NOTE 8. MEASURES OF VARIABILITY IN COUNTRIES' EXTERNAL TRANSACTIONS

79. This note describes the existing and alternative measures of variability of a country's external transactions for use in the quota formulas.

A. Original and Existing Measure of Variability

80. The definition of variability in the original Bretton Woods formula was the difference between the highest and the lowest yearly exports in a five-year period (1934–38). Because this concept also reflected the trend of exports, variability was redefined in 1963 to measure deviations from some normal or trend level. This new measure was also used to calculate shortfalls stemming from export fluctuations in connection with the IMF's Compensatory Financing Facility (CFF) established at the time.[40]

81. The export shortfall in the CFF was measured as the difference between the value of exports in the shortfall year and its medium-term trend value, where trend was defined as the five-year arithmetic average centered on the shortfall year (using projected values for the two future years).[41] In the quota formulas, the same arithmetic five-year average is used for trend, and variability is measured as one standard deviation from this five-year moving average drawn from a 13-year sample period.

B. Alternative Methods of Measuring Variability of a Time Series

82. The existing measure of variability in the quota formulas gives distorted results in the event of discrete and large changes which do not represent fluctuations around trend, such as occurred when oil prices rose sharply in the 1970s and 1980s. Such discontinuities, as well as extreme observations, tend to be magnified by the standard deviation measure based on a slow-moving average. Because of these criticisms, alternative methods of measuring variability were discussed extensively in 1981 (see Box 8.1).

---

[40] The CFF provides financing to members experiencing balance of payments difficulties arising from export shortfalls, insofar as they were temporary and largely attributable to circumstances beyond the member's control. The facility was intended to be of special benefit to primary exporting countries. It was later broadened to cover import *excesses* for food and oil. In 1988 it was renamed the Contingent and Compensatory Financing Facility (CCFF), when the facility was broadened to cover *future* shortfalls (the contingency element). In 2000, the contingency element was discontinued and the facility reverted to the CFF.

[41] In 1979, the trend was redefined as the five-year geometric average centered on the shortfall year.

83. Some of the alternative methods reduced the effect of discontinuities in the time series, but they also tended to produce lower variability figures compared with the existing method. For example, using a faster three-year moving average results in lower measured variability because the relative weight of the central observation is higher. In the case of the mean absolute deviation method, variability is also reduced because this method gives lesser weight to extreme deviations. Further alternative methods of measuring variability were based on the CFF shortfall method, and were found to be very sensitive to the manner in which the "post-shortfall" or extrapolated components of the moving average were calculated. None of the alternative methods considered received sufficient support from the IMF Executive Board, and it was agreed that any shortcomings of the variability measure could be considered in the context of reducing the coefficient of variability in the quota formulas.

84. A further variant on the present method of measuring variability is to calculate trend using a regression equation over the entire sample period.[42] The calculated standard deviation from trend would be greater than under the existing measure of variability, mainly because deviations would no longer be computed relative to a (five-year) trend in which an observation has a greater weight than in the trend regression (which is computed around the mean of the entire sample).

C. Other Economic Indicators of External Vulnerability

85. Other economic indicators of external vulnerability may also be considered. These can be grouped into four sources of vulnerability : (a) variability of other elements in the current account; (b) exchange rate variability; (c) income terms of trade; and (d) variability of current receipts and net long-term capital flows.

Other elements in the current account

86. A country's payments position is also vulnerable to shocks other than those affecting exports of goods and services. For example, external vulnerability based on food or energy import costs can be measured along the same lines as the current variability measure.[43] Alternatively, the relative share of such goods in a country's total imports could be a basis for a vulnerability indicator.[44]

---

[42] The explanatory variable in the equation includes time and also possibly the lagged dependent variable. See, for example, Teizo Taya, "Measurement of Export Instability," September 1980 (IMF, unpublished).

[43] Later amendments of the CFF permitted the IMF to extend financing because of unexpected shifts in food and energy imports, import prices, and interest rates.

[44] Data for such a measure are available from the WTO and UN for some 84 reporting countries, though with a lag of 2–3 years.

87. Another source of external vulnerability is debt service payments, which, particularly for floating-interest-rate debt, fluctuate because of changes in interest and exchange rates. In the CCFF, unexpected increases in net interest costs were measured using benchmark international interest rates (such as LIBOR). However, the unexpected deviations in interest costs stemming from changes in the risk premium and unanticipated external borrowing were not covered.[45] Variability of interest costs was measured net of interest earnings on foreign assets. The definition of variability of net interest costs could follow the deviation from trend approach, or alternatively, the variability of the benchmark international interest rate could be used, weighted by the size of a country's net indebtedness.

Exchange rate volatility

88. Exchange rate volatility has been defined in the economic literature in various ways. One approach is to define exchange rate volatility as the error in a model that determines the exchange rate. Measures of exchange rate volatility have also been devised without relying on exchange rate models. Examples include the absolute percentage change of the exchange rate; the average absolute difference between the previous forward rate and the current spot rate; the variance of the spot rate around its trend; a moving average of the standard deviation of the exchange rate; and the standard deviation of the percentage changes around the mean observed during a subperiod.[46]

89. The introduction of exchange rate variability in the quota formulas was previously explored by IMF staff in 1994. Exchange rate volatility was measured as the standard deviation of a nation's real effective exchange rate from a normal level, represented by a five-year moving average, over a 13-year period. The measure was scaled in order to avoid distorted results for countries of very different size that have the same degree of exchange rate variability.[47]

90. The particular measurement explored by IMF staff was similar to the measurement method for variability of current receipts. Effective exchange rates were used instead of bilateral rates in order to capture the average effect of exchange rates using trade shares as weights. The index was measured in real terms in order to avoid the influence of domestic inflation that might be captured in the movement of the nominal exchange rate (but not the

---

[45] Unanticipated changes in debt servicing costs due to exchange rate changes were also not covered.

[46] Michael D. McKenzie, "The Impact of Exchange Rate Volatility on International Trade Flows," *Journal of Economic Surveys,* Vol. 13, No. 1 (February 1999), pp. 71–106).

[47] An index, $1+V/A$, was first calculated where V is the real effective exchange rate variability, and A the average level of the real effective exchange rate over the sample period. Exchange rate variability was then defined as the index times current receipts.

real exchange rate). Using the real rate would, however, disregard the possible channels of disruption that run from changes in the nominal exchange rate to changes in indebtedness and debt servicing burden.

Income terms of trade

91. The present measure of variability based on current receipts could be broadened so that it also takes account of variations in import prices. Such external vulnerability could be captured by the instability in the income terms of trade, which is measured as nominal export earnings deflated by an import-price index. The income terms of trade measures the purchasing power of exports on foreign markets.[48] A deterioration in the income terms of trade indicates that the country would face difficulties maintaining its volume of imports. The income terms of trade differ from the commodity terms of trade (the ratio of export to import prices) in that the volume of exports is also taken into account in the former but not the latter. When export prices fall relative to import prices, the immediate effect is a worsening in the balance between export earnings and import payments. However, such a decline in export prices may be accompanied by an increase in the volume of exports, which may be rising secularly. Under these circumstances, a deterioration in the terms of trade would not necessarily be accompanied by a worsening balance between current receipts and payments. Thus, the combination of a terms of trade effect and a change in the volume of exports is measured by the income terms of trade.

92. A number of measurement issues arise in connection with data on the income terms of trade. First, income terms of trade are generally defined for merchandise trade only. The extent to which reliable and timely price data for imports of services are available for all countries would need to be explored if the concept is used to include services. Second, the income terms of trade are expressed as an index, and the deflator data should be on a common base period for all countries.

Variability of current receipts and net long-term capital flows

93. The existing variability measure based on current receipts could be expanded to cover also net long-term capital flows. This augmented indicator of vulnerability could also reflect changes in capital flows that are generally considered to be beyond the country's control.[49]

---

[48] See Teame Ghirmay, Subhash C. Sharma, and Richard Grabowski, "Export Instability, Income Terms of Trade Instability and Growth: Causal Analyses," *The Journal of International Trade and Economic Development* 8 (June 1999), pp. 209–29. Long-term developments in the income terms of trade of developing countries have been studied in, e.g., Enzo R. Grilli and Maw Cheng Yang, "Primary Commodity Prices, Manufactured Goods Prices, and the Terms of Trade of Developing Countries: What the Long Run Shows," *The World Bank Economic Review* 2 (January 1988), pp. 1–48.

[49] This measure of variability can be compared with the existing measure of variability. From the Balance of Payments identity

(continued...)

The greater part of a country's short-term capital flows is assumed to depend on domestic policies, mainly on interest rate changes, and hence subject to control by the country's authorities.[50]

94. The compilation of data on long-term capital flows is, however, not straightforward. The IMF's Balance of Payments (BOP) Manual (fifth edition) does not accord major importance to maturity distinction as a classification criterion and not all categories in the capital and financial account are reported by maturity. Therefore, for the purpose of making quota calculations, a practical convention for defining long-term capital flows is needed.

95. The BOP Manual also retains the traditional distinction between long- and short-term investment , which is based on the formal criterion of original contractual maturity, only for assets and liabilities in the category of "other investment" in the capital and financial accounts. Long-term investment is defined as investment with an original contractual maturity of more than one year or with no stated maturity (e.g., equity securities). Short-term investment, which includes currency, is investment payable on demand or with an original contractual maturity of one year or less. In the categories of "direct investment," "portfolio investment" or "reserve assets," long- and short-term investments are not formally distinguished.

$$C - P + NCF = \Delta R$$

where C is current receipts, P is current payments, NCF is net capital flows, and ΔR is the change in reserves. If NCF is decomposed in net short-term capital flows, NCF_S, and net long-term capital flows, NCF_L, the identity can be rewritten as

$$C - P + (NCF_S + NCF_L) = \Delta R$$

or

$$C + NCF_L = P - NCF_S + \Delta R$$

The variability of the left-hand side is likely to be greater than the variability of C alone that is used under the existing five-formula system. The variability of $(C + NCF_L)$ is defined as $VC + VNCF_L - 2\ Cov(C, NCF_L)$, where VC and $VNCF_L$ represent variability of current receipts and variability of net long-term capital flows, respectively.

[50] A small part of short-term capital flows (i.e., autonomous component) may be attributed to factors outside the realm of domestic government policy, such as inertia (including herd behavior) and normal interbank flows. The extent of this autonomous component should be empirically testable.

96. For quota calculation purposes, long-term capital flows may be defined to include:[51] (i) direct investment; (ii) from portfolio investments, the total of "equity securities" but only "bonds and notes" from "debt securities" (i.e., we exclude "money market instruments" and "financial derivatives"); (iii) from "other investment," where the distinction between short- and long-term investments is made, the short-term component of "trade credits" and "loans," and the total of "currency and deposits" and "other assets". (The items, "net error and omissions" and "reserves and related items," are not included in long-term capital flows.)

[51] Using the categories defined in the IMF's BOP Manual, it should be noted that the distinction between short- and long-term direct investment flows becomes increasingly difficult because it depends on arbitrary enterprise decisions on intercompany flows. It is also widely recognized that innovations in the financial markets (e.g., floating rate notes, rollovers, etc.) have diminished the usefulness of the traditional maturity distinction between long- and short-term investments. For example, a creditor and a debtor could have different views as to whether a particular instrument represents access to medium-term financing even though it is nominally a short-term instrument. Also, in many instances, original maturity may have no bearing on the length of time that an instrument will be held.

Box 8.1. Existing and Alternative Measures of Variability of a Time Series

1. The existing measure of variability of a time series Z_t is as follows:

VO: Standard deviation from a five-year moving average. Mathematically, variability is

$$V = \left[\frac{1}{N-4} \sum_{t=3}^{N-2} \left(Z_t - \overline{Z_t} \right)^2 \right]^{1/2} \qquad (1)$$

where $\overline{Z_t} = \frac{1}{5} \sum_{i=t-2}^{t+2} Z_i$ and N is the number of observations.

2. The following alternative definitions of variability were considered by the IMF staff in 1981:

VS: Standard deviation from a three-year moving average. This is the same as the present definition except that the averaging period is shortened from five years to three years.

V1: Mean absolute deviation from a five-year centered moving average.

V2: Shortfall from a centered moving average. Under this procedure, only negative deviations are considered, and the average of their absolute values is taken as the measure of variability.

V3: Shortfall from a moving average set at the fifth year. This is the same as V2, except that the five-year moving average is not centered.

V4: Shortfall from a centered geometric moving average used in the Compensatory Financing Facility (CFF) formula, except that judgmental forecasts are substituted by extrapolations. The extrapolation makes use of the growth rate of the past three years over the preceding three years.

V5: The smaller of the shortfall between the one calculated under V4 above and the negative discrepancy between current receipts for the year in question and the average for the preceding two years.

V6: Shortfall from a moving average determined by an in-sample extrapolation formula. Under this procedure, the moving average is calculated in a similar manner as in V4, except that extrapolations for the fourth and fifth years are made by applying the average compound growth rate covering the whole length of the preceding years rather than two to three years immediately preceding the centered year.

Box 8.1 (continued). Existing and Alternative Measures of Variability of a Time Series

Mathematically, these alternative definitions can be formalized as follows: the variability V of a time series Z_t is defined under alternative VS as the standard deviation of the time series from the three-year moving average, i.e.,

$$V = \left[\frac{1}{N-2} \sum_{t=2}^{N-1} \left(Z_t - \overline{Z_t} \right)^2 \right]^{1/2} \qquad (2)$$

where $\overline{Z_t} = \frac{1}{3} \sum_{i=t-1}^{t+1} Z_i$ and N is the number of observations.

Under V1,

$$V = \frac{1}{N-4} \sum_{t=3}^{N-2} \left| Z_t - \overline{Z_t} \right| \qquad (3)$$

where $\overline{Z_t} = \frac{1}{5} \sum_{i=t-2}^{t+2} Z_i$. For alternatives V2, V3, V4, and V6, variability is defined as:

$$V = \frac{1}{T} \sum_{t} SF_t \qquad (4)$$

where $SF_t = \left| Z_t - \overline{Z_t} \right|$ if $Z_t < \overline{Z_t}$ and $SF_t = 0$ otherwise, T is the number of years for which there are shortfalls, and $\overline{Z_t}$ is defined differently under each alternative.

Under V2, $\overline{Z_t}$ is defined as in (3) above.

Under V3, $\overline{Z_t} = \frac{1}{5} \sum_{i=t-4}^{t} Z_i$.

Under V4, $\overline{Z_t}$ is defined by defined by the CFF formula; i.e.,

$$\overline{Z_t} = \left(Z_{t-2} \cdot Z_{t-1} \cdot Z_t \cdot Z^*_{t+1} \cdot Z^*_{t+2} \right)^{1/5} \qquad (5)$$

where $Z^*_{t+1} \cdot Z^*_{t+2}$ is estimated based on the geometric average growth rate of the past three years over the preceding three years; i.e.,

$$\left(Z^*_{t+1} \cdot Z^*_{t+2} \right)^{1/2} = \frac{\left(Z_{t-2} \cdot Z_{t-1} \right)^{1/2} \left(Z_{t-2} \cdot Z_{t-1} \cdot Z_t \right)^{1/3}}{\left(Z_{t-5} \cdot Z_{t-4} \cdot Z_{t-3} \right)^{1/3}} \qquad (6)$$

Box 8.1. (concluded). Existing and Alternative Measures of Variability of a Time Series

Under V5, $\overline{Z_t}$ is defined as in (5) above and SF_t is defined as:

$$SF_t = \text{Min}\ (A_t, B_t) \tag{7a}$$

where

$$A_t = \begin{cases} \left| Z_t - \overline{Z_t} \right|, \text{if } Z_t < \overline{Z_t} \\ 0, \text{if } Z_t \geq \overline{Z_t} \end{cases} \tag{7b}$$

and

$$B_t = \begin{cases} \left| Z_t - \frac{1}{2}(Z_{t-2} + Z_{t-1}) \right|, \text{if } Z_t < \frac{1}{2}(Z_{t-2} + Z_{t-1}) \\ 0, \text{if } Z_t \geq \frac{1}{2}(Z_{t-2} + Z_{t-1}) \end{cases} \tag{7c}$$

Under V6, $\overline{Z_t}$ is defined as in (5) above except that

$$Z^*_{t+1} = \frac{1}{3}.(Z_{t-2} + Z_{t-1} + Z_t).(1+\alpha_{t-1})^2 \tag{8a}$$

$$Z^*_{t+2} = Z^*_{t+1}.\ (1+\alpha_{t-1}) \tag{8b}$$

where α_{t-1} is the average compound growth rate from the first year of the sample to year t-1.