities, or to groups of securities with the same market price and denominated in the same currency, and then aggregating the results across all securities), or
- On an ***aggregate basis*** (i.e., considering the *total value* of stocks and flows and applying aggregate price and exchange rate indices that take into account their composition by

[13] Estimates for a range comprising four periods are shown in the table (for ease of interpretation, each period may be imagined as a quarter). For simplicity, prices and exchange rates have also been merged into a single variable $P = x\,p$; in other terms, security prices have been expressed in terms of domestic currency.

currency, maturity, and type of securities). Aggregate estimators have been typically used by individual researches (who have less detailed information than national compilers), and may be subject to an aggregation bias.

In the next subsection, we shall examine the accuracy of adjusted and unadjusted stock estimators applied on a security-by-security basis; aggregation issues will be discussed in section III.

C. Estimation accuracy

As mentioned, the IMF model can be used for calculating flows on the basis of stock data; calculating stocks with flow data; or "validating" both sets of data. All such purposes require that the model in question be reasonably accurate; in other terms, that it yields measures that are sufficiently close to the "true" values of the relevant variable. With regard to an individual reference period, the estimation accuracy can be determined by comparing equations (5) and (6) with the "exact" formulas (3) and (1), respectively. As noted, the two sets of equations basically differ as to the way in which transactions are valued; this difference gives rise, in any period, to the following discrepancies between actual and estimated data:[14]

$$(8) \qquad \mathrm{DISCR}_t^F \equiv F_t - \hat{F}_t = \sum_{\tau=1}^{n} \Delta Q_{t-1+\tau/n}^T \,(P_{t-1+\tau/n} - \overline{P}_t)$$

$$(9) \qquad \mathrm{DISCR}_t^K \equiv K_t - \hat{K}_t = -(P_t/\overline{P}_t)\sum_{\tau=1}^{n} \Delta Q_{t-1+\tau/n}^T \,(P_{t-1+\tau/n} - \overline{P}_t) = -(P_t/\overline{P}_t)\,\mathrm{DISCR}_t^F .$$

Sign and size of such discrepancies are difficult to identify a priori, since the intra-period deviations of prices from their mean, as well as those of intra-period transactions, may be either positive or negative. Estimation errors will be zero only under at least one of the following circumstances:

- ***Intra-period prices do not deviate from their average level*** (i.e., when $P_{t-1+\tau/n} = \overline{P}_t$ for all τ). This may happen when (a) prices are constant and do not vary, in which case total valuation adjustments are nil and changes in stocks coincide with BOP flows ($ADJ_t=0$; $\Delta K_t = F_t$); or when (b) intra-period prices "jump" to their period-end level right at the beginning of the period (i.e., when $P_{t-1+\tau/n} = P_t$ for all τ.), in which case only the intra-period valuation adjustments will be equal to zero (see equation 4)
- ***Transactions are distributed evenly within the period***. This may happen when (a) no transactions are made in the reference period (i.e., when $\Delta Q_{t-1+\tau/n} = 0$ for all τ), in which case BOP flows are zero and changes in stocks coincide with valuation adjustments

[14] For simplicity, security prices have been expressed in domestic currency and therefore x and p have been merged into a single variable $P = x\,p$.

($F_t=0;\ \Delta K_t = ADJ_t$); or when (b) the inter-period change in quantities held is distributed linearly in the reference period, in which case both flows and valuation adjustments may differ from zero.[15] This latter is the assumption expressely made in IMF (1988), IMF (1995) and IMF (1996).

The accuracy of variable-benchmarks estimators is therefore inversely related to the combined amount of intra-period dispersion in price and quantity variables: in particular, estimated values would approach the "true" values when transactions are spread more uniformly and/or asset prices (including those of national currencies) are less dispersed around their mean. Such conditions are more likely to prevail when the reference period chosen for compiling BOP and IIP statistics is ***short*** (e.g., a month rather than a quarter or a year). On the other hand, ***accuracy would also improve when flows are smaller compared with the initial stock***, in which case intra-period valuation effects would be of secondary importance. As a consequence, lower-frequency BOP and IIP statistics compiled using the IMF model could be still reasonably accurate when transactions are very small, even in periods of highly dispersed prices and exchange rates.

As regards ***fixed-benchmark estimators***, it is interesting to note that their ***prediction errors have a cumulative nature***, since the errors pertaining to specific "vintages" of flows are "carried forward" to the next period (**Table 3**). In the case of unadjusted estimators, such errors coincide with the cumulated sum of valuation adjustments; in the case of adjusted estimators, new vintages of errors would be added to the previous ones at any step of the iteration, all vintages being valued at current prices.[16]

D. Errors and omissions in the balance of payments

Short-run errors and omissions

Equation (8) highlights circumstances under which ***volatile prices and transactions may generate, in a "mechanical" fashion, net errors and omissions in the balance of payments.*** As noted, that equation is frequently used to estimate net banking flows on the basis of stock data, whose changes are valued at "constant" (average) exchange rates. If the counter-entries to such flows were valued—as they should—at "instantaneous" exchange rates, then an imbalance would obtain and non-zero net errors and omissions would be entered in the balance of payments.

As indicated by equation (8), the absolute size of such errors will be larger when prices and exchange rates are more volatile—in other terms, when the reference period is "too large" to

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[15] I.e., when $\Delta Q_{t-1+\tau/n} = \Delta Q_t/n$ for $\tau=1,2,...,n$. This implies that $DISCR_t^F = \Delta Q_t\ (\overline{P}_t - \overline{P}_t) = 0$.

[16] It is also interesting to note that the two estimators based on fixed benchmarks generate errors that have, as it were, a different "definition". This definition is higher when the adjustment factors applied to different flow vintages relate to the same period of those flows, not to cumulated periods covering all flows involved.

approximate the intra-period levels of the relevant variables. This is only apparently in contrast with the fact that BOP statistics compiled at a higher frequency (say, on a monthly basis) normally feature very volatile errors and omissions, whose variability diminishes when quarterly or annual aggregates are considered. This phenomenon is generally caused by the erroneous attribution of entries that are originally recorded at a lower frequency (e.g., quarterly or annually), *not* by high-frequency compilation (a factor that helps improve the accuracy of the data).

In practice, measurement errors of this sort are likely to occur in statistical systems where monthly banking records are supplemented with data gathered from other sources (such as trade statistics, which are typically valued at higher-frequency prices and exchange rates).[17] They would not arise in statistical systems *entirely* based on monthly banking records and where all BOP entries are valued at period-average prices and exchange rates. In these systems, volatile prices and exchange rates cause *gross* errors that do not show up in *net* errors and omissions because banking flows are always balanced by their counter-entries. However, as shown by equation (8), ***zero errors and omissions would conceal distortions in individual BOP entries*** calculated with an approximated method whose quality diminishes when prices and quantities are more dispersed. The situation changes when some of the counter-entries to banking flows (say, exports and imports of goods) are gathered from alternative sources and valued at "instantaneous" prices and exchange rates. If trade flows were measured correctly, errors and omissions would represent the counterpart of biased banking flows. Their size and sign depend on the actual intra-period distribution of changes in banking assets and liabilities associated to trade flows, as well as on the relevant intra-period prices and exchange rates.[18]

Errors and omissions in the longer run

The measurement errors considered so far are essentially of a short-period (more accurately, intra-period) nature. They can persist as long as price and quantity variables are volatile, but need not exhibit any definite patterns in the long term: in particular, errors made in a specific period may cancel out with errors made in a subsequent period, so that their average value may be close to zero.

[17] Banking records pertain to banks' own transactions and those of their clients; see IMF (1995).

[18] Whether such errors would be empirically correlated with banking flows or trade flows cannot be determined *a priori*. First, banking flows comprise many other transactions than those related to trade, including those made by banks on their own account. Second, trade-related banking flows (so-called *trade settlements*) cannot be compared directly with merchandise trade statistics because of "leads and lags" and commercial credits. Third, the fraction of trade flows settled through domestic banks may vary over time. Fourth, the intra-period distribution of trade flows (which cannot be observed directly) may change from period to period, so that the same prices and exchange rates may result in errors of different size if goods transactions are distributed differently in the reference period. For all these reasons, an empirical relationship of errors and omissions with either banking flows and/or trade flows would be likely very unstable over time.

The analysis of statistical disturbances with non-zero mean is at the center of all studies on "capital flight" and, more in general, of studies on the validation of national balance of payments statistics. The problem has been approached in the literature from three different angles, which are briefly reviewed here:[19]

- A "data-driven" approach based on the empirical correlation between errors and omissions and specific BOP components;
- An "economic model" approach based on behavioral priors for specific BOP items; and
- A "consistency-check" approach based on alternative sources of information for the same BOP variable.

The first approach hinges on the idea that ***balance of payments items strongly correlated with net errors and omissions are also likely determinants of the observed discrepancy.***[20] This approach is flawed and may lead to wrong conclusions. To illustrate this, let us consider a simplified BOP framework with only four components: the trade balance (B_1), the balance of portfolio investment abroad (B_2), the balance of banking flows (B_3), and the balance of all other transactions (B_4). In principle, the sum of these balances should be equal to zero; in practice, because of errors in reported data ($\widetilde{B}_i = B_i + u_i$), this identity is observed in the form $\widetilde{B}_1 + \widetilde{B}_2 + \widetilde{B}_3 + \widetilde{B}_4 - E/O = 0$, where $E/O = u_1 + u_2 + u_3 + u_4$ is a residual comprising all disturbances that cannot be observed separately. As it stands, the observable identity contains four unknowns and cannot be used to identify the disturbances for specific BOP items. Let us assume that portfolio investment outflows are persistently omitted, in part or totally, for a number of periods, while all other data are reported correctly. Average errors and omissions are therefore negative and solely determined by asset undermeasurement ($u_2 > 0$, $u_1 = u_3 = u_4 = 0$). In these circumstances, *E/O* would be likely uncorrelated with B_2 *because the outflows in question were **not** measured* (another way to say this is that *E/O* contains u_2 while $\widetilde{B}_2$ does not). The analyst would be naturally led to reject the hypothesis that *E/O* is determined by omitted entries in portfolio investment assets, and inclined to focus on other BOP items that *just happen* to be correlated with *E/O* but have nothing to do with them. Indeed, the fundamental problem with this approach is that there is no reason why disturbances u_i should be on average correlated with net balances $\widetilde{B}_i$; as well, there is no reason to expect that such a relation be of a positive rather than of a negative sign.[21]

[19] "Rebalancing" techniques used in the compilation of national accounts are not considered here. Such techniques purport to reconcile discrepancies between data gathered from "resource" and "use" sides, which are typically collected on a *gross* basis. Because of this, rebalancing methods cannot be applied to balance of payments statistics on capital flows, which are normally collected on a net basis.

[20] This idea was originally proposed by some balance of payments specialists; see for example Barzik and Laliberté (1992) and Hilpinen (1995).

[21] An additional difficulty for this approach is that in many practical cases it could be difficult to identify a statistically significant correlation between *E/O* and the net balances $\widetilde{B}_i$. Indeed, *E/O* is a net magnitude

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The "economic model" approach consists in ***establishing an expected behavior for specific BOP variables that can be tested against observed data.*** Such analytical priors would be established through formalized models such as $B_i = \Sigma_k \gamma_{i,k} X_{i,k} + \eta_i$, where $X_{i,k}$ is a set of k explanatory variables for the ith BOP item and η_i is a disturbance with standard properties. If predicted values $\hat{B}_i$ approximate the "true" balances, then regression residuals $\hat{\eta}_i = B_i - \hat{B}_i$ can be interpreted as estimates of u_i and employed as explanatory variables for "global" errors and omissions: $E/O = \Sigma_k \delta_{i,k} \hat{\eta}_i + \phi$. A good econometric performance of this latter equation would confirm that E/O could be explained by the regression residuals obtained in the first step. This approach offers two potential advantages over the method described earlier. First, it is immune from problems of spurious correlation; second, it permits to identify *individual components* of the net discrepancy and therefore provides a more comprehensive explanation of circumstances affecting the statistical accuracy of the data. However, the "economic model" approach requires a considerably large amount of data in order to be implemented. In addition, it entails a number of estimation problems. The major difficulties pertain to the estimation of financial flows, whose *levels* (those required for identifying the disturbances) are not modeled explicitly in current econometric practice.[22] Attempts to implement this approach were thus limited to current account variables such as exports and imports of goods and services, with an obvious loss of generality and effectiveness.[23]

The third approach relies on ***consistency checks between data gathered from different sources.*** In essence, the method purports to verify whether two independent sources of information yield, on average, the same measure of a given variable—a procedure called ***validation*** in statistical practice.[24] If there exist alternative source that are believed to be at

summarizing all gross disturbances, some of which may have opposite sign and cancel out. This is likely to result in unstable coefficient estimates, as well as in a greater sensitivity of the regression results to the addition or the subtraction of observations. See Steckler (1991).

[22] As evidenced by modern financial theories, *changes in asset prices can substitute for net capital flows* in restoring equilibrium across internationally integrated markets (IMF, 1991). Indeed, capital flows are only one element of the arbitrage process leading to such equilibria—the other being represented by information flows, the *par excellence* invisible component of international exchanges. Since the effects of this unobservable component are embodied in asset prices, econometric estimates of capital flows proved generally unsuccessful because of an inherent simultaneity bias. In recognition of these difficulties, financial cross-border links are now more conveniently modeled through equilibrium conditions imposed on asset prices (e.g., an interest rate parity relationship that links domestic interest rates through arbitrage to foreign interest rates and to anticipated exchange rate movements) rather than through explicit behavioral equations.

[23] See Fausten and Brooks (1994). Other estimation problems relate to measurement errors in explanatory variables, the omission of relevant independent variables, and structural changes in behavior within the estimation period. It is also worth noting that this procedure can only be applied to variables for which a behavioral equation can be established; it may therefore fail to identify the true factors of discrepancy when this latter reflects disturbances in "exogenous" items of the balance of payments. In principle, this would be evidenced by a poor statistical performance of the equation $E/O = \Sigma_k \delta_{i,k} \hat{\eta}_i + \phi$.

[24] According to Kendall and Buckland (1982), "[...] *validation* is a procedure which provides, by reference to independent sources, evidence that an inquiry is *free from bias* or otherwise conforms to its declared purpose. In

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least as reliable as the one actually employed to measure the variable in question, then comparisons between alternative measures of the same variable permit to formulate a more informed guess on the true value of this variable—hence on the disturbances contained in *E/O*. This method can be applied to various BOP statistics, depending on the availability (and quality) of supplementary information at both the national and international level.[25] Several variants of this method have been considered in the "capital flight" literature, where balance of payments data are generally supplemented with ***estimates of unmeasured or "clandestine" asset flows***.[26] Among the most common estimates are those based on:

a) Comparisons between national data on *trade* and *nonbank deposits abroad* and those published by some international agencies (evidencing unmeasured capital exports through misinvoiced trade flows or bank deposits abroad by private residents);

b) Comparisons between national data on external *liabilities* (mainly in the form of loans) and those published by some international agencies;[27] and

c) ***Comparisons between "measured" and "calculated" capital flows and stocks***. This variant is essentially based on the IMF model, as expressed by equations (5) and (6). In particular, "calculated" flows are those implicit, for given asset prices and exchange

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statistics it is usually applied to a sample investigation with the object of showing that the sample is reasonably representative of the population and that the information collected is accurate" (pp. 205-206). "*Accuracy* in the general statistical sense denotes the *closeness* of computations or estimates *to the exact or true values*" (p. 3). "*Precision* ... is distinguished from accuracy ... [since it] refers to the dispersion of the observations, or some measure of it, whether or not the mean value around which the dispersion is measured approximates to the 'true' value" (p. 152).

[25] As noted, BOP statistics are seldom compiled using a unique source of information (e.g., a reporting system based on bank settlements); more typically, several sources are combined together to produce the final outcome. Some of these sources are available at the national level and may provide information on the same variable (e.g., trade statistics, banking records, enterprise surveys, administrative records, etc.); other sources are available from international agencies and may provide information on variables already measured through national sources (IMF: *Direction of Trade Statistics*; BIS: *International Banking and Financial Market Developments*; OECD: *External Debt Statistics*; World Bank: *World Debt Tables*. Some of these sources have been combined to produce the Joint BIS-IMF-OECD-World Bank Statistics on External Debt, see www.oecd.org/dac/debt).

[26] See Chang, Claessens and Cumby (1997) for a review; for a recent application of this method to Italy, see Committeri (1999).

[27] Estimates of clandestine *assets* based on new information *on the liability side* are not immediately intuitive and require explanation. Per se, any newly identified liability flows are naturally balanced by a corresponding reduction in net errors and omissions. To have an impact on the asset side, the assumption must be made that net errors and omissions are *only* determined by unmeasured financial flows. Under this assumption, any newly identified liabilities also identify an equivalent amount of *net assets* (possibly including some gross liabilities and not, for example, new imports of goods or interest payments). In this way, however, what should be proven is simply taken for granted.

rates, in measured stocks, or those needed to generate, for given stocks and international interest rates, the stream of observed incomes (so-called *Dooley method*).[28]

In subsection C we have examined certain limitations of the IMF model as a means for validating stock and flow data: in particular, those limitations that occur when price and quantity variables are highly dispersed in the reference period. ***Further limitations arise when measured stocks and flows are affected by a similar bias*** (e.g., by a simultaneous underreporting of assets). To illustrate this point, assume that the IMF model approximates the "true" stock-flow relationship in a reasonably good fashion;[29] in addition, assume that both stocks and flows are measured with an error with non-zero mean:

$$(10) \qquad \tilde{K}_t = K_t + \varepsilon_t^K \quad , \quad \tilde{F}_t = F_t + \varepsilon_t^F$$

where $\tilde{K}_t$ and $\tilde{F}_t$ represent actual measures of stocks and flows, respectively. As already noted, $\tilde{K}_t$ can be compared with a "theoretical" value K_t^{calc} obtained by plugging $\tilde{K}_{t-1}$ and $\tilde{F}_t$ into equation (6); symmetrically, $\tilde{K}_t$ and $\tilde{K}_{t-1}$ could be plugged into (5) and that equation solved for F to obtain a theoretical value to be compared with measured flows:

$$(11) \qquad K_t^{calc} = \tilde{K}_{t-1} \frac{x_t}{x_{t-1}} \frac{p_t}{p_{t-1}} + \tilde{F}_t \left(\frac{\bar{x}_t}{x_t} \frac{\bar{p}_t}{p_t} \right)$$

$$(12) \qquad F_t^{calc} = \tilde{K}_t \left(\frac{\bar{x}_t}{x_t} \frac{\bar{p}_t}{p_t} \right) - \tilde{K}_{t-1} \left(\frac{\bar{x}_t}{x_{t-1}} \frac{\bar{p}_t}{p_{t-1}} \right)$$

Deviations between observed and theoretical values can then be expressed in terms of the underlying measurement errors:

$$(13) \qquad D_t^K \equiv \tilde{K}_t - K_t^{calc} = \varepsilon_t^K - \varepsilon_{t-1}^K \left(\frac{x_t}{x_{t-1}} \frac{p_t}{p_{t-1}} \right) - \varepsilon_t^F \left(\frac{\bar{x}_t}{x_t} \frac{\bar{p}_t}{p_t} \right)$$

$$(14) \qquad D_t^F \equiv \tilde{F}_t - F_t^{calc} = \varepsilon_t^F - \varepsilon_t^K \left(\frac{\bar{x}_t}{x_t} \frac{\bar{p}_t}{p_t} \right) - \varepsilon_{t-1}^K \left(\frac{\bar{x}_t}{x_{t-1}} \frac{\bar{p}_t}{p_{t-1}} \right)$$

As noted in IMF (1996, p. 155), independent measures of K and F would be "validated" if D^K and D^F were *small*. If errors had zero mean (i.e., if measurement problems tended to cancel out when considering longer periods of time), such deviations would be small on average.

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[28] The Dooley method requires one additional equation linking current income flows with stocks of assets and liabilities, and solving the system for F.

[29] As noted earlier, this implies that (a) prices and exchange rates do not deviate significantly from their average, and/or (b) transactions are distributed almost evenly during the period.

However, ***D^K and D^F could also be small in the presence of large offsetting errors***: for example, when both ε_t^K and ε_t^F have large and negative averages.[30] Similarly to the net errors and omissions of the balance of payments, equations (13)-(14) can only signal an inconsistency between *recorded* flows and *recorded* stocks, but cannot detect cases in which recorded flows and stocks are affected by errors of the same type.[31] This limitation may be of some relevance in the area of portfolio investment statistics, where asset undermeasurement may prevail for both variables.[32] In this sense, such a procedure should not lead to an "automatic" validation of both sets of data.

III. Numerical Examples

In this section we consider weekly data on security prices, foreign exchange rates, and portfolio holdings for the period 1994-1997, and use them to compute high-frequency stocks, transactions, and valuation adjustments (subsection A). These latter data are then taken as a benchmark to assess the accuracy and precision of checks performed by national compilers, on the assumption that BOP and IIP statistics are collected and compiled on a quarterly basis (subsection B). Finally, in subsection C we assess the accuracy of stock estimates based on an initial end-1993 benchmark.

A. Basic high-frequency data

A U.S. global investor is considered in this example, with an initial portfolio (as at end-December 1993) of about US$2 million, comprising both domestic and foreign equity securities (**Table 4**). It is assumed that (a) equity prices are denominated in the issuer country's currency; (b) securities are only traded in organized exchanges located in the country of residence of the original issuer; and (c) securities trading takes place on the last working day of each week (in other terms, the smallest time interval considered is the "week"). To add the example with some realistic flavor, historical end-of-week data on stock market indices and exchange rates for the period 31/12/1993 through 31/12/1997 are used.[33] Weekly transactions and stocks are obtained by combining such prices and exchange rates

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[30] Such omissions may occur either at the individual level (i.e., when respondents fail to report some or all of their holdings), or when data are reported correctly by respondents but the compiler fails to achieve full coverage of the relevant population.

[31] This problem can be viewed from another angle. Measurement errors cannot be identified through cross-checking stocks and flows because D^K and D^F are linked together by $D^F = D^K\,(\bar{x}_t \bar{p}_t / x_t p_t)$, so that there are two unknowns (ε^F, ε^K) with only one independent equation.

[32] Problems of portfolio investment asset undercounting in the 1980s were identified by the IMF Working Party on the Measurement of International Capital Flows (see IMF 1992, or *Godeaux Report*). The results of the IMF Coordinated Portfolio Investment Survey have confirmed that these problems persisted in the 1990s, as originally conjectured in the Godeaux Report: see IMF (2000).

[33] Data on stock exchange indices and exchange rates were obtained, respectively, from Datastream and the UIC database (www.uic.it).

with a hypothetical portfolio strategy for the investor in question. In particular, we assume that the number of individual shares held by the investor at the end of each week is determined by the following rule:

$$(15) \quad Q_t^i = Q_{t-1}^i + [1 + \alpha(r_t^i - \bar{r}_t)]$$

$$\textit{where } r_t^i = \frac{p_t^i x_t^i}{p_{t-1}^i x_{t-1}^i}, \quad \bar{r}_t = \frac{\sum_{i=1}^{N} Q_t^i p_t^i x_t^i}{\sum_{i=1}^{N} Q_{t-1}^i p_{t-1}^i x_{t-1}^i}, \quad \textit{and} \quad 0<\alpha \leq 1.$$

In other terms, the investor buys (sells) securities whose total return rate is above (below) the average return of its portfolio. This rule (buying "winners" and selling "losers") is known as a "momentum" portfolio strategy. It is used here for illustration purposes and is not meant to be a realistic description of actual investment behavior. (In what follows, parameter α is assumed to be equal to unity.) Securities holdings generated—through this rule—by price and exchange rate variables are shown in **Chart 2**. The corresponding positions, transactions, and adjustments expressed in US dollars are shown in **Chart 3**. They have been calculated on a security-by-security basis, i.e., by applying the "exact" formulas of section II to each security and then aggregating across non-US securities.[34]

The data in question exhibit some features that are likely to prevail in actual financial markets, namely:

a) An ***uneven distribution of transactions*** in the reference period—An indication that portfolio investment transactions are normally distributed in this fashion has been provided by Froot *et al.* (1998), who examined daily transactions on foreign securities made by a large US fund management enterprise (State Street Bank & Trust) on behalf of its clients, from 1994 through 1998;

b) A ***turnover on foreign securities that is disproportionately larger than net transactions***—This depends, at least in part, on the particular portfolio strategy considered in the example: such a strategy looks at the relative performance of individual equities on a weekly basis and therefore generates high-frequency portfolio rebalancing. As is clear, gross turnover would be smaller with momentum strategies based on returns over longer periods of time. In any event, a similar behavior was found by Froot *et al.* (1998); and

c) ***Large and erratic valuation adjustments***—These adjustments establish differences in flows and changes in stocks, as regards to both their size and evolution over time. As noted in the previous section, they reflect *inter-period* changes in prices and exchange rates, as well as the *intra-period* dispersion of such variables (**Chart 4**). As regards inter-

[34] US securities were excluded because irrelevant for BOP and IIP compilation purposes.

period changes, the US dollar *depreciates* from 94Q1 through 95Q3 and *appreciates* during 95Q4-97Q4: for this reason, exchange rate adjustments tend to be *positive* in the first sub period and *negative* in the second. On the other hand, stock prices are *falling* in 94Q1-95Q1 and *growing* in 95Q2-97Q4: price adjustments are therefore predominantly *negative* in the first sub period and *positive* in the second. Deviations from these patterns are also determined by intra-period volatility, which is particularly intense in 1997.

Under the assumptions made, these are the actual or "true" values that compilers should endeavor to measure. Two different cases are discussed in this section: (a) a situation in which data on stocks and flows are collected and compiled at the same frequency; and (b) a situation in which data on stocks are collected at a lower frequency than flow data, or not collected altogether.

B. Cross-checking quarterly data: is validation possible?

We assume that BOP and IIP statistics are both collected and compiled on a quarterly basis. At the end of the reference period compilers receive, separately for external financial assets and liabilities, quarterly information on net flows, end-of-period positions, and valuation adjustments (note that there are no "other" adjustments in this example). We also assume that reported data are computed using the "exact" formulas of section II and therefore coincide with actual or "true" values.

Compilers can observe the prices and exchange rates applicable to all transactions but ignore how these latter are actually distributed within each quarter. Compilers also ignore whether reported data are the "true" ones and want to verify their accuracy. As is clear, mere algebraic consistency in reported data (i.e., $K_t=K_{t-1}+F_t+ADJ_t$) would not be sufficient to validate this information—the issue here is not whether respondents were able to square their accounts, but whether exact formulas were employed to report this information. To this end, alternative measures of K, F, and ADJ could be computed and compared with reported data. Such measures would depend on the amount of information available to the compiler: more specifically, on whether it pertains to individual securities (***security-by-security approach***) or to the total value of portfolio (***aggregate approach***). Compilers possessing more detailed information would apply formulas (5-6) to reported data, for all homogeneous combinations of instruments and currencies, and would aggregate the results across all such combinations. Compilers following an aggregate approach would consider, for each reporting agent or perhaps for the entire population of respondents, *total* reported values for K and F and adjust such magnitudes with aggregate price and exchange rate indices.[35]

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[35] Such indices could be computed as weighted geometric means of the relevant variables, i.e.

$\tilde{p}_t = exp\{\sum_{i=1}^{N} \ln(p_t^i)\, w_t^{pi}\}$ and $\tilde{x}_t = exp\{\sum_{i=1}^{N} \ln(x_t^i)\, w_t^{xi}\}$, where N is the total number of foreign securities held in portfolio. Four alternative weighting systems are considered in the example (recall that the composition of portfolio holdings by currency and by instrument coincide): (a) fixed weights, based on end-1993 values: $w_t^{xi} = w_t^{pi} = K_{93Q4}^i / K_{93Q4}$; (b) variable weights, end-of-quarter values: $w_t^{xi} = w_t^{pi} = K_t^i / K_t$; (c) variable

(continued...)

Estimates for stocks and flows are presented in **Tables 5** and **6**, respectively, and compared with actual or "true" values. As regards to stock data, all estimates are highly correlated with actual values; however, *estimates performed at the level of individual securities are much closer to actual values than aggregate estimates*. Within the class of aggregated estimators, the one based on moving-averaged weights turns out to be more accurate than the others, although it performs less satisfactorily than the security-by-security estimator. Flow estimates performed on a security-by-security basis also dominate the other estimators, as to both their correlation with (and closeness to) actual values.

Nonetheless, ***discrepancies between actual and estimated flows remain large*** and estimates have occasionally a wrong sign. As noted in the previous section, this is to be attributed to the combined effects of a high dispersion of prices and exchange rates within the reference period. What would have happened if such dispersion had been lower and transactions distributed more evenly? To answer this question, we express the amount of intra-period dispersion in prices and quantities in terms of two parameters α and β, respectively, which vary between zero and one. In particular, we compute new high-frequency time series for prices $P(\alpha)$ and transactions $\Delta Q(\beta)$ defined as:

$$(16) \quad P(\alpha)^i_{t-1+\tau/n} = P^i_{t-1+\tau/n} + \alpha\,(P^i_t - P^i_{t-1+\tau/n})$$

for t = 94Q1, 94Q2, ..., 97Q4 , i = 1,2, ..., N , τ = 1, 2, ..., (n-1),

$$\Delta Q(\beta)^i_{t-1+\tau/n} = \Delta Q^i_{t-1+\tau/n} + \beta\,(\frac{Q^i_t - Q^i_{t-1}}{n} - \Delta Q^i_{t-1+\tau/n})$$

for t = 94Q1, 94Q2, ..., 97Q4 , i = 1,2, ..., N , τ = 1, 2, ..., (n)

where P^i is the price of security i in US dollars, n is the number of weeks in each quarter, N is the total number of foreign securities held in portfolio, and $0<(\alpha, \beta)<1$. Such time series are obtained on the basis of those already used in Tables 3 and 4, and coincide with the original series when α and β are equal to zero.[36] When α and β increase, prices get closer to their end-period values and transactions are spread more uniformly over the reference period; the dispersion of prices and transactions is zero when α and β are equal to unity. (Note that "calculated" end-period values for P and Q always coincide with the original ones, irrespective of the values of parameters α and β.)

weights, 2-quarter moving averages: $w^{xi}_t = w^{pi}_t = (K^i_t + K^i_{t-1})/(K_t + K_{t-1})$; and (d) variable weights, linear interpolation of end-year values: $w^{xi}_t = w^{pi}_t = \hat{K}^i_t / \hat{K}_t$.

[36] In other terms, when both α and β are equal to zero the intra-period dispersion of P and ΔQ is the same as that prevailing in the original example.

Actual and estimated flows have been computed for selected values of α and β in the interval *[0,1]*; deviations between estimated and actual values are presented in **Table 7**. They confirm what noted in section II, namely that the accuracy of the IMF model is inversely related to the intra-period dispersion in price and quantity variables. In particular, it is confirmed that estimated flows would approach their "true" values if prices and exchange rates were less dispersed, or transactions distributed more uniformly, or with a combination of these factors; per contra, the same degree of accuracy would obtain with a higher dispersion of prices and transactions distributed more uniformly.[37]

These considerations lead us to the heart of the problem. When compilers do not know the intra-period distribution of transactions they are forced to assume that these latter are distributed evenly. On the basis of this assumption, "calculated" measures are constructed, and compared with reported data. ***This comparison could be inconclusive (if not misleading) when prices and quantities are highly dispersed in the reference period.***

In particular, large discrepancies between reported and estimated data could arise in two very different circumstances:

i. Transactions were distributed in the postulated fashion (in which case the intra-period dispersion of prices was irrelevant) and respondents did not report the data correctly;

ii. The data were reported correctly, but transactions were distributed differently from what postulated (in which case price dispersion also contributed to estimation errors).

On the other hand, small discrepancies could be observed when

i. Transactions were distributed in an approximately even fashion and data were reported correctly by respondents; or when

ii. Transactions were distributed unevenly, but reported data were computed in the same fashion as the compiler's estimates (i.e., using the IMF model; in this case, reported data would be an only poor approximation to actual values if prices are highly dispersed).

In any event, a decision to accept or reject the reported data would be problematic.[38] More in general, the ***compiler's dilemma*** is what to do in the presence of large discrepancies between

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[37] The table also shows that, to contain estimation errors within acceptable bounds, the dispersion of equity prices and exchange rates should have been much lower than that *actually observed* during the period in question. Note that prices and exchange rates have been combined together in this particular example, where only prices *expressed in US dollars* are considered. As a result, an uniform distribution of transactions within the reference period is sufficient to ensure that security-by-security estimates coincide with actual values for both flows and stocks.

[38] This indeterminacy may be viewed from another angle. When transactions are distributed uniformly in the reference period (i.e., when $\Delta Q_{t-1+\tau/n}=(Q_t-Q_{t-1})/n$ for all τ), confidence intervals for $\hat{F}_t$ are zero because this is

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reported data and calculated measures built for validation purposes. To maintain such discrepancies as small as possible, respondents could be instructed to report flow data "at constant exchange rates" (see equation 5 in section II). In this way, the compiler could effectively check on whether respondents are reporting in the recommended fashion; however, the accuracy of *all* balance of payments statistics might diminish dramatically when the dispersion of prices and transactions is above a certain threshold (see equation 8 in section II). On the other hand, if a recommendation were made to report flows in the "exact" fashion, compilers might be unable to verify whether this recommendation was implemented. As is clear, this dilemma would be strengthened in periods of enhanced volatility of prices, exchange rates, and transactions.

In conclusion, high ***price/transaction volatility may render inconclusive the consistency checks*** performed by national compilers. Per se, of course, this does not imply an effective deterioration in the quality of available data; it only means that the ability to accept or reject the reported data is reduced when price and quantity variables are more volatile. On the other hand, data collected in periods of enhanced volatility would be likely incorrect when respondents are more uncertain about the appropriate prices attached to their transactions, or when they fail to report such transactions in a correct fashion. A fortiori, such shortcomings in reported data could not be identified easily in these periods, especially if cross-checks are made in an aggregate fashion. In either way, an enhanced volatility is likely to imply that the ***quality of available statistics deteriorates in periods of crisis***, i.e., when the need for accurate information is stronger. However, the availability of more detailed financial information (in particular, details on the currency of denomination, maturity, and type of relevant securities) would make it possible to classify reported data into homogeneous groups and obtain estimates that are closer to the actual values of the relevant variables, irrespective of the intra-period dispersion of prices and exchange rates.

C. Estimation of stocks

We now consider what happens when the IMF model is used to estimate a whole time series of position data by cumulating flows on an initial benchmark observed at the end of 1993.[39] (Recall that, differently from the previous example, estimation errors would cumulate over time in this case, according to the patterns indicated in Table 3.)

We assume that data on flows are collected on a quarterly basis and are reported correctly by respondents. Compilers know the composition of end-1993 stocks by currency and instrument and can observe the prices and exchange rates applicable to all transactions. Three

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always an exact measure of F_t. When ΔQ is allowed to vary, the width of such intervals may increase dramatically because the effects of the intra-period dispersion of ΔQ are combined with those of the intra-period dispersion of P. Standard confidence intervals (defined for a 90-95 percent confidence level) may be very wide, depending on the assumptions made on how changes in quantities are distributed within the period.

[39] As noted, such a model—or variants of it— has been employed by both national compilers and individual researches to obviate the lack of relevant stock information.

types of fixed-benchmark estimates are considered: (a) *unadjusted* estimates based on flows and stocks valued at historical prices and exchange rates; (b) adjusted estimates on an *aggregate* basis (to this purpose, an aggregate index of security prices in US dollar is calculated as a weighted geometric mean of all relevant indices, using end-1993 values as weights); and (c) adjusted estimates on a *security-by-security* basis.

End-year deviations of such estimates from actual values are presented in **Table 8**, for selected values of α and β in the interval *[0,1]*. Three main results should be noted. First, as expected, unadjusted estimators are outperformed by adjusted estimators for all values of α and β. Second, as noted earlier, security-by-security estimates coincide with actual values when either α=0, or β=0, or α=β=0 (i.e., when the dispersion of prices, or transactions, or both variables is zero). Third, aggregate (AGG) and security-by-security (SBS) estimators perform in a similar fashion for all periods except 1997, which is characterized by strong inter- and intra-period changes in prices, exchange rates, and quantities. These factors exacerbate the bias in AGG compared to that in SBS. As shown in the table, such an aggregation bias is positively related to volatility in prices and quantities (i.e., it diminishes when α and β increase); however, differently from what happens for the SBS estimator, the bias in question would not disappear when either α=0, or β=0, or α=β=0.

In conclusion, when prices and quantities are more dispersed in the reference period, fixed-benchmark estimates performed on a security-by-security basis are much closer to actual values than aggregate estimates.

IV. Conclusions

The analytical relevance of IIP statistics is enhanced by an ability to show their connections with the financial flows recorded in the balance of payments: indeed, financial stocks and flows represent two sides of the same coin, and their reconciliation would help identify various factors affecting the financial sector of an economy over time.

A full-fledged reconciliation between independent measures of stocks and flows is, however, a very complex task, which requires an enormous amount of financial information to be implemented in an accurate fashion; because of this, some simplifying assumptions or models are needed to facilitate empirical applications. In this paper, we have examined the most popular model used to compute, cross-check, and validate BOP, IIP, and external debt statistics (the IMF model). This model offers a conveniently simplified stock-flow relationship, as well as more manageable formulas for price and exchange rate adjustments. Analytical expressions have been derived to assess the estimation accuracy of the IMF model and discuss (a) how such accuracy is affected by volatile asset prices and transactions and (b) how net errors and omissions of the balance of payments are related to this approximated stock-flow relation.

The main conclusion is that ***the accuracy of the IMF model is negatively affected by enhanced volatility of financial asset prices and transactions***; numerical examples based on equity prices and exchange rates actually observed in the 1990s suggest that the extent of the bias (which cannot be observed directly) might have been especially large when the approximated model was used to compute estimates based on less detailed financial information. ***Serious consideration should be therefore given by national compilers to increase the amount of financial information used for compiling BOP and IIP statistics.***

In particular, an increased volatility of price and quantity variables affects the quality of existing BOP and IIP statistics in various ways. First, it ***reduces the quality of flow estimates "at constant exchange rates"***: by implication, a substantial bias might have affected balance of payments statistics entirely based on banking records (not only those pertaining to financial flow, but also those on current account transactions). Volatile prices and exchange rates might have also resulted in ***larger errors and omissions*** in balances of payments where banking records are supplemented with higher-frequency data gathered from other sources (such as trade statistics). Second, it ***diminishes the ability to identify separately price and exchange rate valuation effects*** using the standard approximation proposed by the Fund, and ***reduces the accuracy of stock estimators*** based on cumulated flows. Third, increased volatility ***impairs the ability of national compilers to cross-check and "validate" stock and flow data***. Per se, of course, this does not imply an effective deterioration in the quality of available data; it only means that the ability to accept or reject the reported data is reduced when price and quantity variables are more volatile. On the other hand, an effective quality deterioration could not be identified easily in periods of enhanced volatility, especially if cross-checks were made in an aggregate fashion. In either way, an enhanced volatility is likely to imply that the ***quality of available statistics deteriorates in periods of crisis***, i.e., when the need for accurate information is stronger. However, the availability of more detailed financial information (in particular, details on the currency of denomination, maturity, and type of relevant securities) would make it possible to obtain estimates that are closer to the actual values of the relevant variables, irrespective of the intra-period dispersion of prices and exchange rates.

Table 1. Reconciliation of stocks and flows: summary

			Based on exact relations	Based on approximated relations
Opening Position		K_{t-1}	$Q_{t-1}\, x_{t-1}\, p_{t-1}$	$Q_{t-1}\, x_{t-1}\, p_{t-1}$
Transactions		F_t	$\sum_{\tau=1}^{n} \Delta Q^{T}_{t-1+\tau/n}\, x_{t-1+\tau/n}\, p_{t-1+\tau/n}$	$(Q_t - Q_{t-1})\, \bar{x}_t\, \bar{p}_t$
Reconciliation adjustments	**Exchange Rate**	ADJ_t^{xrate}	$Q_{t-1}(x_t - x_{t-1})\, p_{t-1} + \sum_{\tau=1}^{n} \Delta Q^{T}_{t-1+\tau/n}(x_t - x_{t-1+\tau/n})\, p_{t-1}$	$Q_{t-1}(x_t - x_{t-1})\, p_{t-1} + F_t\left(\frac{x_t}{\bar{x}_t} - 1\right)$
	Price	ADJ_t^{price}	$Q_{t-1}(p_t - p_{t-1})\, x_{t-1} + \sum_{\tau=1}^{n} \Delta Q^{T}_{t-1+\tau/n}(p_t - p_{t-1+\tau/n})\, x_{t-1}$	$Q_{t-1}(p_t - p_{t-1})\, x_{t-1} + F_t\left(\frac{p_t}{\bar{p}_t} - 1\right)$
	Non-transaction	ADJ_t^{other}	$\sum_{\tau=1}^{n} \Delta Q^{N}_{t-1+\tau/n}\, x_t\, p_t$	$\sum_{\tau=1}^{n} \Delta Q^{N}_{t-1+\tau/n}\, x_t\, p_t$
	Residual	ADJ_t^{res}	$Q_{t-1}(x_t - x_{t-1})(p_t - p_{t-1}) + \sum_{\tau=1}^{n} \Delta Q^{T}_{t-1+\tau/n}[x_t(p_t - p_{t-1}) - x_{t-1}(p_t - p_{t-1+\tau/n}) + x_{t-1+\tau/n}(p_{t-1+\tau/n} - p_{t-1})]$	$Q_{t-1}(x_t - x_{t-1})(p_t - p_{t-1}) + F_t \frac{(x_t - \bar{x}_t)(p_t - \bar{p}_t)}{\bar{x}_t\, \bar{p}_t}$
Closing Position		K_t	$Q_t\, x_t\, p_t$	$Q_t\, x_t\, p_t$

Table 2. Stock estimators based on cumulated flows

	Unadjusted (1)		Adjusted (2)		
	Shifting Bench-mark (3)	Fixed Benchmark(4)	Shifting Benchmark (3)	Fixed benchmark (4)	
				Adjustment factors for specific periods (5)	Adjustment factors for cumulated periods (6)
	(a)	(b)	(c)	(d)	(e)
$\hat{K}_t$	$K_{t-1}+F_t$	$K_{t-1}+F_t$	$K_{t-1}\left(\frac{P_t}{P_{t-1}}\right)+F_t\left(\frac{P_t}{\bar{P}_t}\right)$	$K_{t-1}\left(\frac{P_t}{P_{t-1}}\right)+F_t\left(\frac{P_t}{\bar{P}_t}\right)$	$K_{t-1}\left(\frac{P_t}{P_{t-1}}\right)+F_t\left(\frac{P_t}{\bar{P}_t}\right)$
$\hat{K}_{t+1}$	K_t+F_{t+1}	$\hat{K}_t+F_{t+1}=$ $K_{t-1}+F_t+F_{t+1}$	$K_t\left(\frac{P_{t+1}}{P_t}\right)+F_{t+1}\left(\frac{P_{t+1}}{\bar{P}_{t+1}}\right)$	$\hat{K}_t\left(\frac{P_{t+1}}{P_t}\right)+F_{t+1}\left(\frac{P_{t+1}}{\bar{P}_{t+1}}\right)=$ $K_{t-1}\left(\frac{P_{t+1}}{P_{t-1}}\right)+F_t\left(\frac{P_{t+1}}{\bar{P}_t}\right)+F_{t+1}\left(\frac{P_{t+1}}{\bar{P}_{t+1}}\right)$	$K_{t-1}\left(\frac{P_{t+1}}{P_{t-1}}\right)+(F_t+F_{t+1})\left(\frac{P_{t+1}}{\bar{P}_{t,t+1}}\right)=$ $K_{t-1}\left(\frac{P_{t+1}}{P_{t-1}}\right)+F_t\left(\frac{P_{t+1}}{\bar{P}_{t,t+1}}\right)+F_{t+1}\left(\frac{P_{t+1}}{\bar{P}_{t,t+1}}\right)$ *where* $\bar{P}_{t,t+1}=(\bar{P}_t+\bar{P}_{t+1})/2$
$\hat{K}_{t+2}$	$K_{t+1}+F_{t+2}$	$\hat{K}_{t+1}+F_{t+2}=$ $K_{t-1}+F_t+F_{t+1}$ $+F_{t+2}$	$K_{t+1}\left(\frac{P_{t+2}}{P_{t+1}}\right)+F_{t+2}\left(\frac{P_{t+2}}{\bar{P}_{t+2}}\right)$	$\hat{K}_{t+1}\left(\frac{P_{t+2}}{P_{t+1}}\right)+F_{t+2}\left(\frac{P_{t+2}}{\bar{P}_{t+2}}\right)=$ $K_{t-1}\left(\frac{P_{t+2}}{P_{t-1}}\right)+F_t\left(\frac{P_{t+2}}{\bar{P}_t}\right)+F_{t+1}\left(\frac{P_{t+2}}{\bar{P}_{t+1}}\right)+F_{t+2}\left(\frac{P_{t+2}}{\bar{P}_{t+2}}\right)$	$K_{t-1}\left(\frac{P_{t+2}}{P_{t-1}}\right)+(F_t+F_{t+1}+F_{t+2})\left(\frac{P_{t+2}}{\bar{P}_{t,t+2}}\right)=$ $K_{t-1}\left(\frac{P_{t+2}}{P_{t-1}}\right)+F_t\left(\frac{P_{t+2}}{\bar{P}_{t,t+2}}\right)+F_{t+1}\left(\frac{P_{t+2}}{\bar{P}_{t,t+2}}\right)+F_{t+2}\left(\frac{P_{t+2}}{\bar{P}_{t,t+2}}\right)$ *where* $\bar{P}_{t,t+2}=(\bar{P}_t+\bar{P}_{t+1}+\bar{P}_{t+2})/3$
$\hat{K}_{t+3}$	$K_{t+2}+F_{t+3}$	$\hat{K}_{t+2}+F_{t+3}=$ $K_{t-1}+F_t+F_{t+1}$ $+F_{t+2}+F_{t+3}$	$K_{t+2}\left(\frac{P_{t+3}}{P_{t+2}}\right)+F_{t+3}\left(\frac{P_{t+3}}{\bar{P}_{t+3}}\right)$	$\hat{K}_{t+2}\left(\frac{P_{t+3}}{P_{t+2}}\right)+F_{t+3}\left(\frac{P_{t+3}}{\bar{P}_{t+3}}\right)=$ $K_{t-1}\left(\frac{P_{t+3}}{P_{t-1}}\right)+F_t\left(\frac{P_{t+3}}{\bar{P}_t}\right)+F_{t+1}\left(\frac{P_{t+3}}{\bar{P}_{t+1}}\right)+F_{t+2}\left(\frac{P_{t+3}}{\bar{P}_{t+2}}\right)+F_{t+3}\left(\frac{P_{t+3}}{\bar{P}_{t+3}}\right)$	$K_{t-1}\left(\frac{P_{t+3}}{P_{t-1}}\right)+(F_t+F_{t+1}+F_{t+2}+F_{t+3})\left(\frac{P_{t+3}}{\bar{P}_{t,t+3}}\right)=$ $K_{t-1}\left(\frac{P_{t+3}}{P_{t-1}}\right)+F_t\left(\frac{P_{t+3}}{\bar{P}_{t,t+3}}\right)+F_{t+1}\left(\frac{P_{t+3}}{\bar{P}_{t,t+3}}\right)+F_{t+2}\left(\frac{P_{t+3}}{\bar{P}_{t,t+3}}\right)+F_{t+3}\left(\frac{P_{t+3}}{\bar{P}_{t,t+3}}\right)$ *where* $\bar{P}_{t,t+3}=(\bar{P}_t+\bar{P}_{t+1}+\bar{P}_{t+2}+\bar{P}_{t+3})/4$
...	...	...	...	...	...

(1) Stocks and flows are valued at historical prices and exchange rates. – (2) Stocks and flows are valued at period-end prices and exchange rates. – (3) Current flows are cumulated on the stock at the end of the previous period; the benchmark is therefore changing at each step of the iteration. – (4) The same benchmark (K_{t-1}) is used for all iterations; the relevant flows are added at each step, and valued at period-end prices and exchange rates. (5) Each vintage is adjusted using price averages defined over the corresponding period. – (6) Each vintage is adjusted using price averages defined over the whole (cumulated) period including all vintages.

Table 3. Estimation bias for stocks

(Difference between actual and estimated values)

	Unadjusted (1)		**Adjusted** (2)		
				Fixed benchmark 4)	
	Shifting Bench-mark(3)	**Fixed Bench-mark**(4)	**Shifting benchmark** 3)	**Adjustment factors for individual periods**	**Adjustment factors for cumulated periods**
	(a)	**(b)**	**(c)**	**(d)**	**(e)**
t	ADJ_t	ADJ_t	$\left(\frac{P_t}{\bar{P}_t}\right)\sum_{\tau=1}^{n}\Delta Q_{t-1+\tau/n}(\bar{P}_t - P_{t-1+\tau/n})$	$\left(\frac{P_t}{\bar{P}_t}\right)\sum_{\tau=1}^{n}\Delta Q_{t-1+\tau/n}(\bar{P}_t - P_{t-1+\tau/n})$	$\left(\frac{P_t}{\bar{P}_t}\right)\sum_{\tau=1}^{n}\Delta Q_{t-1+\tau/n}(\bar{P}_t - P_{t-1+\tau/n})$
t+1		ADJ_t		$\left(\frac{P_{t+1}}{\bar{P}_t}\right)\sum_{\tau=1}^{n}\Delta Q_{t-1+\tau/n}(\bar{P}_t - P_{t-1+\tau/n})$	$\left(\frac{P_{t+1}}{\bar{P}_{t+1}}\right)\sum_{\tau=1}^{n}\Delta Q_{t-1+\tau/n}(\bar{P}_{t+1} - P_{t-1+\tau/n})$
	ADJ_{t+1}	$+ ADJ_{t+1}$	$\left(\frac{P_{t+1}}{\bar{P}_{t+1}}\right)\sum_{\tau=1}^{n}\Delta Q_{t+\tau/n}(\bar{P}_{t+1} - P_{t+\tau/n})$	$+\left(\frac{P_{t+1}}{\bar{P}_{t+1}}\right)\sum_{\tau=1}^{n}\Delta Q_{t+\tau/n}(\bar{P}_{t+1} - P_{t+\tau/n})$	$+\left(\frac{P_{t+1}}{\bar{P}_{t+1}}\right)\sum_{\tau=1}^{n}\Delta Q_{t+\tau/n}(\bar{P}_{t+1} - P_{t+\tau/n})$
t+2		ADJ_t		$\left(\frac{P_{t+2}}{\bar{P}_t}\right)\sum_{\tau=1}^{n}\Delta Q_{t-1+\tau/n}(\bar{P}_t - P_{t-1+\tau/n})$	$\left(\frac{P_{t+2}}{\bar{P}_t}\right)\sum_{\tau=1}^{n}\Delta Q_{t-1+\tau/n}(\bar{P}_{t+2} - P_{t-1+\tau/n})$
		$+ ADJ_{t+1}$		$+\left(\frac{P_{t+2}}{\bar{P}_{t+1}}\right)\sum_{\tau=1}^{n}\Delta Q_{t+\tau/n}(\bar{P}_{t+1} - P_{t+\tau/n})$	$+\left(\frac{P_{t+2}}{\bar{P}_{t+1}}\right)\sum_{\tau=1}^{n}\Delta Q_{t+\tau/n}(\bar{P}_{t+2} - P_{t+\tau/n})$
	ADJ_{t+2}	$+ ADJ_{t+2}$	$\left(\frac{P_{t+2}}{\bar{P}_{t+2}}\right)\sum_{\tau=1}^{n}\Delta Q_{t+1+\tau/n}(\bar{P}_{t+2} - P_{t+1+\tau/n})$	$+\left(\frac{P_{t+2}}{\bar{P}_{t+2}}\right)\sum_{\tau=1}^{n}\Delta Q_{t+1+\tau/n}(\bar{P}_{t+2} - P_{t+1+\tau/n})$	$+\left(\frac{P_{t+2}}{\bar{P}_{t+1}}\right)\sum_{\tau=1}^{n}\Delta Q_{t+1+\tau/n}(\bar{P}_{t+2} - P_{t+1+\tau/n})$
t+3		ADJ_t		$\left(\frac{P_{t+3}}{\bar{P}_t}\right)\sum_{\tau=1}^{n}\Delta Q_{t-1+\tau/n}(\bar{P}_t - P_{t-1+\tau/n})$	$\left(\frac{P_{t+3}}{\bar{P}_t}\right)\sum_{\tau=1}^{n}\Delta Q_{t-1+\tau/n}(\bar{P}_{t+3} - P_{t-1+\tau/n})$
		$+ ADJ_{t+1}$		$+\left(\frac{P_{t+3}}{\bar{P}_{t+1}}\right)\sum_{\tau=1}^{n}\Delta Q_{t+\tau/n}(\bar{P}_{t+1} - P_{t+\tau/n})$	$+\left(\frac{P_{t+3}}{\bar{P}_{t+1}}\right)\sum_{\tau=1}^{n}\Delta Q_{t+\tau/n}(\bar{P}_{t+3} - P_{t+\tau/n})$
		$+ ADJ_{t+2}$		$+\left(\frac{P_{t+3}}{\bar{P}_{t+2}}\right)\sum_{\tau=1}^{n}\Delta Q_{t+1+\tau/n}(\bar{P}_{t+2} - P_{t+1+\tau/n})$	$+\left(\frac{P_{t+3}}{\bar{P}_{t+2}}\right)\sum_{\tau=1}^{n}\Delta Q_{t+1+\tau/n}(\bar{P}_{t+3} - P_{t+1+\tau/n})$
	ADJ_{t+3}	$+ ADJ_{t+3}$	$\left(\frac{P_{t+3}}{\bar{P}_{t+3}}\right)\sum_{\tau=1}^{n}\Delta Q_{t+1+\tau/n}(\bar{P}_{t+3} - P_{t+2+\tau/n})$	$+\left(\frac{P_{t+3}}{\bar{P}_{t+3}}\right)\sum_{\tau=1}^{n}\Delta Q_{t+2+\tau/n}(\bar{P}_{t+3} - P_{t+2+\tau/n})$	$+\left(\frac{P_{t+3}}{\bar{P}_{t+3}}\right)\sum_{\tau=1}^{n}\Delta Q_{t+2+\tau/n}(\bar{P}_{t+3} - P_{t+2+\tau/n})$
..	...	...	...	...	...

(1) Stocks and flows are valued at historical prices and exchange rates.– **(2)** Stocks and flows are valued at period-end prices and exchange rates.– **(3)** Current flows are cumulated on the stock at the end of the previous period; the benchmark is therefore changing at each step of the iteration. – **(4)** The same benchmark (K_{t-1}) is used for all iterations; the relevant flows are added at each step, and valued at period-end prices and exchange rates.

Table 4. Initial portfolio of an US investor as at end-December 1993

#Shares (Q^i)	Country of issuer (i)	Unit price in national currency (p^i)	Exchange rate (Nat. currency per US$) ($1/x^i$)	Value of holdings (in US$) ($K^i$)	Portfolio composition (percentages)	
					Including US equities	Excluding US equities
Advanced economies				*783,976*	*79.03*	*76.68*
90	Australia	147.4	1.47	8,999	0.91	1.01
50	Austria	1,220.0	12.20	4,999	0.50	0.56
300	Belgium	3,620.0	36.19	30,012	3.03	3.36
300	Canada	132.3	1.32	29,993	3.02	3.36
1200	Germany	173.6	1.74	120,035	12.10	13.46
700	France	590.5	5.90	70,006	7.06	7.85
250	Ireland	70.9	0.71	25,007	2.52	2.80
300	Italy	171,000.0	1710.76	29,987	3.02	3.36
800	Japan	11,220.0	112.20	79,998	8.06	8.97
350	Netherlands	194.1	1.94	34,984	3.53	3.92
50	New Zealand	179.3	1.79	5,000	0.50	0.56
50	Portugal	17,670.0	176.62	5,002	0.50	0.56
100	Spain	14,280.0	142.81	9,999	1.01	1.12
300	Sweden	836.0	8.36	29,993	3.02	3.36
500	Switzerland	148.0	1.48	49,983	5.04	5.60
1500	United Kingdom	67.5	0.68	149,978	15.12	16.81
1000	United States	100.0	1.00	100,000	10.08	-
Emerging Latin America				*80,018*	*8.07*	*8.97*
300	Argentina	100.0	1.00	30,000	3.02	3.36
150	Chile	43,000.0	429.84	15,006	1.51	1.68
350	Mexico	311.5	3.11	35,012	3.53	3.93
Emerging Asia				*128,008*	*12.90*	*14.35*
80	China	580.0	5.80	8,001	0.81	0.90
200	Hong Kong SAR	774.0	7.74	19,991	2.02	2.24
100	Indonesia	212,300.0	2122.53	10,002	1.01	1.12
150	Korea	81,100.0	810.79	15,004	1.51	1.68
150	Malaysia	257.7	2.58	14,994	1.51	1.68
250	Philippines	2,708.0	27.07	25,006	2.52	2.80
100	Singapore	159.8	1.60	10,003	1.01	1.12
150	Taiwan	2,675.0	26.74	15,006	1.51	1.68
100	Thailand	2,550.0	25.50	10,000	1.01	1.12
	TOTAL			*1,984,003*	*100.00*	*100.00*

Table 5. Validation of quarterly data on stocks: actual and estimated values

(US dollars and percentages)

Periods	Actual values	Unadjusted estimators (*)		Adjusted estimators (*)									
				Security-by-security approach (1)		Aggregate approach (2)							
						Fixed weights		Variable weights					
			(**)		(**)	(A)	(**)	(B)	(**)	(C)	(**)	(D)	(**)
93Q4	**892,002**	-	-	-	-	-	-	-	-	-	-	-	-
94Q1	**897,118**	902,152	*0.56*	899,645	*0.28*	890,788	*-0.71*	912,000	*1.66*	901,361	*0.47*	895,777	*-0.15*
94Q2	**887,927**	910,695	*2.56*	889,852	*0.22*	881,043	*-0.78*	900,826	*1.45*	903,523	*1.76*	893,726	*0.65*
94Q3	**938,545**	917,161	*-2.28*	941,697	*0.34*	950,310	*1.25*	933,970	*-0.49*	943,570	*0.54*	953,476	*1.59*
94Q4	**913,982**	921,256	*0.80*	916,934	*0.32*	905,234	*-0.96*	926,755	*1.40*	916,040	*0.23*	931,584	*1.93*
95Q1	**912,955**	920,436	*0.82*	915,610	*0.29*	901,105	*-1.30*	922,992	*1.10*	925,767	*1.40*	911,505	*-0.16*
95Q2	**962,061**	921,657	*-4.20*	964,425	*0.25*	968,043	*0.62*	965,664	*0.37*	970,186	*0.84*	966,425	*0.45*
95Q3	**981,009**	918,302	*-6.39*	982,679	*0.17*	982,956	*0.20*	984,165	*0.32*	983,915	*0.30*	986,703	*0.58*
95Q4	**998,394**	918,017	*-8.05*	1,000,477	*0.21*	1,001,043	*0.27*	997,171	*-0.12*	1,000,600	*0.22*	1,006,353	*0.80*
96Q1	**1,031,633**	919,250	*-10.89*	1,033,321	*0.16*	1,036,595	*0.48*	1,032,986	*0.13*	1,031,457	*-0.02*	1,032,179	*0.05*
96Q2	**1,068,708**	921,436	*-13.78*	1,069,840	*0.11*	1,074,039	*0.50*	1,069,652	*0.09*	1,068,740	*0.00*	1,072,925	*0.39*
96Q3	**1,083,291**	922,099	*-14.88*	1,084,588	*0.12*	1,075,772	*-0.69*	1,094,299	*1.02*	1,090,108	*0.63*	1,092,704	*0.87*
96Q4	**1,130,640**	918,925	*-18.73*	1,132,020	*0.12*	1,116,607	*-1.24*	1,146,776	*1.43*	1,142,415	*1.04*	1,145,830	*1.34*
97Q1	**1,196,985**	928,312	*-22.45*	1,198,988	*0.17*	1,192,134	*-0.41*	1,205,378	*0.70*	1,210,878	*1.16*	1,203,892	*0.58*
97Q2	**1,304,807**	925,255	*-29.09*	1,307,482	*0.21*	1,305,085	*0.02*	1,311,420	*0.51*	1,313,551	*0.67*	1,318,914	*1.08*
97Q3	**1,331,946**	921,697	*-30.80*	1,335,572	*0.27*	1,287,313	*-3.35*	1,371,996	*3.01*	1,350,940	*1.43*	1,358,401	*1.99*
97Q4	**1,256,955**	918,457	*-26.93*	1,259,895	*0.23*	1,182,242	*-5.94*	1,286,659	*2.36*	1,289,836	*2.62*	1,293,742	*2.93*
Correlation between actual and estimated values													
• **Levels**		**0.551**		**1.000**		**0.992**		**0.998**		**0.999**		**0.999**	
• **First differences**		**0.003**		**1.000**		**0.966**		**0.956**		**0.988**		**0.981**	

(*) Unadjusted and adjusted estimators are those shown in Table 2, columns (a) and (c), respectively. – (**) Difference between estimated and actual values, as a ratio to actual values – **(1)** Procedure applied to each security and results aggregated across securities. – **(2)** Procedure applied to total stocks and flows, using aggregate price and exchange rate indices calculated as weighted geometric means of the relevant variables. – **(A)** Fixed weights, based on year-end values – **(B)** Variable weights based on end-of-quarter values – **(C)** Variable weights based on 2-quarter moving averages – **(D)** Variable weights based on values obtained through linear interpolation on year-end values

Table 6. Validation of quarterly data on flows: actual and estimated values

(US dollars)

Periods	Actual values	Unadjusted estimators	Adjusted estimators				
			Security-by-security approach (1)	Aggregate approach (2)			
				Fixed weights	Variable weights		
				(A)	(B)	(C)	(D)
94Q1	**10,151**	5,116	7,524	16628	-4965	5824	11520
94Q2	**8,543**	-9,190	6,590	15592	-4577	-7353	2628
94Q3	**6,466**	50,618	3,544	-5249	11018	1455	-8417
94Q4	**4,095**	-24,563	551	13084	-8864	1996	-13764
95Q1	**-820**	-1,027	-3,446	-59089	-10652	-13401	605
95Q2	**1,221**	49,106	-1,164	2457	-2341	-6827	-3103
95Q3	**-3,355**	18,948	-5,015	-1285	-6510	-6265	-9057
95Q4	**-286**	17,386	-2,314	-2711	908	-2440	-8052
96Q1	**1,233**	33,239	-425	-6878	-100	1408	694
96Q2	**2,186**	37,075	1,111	4722	1255	2154	-1975
96Q3	**663**	14,583	-594	2880	-10090	-6002	-8531
96Q4	**-3,175**	47,349	-4,614	9235	-19021	-14769	-18092
97Q1	**9,387**	66,346	7,444	-47645	1155	-4267	2596
97Q2	**-3,057**	107,821	-5,546	-1449	-9279	-11294	-16356
97Q3	**-3,558**	27,139	-7,305	14589	-42744	-22237	-29441
97Q4	**-3,240**	-74,991	-6,561	27792	-33341	-36723	-40519
Total estimation bias (3)		**85.158**	**0.243**	**9.4096**	**6.330**	**8.555**	**22.036**
Correlation between actual and estimated values							
• **Levels**		**0.551**	**0.986**	**-0.168**	**0.579**	**0.619**	**0.694**
• **First differences**		**0.003**	**0.992**	**0.202**	**0.499**	**0.516**	**0.645**

(1) Equation (6) is applied to each security and results are aggregated across securities. – **(2)** Equation (6) is applied to total stocks and flows, using aggregate price and exchange rate indices calculated as weighted geometric means of the relevant variables. – **(3)** Estimation bias is measured as $\sum_{t=94Q1}^{97Q4}\left(\hat{F}_t - F_t\right)^2 / \sum_{t=94Q1}^{97Q4} F_t^2$. (Lower values indicate greater accuracy.) – **(A)** Based on year-end values – **(B)** Based on end-of-quarter values – **(C)** Based on 2-quarter moving averages – **(D)** Based on values obtained through linear interpolation on year-end values

Table 7: Estimation bias for flows and intra-period dispersion of prices and transactions

(Percentages) (1)

Dispersion of transactions around their mean (parameter β)	Dispersion of prices (in US dollars) around their period-end values (parameter α)																				
	0.00	**0.05**	**0.10**	**0.15**	**0.20**	**0.25**	**0.30**	**0.35**	**0.40**	**0.45**	**0.50**	**0.55**	**0.60**	**0.65**	**0.70**	**0.75**	**0.80**	**0.85**	**0.90**	**0.95**	**1.00**
0.00	24.30	22.47	20.22	18.08	16.05	14.14	12.34	10.66	9.09	7.65	6.33	5.13	4.05	3.10	2.28	1.58	1.01	0.57	0.25	0.06	0.00
0.05	22.73	20.64	18.50	16.53	14.67	12.95	11.26	9.72	8.29	6.98	5.76	4.66	3.68	2.82	2.07	1.43	0.92	0.52	0.23	0.06	0.00
0.10	20.68	18.70	16.88	15.02	13.32	11.72	10.56	8.81	7.51	6.31	5.67	4.21	3.33	2.54	2.28	1.29	0.83	0.46	0.41	0.05	0.00
0.15	18.69	16.88	15.12	13.55	12.01	10.56	9.45	7.93	6.76	5.67	5.07	3.79	2.99	2.28	2.03	1.16	0.74	0.41	0.37	0.05	0.00
0.20	16.73	15.12	15.12	12.13	10.75	9.45	9.45	7.09	6.04	5.07	5.07	3.38	2.66	2.03	2.03	1.03	0.66	0.37	0.37	0.04	0.00
0.25	14.85	13.74	12.06	10.76	9.54	8.56	7.30	6.29	5.35	4.58	3.70	2.99	2.35	1.83	1.31	0.91	0.58	0.33	0.14	0.04	0.00
0.30	13.05	11.80	10.25	9.46	8.38	7.36	6.40	5.52	4.70	3.94	3.42	2.62	2.06	1.57	1.36	0.80	0.51	0.28	0.24	0.03	0.00
0.35	11.35	10.25	8.79	8.22	7.28	6.40	5.49	4.80	4.08	3.42	2.93	2.27	1.79	1.36	1.17	0.69	0.44	0.24	0.21	0.03	0.00
0.40	9.72	8.79	8.79	7.05	6.25	5.49	5.49	4.12	3.50	2.93	2.93	1.95	1.53	1.17	1.17	0.59	0.37	0.21	0.21	0.02	0.00
0.45	8.21	7.89	6.68	5.96	5.29	4.92	4.04	3.48	2.96	2.62	2.04	1.65	1.30	1.04	0.72	0.50	0.32	0.19	0.08	0.02	0.00
0.50	6.81	6.16	5.01	4.95	4.39	3.86	3.14	2.89	2.46	2.06	1.68	1.37	1.08	0.82	0.67	0.41	0.26	0.15	0.12	0.02	0.00
0.55	5.54	5.01	3.96	4.03	3.57	3.14	2.49	2.36	2.00	1.68	1.33	1.12	0.88	0.67	0.53	0.34	0.21	0.12	0.09	0.01	0.00
0.60	4.37	3.96	3.96	3.19	2.84	2.49	2.49	1.87	1.59	1.33	1.33	0.89	0.70	0.53	0.53	0.27	0.17	0.09	0.09	0.01	0.00
0.65	3.34	3.58	2.74	2.45	2.18	2.25	1.67	1.44	1.22	1.20	0.85	0.68	0.54	0.47	0.30	0.20	0.13	0.08	0.03	0.01	0.00
0.70	2.45	2.23	1.54	1.80	1.60	1.41	0.98	1.06	0.90	0.76	0.53	0.50	0.39	0.30	0.21	0.15	0.10	0.05	0.04	0.01	0.00
0.75	1.70	1.54	0.98	1.25	1.11	0.98	0.63	0.74	0.63	0.53	0.34	0.35	0.28	0.21	0.13	0.10	0.07	0.04	0.02	0.00	0.00
0.80	1.08	0.98	0.98	0.80	0.71	0.63	0.63	0.47	0.40	0.34	0.34	0.23	0.18	0.13	0.13	0.07	0.04	0.02	0.02	0.00	0.00
0.85	0.60	1.10	0.50	0.45	0.40	0.70	0.31	0.27	0.23	0.38	0.16	0.13	0.10	0.15	0.06	0.04	0.02	0.03	0.01	0.00	0.00
0.90	0.27	0.24	0.06	0.20	0.18	0.16	0.04	0.12	0.10	0.09	0.02	0.06	0.04	0.03	0.01	0.02	0.01	0.01	0.00	0.00	0.00
0.95	0.07	0.06	0.00	0.05	0.04	0.04	0.00	0.03	0.03	0.02	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

(1) Estimation bias is measured as $\sum_{t=94Q1}^{97Q4}\left(\hat{F}_t - F_t\right)^2 / \sum_{t=94Q1}^{97Q4} F_t^2$. (Lower values indicate greater estimation accuracy.) Flows have been estimated on a security-by-security basis. The dispersion of prices and transactions is expressed by an index varying between zero and one. When the index is equal to zero, price and quantity variables coincide with those used in **Tables 3** and **4**. Dispersion gets lower when the index increases, and is zero when the index is equal to unity.

Table 8: Stock estimates based on cumulated flows and end-1993 holdings and intra-period dispersion of prices and transactions

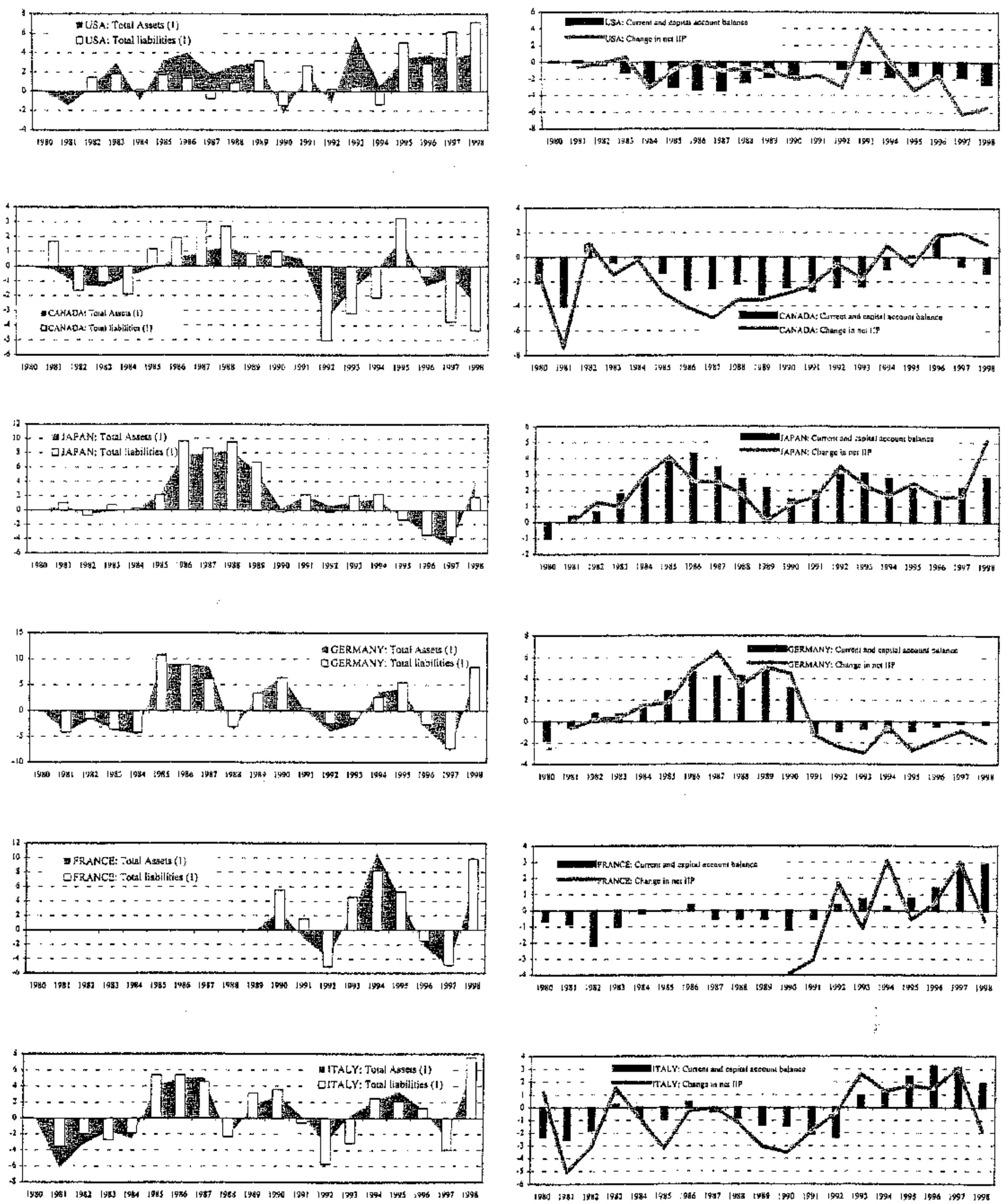
(Percentage deviations from actual values)

Dispersion of transactions around their mean	years	Dispersion of prices around their period-end values														
		α=0.00			α=0.25			α=0.50			α=0.75			α=1.00		
		(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
β=0.00	1994	0.80	-1.18	1.13	0.80	-1.16	0.85	0.69	-0.67	0.59	0.64	-0.60	0.30	0.61	-0.63	–
	1995	-8.05	-1.40	1.92	-8.10	-1.44	1.44	-3.95	-0.49	1.04	-1.73	-0.46	0.54	0.62	-0.64	–
	1996	-18.73	-2.35	2.43	-18.75	-2.37	1.83	-10.12	-0.59	1.32	-5.06	-0.40	0.69	0.63	-0.66	–
	1997	-26.93	-11.58	3.07	-26.87	-11.53	2.30	-16.46	-4.50	1.83	-9.06	-2.14	1.02	0.66	-0.69	–
β=0.25	1994	0.68	-1.29	0.84	0.65	-0.95	0.64	0.62	-0.73	0.44	0.61	-0.63	0.22	0.60	-0.63	–
	1995	-8.23	-1.62	1.41	-6.18	-0.92	1.10	-4.03	-0.58	0.76	-1.78	-0.50	0.39	0.60	-0.63	–
	1996	-17.05	-0.45	1.82	-13.20	0.34	1.41	-9.01	0.55	0.97	-4.42	0.23	0.50	0.60	-0.63	–
	1997	-25.82	-10.47	2.27	-21.14	-6.60	1.83	-15.45	-3.66	1.32	-8.37	-1.61	0.72	0.61	-0.64	–
β=0.50	1994	0.56	-1.41	0.56	0.56	-1.04	0.43	0.56	-0.79	0.29	0.57	-0.65	0.15	0.60	-0.62	–
	1995	-8.41	-1.82	0.93	-6.31	-1.06	0.72	-4.12	-0.67	0.50	-1.82	-0.53	0.26	0.59	-0.61	–
	1996	-15.38	1.43	1.21	-11.78	1.86	0.93	-7.94	1.63	0.63	-3.83	0.81	0.32	0.58	-0.60	–
	1997	-24.74	-9.40	1.49	-20.08	-5.62	1.19	-14.51	-2.87	0.85	-7.76	-1.13	0.46	0.58	-0.60	–
β=0.75	1994	0.45	-1.52	0.28	0.47	-1.13	0.21	0.50	-0.85	0.14	0.54	-0.68	0.07	0.59	-0.61	–
	1995	-8.58	-2.02	0.45	-6.43	-1.20	0.35	-4.19	-0.75	0.24	-1.86	-0.56	0.13	0.57	-0.60	–
	1996	-13.73	3.30	0.60	-10.40	3.34	0.46	-6.92	2.67	0.31	-3.27	1.36	0.16	0.55	-0.58	–
	1997	-23.69	-8.35	0.74	-19.06	-4.69	0.58	-13.64	-2.14	0.41	-7.20	-0.69	0.22	0.54	-0.56	–
β=1.00	1994	0.33	-1.63	–	0.38	-1.21	–	0.44	-0.91	–	0.51	-0.71	–	0.59	-0.61	–
	1995	-8.74	-2.22	–	-6.54	-1.34	–	-4.27	-0.83	–	-1.90	-0.60	–	0.56	-0.58	–
	1996	-12.08	5.16	–	-9.05	4.79	–	-5.94	3.67	–	-2.74	1.88	–	0.53	-0.55	–
	1997	-22.66	-7.33	–	-18.09	-3.80	–	-12.82	-1.46	–	-6.69	-0.29	–	0.51	-0.53	–

(1) Unadjusted estimates
(2) Adjusted estimates, aggregate basis
(3) Adjusted estimates, security-by-security basis

Chart 1. Stocks, total reconciliation adjustments, and current account balances

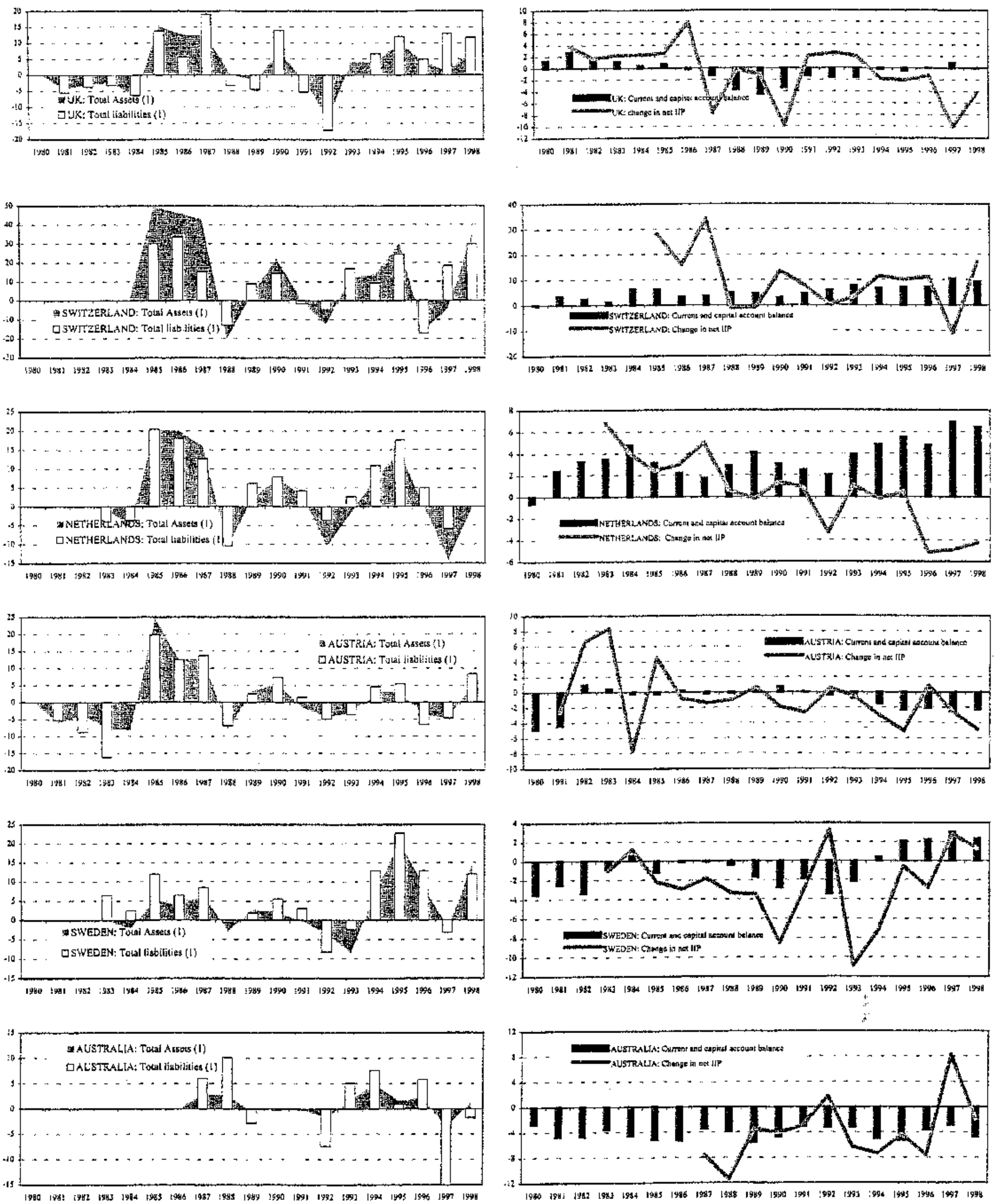
(percentage ratios to GDP)



(1) Changes in stocks minus balance of payments flows; all variables are expressed in US dollars.

Source : IMF International Financial Statistics Yearbook

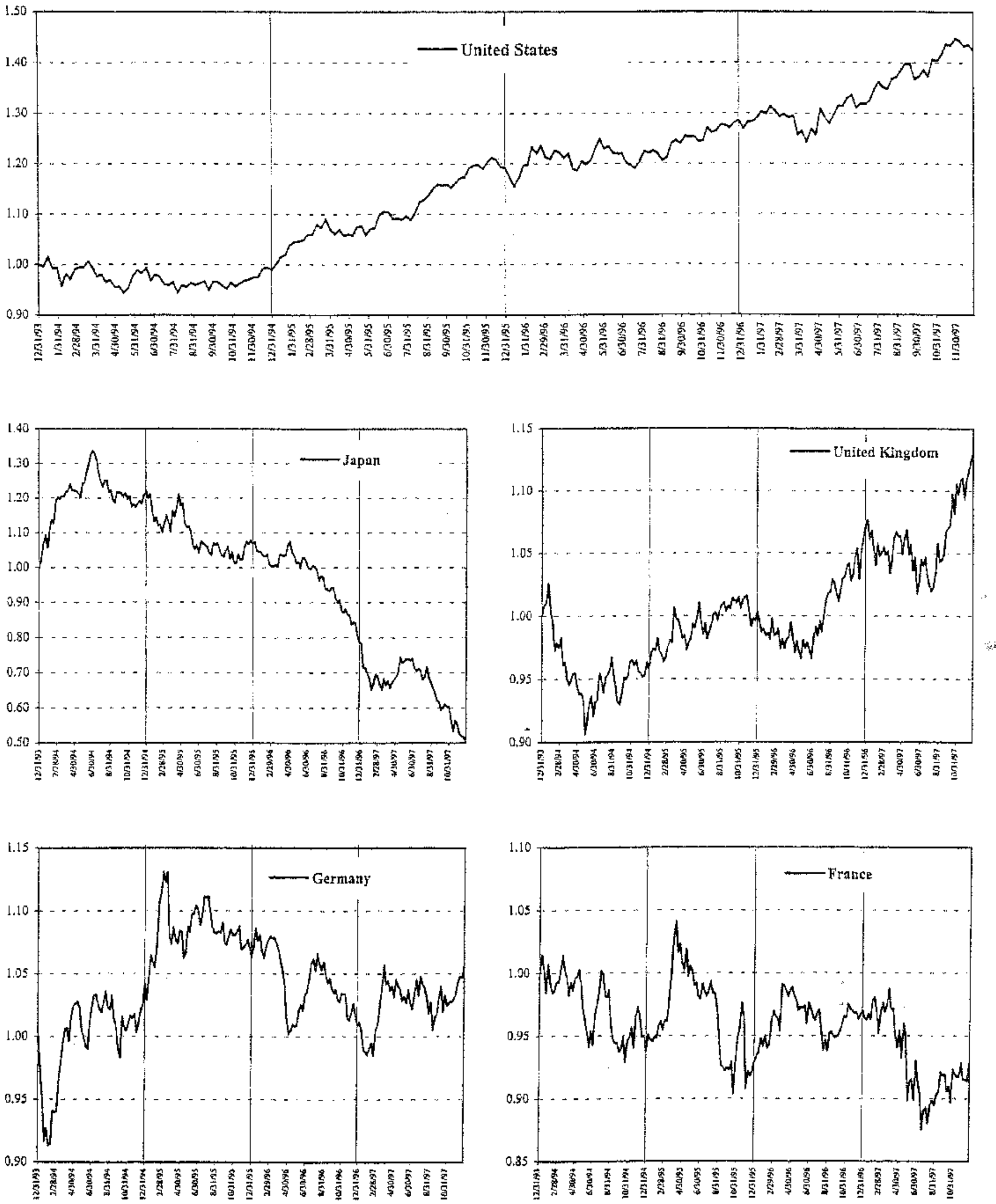
Chart 1. (continued)



(1) Changes in stocks minus balance of payments flows; all variables are expressed in US dollars.

Source : IMF International Financial Statistics Yearbook

Chart 2. End-of week holdings of domestic and foreign securities (*)
(indices, 12/31/1993 = 1)



(*) Number of shares held in portfolio, as determined by investment rule (15).

Chart 2. (Continued)

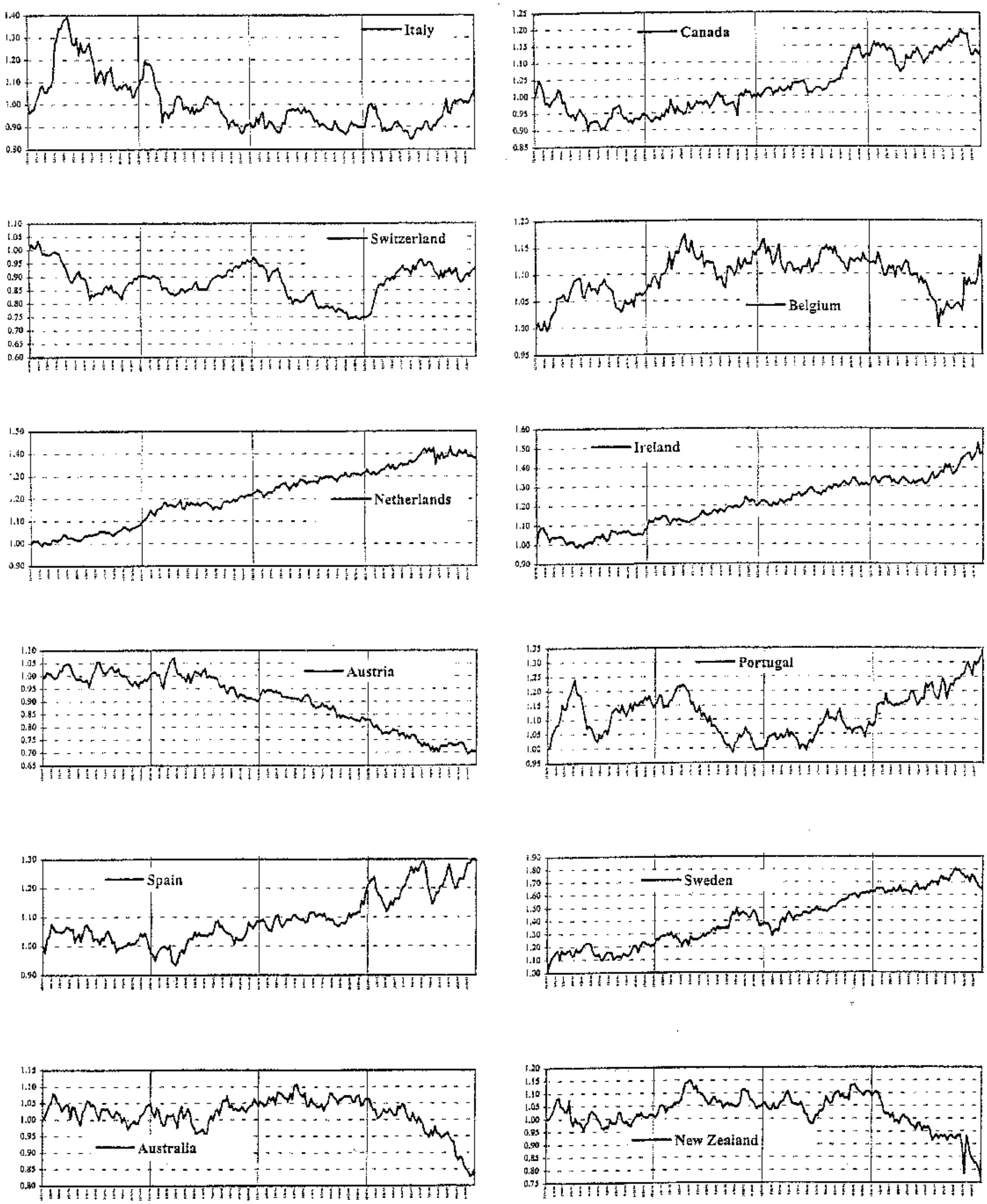


Chart 2. (Concluded)

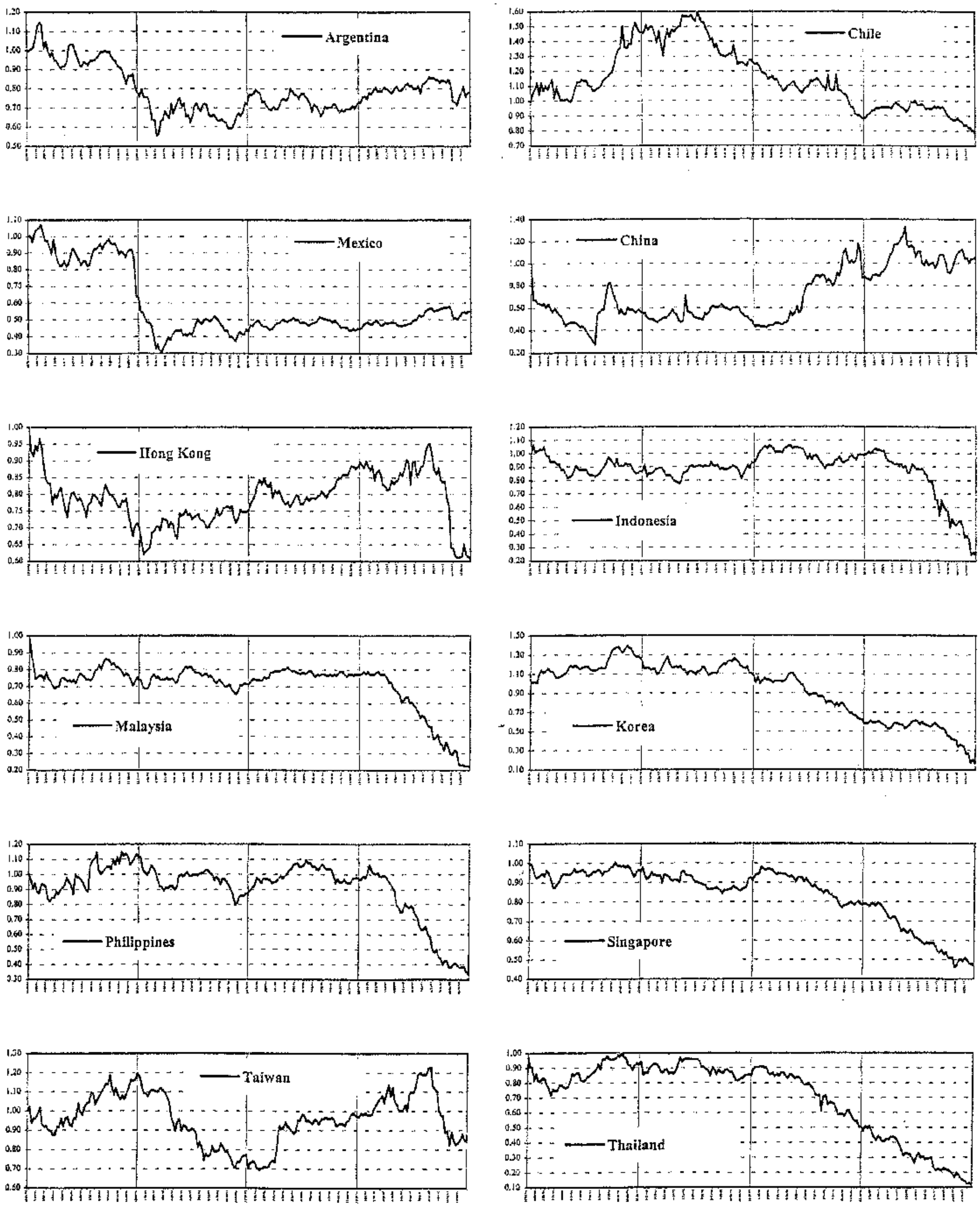
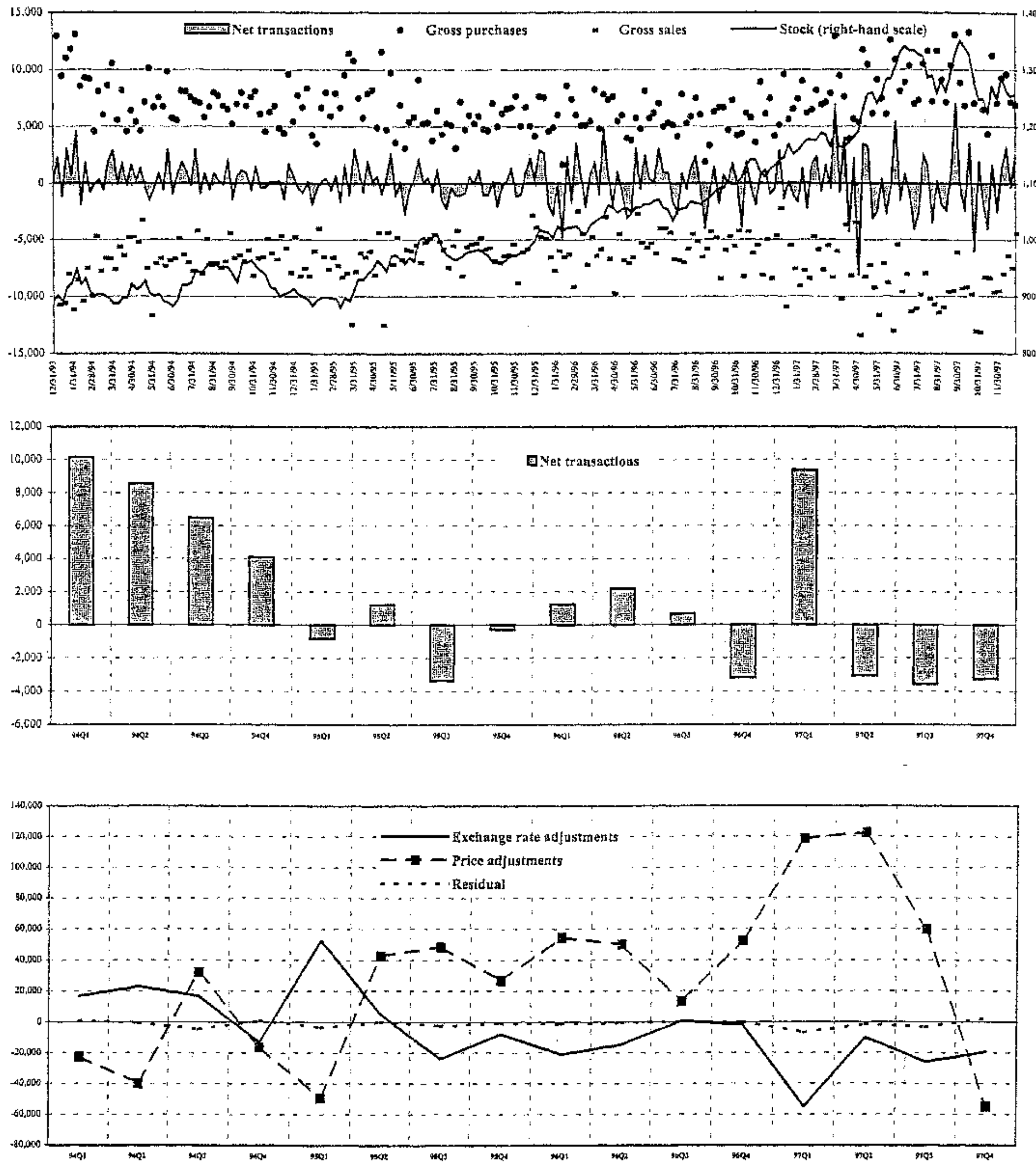


Chart 3. Actual stocks, flows, and adjustments

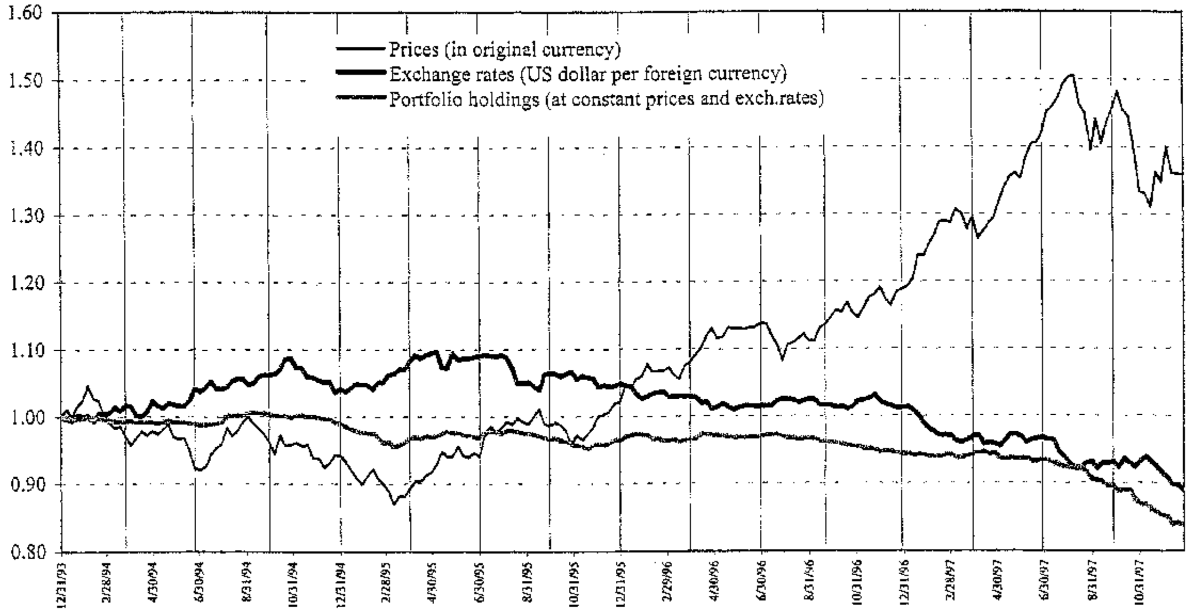
(in US dollars)



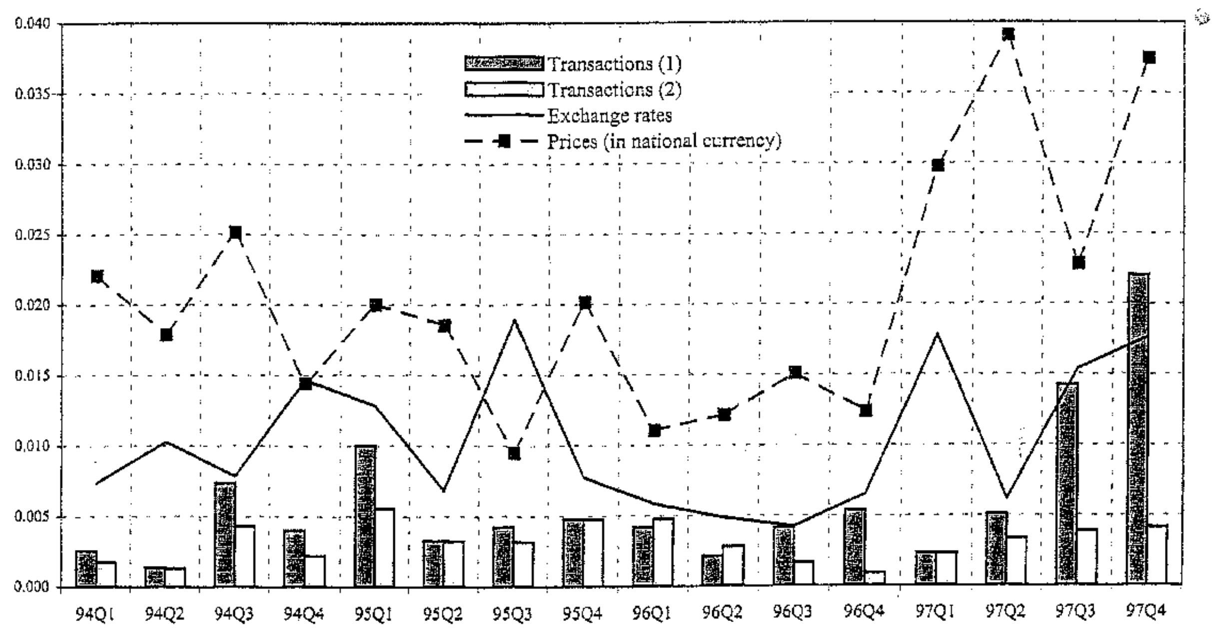
Source : based on Datastream and UIC data on stock exchange market indices and foreign exchange rates, plus investment rule (15).

Chart 4: Volatility of prices, exchange rates, and transactions

Weekly indices (a)



Quarterly volatility (b)



(a) Weighted geometric means of the relevant variables, based on end-1993 values.

(b) For prices and exchange rates, quarterly volatility is measured by the standard deviation of logarithmic differences between intra-period and period-end values of the relevant variable. For transactions, volatility is measured (1) in the same fashion as for prices and exchange rates and (2) by the standard deviation of logarithmic differences between intra-period holdings (at constant prices and exchange rates) and intra-period values obtained through linear interpolation of period-end holdings.

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