WP/02/230

IMF Working Paper

Compiling and Using Export and Import Price Indices

Jemma Dridi and Kimberly Zieschang

INTERNATIONAL MONETARY FUND

© 2002 International Monetary Fund

WP/02/230

IMF Working Paper

Middle Eastern Department and Statistics Department

Compiling and Using Export and Import Price Indices[1]

Prepared by Jemma Dridi and Kimberly Zieschang

Authorized for distribution by Adriaan M. Bloem and Edward Gardner

December 2002

Abstract

The views expressed in this Working Paper are those of the author(s) and do not necessarily represent those of the IMF or IMF policy. Working Papers describe research in progress by the author(s) and are published to elicit comments and to further debate.

Export and import price indices are essential for assessing the impact of international trade on the domestic economy. Among their most important uses are analyzing developments in the trade balance, measuring foreign prices' contribution to domestic inflation and deflating nominal values of exports and imports for estimating the volume of gross domestic product. This paper discusses the main uses of trade indices and the data sources used to compile them. It also presents various approaches used to compile foreign trade price indices, addresses various problems encountered in developing these indices, and provides some recommendations on how to address them.

JEL Classification Numbers: C81, C82, F10

Keywords: Price index, international trade, economic statistics

Authors' E-Mail Address: jdridi@imf.org; kzieschang@imf.org

---

[1] We are grateful to Adriaan M. Bloem, Paul Armknecht, and Manik Shrestha for their valuable comments on earlier drafts of this paper. We would also like to thank Joël Toujas-Bernaté and Edward Gardner for their support, and Nathalie Baumer for her helpful editorial assistance at an earlier stage.

Contents Page

I. Introduction 4

II. Uses of Foreign Trade Indices 6
    A. Analyzing the Balance of Payments Current Account 6
    B. Making Economic Policy 6
    C. Analyzing Country Competitiveness 7
    D. Drawing up Trade Contracts 8
    E. Measuring Inflation, Forecasting Future Price Trends 8
    F. Analyzing Exchange Rates 8
    G. Compiling National Accounts 8

III. Index Numbers 9
    A. Index Number Theory 9
    B. Simple Formulas 12
    C. Superlative Formulas 15
    D. Fixed Base and Chained Indices 15

IV. Constructing Price Indices for Exports and Imports 17
    A. Export and Import Price Indices 17
        Transactions, elementary items, and unit values 18
        Price indices for elementary aggregates 20
        Price indices for upper aggregates 23
    B. The Terms of Trade 23

V. Data Sources 25
    A. The four modes of supply 25
        Goods and services and the modes of trade 26
        Exports and imports and the modes of trade 27
    B. Administrative Sources 29
        Index weights for elementary and upper aggregates 29
        Unit values for elementary items 34
    C. Survey sources 34
        Index weights for elementary and upper aggregates 34
        Unit values for elementary items 36

VI. Setting Up a System to Compile Foreign Trade Price Indices 38
    A. Determining the Elementary Aggregates and Their Weights 38
    B. Determining the Sample of Elementary Items 38
        Goods: Testing customs elementary aggregates for multiple elementary items 38
        Goods and services: Surveying international transactors to identify elementary items 44

VII. Compilation Issues 47
    A. General 47

Quality change 47
Unique and infrequently traded commodities 48
Seasonality and discontinuities 50
B. Unit Values as Elementary Aggregate Indices 50
Heterogeneous commodities and commodities lacking volume data 50
Size of shipment 52
Terms of transactions 53
C. Price Indices for Elementary Aggregates 53
Instability in the trader population 53
Shipment not made in the current period 54
Prices appear not to be transaction prices 54
Significant price variations within a commodity, between country of destination (or country of origin) 54

VIII. Data Dissemination and Revisions 54
A. Data Dissemination 54
B. Data Revisions 55

IX. Conclusions and Recommendations 56

References 58

Boxes Page

Box 1. The Test or Axiomatic Approach to Assessing Index Numbers 11
Box 2. Unit Values and Product Mix 43
Box 3. Using Price Surveys and Customs Unit Values in the Same "Hybrid" Index 46
Box 4. Effect of Quality Change 49
Box 5. Imputation of Missing Observations 51

Compilation and Use of Foreign Trade Price Indices

I. INTRODUCTION

1. Foreign trade price indices are important indicators for analyzing growth and inflation in an open economy. The price and volume factors comprising the relative changes in exports and imports are required for understanding developments in the goods and services component of the balance of payments current account. They are required for policy analysis and assessing the effects of exchange rate dynamics on the international competitiveness of a country's producers. They are used for escalating the terms of international contracts and forecasting changes in domestic inflation. They are used for exchange rate analysis and, bearing on all of the above uses, they are used in estimating GDP volume, the primary summary indicator of economic growth.

2. Traditionally, compilers have thought of export and import price indices in the context of the principal administrative source of data used to compile them: customs documents. With only a few exceptions around the world, foreign trade price indices equate the prices of goods exported or imported with the "unit values" of transactions for detailed customs classes of goods. Compilers of export and import price indices obtain the unit value for each detailed commodity class by dividing the aggregate monetary value of export or import transactions in the class by the aggregate quantity shipped. They then average the relative changes in these unit values across classes to construct export and import price indices. The commodity classes come from the Harmonized System of Commodity Classification and Coding (HS). National customs administrations collectively have developed the HS through the World Customs Organization (WCO) and it is used worldwide. The WCO maintains this classification for levying import tariffs and export taxes, but its detail makes it serviceable for statistical uses as well.

3. To measure price and volume change accurately, compilers should measure prices at the highest level of detail by the unit values of sufficiently detailed classes of transactions. We call these ultimate classes "elementary items." We identify an elementary item by a particular set of price-determining characteristics common to the goods and services transactions in that item. When the characteristics of goods are heterogeneous within a given detailed commodity class, there are multiple elementary items and thus multiple unit value prices within the class. Compilers should measure price change for such a commodity class as an index number of the multiple elementary item prices, not as the change in a single unit value for the class as a whole. Although widely used as a source of price information, customs documents do not contain enough detail to identify the elementary items needed to compile a price index for many customs classes of goods. Classes of complex goods such as automated machinery are examples of categories where customs detail falls short.

4. At the highest level of aggregation, a price index should adequately cover the full scope of the transactions domain of interest. The *System of National Accounts* and

Balance of Payments Manual, 5th Edition define this domain as all transactions in goods and services between the residents and nonresidents of a country.[2] Customs data typically cover only exported and imported goods (commodities or merchandise) and the freight and insurance services employed to ship imported goods. They do not cover other internationally traded services. Also, customs data often are limited to transactions that are subject to taxation (e.g., to import tariffs or export taxes) or some form of regulation (e.g., strategic restrictions on exports). They may exclude or at least not fully cover unregulated transactions (e.g., international transactions in free trade zones).

5. Thus, although customs data are readily available as a by product of tax and foreign policy administration, they have detail and scope limitations. Compilers need to collect supplemental statistical collections or surveys to address these limitations.

6. This paper considers first the main uses of trade indices in Section II. We then turn to various formulas that can be used for compiling foreign trade price indices in Section III. Section IV explains the main steps involved in constructing price indices for exports and imports. Section V describes the main data sources of foreign trade statistics. Section VI explains the various steps involved in designing a system for compiling foreign trade indices and highlights key elements to consider in this process. Section VII discusses the problems usually encountered in developing foreign trade price indices and offers some practical recommendations to overcome these problems. Section VIII discusses the dissemination and revision processes for export and import price indices. Section IX summarizes the main conclusions and recommendations of the paper.

7. We follow established international statistical standards throughout, referencing the following:

National accounts
    —*System of National Accounts 1993* (*1993 SNA*) (1993)
Balance of payments
    —*Balance of Payments Manual, Fifth edition* (*BPM5*) (1993)
    —*Balance of Payments Compilation Guide* (1995)
International trade in goods and services
    —*International Trade in Merchandise Trade Statistics: Concepts and Definitions* (1998)
    —*Manual on Statistics of International Trade in Services* (forthcoming 2002).

---

[2] The international standard for residency is that a unit have a center of economic interest there. (See *1993 SNA*, paragraph 1.28, *BPM5*, paragraph 22.) International guidance operationalizing the concept of center of economic interest in a country ("economic territory") is that a unit be physically located or established in a country for at least one year. The operational guidance is to be interpreted flexibly, however. See, for example, *Balance of Payments Compilation Guide*, paragraph 452, and *Manual on Statistics of International Trade in Services*, paragraph 3.7.

II. USES OF FOREIGN TRADE INDICES

8. Foreign trade price and volume indices have a variety of uses. They are employed in analyzing the balance of payments current account, making economic policy, analyzing competitiveness, concluding trade contracts, measuring and forecasting inflation, analyzing exchange rates, and compiling national accounts.

A. Analyzing the Balance of Payments Current Account

9. The relationship between the current account of the balance of payments and the prices of exports and imports is of central importance for policymakers and for economic theorists.[3] The balance of trade often is the dominant part of the current account balance. Analysts can use price and volume indicators for goods and services trade to decompose movements in the trade balance into price and volume components. The balance of trade often is analyzed in volume terms, and the volume indicators usually come from deflating exports and imports in current prices. Analysts calculate price and output elasticities from models setting export or import volume as a function of export or import prices and the volume of gross domestic product. Price elasticities measure how the quantity of traded responds to price changes as measured by the import and export price indices. Income elasticities measure how trade volume responds to changes in GDP volume.

B. Making Economic Policy

10. Foreign trade indices are critical for government economic policy because they support budget projections and forecasts of economic trends, and are essential in preparing for financial negotiations with multilateral lenders and undertaking market research.

11. Governments make regular budget projections to determine the amount of additional revenue needed to finance current spending and capital formation programs. As a significant component of government revenue, customs revenue is forecast based on past trends in the export and import values that make up the tax base. Forecasts of revenue can be made for individual product groups based on the principal duty rates. Government budget and public spending program forecasts are often part of a macroeconomic framework organizing projections of economic performance for various sectors (such as agriculture, industry, and services). This helps ensure that budget and public spending program forecasts are consistent with macroeconomic objectives.

12. The fiscal deficit is government revenues less government expenditures. Multilateral lenders extend finance on the condition that national authorities successfully meet macroeconomic targets, such as the ratio of the fiscal deficit to GDP. The deficit

---

[3] A consensus seems to emerge from various studies that the effect of external price shocks on the current account is ambiguous, especially in the case of imports. Temporary import price changes give raise to income and substitution effects that work in different directions while for temporary exports price changes, they reinforce.

thus is central in the negotiations between governments and foreign capital providers. These negotiations need accurate information on the sources of revenue and purposes of expenditure. Customs duties often are a significant source of government revenue. The revenue collected depends on the levels of exports, and most importantly, imports. International lenders thus closely watch foreign trade prices and volumes, among other indicators of government revenue, to ensure the government consistently meets the lenders' conditions for securing international finance.

13. The government uses export and import price and volume indices to design broad macroeconomic and international trade policy. Finally, it disseminates these indicators to users in the private sector to improve the information on which they base their economic decisions.

C. Analyzing Country Competitiveness

14. An industry remains competitive only if its prices are kept in line with the world market. Analysts assess competitiveness by calculating terms of trade and other indices.[4] On the supply side, exporters want to know how prices evolve for products similar to their own from suppliers in other countries. On the demand side, importers need to know how the prices of the products they purchase evolve to secure the least cost source among supplying countries.

15. Studies of competitiveness analyze the price developments not only in the domestic currency but also in the currencies of the country's main trading partners. For example, a stable export price index may mask the effect of a devaluation of the domestic currency against that of a trading partner (trading partners). In this case, a devaluation could make a country's products less expensive in foreign currencies compared with other world suppliers. The devaluation thus makes the country at least temporarily more competitive.[5]

---

[4] Such as effective exchange rates (EERs). The "nominal" EER of a country of interest is an index of numeraire currency to national currency exchange rates. The U.S. dollar usually is chosen as the numeraire currency. The EER's weights are the market shares of countries selling into the same product markets as the country supplies. A "real" EER (REER) is the ratio of the nominal EER with an index of the prices in national currency of tradable goods and services. The weights of this denominator index are the shares of tradable goods and services production in the total output of the country. We could characterize the denominator index, therefore, as a subindex of the PPI that excludes nontradable goods and services. This said, there are other variants of REERs using different price index denominators, among which, more to the point of this working paper, is the export price index.

[5] In a country with the franc as the national currency, exporting coffee to the United States, for example, the export price index in francs (F) for coffee shows zero inflation because the price of a kilogram is constant at f 100 in successive years, whereas the export price index in dollars ($) shows a decline of 1.5 [(100/10)/(100/15)]). This is because the exchange rate (F/$) increases (devaluation of the franc) from $1 = F 10 in the first year to $1 = F 15 in the next.

D. Drawing up Trade Contracts

16. Producers and potential investors may analyze world supply and demand of a given product by conducting market surveys to decide whether it would be profitable to produce, and if so, to export. The most accurate of these surveys collect detailed information about the product. Other relevant information includes existing world sources of supply, potential demand, price, and identification of the main exporters and main national trading partners.

17. Negotiators may use import and export price indices to escalate the agreed price of an international contract to ensure payment will cover the agreed volume to be delivered over the duration of the contract. For instance, negotiators may select suitable import price indices for a long-term contract to buy inputs from abroad. Similarly, they may select export price indices for a long-term contract to deliver a product to a foreign buyer.

E. Measuring Inflation, Forecasting Future Price Trends

18. Foreign trade indices are also important for explaining the sources of domestic inflation. Imports are used as intermediate inputs, in capital formation, and in consumption. The import price index thus partly explains fluctuations in the price indices for all three. Price change in intermediate inputs and capital formation normally results in lagged changes in the prices of output. The import price index thus is one indicator of cost-push inflation. It can be used along with other indicators for forecasting the future course of output prices.

F. Analyzing Exchange Rates

19. To understand how exchange rate adjustments affect goods and services prices, it is important to know the fraction of exchange rate movements passed through to the prices of exports and imports. Pass-through rates measure the contribution of exchange rate changes to changes in the import and export price indices. If a local currency appreciates against foreign currencies, import prices will fall while export prices should rise. A depreciation of the local currency would have the opposite effect. Pass-through rates usually are between zero and 100 but can assume any value in given months or quarters.[6]

G. Compiling National Accounts

20. By one calculation GDP is consumption, capital formation, and exports, less imports. These components of GDP comprise individual goods and services transactions. Each transaction is the product of a quantity and a price of a specific good or service. Policy analysts study the contributions to movement in GDP made by changes in the

---

[6] The pass-through rate for imports is the ratio of the import price index to the average exchange rate index.

quantities as well as the prices of goods and services. One approach to producing such a summary quantity or volume indicator is to average the movements in the quantities of the many types of goods and services involved in the transactions that compose GDP. Another approach is to remove the effect of price change from movement in the current price value of GDP by dividing it by an appropriate price index. For most components of GDP it is easier to take the latter "price deflation" approach than the former "quantity aggregation" approach. Prices tend to be correlated, while quantities often are quite uncorrelated. On the whole, it thus takes a smaller sample of prices to accurately estimate average price change than of quantities transacted to accurately estimate average quantity change. Because larger samples cost more, compilers usually can get more accuracy for the money by surveying prices rather than quantities. For this reason, with few exceptions compilers estimate export and import volumes using deflation with price indices rather than compiling direct indices of quantities traded.

III. INDEX NUMBERS

A. Index Number Theory

21. Price index numbers summarize the relative price changes from individual transactions. Price index formulas are functions of the prices *p* and quantities *q* of transactions *i* classified into a given domain *D*. The *value aggregate V* of the domain is simply the total value of the transactions that fall into it. In prices and quantities, it is

$$V^t = \sum_{i \in D} p_i^t q_i^t .$$

The relative change in the value aggregate over time is

$$\frac{V^t}{V^0} = \frac{\sum_{i \in D} p_i^t q_i^t}{\sum_{i \in D} p_i^0 q_i^0},$$

where period 0 is a specific period in the past, called the *base period*.[7] A useful way to think of a price index is that it is the part of relative change in the value aggregate resulting solely from price change. Viewed this way, a price index is the factor *P* in

---

[7] There is little formal difference between index number comparisons over time and other domains. We can think of reference and comparison as two distinct places or countries for a given period of time as well as two time periods for a given country. For an index number time series, the index base period corresponds to the period to which the index weights (trade shares in the case of foreign trade price indices) relate while the index reference period is the period for which the index equals 100.

$$\frac{V^t}{V^0}=\frac{\sum_{i\in D}p_i^t q_i^t}{\sum_{i\in D}p_i^0 q_i^0}=P^{0,t}Q^{0,t}$$

where *P* is a function, or formula, of individual prices and quantities in the base and current periods. There are many formulas available for *P*. Irving Fisher (1922) assembled what still is the most extensive inventory of these formulas.

22. To decide which price index formula is best, Fisher evaluated them against a set of, in his view, desirable axiomatic properties. He was not the first to consider testing index formulas against axioms, but did so in a more systematic and comprehensive way than earlier analysts. His 1922 book thus initiated the axiomatic or test school of thought on index numbers. While Fisher considered a long list of tests or axioms, Eicchorn and Voeller (1982) proved that no index formula can satisfy all of them. One consistent subset of Fisher's tests appear in this working paper: proportionality, commensurability, time reversal, monotonicity, circularity, and factor reversal. See Box 1 for more on these properties. Fisher and some present day index number theorists argue that the more of these properties an index satisfies, the better it is. Based on his tests, Fisher preferred what he called the "Ideal" index and what now has been named the Fisher Ideal index after him. This section provides further details on this important index formula below.

23. Shortly after Fisher published his inventory of formulas, another school of thought about price indices emerged.[8] Konus (1926) inferred index number properties from the microeconomic behavior of consumers and began the economic index number school. It subsequently was extended to producers by Archibald (1975). Among the properties important to the economic school are proportionality, monotonicity, and time reversal. Diewert (1976) derived not only Fisher's "Ideal" index from microeconomic first principles, but a whole class of indices. This class, which Diewert called ***superlative***, included other indices studied by Fisher, as well as some that have been introduced since the 1920s. Most notable among the other superlative indices is the Törnqvist index, identified by Fisher in 1922 but named for an economist at the Bank of Finland who wrote about it in 1936.[9] We will consider these two superlative indices after first considering some simple index numbers.

---

[8] Our very brief description of how economic index numbers evolved borrows heavily from Chapter 2 of National Research Council (2002).

[9] See Törnqvist (1936).

Box 1. The Test or Axiomatic Approach to Assessing Index Numbers

The axiomatic approach to index numbers evaluates different index number formulas based on a set of *tests* or *axioms* proposed by Irving Fisher (1922). These tests can provide reasonable criteria to use for choosing a price index formula. The most important of these are

Proportionality. If all prices change by some common factor, the price index should also change by that common factor. For example if all prices double, the aggregate price index should double.

Commensurability. The price index should be invariant to changes in the units of measure. For example, if the measure of one good is converted from pounds to kilograms, the index should yield the same result.

Time Reversal. If prices between periods are reversed, then the price index assumes the reciprocal of its previous value.

Monotonicity. If there are one or more price increases in the current period with no price declines, then the price index should increase.

Circularity. This is a multiperiod transitivity property. The product of the price index change going from period 1 to 2 times the price index change going from period 2 to 3 should equal the price index going directly from period 1 to 3.

Factor Reversal. A price index multiplied by its corresponding quantity index is equal to the ratio of the values for the two comparison periods.

24. The six axioms shown in Box 1 derive both from the Fisher axiomatic and the economic index number approaches.[10] Two additional properties, additivity and consistency in aggregation, are important to many users of index numbers for practical reasons. An *additive* index may be expressed as a sum of weighted components.[11] This is a useful analytical property because the index is the sum of the contributions to change of each of its components.[12] Index formulas that are *consistent in aggregation* produce the same aggregate index regardless of the intermediate aggregations of the basic elements.

B. Simple Formulas

25. The Laspeyres index formula is written alternatively as

$$(1) \qquad P_L^{0t} = \frac{\sum_{i=1}^{n} p_i^t q_i^0}{\sum_{i=1}^{n} p_i^0 q_i^0}$$

or

$$(2) \qquad P_L^{0t} = \sum_{i=1}^{n} s_i^0 \left(\frac{p_i^t}{p_i^0} \right) \text{ where } s_i^0 = \frac{p_i^0 q_i^0}{\sum_{i=1}^{n} p_i^0 q_i^0}.$$

The Laspeyres index keeps the quantities (q) fixed in the base period (0) to compare the levels of prices (p) between the base period and the present (t). For exports (imports), it is the ratio of what it cost today for nonresidents (residents) to purchase the same set of goods and services produced by residents (nonresidents) that they purchased in the base period. From equation (2), the Laspeyres price index can be restated as a base period weighted average of the price relatives of the elementary goods and services in scope for the index.

---

[10] See Diewert (1978) on these properties of index numbers.

[11] Preferences and technology must remain (or be assumed) static over the period of comparison.

[12] National accountants value the additivity property for volume indices, as it associates with a particularly transparent methodological description. One simply deflates the detailed components of value aggregates by the appropriate detailed price indices and adds up the deflated components to get the aggregate volume indicator.

26. The Paasche index formula is written alternatively as

$$(3) \qquad P_P^{0t} = \frac{\sum_{i=1}^{n} p_i^t q_i^t}{\sum_{i=1}^{n} p_i^0 q_i^t}$$

or

$$(4) \qquad P_P^{0t} = \frac{1}{\sum_{i=1}^{n} s_i^t \left(\frac{p_i^0}{p_i^t} \right)} \text{ where } s_i^t = \frac{p_i^t q_i^t}{\sum_{i=1}^{n} p_i^t q_i^t}.$$

27. The Paasche index fixes quantities at their levels in the current period (t). By implication, the quantities change from period to period, unlike a Laspeyres index. In its simplest form the Paasche index is, in the case of imports for example, the ratio of what today's purchases abroad cost compared with what they would have cost in a specific previous period. This also can be viewed as the current value of the current basket relative to what is often (and logically) called its *constant price* value. From equation (4), the Paasche price index can be restated as a current period *weighted harmonic mean* of price relatives.

28. The Laspeyres and Paasche indices fix the quantities transacted at their levels from only one of the two periods compared. They do not admit the possibility that economic agents may change those quantities in response to changes in relative prices. They thus are subject to substitution bias. The direction of this bias depends on whether the price index is for uses of goods and services, such as exports, or for supplies of goods and services, such as imports.

29. Laspeyres price indices for uses aggregates have upward substitution bias, while Paasche price indices for these aggregates have downward substitution bias. The reasoning supporting this relies on microeconomics. We analyze aggregates for uses as composed of the expenditures of cost-minimizing economic agents. When confronted with a price change, agents seek a new combination of goods and services leaving them as well off as in their initial situation. The combination they choose will cost no more than the old set of goods and services would at the new prices. The old combination will be chosen only if all other possibilities yielding the same welfare cost more than the old combination at the new prices. Since there are almost always new combinations of products at least as good as the old combination and costing less at the new prices, staying with the old is not likely. Thus, the numerator of the Laspeyres index, which is the cost of the old set of goods at the new prices, is too high. The Laspeyres uses price index thus is too high. By the same reasoning, the denominator of the Paasche index, which is the cost of the new set of goods at the old prices, also is too high. The Paasche uses price index thus is too low.

30. By the same reasoning, the Laspeyres price indices for supply aggregates have downward substitution bias, while Paasche indices for these aggregates have upward

substitution bias. Again, microeconomics lies at the heart of the argument. We analyze supply aggregates as composed of economic agents using given inputs to maximize the value of output supplied. When confronted with a price change, agents seek a new combination of products to supply that is feasible with their given set of inputs. The combination they choose will yield as least as much in value as would supplying the old set of products at the new prices. They will choose the old combination only if all other possibilities requiring the same inputs to produce yield less than the old combination at the new prices. There almost always are new combinations of products needing no more inputs than the old combination and yielding more at the new prices. Staying with the old combination is unlikely. Thus, the numerator of the Laspeyres index, which is the value of the old set of goods at the new prices, is too low. The Laspeyres supply price index thus is too low. By the same reasoning, the denominator of the Paasche index, which is the value of the new set of goods at the old prices, is too low. The Paasche supply price index thus is too high.

31. The geometric mean price index maintains that product substitution takes place across products with unitary elasticity in response to changes in relative prices. For most goods and services, this is more realistic than the Laspeyres and Paasche index assumption that no substitution takes place. The geometric mean formula is written from the Laspeyres perspective as

$$(5) \qquad P_{GL}^{ot} = \prod_{i=1}^{n} \left(\frac{p_i^t}{p_i^0} \right)^{s_i^0}$$

or the Paasche perspective as

$$(6) \qquad P_{GP}^{ot} = \prod_{i=1}^{n} \left(\frac{p_i^t}{p_i^0} \right)^{s_i^t}$$

where

$$s_i^t = \frac{p_i^t q_i^t}{\sum_{i \in D} p_i^t q_i^t} .$$

32. How do the simple indices stack up against Fisher's axioms or tests? All of the simple indices pass the proportionality and commensurability tests. All of the simple indices fail the time reversal and factor reversal test. The Laspeyres and Laspeyres geometric indices pass the monotonicity test, but the the Paasche and Paasche geometric do not. The Laspeyres and Laspeyres geometric indices satisfy the circularity test, but the Paasche and Paasche geometric do not. Of the group, the Laspeyres and Laspeyres geometric satisfy 4 of the 6 axioms, while the Paasche and Paasche geometric satisfy 2, so the Laspeyres-type simple indices rank first. Considering our two supplemental

properties, only the Laspeyres index is strictly additive in prices.[13] The simple indices all are exactly consistent in aggregation.

C. Superlative Formulas

33. In our discussion of substitution bias, we introduced the microeconomic notions of cost minimizing users of products and output maximizing producers. Superlative index formulas can reflect the substitution behavior of economic agents to a very close approximation, closer than the Paasche, Laspeyres, or their geometric mean counterparts. These indices use weight information from both the base and current periods, rather than from one or the other. Because they are symmetric, they satisfy the time reversal test, unlike the Laspeyres and Paasche. The best known is the Fisher Ideal index, which is the geometric mean (square root) of the Laspeyres and Paasche indices:

$$(7) \qquad P_F^{0t} = \left(P_L^{0t} P_P^{0t}\right)^{\frac{1}{2}}.$$

Another well-known superlative index is the Törnqvist index, which is

$$(8) \qquad P_T^{0t} = \prod_{i=1}^{n} \left(\frac{p_i^t}{p_i^0}\right)^{s_i^{0t}} = \left(P_{GL}^{0t} P_{GP}^{0t}\right)^{\frac{1}{2}} \text{ where } s_i^{0t} = \tfrac{1}{2}\left(s_i^0 + s_i^t\right) \text{ and } s_i^t = \frac{p_i^t q_i^t}{\sum_{i \in D} p_i^t q_i^t}.$$

The Törnqvist index thus is equal to the geometric average of the Laspeyres and Paasche perspective geometric mean indices of equations (5) and (6).

34. The Fisher Ideal index formula satisfies five of the six index tests, failing only circularity, earning Fisher's "Ideal" moniker. The Törnqvist index passes four of the six tests, failing circularity and monotonicity. Besides having good axiomatic properties, as noted at the start of this section superlative indices also better reflect economic behavior when relative prices between products are changing. Unlike the Laspeyres index, the Fisher and Törnqvist indices are not additive, nor exactly consistent in aggregation. The superlative indices are consistent in aggregation to a close approximation, however.[14]

D. Fixed Base and Chained Indices

35. *Fixed-base indices* have a common point of comparison to which the prices of all goods and services in the domain of the index relate. Thus, the index is a function of direct relative price comparisons between the current period and the single period of reference, or base period. *Chained indices* are the result of linking several, differently-based series. If the frequency of linking is every period, a chained index is the product of

---

[13] However, the other basic indices are additive up to a montone transformation. The Paasche index is additive in the transformation $1/x$ and the geometric indices are additive in the transformation $\ln x$.

[14] See Diewert (1978).

a series of short-term, month to month, quarter to quarter, or year to year indices, according to the periodicity of the index.

36. The Laspeyres index formula often is used in foreign trade indices because, it is argued, users understand this index more easily than other indices. The idea underlying the Laspeyres index, which compares the current value of a fixed "market basket" of imported or exported goods and services with its value in a past period, certainly is straightforward to convey. The problem with holding the base fixed for extended periods, however, is that the index gets out of date and loses relevance. Its weights and products become uncharacteristic of current transactions. Consequently, if the product shares for transactions covered by the domain of the index change markedly over short intervals of time, more frequent chaining is advisable. This is almost universally the case for external trade in goods and services.

37. In general, then, compilers can chain when they have new information about the weights or shares at some level of aggregation in the index.[15] Hence, it is not a matter of deciding to chain an index, but whether and how frequently new information becomes available for the weights to enable chaining. If the weighting information is available at frequent intervals, chaining can occur more often than when it is available at intervals of several years. Some countries chain certain indices such as the CPI at intervals as lengthy as a decade. They chain infrequently because the information on shares of household expenditure can be expensive and time-consuming to obtain. The responsible agency can publish and make official a version of the CPI incorporating the new weighting information only well after the reference period of the weights. If, as with the CPI, the index is not revised to incorporate slow-arriving weighting information, there is little alternative to the fixed base Laspeyres index. This, however, is not such an important argument for the Laspeyres index in the case of international trade price indices. The available source information for the shares often is as current as the information on the prices and frequent chaining thus is viable.

38. In a given link for a chain index, the expenditure shares are for the previous period (Laspeyres-type, equations 1 and 5) or the current period (Paasche-type, equations 3 and 6), or both (Fisher Ideal and Törnqvist, equations 7 and 8). The chain Laspeyres Index can be written as

$$(9) \qquad P_L^{t-1,t} = \sum_{i=1}^{n} s_i^{t-1} \left(\frac{p_i^t}{p_i^{t-1}} \right)$$

---

[15] We also chain when we replace or supplement the sample of elementary items whose prices are followed within each elementary aggregate. In a probabilistic sense, this also can be viewed as effectively changing the weights by sampling from a more recent and differently composed population of transactions.

$$(10)\quad P_{LC}^{0t} = P_L^{01} \times P_L^{12} \times P_L^{23} \times \cdots \times P_L^{t-1,t} = \prod_{\tau=1}^{t} P_{LC}^{\tau-1,\tau}$$

and the chain Paasche Index can be written as:

$$(11)\quad P_P^{t-1,t} = \frac{1}{\sum_{i=1}^{n} s_i^t \left(\frac{p_i^{t-1}}{p_i^t}\right)}$$

$$(12)\quad P_{PC}^{0t} = P_P^{01} \times P_P^{12} \times P_P^{23} \times \cdots \times P_P^{t-1,t} = \prod_{\tau=1}^{t} P_{PC}^{\tau-1,\tau} .$$

The chain geometric Lapeyres and Paasche indices are constructed similarly as a product of short-term index links with updated weights computed using the geometric formulas instead of the Laspeyres and Paasche.

39. In general, the chain Laspeyres index has less upward substitution bias than the fixed-based version and the chain Paasche has less downward bias than the fixed-base version. Thus, the difference between the two chained measures usually is smaller than for the fixed-base versions.[16] The chain Fisher is the geometric mean of the chain Laspeyres and chain Paasche indices. Similarly, the chain Törnqvist is the geometric mean of the chain Geometric Laspeyres and chain Geometric Paasche indices, respectively.

$$(13)\quad P_{FC}^{0t} = \left(P_{LC}^{0t} P_{PC}^{0t}\right)^{\frac{1}{2}} = \prod_{\tau=1}^{t} \left(P_L^{\tau-1,\tau} P_P^{\tau-1,\tau}\right)^{\frac{1}{2}}$$

$$(14)\quad P_{TC}^{0t} = \left(P_{GLC}^{0t} P_{GPC}^{0t}\right)^{\frac{1}{2}} = \prod_{\tau=1}^{t} \left(P_{GL}^{\tau-1,\tau} P_{GP}^{\tau-1,\tau}\right)^{\frac{1}{2}} .$$

Chained indices are not additive in aggregation when comparisons are made across linking periods, nor are they transitive (they do not pass the circularity test).

IV. CONSTRUCTING PRICE INDICES FOR EXPORTS AND IMPORTS

A. Export and Import Price Indices

40. The main steps for compiling export and import price indices are no different from other major price indices such as the CPI and PPI. The basic element of information

---

[16] With a cautionary proviso to be discussed in Section IV: chaining the Laspeyres and Paasche indices at too high a frequency can lead to unacceptable amounts of "chain drift," under which the chained index deviates by too wide a margin from the fixed base index as a result of, for example, random measurement error in the prices and/or weights.

is the ***transaction***, whose dimensions are a price and a quantity and a complete description or set of characteristics. Index compilation begins with *recording* the *prices* (as well as characteristics and, preferably, quantity transacted) for individual transactions in goods and services. The transactions are dated and grouped in time according to the periodicity of the index, usually one month. There are three major stages to compiling a price index.

- The **first stage** is to compute **unit values** for detailed products, which are termed **elementary items** (or *varieties* or *item specifications*), by averaging prices across **transactions**. *Elementary items are the smallest entities on which prices are measured from period to period.* Because of the often large number of transactions for each elementary item, price indices for them usually (but not always) are based on samples of transactions. Because there typically are so many elementary items, however, the transaction sample for an elementary item may comprise as few as a single observation. In this case, the estimator for the elementary item unit value is the price quote for this single sampled transaction.

- The **second stage** is to compute **indices** for the **elementary aggregates** (or *basic headings* or *item groups* or simply *items*) from information on the relative change in the prices (unit values) of the elementary items. *Elementary aggregates are the smallest entities for which price index estimates are to be made.* Because of the very large number of varieties of detailed types of products in transactions, price indices for them usually are based on samples of elementary items rather than a complete enumeration.

- The **third stage** to compute **indices** for the **upper aggregates** by combining the indices for the elementary aggregates.

Transactions, elementary items, and unit values

41. In any price index it is necessary to establish an unambiguous way of identifying each elementary item. This is done by observing the *price-determining characteristics* of transactions in each class of goods and services. A price-determining characteristic must significantly explain variations in the price observed for a given transaction in a certain type of good or service within a reasonably short period, such as a month. A characteristic having no cross-sectional impact on price is irrelevant for defining an elementary item. By this "price explanatory power" criterion, *we will have successfully enumerated the price-determining characteristics if there is very little variability in the prices of the transactions with that specific set of characteristics.*

42. Examples of price-determining characteristics include mode of shipment, size, weight, dimensions, and terms of transaction. Such characteristics may include class and quality of wheat, clock speed and word size of a microprocessor, horsepower and interior volume of a car, or whether a milling machine has an interface to a computerized control.

43. For a given elementary item properly defined according to particular values of its price-determining characteristics, it is possible to observe multiple transactions. For example, we might consider an export elementary item within the class of magnetic disk

drives with characteristics of Capacity, Seek time, Revolutions per minute (RPM), and Interface, as follows:

Product code = 8471705095
Description = MAGNETIC DISK DRIVE UNIT
Capacity = 40 gigabytes
Seek time = 4 milliseconds
RPM = 4200
Interface = SCSI2 (small computer system interface version II)
Source = Malaysia
Destination = Russia

There may be 150 transactions fitting this description. If a compiler were to measure all such transactions in a given month, he would determine the price of this elementary item ideally as the quantity weighted average or *unit value* of these transactions.

44. Prices for elementary items are obtained as unit values by dividing the total value of import or export transactions in the elementary item by the sum of the corresponding quantities. Let $p_{\tau i}^{t}$ be the price in period t of the τ^{th} transaction in the i^{th} elementary item and let $q_{\tau i}^{t}$ be the corresponding quantity transacted. Then the price and quantity of the i^{th} elementary item is

$$(15) \quad p_i^t = \frac{\sum_{\tau \in \{i\}} p_{\tau i}^t q_{\tau i}^t}{\sum_{\tau \in \{i\}} q_{\tau i}^t}$$

$$(16) \quad q_i^t = \sum_{\tau \in \{i\}} q_{\tau i}^t$$

(15) and (16) are the price and quantity arguments that appear in the index number formulas of the section on index numbers. If, as we would expect, there is little or no variation in price across transactions within elementary item i, then the unit value (15) is essentially invariant to its transaction quantity weights

$$\frac{q_{\tau i}^t}{\sum_{\tau \in \{i\}} q_{\tau i}^t}$$

and the unit value can be estimated accurately by the unweighted average of prices of transactions in the elementary item, or if the variance in prices is sufficiently low, by the price of any one of the transactions τ.

Price indices for elementary aggregates

45. The elementary aggregates are the basic index building blocks from which compilers produce price indices. They are defined principally by the purposes to which detailed index information will be put. For example, as noted in Section II, customs authorities may want to forecast tax revenue taking into account trends in the prices of specific product categories. In this case, the customs classification of products in international trade is at least one of the defining criteria of an elementary aggregate. In addition, national accountants will need price indices for detailed product classes to track the supply and use of goods and services. Here, the national product classification is a defining criterion. Marketing analysts will want to know price trends by product and by source (imports) or destination (exports) country. To accommodate this use, the elementary aggregate is defined not only by product but also by source or destination country.

46. In certain cases, the elementary aggregate is defined by statistical requirements at such a detailed level that it contains a single elementary item. Some agricultural products and mineral ores may fall into this category. The price index for such an elementary aggregate is simply the ratio of the dated unit values of the single elementary item comprising it.

(17) $R_{jk}^{0,t} = \frac{p_i^t}{p_i^0}$ where $i \in$ the elementary aggregate$\{jk\}$, with

j = product code and

k = country code.

47. More commonly, there will be multiple elementary items within an elementary aggregate. This being the case, the price index for the elementary aggregate would be calculated in principle exactly as in the section on index numbers. The weight for each of the elementary items in this calculation would be its value share in the elementary aggregate. Formulas such as the Laspeyres (2), Paasche (4), Geometric Laspeyres (5), Geometric Paasche (6), Fisher Ideal (7), or Törnqvist (8) and their chain versions (11)-(14) thus would be used to calculate the price index for the elementary aggregate $R_{jk}^{0,t}$.

48. However, while compilers usually know the share weights of elementary aggregates in total exports or imports, they usually do not know the shares of elementary items within an elementary aggregate. The source data for elementary items are *sample surveys*. As discussed in Section V, these surveys discover the elementary items when survey statisticians probabilistically select the sample of export or import transactions from the reporter. The mere presence of elementary items in the sample thus probabilistically represents their weight in the elementary aggregate. The price index estimator for the elementary aggregate usually is constructed as one of several types of unweighted averages of relative price change for the sampled elementary aggregates. These averages are broadly similar to the price indices discussed in Section III, except all the price relatives for the elementary items are equally weighted. As estimators of the

weighted price indices over all elementary items in the aggregate these unweighted aggregators can have good statistical properties. If the average of these unweighted elementary aggregator indices is made over over many samples, the result may converge toward a particular price index with the correct share weights under certain conditions.

49. The basic elementary aggregate formulas are the Carli or average of price relatives index, the Dutot or ratio of price averages index, and the Jevons or geometric mean of price relatives index. The expressions for these indices are:

Carli:

$$(18)\qquad \hat{R}^{0,t}_{Cjk}=\frac{1}{n^{0,t}_{jk}}\sum_{i\text{ in agg. }jk}\frac{p^{t}_{i}}{p^{0}_{i}}$$

Dutot:

$$(19)\qquad \hat{R}^{0,t}_{Djk}=\frac{\frac{1}{n^{0,t}_{jk}}\sum_{i\text{ in agg. }jk}p^{t}_{i}}{\frac{1}{n^{0,t}_{jk}}\sum_{i\text{ in agg. }jk}p^{0}_{i}}$$

Jevons:

$$(20)\qquad \hat{R}^{0,t}_{Jjk}=\left[\prod_{i\text{ in agg. }jk}\frac{p^{t}_{i}}{p^{0}_{i}}\right]^{\frac{1}{n^{0,t}_{jk}}}.$$

Notice that under the geometric averaging of the Jevons index, the ratio of geometric averages of prices is the same as the geometric average of price relatives. This does not obtain under the arithmetic averaging of the Carli and Dutot indices.

50. A less well-known option for the elementary aggregate index formula is the

Harmonic[17]:

$$(21)\qquad \hat{R}^{0,t}_{Hjk}=\left[\frac{1}{n^{0,t}_{jk}}\sum_{l\text{ in agg. }jk}\left(\frac{p^{t}_{jkl}}{p^{0}_{jkl}}\right)^{-1}\right]^{-1}.$$

---

[17] Coggeshal (1884) seems to have been the first to consider this formula in a price index.

From the Carli (18) and the Harmonic (21) formulas, a last option for the elementary aggregator is the

Carruthers-Sellwood-Ward-Dalén (CSWD)[18]:

(22) $\hat{R}^{0,t}_{CSWD,jk} = \left[\hat{R}^{0,t}_{C,jk}\hat{R}^{0,t}_{H,jk}\right]^{\frac{1}{2}}$.

51. The Carli index mimics the Laspeyres, the Harmonic index mimics the Paasche, the Jevons mimics the Geometric and Törnqvist, and the CSWD mimics the Fisher Ideal. As with the Laspeyres and Paasche indices, the Carli and Harmonic indices will be subject to substitution bias as discussed in Section III. High substitution effects have been found within elementary aggregates by empirical studies of selected goods and services. Because it allows for a specific level of product substitution, the Jevons index has found favor as the preferred elementary aggregator for the majority of elementary aggregates.

52. Because of the large turnover in the product varieties within elementary aggregates of foreign trade data, compilers routinely chain elementary aggregate indices. The Dutot (19) and Jevons (20) indices satisfy Fisher's circularity property. They are invariant whether computed in fixed base or chained form even when the items in an elementary aggregate are subject to seasonal availability or temporary supply interruptions.

53. On the other hand, Schultz (1983) has shown the Carli (18) and Harmonic (21) indices are biased when they are chained. The bias worsens when there is (a) a high variance in relative price changes and (b) the normally expected correlation between changes in prices and quantities. Both indices "drift" compared with their unchained, fixed base counterparts. In other words, they violate the circularity property by a margin that widens significantly over time under conditions (a) and (b).[19] Seasonal and temporarily unavailable items only worsen the drift problem.

54. The CSWD index (22), however, reduces the bias of the Carli and Harmonic indices comprising it. The biases of the Carli and Harmonic aggregators were shown by Schultz (1983) to be in opposite directions. Diewert (2002, p.54) has shown that the CSWD aggregator closely approximates the Jevons elementary aggregator when period to period price changes are small, and that the Jevons satisfies the circularity property, protecting it from chain "drift." Balk (2002) demonstrates that under certain probability sampling schemes, the expected value of the CSWD index converges to the Fisher Ideal.

---

[18] Carruthers, Sellwood, and Ward (1980), and Dalén (1992).

[19] It is not a foregone conclusion that a good price index should satisfy circularity exactly. For example, chaining by itself sacrifices circularity as already noted. The broad guidance on this is that, while circularity need not hold exactly, large deviations from circularity are a cause for concern, as they may be a result of measurement errors rather than shifts in the underlying structure of the economy.

Price indices for upper aggregates

55. Formulas such as the Laspaeyres (2), Paasche (4), Geometric Laspeyres (5), Geometric Paasche (6), Fisher Ideal (7), or Törnqvist (8) are used to calculate the price index for the upper index aggregates. Instead of price ratios, the upper aggregate indices would contain elementary aggregate price indices as arguments, as in the following:

(23) $P_{L}^{0t} = \sum_{j}\sum_{i} s_{ij}^{0} \hat{R}_{ij}^{0,t}$ [Laspeyres, reference equation (2)]

(24) $P_{P}^{0t} = \dfrac{1}{\sum_{j}\sum_{i} s_{ij}^{t} \left(\hat{R}_{ij}^{0,t}\right)^{-1}}$ [Paasche, reference equation (4)]

(25) $P_{GL}^{ot} = \prod_{j}\prod_{i=1} \left(\hat{R}_{ij}^{0,t}\right)^{s_{ij}^{0}}$ [Geometric Laspeyres, reference equation (5)]

(26) $P_{GP}^{ot} = \prod_{j}\prod_{i}^{n} \left(\hat{R}_{ij}^{0,t}\right)^{s_{ij}^{t}}$ [Geometric Paasche, reference equation (6)]

$P_{F}^{0t} = \left(P_{L}^{0t} P_{P}^{0t}\right)^{\frac{1}{2}}$ [Fisher Ideal, equation (7)]

$P_{T}^{0t} = \left(P_{GL}^{0t} P_{GP}^{0t}\right)^{\frac{1}{2}}$ [Törnqvist, equation (8)]

56. Relative trade prices by product and source or destination country may change significantly over annual periods. Since this is the rule rather than exception, the Fisher Ideal or Törnqvist chained indices would be more accurate measures of the relative change in prices for upper aggregates than the Laspeyres-type or Paasche-type chained indices. The short-term biases of the latter indices tend to compound over time. Further, as a rule the value shares of elementary aggregates within exports and imports also change significantly over annual periods. Because of this, annual chaining is recommended rather than adjusting the weights over longer durations.

B. The Terms of Trade

57. Broadly speaking, the terms of trade are a measure of the degree to which a country gets favorable transaction terms (prices) for its exports relative to its imports. It generally involves some notion of the purchasing power of income. There are a number of terms of trade concepts and no consensus on which is definitive. We briefly consider a selection of common alternatives.

58. The *simple terms of trade index* (TT^{t}_{Simple}) is calculated by dividing a price index (or unit value index proxy) for exports by a price index (or unit value index proxy) for imports:

$$(27) \qquad TT^{t}_{Simple} = \frac{P_X^{0,t}}{P_M^{0,t}}$$

where $P_X^{0,t}$ and $P_M^{0,t}$ are the price indices for, respectively, exports (X) and imports (M).

59. The dual *relative volume index* (TT^{t}_{Vol}) is defined as the ratio of an index of the quantity of commodity imports to an index of the quantity of commodity exports, where the quantity index of exports (imports) is the ratio of the value of exports (imports) to the unit-value index of exports (imports).

$$(28) \quad TT^{t}_{Vol} = \frac{\dfrac{V_M^t / V_M^0}{P_M^{0,t}}}{\dfrac{V_X^t / V_X^0}{P_X^{0,t}}}$$

which can be rewritten as:

$$(29) \quad TT^{0,t}_{Vol} = \frac{V_M^t / V_M^0}{V_X^t / V_X^0} \times TT^{0,t}_{Simple}$$

60. The *income terms of trade index* measures the quantity of imports a country can purchase with its exports. It is equivalent to the country's purchasing power of exports, or its capacity to import.

$$(30) \qquad TT^{0,t}_{Income} = \frac{V_X^t / V_X^0}{P_M^{0,t}} = \frac{P_X^{0,t} \times Q_X^{0,t}}{P_M^{t}} = \frac{P_X^{0,t}}{P_M^{0,t}} \times Q_X^{0,t}$$

where $Q_X^{0,t}$ is the volume index for exports. Equation (30) can be rewritten as:

$$(31) \qquad TT^{0,t}_{Income} = Q_X^{0,t} \times TT^{0,t}_{Simple}$$

61. The *1993 SNA* (paragraphs 151 to 156 of Chapter XVI) defines the trading gains or losses, T, of a country as the difference between the "real" trade balance and the trade balance at constant prices:

$$(32) \quad TT_{SNA}^{0,t} = \frac{X_t - M_t}{P^{0,t}} - \left[\frac{X_t}{P_X^{0,t}} - \frac{M_t}{P_M^{0,t}} \right]$$

where

X = exports at current prices
M = imports at current prices
$P^{0,t}$ = a price index based on some selected numeraire

(32) is similar to (31), but defined in terms of the difference between exports and imports rather than their ratio. The *1993 SNA* recognizes that no one choice of the general price index $P^{0,t}$ with which to deflate the current trade balance is optimal in all circumstances. There are three broad choices for this index. The first is a trade price index such as the import price index, the export price index, or a combination of the two. The second is a general price index not derived from foreign trade (e.g., the CPI or the price index for gross domestic final expenditure comprising consumption and capital formation). The GDP deflator is a third choice, which combines both foreign (net exports) and domestic (consumption and capital formation) price information.

62. The Diewert (1983) and Diewert and Morrison (1986) terms of trade measure recalls the *1993 SNA* trading gains indicator (32) as well as the simple terms of trade index (27). It has a specific and natural interpretation linked to the GDP deflator. It decomposes the GDP expenditure deflator into two multiplicative factors. The first factor measures the contribution to change in the deflator arising from changes in the prices of domestically produced and used goods and services. The second factor measures the contribution to change in the GDP deflator of changes in exports (domestically produced but used by nonresidents) and imports (domestically used but produced by nonresidents). This latter factor is the contribution of the terms of trade to change in the GDP deflator. The Diewert-Morrison terms of trade indicator is calculated

$$(33) \quad TT_{DM}^{0,t} = \frac{\left(P_X^{0,t}\right)^{\frac{1}{2}\left(\frac{X^0}{GDP^0} + \frac{X^t}{GDP^t}\right)}}{\left(P_M^{0,t}\right)^{\frac{1}{2}\left(\frac{M^0}{GDP^0} + \frac{M^t}{GDP^t}\right)}} .$$

63. Because this terms of trade index is a contribution to change factor within a broader GDP price index two points are worthy of note. First, its weights do not sum to unity. It is thus not proportional to a simple scaling of the prices of exports or inversely proportional to a scaling of the prices of imports. Second, it will not be invariant to an equal scaling of export and import prices unless the balance of trade is zero. It will increase with an equiproportional scaling of export and import prices when the trade balance is positive and decrease if the trade balance is negative.

V. DATA SOURCES

A. The four modes of supply

64. The General Agreement on Trade in Services (GATS) identifies modes of trade in services that also can be applied to trade in goods. The GATS modes are:

> Mode 1—Cross border supply: from the territory of one country into the territory of any other country;
>
> Mode 2—Consumption abroad: in the territory of one country to the consumer of any other country;
>
> Mode 3—Commercial presence: by a service supplier of one country, through commercial presence in the territory of any other country;
>
> Mode 4—Presence of natural persons: by a service supplier of one country, through presence of natural persons of that country in the territory of any other country.

The principal modes utilized for goods and services transactions differ, and the modes nicely organize the data sources for these transactions.

Goods and services and the modes of trade

65. Goods supply follows modes 1 and 2. Mode 1 covers the normal shipment of goods from a supplier resident in one country to a user resident in another. The user takes physical possession *within* the territory of his own country. Mode 2 covers goods purchases of users resident in one country from suppliers resident in another country, where the user takes possession *outside* the territory of his own country. Mode 2 trade usually associates with personal travel.

66. Services may follow all four modes. Quoting the *Manual on Statistics of International Trade in Services* (paragraph numbers included)

> 2.16. Mode 1, cross border supply, takes place when the consumer remains in his or her home territory while the service crosses national borders, the supplier being located in a different country. The delivery of the service can be effected, for example, by telephone, fax, internet or other computer mediated links, television, or by the sending of documents, disks, tapes, and so on by mail or courier. It is similar to the traditional notion of trade in goods, where both the consumer and the supplier remain in their respective territory when the product is delivered. Indeed, freight transport services, which support trade in goods, are themselves examples of cross border supply of services. Correspondence courses and telediagnosis are other examples.
>
> 2.17. Mode 2, consumption abroad, occurs when a consumer moves outside his or her home territory and consumes services in another country. Tourist activities such as visits to museums and theatres are typical examples of consumption abroad. Medical treatment of non-resident persons and language courses taken abroad are other examples of consumption abroad. Activities such as ship repair abroad, where only the property of the consumer moves or is situated abroad, are also covered.

> 2.18. Mode 3, commercial presence, recognises that often for services it is necessary to establish a commercial presence abroad as a way to ensure a close contact with the consumer in his or her home territory at the various stages of production and delivery, as well as after delivery. Commercial presence in a market abroad covers not only juridical persons in the strict legal sense, but also legal entities that share some of the same characteristics, such as representative offices and branches. Under the GATS rules, "supply of a service" includes production, distribution, marketing, sale, and delivery. Medical services provided by a foreign owned hospital, courses in a foreign owned school, and services supplied by a domestic branch or a subsidiary of a foreign bank are examples of supplies through commercial presence.
>
> 2.19. Mode 4, presence of natural persons, occurs when an individual has moved into the territory of the consumer to provide a service, whether on his or her own behalf or on behalf of his or her employer. Thus, it covers two distinct categories of natural persons: self-employed and employees.
>
> 2.20. Mode 4 also applies to two areas: trade in services in the *BPM5* sense (e.g., financial auditing services by an auditor sent by a foreign firm or provision of entertainment services by a self employed professional foreign entertainer who is temporarily on tour in the host economy), and employment, meaning labour input in the production process. Presence of natural persons covers only non-permanent employment in the country of the consumer. However, the GATS provides no definition of "non-permanent" employment. In countries' commitments, the temporary status generally covers two to five years, and it may be different for different categories of natural persons.
>
> 2.21. Short-term employment of foreign doctors or teachers is covered under Mode 4. Intracorporate staff transfers and, more generally, short-term employment of foreign staff in foreign affiliates are particularly relevant in the GATS context because many countries have referred to this subcategory of natural persons in their schedules of commitments. Other examples are short-term employment of construction workers or paid domestic helpers.

Exports and imports and the modes of trade

67. The statistical standards for national accounts (*1993 SNA*) and balance of payments (*BPM5*) include only modes 1, 2, and 4 in exports and imports of goods and services. There is one exception to excluding mode 3 from international services trade. It involves the residency status in the host country of a services establishment of a nonresident enterprise. If the establishment does not meet the criteria for residency in the host country (e.g., a short-lived establishment operating in the host country for less than

one year), it is not a *direct investment enterprise* of the *BPM5* and *1993 SNA*. Therefore, the establishment's output is an import to the host country.[20] It is, however, still a *commercial presence* in the language of GATS.[21] Hence the nonresident establishment provides services to residents of the host country through mode 3 of GATS. In the *Manual on Statistics of Trade in Services* this case effectively applies only to international trade in construction services. It specifically accounts for those site offices of nonresident construction enterprises located in the project host country that remain in operation for less than one year.

68. The modes of trade are associated with different sources of statistical information. We consider administrative and survey sources in the next section. We further subdivide the discussion by considering sources for index weights and sources for prices, as well as sources for goods and sources for services.

---

[20] *Balance of Payments Compilation Guide*, paragraphs 452-453, and *Manual on Statistics of International Trade in Services*, paragraphs 3.5-3.7. On the other hand, the output of subsidiaries of nonresident construction enterprises that satisfy the conditions for residency in the project host country are excluded from the host country's international trade and included in its domestic product. See *Manual on Statistics of International Trade in Services*, paragraph 3.97.

[21] According to the *Balance of Payments Compilation Guide*, paragraph 685

> ... A direct investment enterprise is an incorporated or unincorporated enterprise in which a direct [nonresident] investor owns 10 percent or more of the ordinary shares or voting power (for an incorporated enterprise) or equivalent (for an unincorporated enterprise). ...

In addition, in view of the requirement that the direct investment relationship be long-term, the direct investment enterprise must be resident in the host country under the *BPM5*. This generally requires it to be in operation for at least one year. Direct investment enterprises comprise the following subclasses:

Branches	Unincorporated enterprises, wholly or jointly owned by the direct investor
Subsidiaries	Incorporated enterprises that are more than 50 percent owned by the direct investor
Associates	Incorporated enterprises that are between 10 and 50 percent owned by the direct investor.

In the *Manual on Statistics of International Trade in Services* 'foreign affiliates' effectively comprise *1993 SNA* and *BPM5* 'branches' and 'subsidiaries'. The definition of 'foreign affiliate' is close to the *1993 SNA* 'foreign-controlled enterprise' concept, except that the latter permits inclusion of 'associates' judged to be under the effective control of a nonresident unit, notwithstanding minority ownership, and the former does not.

B. Administrative Sources

Index weights for elementary and upper aggregates

Customs

69. Ideally, the customs administration records all flows of **goods** that enter and leave the economic territory. The value of **imported** goods includes **insurance and freight services** for tariff purposes, though in some instances these services may not be itemized in the administrative statistics on imports. Customs usually stores the contents of clearance documents in a database that commonly serves as an important source for foreign trade statistics.

70. There are several gaps in customs data coverage. The data do not cover transport and insurance services employed in shipping exported goods and transporting passengers. They also do not cover other internationally traded services, such as consulting, accounting, legal, financial, and construction services, as well as insurance services not related to international transport. Customs does not cover or often does not cover well the trade flows between countries that belong to customs unions such as, for example, the North American Free Trade Area, the European Union, and the South African Common Customs Area. The same can be said for the free trade zones that some countries have set up for processing imported materials into manufactured articles.

71. The detail of the international standard customs product and country classification structures implemented worldwide serve statistical as well as administrative purposes. Their commodity and country codes define the elementary aggregates for goods in export and import price indices. Trade values by detailed product and country classification thus are an important source of the weights for goods and transportation and insurance services in export and import price indices.

72. As discussed under the modes of supply, goods follow modes 1 and 2. Mode 1 goods trade and the insurance and transport services trade associated with imports are covered as a by product of customs administration in ports and inland international entry points (e.g., international airports). Customs documents filed by international passengers capture Mode 2 goods trade.

73. In most countries, a customs declaration is required for merchandise imports and exports, whether or not these goods are subject to customs duties (but there are important exceptions to this, as noted above in this section). In principle, a customs declaration identifies the importer or exporter, the product code, the value of the shipment, the number of units involved and other appropriate measures of the good's physical dimensions, duties paid, the country of origin or destination, the port of entry or exit, the mode of transport, the costs of transport, and the costs of insurance and freight. Customs, the statistical office, or another agency process copies of the customs documents to compile statistics on foreign trade.

74. The principal data items on customs documents used in the calculation of trade price and volume indices are:

- *The 10-digit detailed commodity code:* For almost all countries, the classification structure for the first six digits of this classification are from the HS; the last four digits are for national use.[22]

- *The country code:* This is a code designating the country of last known destination for exports of the country of first known origin of imports.

- *The value of the exported or imported commodities:* Shipment values must be converted into national currency to make them comparable with other national statistical aggregates. The values of all shipments reported in other currencies are converted to the national currency for statistical purposes using exchange rates valid for the day that the customs declaration was submitted. These values are determined in current contract prices and are reported as "free on board" (f.o.b.) for exports and as "cost, insurance, and freight" (c.i.f.) for imports.[23,24]

- *The shipping quantity(ies) of exported or imported commodities:* The unit of quantity will vary by product category, and for some 10-digit commodities there may be more than one unit of quantity reported (e.g., "kilograms" and "pieces").

75. Under mode 1 trade, these data elements are recorded on a tariff form for imports or a shipper's export declaration for exports, sometimes combined into a single form as in the European Union's Single Administrative Document. The forms contain entries giving the value of a shipment in cost, insurance, and freight (c.i.f.) for imports or free on board (f.o.b.) for exports. The form will also include a shipping volume, but this often bears

---

[22] The UN (1998) recommended that countries use the HS for the collection, compilation, and dissemination of international merchandise statistics.

[23] Customs record exports on a *f.o.b.* basis and imports on a *c.i.f.* basis. For exports, the same valuation principle is applied in various statistical systems such as the balance of payments (*BPM5*) and the national accounts (*1993 SNA*), which allows the use of unit-value/price indices of exports for deflation purposes without further adjustment to these indices. In the case of imports, both the *BPM5* and the *1993 SNA* recommend that total imports be valued on an *f.o.b.* basis (see *1993 SNA*, paragraphs 14.36 to 14.43 and *Balance of Payments Compilation Guide* paragraph 51) by adjusting (marking down) *c.i.f.*-based values for insurance and freight costs. However, due to difficulties in obtaining detailed imports by commodities (or by country of origin), the detailed imports in the *1993 SNA* are recorded on a *c.i.f.* basis (see *1993 SNA*, paragraph 15.35). To reconcile the different valuation used for total imports and the product components of imports, a global *c.i.f./f.o.b.* adjustment on imports is made (see *1993 SNA*, paragraphs 15.68 to 15.69). Consequently, unit-value/price indices measured on a *c.i.f.* basis are needed for deflating the detailed imports at current prices.

[24] The practice of converting to national currency on the date goods cross national frontiers is only valid for calculating customs duties and export taxes, as this is the date these taxes usually accrue to the government and are payable by the resident importer or exporter. At the end of this section, we argue the value of goods and services exported and imported otherwise should be determined on the date they change ownership. This rarely is the same as the date goods and services cross national frontiers, and often antedates it. Thus, the exchange rate for calculating export taxes and import duties may well differ from the exchange rate determining the national currency value of exports and imports.

only a remote relationship to the quantity of the item actually agreed to between the resident and nonresident counterparties to the international trade transaction bringing the shipment about.

76. Customs data collected under mode 2 for import trade generally are less detailed. The items collected on tariff forms completed by incoming travelers comprise

- a listing of countries visited by the traveler,
- the value of merchandise purchases made abroad, and
- an itemization of the values of purchases by type of good if the total exceeds a prescribed threshold.[25]

77. Customs data collected under mode 2 for export trade may be subject to a higher threshold. However, items carried by a traveler out of country whose aggregate value crosses this threshold legally may be subject to completing full shipper's export declaration.

78. In addition to the gaps in the domain of international transactions customs data cover, there are under-reporting and misreporting problems that include the following:

- Not all of the information required by the form is collected on every declaration, particularly data on insurance and freight.
- Customs administrations collect the declarations mainly for revenue purposes and tend to pay much more attention to the accuracy of the details on import declarations and much less attention to the same details for export declarations, as the latter usually are not subject to customs duty.
- The quality of data on imported commodities varies from country to country; some commodities are subsidized while others are not; and some importers undervalue imports to avoid high import duties.
- Trade among related *direct investment enterprises* and with their parent enterprise may reflect transfer pricing valuations significantly different from market values in order to effect tax advantages for the multinational group.[26]

---

[25] For example, the U.S. threshold is $400 per family for U.S. residents and $200 for nonresidents. The U.S. export threshold is $2,500. See U.S. Customs Service at http://www.customs.ustreas.gov/impoexpo/impoexpo.htm .

[26] Direct investment enterprises are enterprises of which a nonresident institutional unit (corporation, government, nonprofit institution, or household) owns the equivalent of at least 10 percent of the ordinary shares or voting power.

Further regarding mode 2 transactions,

- Both imports and exports of items with high value that are easily concealed may not be captured on the import or export declarations of travelers.

79. Customs data are not always easily accessible to statistical agencies in a timely and regular manner. Among the problems faced by statistical agencies using customs data are delays in receiving it because the customs administration is slow to process declarations. In cases where statistical agencies have access to the individual declarations, there often are delays in receiving the declarations and in dealing with missing declaration forms. As noted in Section III.C, this may affect the frequency and methodology with which the statistical agency can chain new weighting information into export and import price indices.

80. Finally, customs documents and the data recorded on them are dated when the goods cross the national frontier, rather than when the goods change ownership. The latter is the *BPM5* and *1993 SNA accrual basis of recording* that should be used for export and import price indices. These two international standard accounting systems accrue on the change of ownership date to consistently and symmetrically record exports and import between buyers and sellers. Price indices use the (change of ownership) accrual principle to make them fit for their most important uses, as discussed in the Introduction.[27,28]

International Transactions Reporting System

81. Most countries have an international transactions recording system (ITRS) to administer current or former foreign exchange regulations. The ITRS records all transactions between residents and nonresidents in which banks serve as intermediaries. In principle the ITRS covers **both goods and services trade** under **modes 1, 2, and 4**. The ITRS can be a good source for **services** transactions under **mode 4** because it captures the great bulk of repatriated income payments from nonresidents to residents and from residents to nonresidents.

---

[27] These uses were (1) understanding developments in the goods and services component of the balance of payments current account, (2) policy analysis and assessing the effects of exchange rate dynamics on the international competitiveness of a country's producers, (3) escalating the terms of international contracts, (4) forecasting changes in domestic inflation, (5) exchange rate analysis and, (6) estimating GDP volume.

[28] Price indices for customs exports and imports, as opposed to balance of payments exports and imports, make little economic sense for another reason. The accrual principle of the balance of payments and national accounts is broadly consistent with the valuation principle determining the behavior of the buyers and sellers doing the transactions making up exports and imports. This consistency with microeconomic theory allows analysts to understand the economic properties of the price and volume decompositions of these export and import aggregates. In turn, they then can infer the economic consequences of developments in the price and volume components of these export and import aggregates.

82. However, ITRS data vary in coverage from country to country, depending in part on variations in the transaction threshold at which financial institutions must report information into the system.[29] There also are variations in the scope of coverage of international transactions in payment for services. These variations depend in part on the nature of the transactors. The ITRS does not automatically cover internal interenterprise transactions in goods and services between a resident parent and a nonresident direct investment enterprise. Nor does it necessarily cover transactions between a resident direct investment enterprise and a nonresident parent. While such transactions in goods may be detected eventually by customs clearances, they cannot be detected by customs until the goods have been shipped and enter or leave the customs area. This causes potentially large timing errors resulting in trade being allocated to the wrong month, quarter, and/or year. Further, as noted above, the transfer pricing practices of related enterprises produces inaccurate valuations of trade flows.

83. A further problem with ITRS information is that it records transactions on the date of payment rather than the date of change of ownership. The latter is the *BPM5* and *1993 SNA accrual basis of recording* that would be used for export and import price indices.

Specific Agencies Providing Data on Services

84. Exports and imports of services can follow all four modes of trade, but data for services transactions typically are not collected at the border of the economy. [30] Services data usually are collected by several agencies that focus on specific industries. The agencies' survey instruments and databases are specific to the needs of the agency and its data users.

85. The country's ministry or department of transportation database can be a source of information on international transportation exports. For example, these data can be used to select a sample of air carriers that regularly provide data on air freight. The data may include the origin and destination airports, shipment weight, dimensions of shipment, whether shipment is containerized, type of product shipped, type of buyer of the service, and any special services provided by carriers. The same database is used as the primary sampling source for air passenger fares. The required information in this case are data on passenger counts, revenues, origin and destination airports, fare classes for international trips (business, first, or coach class), and fare type (one-way or round-trip).

---

[29] In some countries the threshold may derive in part from banking regulations capturing both domestic and international transactions into an administrative database. In the United States, the threshold is $10,000. It may be higher or lower in other countries.

[30] The import and export services definitions are based on *BPM5* definitions for services. Imports are payments made by residents of the domestic economy to foreign residents for the service and exports are receipts of residents of the domestic economy from foreign residents for the service.

86. The main source of data for exports of travel and tourism goods and services purchased by international visitors during their stay in the country may be the ministry or department of tourism database.[31] This database usually covers expenditure data on the following industries: roundtrip international airfare, tour packages, airport expenditures, transportation, lodging, food and beverages, gifts and souvenirs, entertainment and recreation, and other.

87. The ministry of finance or treasury can be a significant source of information. International trade within a customs union may be covered by requiring additional information itemizing goods and services purchases by source country and sales by destination country on value-added tax returns, for example.

Unit values for elementary items

Customs

88. Customs data are a source of price information because, besides the elementary aggregates determined from customs statistics, shipping unit values can be computed from the data collected on customs documents for each such elementary aggregate. These unit values may or may not be a good source of price information, however. More often than not, the elementary aggregates that can be defined from customs information contain multiple elementary items about which the customs data can say little. Consequently, supplementary surveys also may be needed in identifying and measuring the average transaction prices for the elementary items making up detailed customs aggregates of transactions. Additional surveys clearly also will be needed to measure the prices of the goods and services lying outside the scope of ordinary customs administration such as international trade in services unrelated to shipping imported goods. In addition, the shipping quantity (e.g. weight or piece count) used to calculate the customs unit value may differ from the transaction quantity (e.g., quality adjusted units in the case of complex, variably-featured machinery), whether or not the customs category contains a single elementary item.

C. Survey sources

Index weights for elementary and upper aggregates

89. Customs information does not extend to services not related to shipments comprising, for example, business and financial services. Obtaining share weights for exports of these products requires surveys of the establishments operating in these activities and selling to nonresidents. Obtaining weights for imports of these services

---

[31] The UN and WTO define an "International Visitor" as "any person who travels to a country other than that in which s/he has his/her usual residence but outside his/her usual environment for a period not exceeding 12 months and whose main purpose of visit is other than the exercise of an activity remunerated from within the country visited."

requires surveys of resident purchasers of such services and/or the cooperation of the nonresident suppliers of such services in surveys of their sales to residents.

90. We also noted that customs coverage may not cover fully either international trade within a customs union or trade through a tax-free manufacturing zone, because no revenue is raised on these flows and they are otherwise largely unregulated. Like the services activities in the previous paragraph, the transactions comprising these flows must be captured by supplementing customs data with information from other sources. These other sources typically will be special statistical survey collections, although there still may be administrative sponsors for them. For example, as noted in the discussion of the ministry of finance as an administrative data source, intracustoms union trade may be captured by requiring additional information in the value-added tax filings of businesses.

Direct investment enterprises: Statistics on Foreign Affiliates Trade in Services (FATS)

91. We earlier encountered transfer pricing issues related to the customs valuation of the goods trade of direct investment enterprises. Services transactions may not be captured for these enterprises at all by administrative statistics because, inter alia, the payments may be effected entirely through corporate accounting systems.

92. To fill much of this gap, FATS statistics measure via surveys the commercial presence abroad of service suppliers through their affiliates in foreign markets. Foreign affiliates are units established abroad and majority owned by a service supplier to deliver ***services*** that require close contact with the consumer in his or her home territory at various stages of production and delivery. Such a commercial presence abroad covers juridical persons in the strict legal sense as well as legal entities such as representative offices and branches that share some of the same characteristics as persons.[32] Foreign affiliates are resident entities in their host country and, as noted above, their sales of services to users resident in the host country consequently are not reflected in host country statistics on international trade, which record transactions between residents and non-residents. Like any other resident enterprise, however, their transactions with nonresidents, including those in the headquarters country and in particular the headquarters enterprise and its affiliates in other countries, would be considered part of the international trade of the host country. Thus, FATS statistics relevant for determining the weight of inter-affiliate services trade could be developed from enterprise surveys, or from special collections of data as part of an ITRS.[33]

---

[32] Supply of a service includes production, distribution, marketing, sale, and delivery. Medical services provided by a (foreign owned) hospital, courses in a foreign-owned school, and services supplied by a domestic branch or a subsidiary of a foreign bank are examples of supplies through commercial presence.

[33] To provide useful information for analyzing globalization phenomena comprehensive FATS statistics combine balance of payments, parent enterprise, and affiliate information generally collected from separate questionnaires, and, thus separate administrative and/or survey sources. Depending on the main sources of information used, exports and imports might usefully be disaggregated by primary activity of the affiliate and by product. In addition, trade with the country of the parent enterprise could be distinguished from trade with other countries. FATS statistics also cover a range of variables that are useful for analytical

Unit values for elementary items

93. When customs or other administrative sources are seen to be inadequate for identifying elementary items and tracking their prices, surveys again are used to fill this gap. The surveys may take the form of a collection directed specifically at prices for foreign trade, or may have been undertaken for another purpose, such as compiling the producer price index (PPI).

Export and Import price surveys

94. In the standard methodology, a set of establishments is selected, preferably with the selection probability of each establishment proportional to the establishment's share in imports or exports. This may be accomplished explicitly by probabilistically selecting export and import samples of establishments from lists, or *frames*, of establishments engaged in external trade that are assembled from tariff and export declaration documents. It also is done heuristically by selecting the set of establishments representing the top, say, 50 to 75 percent of the value of trade during the period referenced by the frame. The first are called *probability samples* and the second *cutoff samples*. Both types of samples require the existence of the described frame.

95. Sample transactions then are selected from each establishment. A methodology called *disaggregation* may be used to select a sample of transactions with probability proportional to the importance of the product and transaction type in the establishment's total value of exports or imports. Alternatively, an establishment representative may be asked for the items among those exported or imported that collectively account for, say, 50 to 75 percent of the value of export or import business done by the establishment. For each transaction, the price and the quantity transacted is recorded. In addition, a set of transaction and product characteristics is recorded. Among these characteristics would be the date of shipment as a best convention for the desired change of ownership accrual principle.

96. Identification of elementary items within the elementary aggregate could then proceed using the price (shipment unit value) and the characteristics information to cluster the transactions. Elementary items would be equated with the identified clusters. If there is little bunching or clustering of transactions, a regression analysis of price on characteristics would be run to see if elementary items are effectively distributed along a price-characteristics locus. If the regression fits well, the regression coefficients themselves can be used via so-called hedonic quality adjustment methodologies to adjust for changes in the elementary item composition of the elementary aggregate.

---

purposes, including sales or turnover, output, employment, value added, exports and imports of goods and services, number of enterprises, gross fixed capital formation, and income taxes.

Producer price index

97. Because establishments directly involved in export and import trade often specialize in international wholesale and retail distribution, these distributive activities are likely to be heavily represented in the target population of international transactors in goods and services. However, producers specialized in other activities also may engage directly in transactions with nonresident buyers to sell their output. Hence, the PPI price surveys, which usually cover the nondistributive activities of mining, manufacturing, and energy production and distribution, also can be sources of price data for the export price index provided export transactions in the PPI price sample are identified as such. There is a good a priori reason for integrating price collection between the export price index and the PPI in order to place the minimum response burden on establishments that are contacted to report prices for both the PPI and the export price index.[34] Further, as a PPI is developed for distributive services, PPI coverage of the specialized export-import firms important in the international trade price indices can be employed as part of the calculation of the output price index for the wholesale/retail margin, which is the national accounts measure of output for the distributive services group.

Consumer Price Index

98. Household purchases of goods and services abroad as a result of recreational tourism are in scope for the CPIs of most countries in principle. We discussed this subject in the section on exports and imports and the modes of trade, noting that it would be classified as mode 2 goods trade and usually would be measured via the passenger debarkation documents collected by customs at ports, border crossings, and international airports. It is thought to be an important component of household consumption, particularly for countries too small to have an advanced retail distribution industry, but a short distance from larger countries that do possess such an industry.

99. Few countries currently attempt to collect prices for the imports generated by this cross-border shopping because it would involve collecting prices from nonresident retailers or establishing data-sharing agreements with the statistical offices of neighboring countries. In the latter case, the prices of household mode 2 imports for one country would be in scope for the mode 2 export retail distribution price index and the CPI surveys of its neighboring countries as well as the other countries comprising the tourist destinations of its residents. Household expenditure surveys generally do not exclude goods and services purchased abroad and thus most CPIs include these purchases in their expenditure weights. By implication, statistical offices impute the price index of cross-

---

[34] In some countries, export and import price indices are estimated from components of the wholesale price survey. However, the use of wholesale price indices as proxies for import and export price indices is likely to introduce bias in foreign trade indices. Two important reasons for this are that the price representation in terms of firms and commodity items in the domestic market may be significantly different from the situation in the external market, and that prices usually move in different ways in the domestic and external market owing to the existence of different competitive conditions and tax structures.

border shopping for each good or service item by the price index of domestic purchases of the item.

VI. SETTING UP A SYSTEM TO COMPILE FOREIGN TRADE PRICE INDICES

A. Determining the Elementary Aggregates and Their Weights

100. As noted in the discussion of administrative source data, the customs and ITRS sources of data for weights will not necessarily closely comply with the accrual principle of dating transactions when change of ownership occurs, unless supplementary information on the transaction date can be added to the administrative forms. Thus, to the extent possible, the balance of payments should be the principal source of data on weights, because adjustments are made to the source information in order to compile goods and services trade on a change of ownership basis.

101. Unfortunately, the balance of payments information on goods and services exports and imports may lack the detail required to calculate weights for elementary aggregates at the highest level of product and destination /source detail identified in customs and service trade survey data. A reasonable approach to this problem is to allocate the available balance of payments product aggregates to detailed HS and CPC categories crossed with destination/source by using customs and service trade survey data. Consistency between the coverage of export and import price indices and the balance of payments goods and services aggregates will thereby be assured.

B. Determining the Sample of Elementary Items

Goods: Testing customs elementary aggregates for multiple elementary items

102. The first phase in setting up a compilation system for export and import goods price indices is to identify the elementary items whose prices will be tracked by the index. The logic of this process is to begin with evaluating the data already available from customs sources. The objective is to test whether each elementary aggregate of goods defined by the detailed customs commodity code and destination or source country comprises a single elementary item. If so, because the unit value can be used as a price, a price relative can be formed from them directly, and no further collections are required, assuming customs timing errors are not too severe relative to the change of ownership principle. If not, additional surveys will be required to identify the underlying elementary items within those commodity codes. To evaluate the fitness of customs unit values as the basis for elementary aggregate price indices, we consider two suites of testing protocols.

Price dispersion test

103. Our definition of an elementary item is fundamentally based on the price dispersion of all transactions falling within the group defined by the item. We can consider a given domain of export or import transactions defined by a particular set of commodity and transaction characteristics to be an elementary item if there is very little

price dispersion within the domain at any given point in time. By implication, an elementary aggregate defined by a customs commodity class crossed with destination/source country may satisfy this condition. In this case, there is one elementary item in the elementary aggregate and the unit value that can be derived from customs information may be considered a reasonable estimator of the desired unit value estimate for the elementary item.

104. We would test this for a given month by constructing a unit value for every transaction (customs document) in the domain in that month and measuring the statistical variance of the resulting collection of unit values. A sufficiently low variance measurement would allow us to use the customs unit value of the elementary aggregate as the basis for an index, following the simple unit value relative in equation (17). There are caveats to the accuracy of this empirical test, however.

- First, as noted in the previous section, the quantity measure available on customs documents is a shipping quantity rather than a transaction quantity. The shipping quantity and the transaction quantity must be in a fixed (for all time) proportion to one another across all transactions in the elementary aggregate for the customs (shipping) unit values to be accurate estimators for the desired transactions unit values. They can and often do differ because of recording errors in the shipping quantities on the customs form, as already noted.

- Second, the date of each customs document must be within the same month as the date of the change of ownership of the goods in question (i.e., the date the transaction accrues).

105. If the first condition is seriously violated, the shipping unit values are inaccurate estimators for the desired transaction unit values. If the second condition is violated, the unit values will be classified in the wrong month even if they are correctly calculated. Both of these types of error would tend to cause us to conclude that a customs elementary aggregate is not coincident with a single elementary item, even if it is true.

106. Consider the following price dispersion testing suite to ascertain whether a customs elementary aggregate contains one or multiple elementary items:

- Compute trade values, total shipping quantities, and unit values for each customs document classified into a set of **cells** of data defined by the
    - **Month or quarter** of observation,
    - Detailed (6- to10-digit HS) **commodity code**, and
    - Destination (exports) or source (imports) **country**.
- Compute and examine the mean and standard deviation of the unit values in each cell.
    - For those cells whose unit value coefficient of variation is **greater than 0.5**, **test for multiple elementary items** within the cell.

  - Construct a histogram of the unit values within the cell.
  - Examine the unit values in the cell for a few extreme upper or lower outlier unit values, for example three or more standard errors from the mean unit value, whose removal might significantly reduce the coefficient of variation. If there is evidence of outliers, examine the customs document of the outlier for errors (e.g., in order of magnitude) in the value or quantity recorded, or consult the text description for indications of different product or transaction characteristics explaining the unusual unit value from the document. Examine several quarters of data to verify the persistence of any observed patterns.

- Examine the histogram for evidence of separate clusters of unit values. If two or more clusters are visually identified, examine the customs forms in the identified clusters for comments indicating differences in product or transaction characteristics explaining the difference in the unit values represented between the clusters. Examine several quarters of data to verify the persistence of any observed patterns.
  - If outliers or clustering identified by differences in product or transaction characteristics are not present or occur only once in several quarters, trim the outliers and smallest clusters from the cell and examine the time series of the resultant "winsorized" estimates of unit values for the cell for erratic temporal behavior inconsistent with any available anecdotal evidence about the prices in the product class and concurrent exchange rate movements.
  - If outliers or clustering identified by differences in product or transaction characteristics are persistent (e.g., more than one in five quarters)
  - Recommend adding a coded data item identifying the clusters of items on the customs forms for the product class to permit sub-classifications of customs forms within the existing cell; and/or
  - Consider collecting a survey of export/import transactors (discussed below) to measure and test for statistically significant price determining characteristics within the product cell.
- If there is no conclusive evidence of outliers and clustering but there is an erratic time series of cell unit values at the desired frequency of the export or import price index (e.g., quarterly or monthly)
  - Consider collecting a survey of export/import transactors (discussed below) to measure and test for statistically significant price determining characteristics within the product cell.
- If the cell coefficient of variation in customs form unit values is consistently less than or equal to 0.5 or there is no conclusive evidence of outliers and clustering

and a reasonable time series of winsorized cell unit values at the desired frequency of the export or import price index

  - Consider the commodity/country cell as an elementary item and the cell unit values as the average prices of elementary items.

107. In the presence of some price dispersion in the elementary aggregate, a further test would require additional information on the price-determining characteristics of the transactions in the customs elementary aggregate, if available. If there is no variation in any of these characteristics, we would tend to accept that there is a single elementary item in the aggregate. If, however, there is significant variation in the price determining characteristics, we would conclude that the customs aggregate contains more than one elementary aggregate.

108. Detection of variation in price determining characteristics usually would proceed judgmentally on the basis of any text notes included on the customs documents in the domain of the elementary aggregate. Multiple elementary items also might be suspected if there are dissimilar clusters of shipment unit values within the domain. Credible evidence of multiple elementary items within a customs elementary aggregate would be the basis for augmenting customs data with survey information in order to identify those elementary items by measuring the associated product and transaction characteristics common to the elementary aggregate.

Quantity proportionality test

109. We note for completeness that if the quantities transacted of elementary items within an elementary aggregate are highly correlated from period to period—that is, product quantities remain in roughly fixed proportions—then unit values across elementary items can be used to track price change in the elementary aggregate *even if it fails the price dispersion suite*. Fixed quantity proportions over time at high levels of product detail is, however, an untenable assumption for most price indices, and this is certainly true of export and import price indices. Box 2 illustrates the pitfalls of using unit values to produce a price index for a metals elementary aggregate in a case where there has been no change in prices, but there has been a shift in relative quantities.

110. The challenge to constructing a test of proportional quantities within a customs product-destination/source cell is that it often is not possible to obtain repeated observations of the value and quantity shipped by a given shipper of a given specific product, as this would require a laborious process of going through customs documents from month to month looking for possibilities of matches. In some months for some types of products, there will be few if any matches to be found even if the effort is spent to find them. This tends to bolster the view that if the price dispersion suite fails, the default methodology is to survey transactors in the cell.

111. Nevertheless, an approach to testing for proportional shipping quantities would be to examine the average shipping quantity across quantiles (say, quintiles or deciles) of the values of shipments, and compare relatives of the average quantity shipped between

months for each quantile. If the quantity relatives are all the same or tightly clustered, some support would be lent to the proposition that relative quantities have not changed.

112. The steps involved in designing a survey for a particular elementary aggregate could be enumerated as

- Determine the scope of elementary aggregates that will be the focus of the survey.

Box 2. Unit Values and Product Mix

This example uses import data for three commodities considered to be three specifications of the same item where the nature of the sales contract (spot versus long term) affects the price.

Commodity		Period *t-1*			Period *t*		
2616100010 Source: Shipping volume: metric ton	SILVER ORES AND CONCENTRATES: COPPER CONTENT Orlandia	Value (V) (1)	Quantity (q) (2)	Unit value (p) (3) = (1)/(2)	Value (V) (1)	Quantity (q) (2)	Unit value (p) (3) = (1)/(2)
		Observed consignment customs value and shipping volume					
A –	Acme Ores, spot market transaction, Orlandia metals exchange	300	6	50	600	12	50
B –	Acme Ores, contract with Orlandia Metals Corporation	450	10	45	450	10	45
C –	Metals, Inc., contract with Orlandia Mining Company	1200	30	40	1200	30	40
Total		1950	46	135	2250	49	135
Weighted average unit value (A, B, C)				42.39			45.92

Illustrating the discussion in the text, we have been able to match only three unit value calculations in this customs aggregate between periods *t*-1 and *t*. The price dispersion test for these three would be inconclusive, though possible elementary items would be [A B], which combines on the basis of the shipper (here, Acme Ores) or [B C], which combines on the basis of the type of transaction (here, long-term contract). A quantity proportionality test applied to this example suggests that quantities are not proportional for any combination except [B C]. Hence there are at least two elementary items in this matched subset of customs elementary aggregate 2616100010, namely A and [B C]. Accordingly, it will be necessary to survey transactors in silver ores with copper content in order to accurately measure price change.

To demonstrate the importance of identifying and tracking elementary items in customs aggregates observe that in this example prices remain unchanged, but quantities (product mix) change. This leads to change in the unit value of the customs subset from

$$\mathbf{42.39} = ([\sum_{j=A}^{C} p_j^{t-1} q_j^{t-1}]/3) \text{ to } \mathbf{45.92} = ([\sum_{j=A}^{C} p_j^{t} q_j^{t}]/3).$$

In other words, the unit-value index based on data for specific transactions A, B, and C equals **108.33** (or 45.92/42.39). On the other hand, because the price relative of each of the individual goods is equal to **one** between *t*-1 and *t* in our example, any price index formula applied to the price, quantity, and value data for varieties A, B, and C would yield the value **100.00** for the commodity group comprising them. The unit value thus has a **composition error** of 108.33 – 100.00 = **8.3 percent**.

Goods and services: Surveying international transactors to identify elementary items

- When a customs elementary aggregate is deemed to contain multiple elementary items, or in order to survey goods and services transactions beyond the scope of customs sources, it is necessary to design surveys of international transactors to obtain elementary item prices. In part because statistical surveys can be designed for export and import price indices whereas customs administrative files are designed principally for tax collection, surveys can capture information on the characteristics of goods and services to a level of specificity beyond what is required to identify elementary items. The kinds of characteristics of products and transactions on which survey information is to be recorded for each product type are determined as a result of review of trade association literature, comment fields on customs forms, various press sources, and previous survey experience with the elementary aggregate, if available.
    - These aggregates generally will be defined for goods by the same detailed Harmonized System codes used by the customs administration, crossed with destination (exports) or source (imports) country. The particular goods aggregates subject to survey will be those that testing has indicated contain multiple elementary items, or for which no customs data are available.
    - For services, the best set of definitions for elementary aggregates would be the five digit codes under the United Nations Central Product Classification, version 1.0, divisions 5-9.
- Assemble a comprehensive list or frame of resident international transactors in the various goods and services to be surveyed.
    - For goods, transactor sample frames normally are set up using the customs source, as the names of the seller and buyer should be on each customs form. The seller's name would be captured from export declarations to form an establishment sample frame for exports, and the buyer's name would be captured from tariff filings to form the frame for imports.
    - Lists of establishments engaged in international trade in services also may be set up from administrative sources, for example exporters of services might be assembled from individual and business income tax filings reporting a foreign source of, respectively, earned income and sales, after making a comparison with foreign sales of goods from examination of shippers' export declarations collected by customs. A good if less focused alternative would be implementing and/or expanding general establishment survey collections for service activities, such as for the PPI. These collections are based on survey frames compiled from lists of resident establishments and enterprises extracted from business registers, or from frames assembled from tax filings. Elementary items comprising export transactions can be determined and collected from the same sample

of establishments used for these general collections, but large increases in sample size may be required to capture an adequate sample of elementary items for external trade activity.

  - However, for transportation and transportation insurance activities related to imports, if the transactor information is recorded on properly completed customs documents then customs sources can be used to assemble the survey frame of establishments.

113. Other factors to consider in sourcing data for trade price indices from direct price surveys are

- The elementary items should be periodically reselected within the elementary aggregates, at least every five years, to keep the sample representative of current trade flows—usually a costly process for both the statistical agencies and the respondents.
- For customs elementary aggregates containing multiple elementary items, the coverage of commodities and transactors from samples may be volatile from month to month or quarter to quarter if infrequent (or casual) transactors account for an important share of exports or imports.
- Through a properly designed questionnaire and good response from sampled establishments, the timing of prices collected through direct surveys can be made to closely approximate the change of ownership accrual principle required by the *BPM5* and *1993 SNA*.

114. Box 3 provides a stylized example of how both customs and survey sources of price data could be incorporated into an import price index. In this example customs classes

- 2616100010 SILVER ORES AND CONCENTRATES: COPPER CONTENT;
- 2701200000 BRIQUETTES, OVOIDS AND SIMILAR SOLID FUELS FROM COAL, and
- 2707100000 BENZENE, WEIGHT OF AROMATIC CONSTITUENTS GREATER THAN NONAROMATIC

are considered to comprise only one elementary item, while

- 8419899085 INDUSTRIAL MACHINERY, PLANT OR EQUIPMENT FOR THE TREATMENT OF MATERIALS, INVOLVING A CHANGE IN TEMPERATURE

comprises multiple elementary items. Hence, a sample of elementary items is developed for industrial machinery, comprising

- Cracking tower, heavy crude oil feedstock; mfr: Petro-Equipment Corporation

Box 3. Using Price Surveys and Customs Unit Values in the Same "Hybrid" Index

Commodity/source (destination) *Trade index item group – import example*	Period t-1			Period t		
	Value (V) (1)	Quantity (Q) (2)	Unit value or price (P) (3) = (1)/(2)	Value (V) (4)	Quantity (Q) (5)	Unit value or price (P) (6) = (4)/(5)
1 – 2616100010 SILVER ORES AND CONCENTRATES: COPPER CONTENT; Source: Orlandia; Shipping volume: metric tons	300	6	50	1200	20	60
2 – 2701200000 BRIQUETTES, OVOIDS AND SIMILAR SOLID FUELS FROM COAL; Source: Mineland; Shipping volume: metric tons	450	10	45	450	10	45
3 – 2707100000 BENZENE, WEIGHT OF AROMATIC CONSTITUENTS GREATER THAN NONAROMATIC; Source: Lubovia; Shipping volume: metric tons	1200	30	40	600	22	27
Total value of unit value items	1950			2250		
4 – 8419899085 INDUSTRIAL MACHINERY, PLANT OR EQUIPMENT FOR THE TREATMENT OF MATERIALS, INVOLVING A CHANGE IN TEMPERATURE; Source: North Machindia.	***600***			***700***		
The following specific transactions collected from a survey sample:						
A – Cracking tower, heavy crude oil feedstock; mfr: Petro-Equipment Corporation	***500***		***500***	***500***		***500***
B – Paint drying booth; 4mx10m; mfr: Radiant Products, Pte.	***100***		***10***	***200***		***30***
Total value of hybrid items (unit value and directly priced)	**2550**			**2950**		

Unit value price index for items 1-3, and also aggregate unit value price index if index for 1-3 is imputed to item 4

Laspeyres: $[300/1950 \times 60/50 + 450/1950 \times 45/45 + 1200/1950 \times 27/40] \times 100 =$ 83.08

Paasche: $([1200/2250 \times (60/50)^{-1} + 450/2250 \times (45/45)^{-1} + 600/2250 \times (27/40)^{-1}])^{-1} \times 100 =$ 96.20

Fisher Ideal: $[(83.08 \times 96.20)^{1/2}] =$ 89.40

Elementary aggregate price index for item 4

Laspeyres: $[500/600 \times 500/500 + 100/600 \times 30/10] \times 100 =$ ***133.33***

Paasche: $((500/700) \times (500/500)^{-1} + (200/700) \times (30/10)^{-1})^{-1} \times 100 =$ ***123.53***

Aggregate hybrid external trade price index

Laspeyres: $1950/2550 \times 83.08 + 600/2550 \times$ ***133.33*** = **94.90**

Paasche: $(2250/2950 \times (96.20)^{-1} + 700/2950 \times (123.53)^{-1})^{-1} =$ **101.53**

Fisher Ideal: $[(94.90 \times 101.53)^{1/2}] =$ **98.16**

This example presumes that the elementary aggregates silver ores with copper content, coal briquettes, and aromatic benzene each comprise a single elementary item and consequently that period to period relatives of their unit values are proper estimators for their price indices.

- Paint drying booth; 4m ×10m; mfr: Radiant Products, Pte.

VII. COMPILATION ISSUES

115. Beyond the comprehensiveness and coverage of the source data, the quality of trade indices depends on how well certain issues are addressed in the compilation process.

A. General

Quality change

116. Significant changes in the characteristics of the commodities selected for the construction of measures of price change can be a major source of error if not handled properly. For the prices of these commodities to be compared over time, each price should be preceded by a full enumeration of characteristics, particularly in the case of manufactured commodities. In this way, another price may be declared comparable to an existing one if its accompanying list of characteristics matches the first. Otherwise, adjustment for quality differences between the two prices should be made. In most statistical agencies, quality changes are adjusted for using direct and estimation techniques. Direct adjustment involves assigning a monetary value to the quality difference and then adjusting the price for this difference. The standard estimation techniques are the overlap pricing technique, link technique, or use a statistical regression model (hedonic regression).

117. **Overlap pricing** is limited to situations where old and new products coexist in the market for at least one period. Once a decision to substitute the new variety for the old product is made, the price of the new variety should be used to compile the index. This implies the imputation of a base price that reflects the same level of quality as the new variety. To get this price, we multiply the base price of the old variety by the ratio of the new variety's price to the old variety's price in the overlapping period.

118. **The link technique** is employed when neither overlapping prices nor a direct estimation of the cost of quality difference between the old product and its substitute exist. To substitute the replacement variety to the discontinued one, we first impute a price for the old variety in month *t* by multiplying its previous period price by the average of price change for other varieties in the same category of products. The imputation of a base price that reflects the same level of quality as the new variety is then required. To obtain this price, we multiply the base price of the old variety by the ratio of the new variety's price to the old variety's imputed price in month *t*.

119. **Statistical regression models** (hedonic models) assume that the price of different models or varieties is related to the quality characteristics of the item. The prices paid for the products are regressed on the various characteristics to estimate the contribution to the final price of each characteristic. When characteristics change, the value of the quality change can be estimated from the regression equation. The amount of price change which should be reflected in the price/unit-value index is then derived as a residual.

120. The assessment of product quality is a very difficult task, especially for price collectors dealing with all kinds of commodities and respondents. Nevertheless, an agency compiling trade price indices could take measures to ensure that, at least, some minimum adjustment for quality effect is undertaken. For example, the agency could perform any number of measures, including: (1) providing appropriate training for price collectors in understanding the need for a replacement product and identifying the best substitute; (2) instructing these collectors to periodically ask the respondents questions concerning the main characteristics of a given commodity, such as the model, the size, and other major features; and (3) including in the collection questionnaire as many details as possible regarding the characteristics of the commodities to provide the collectors with sufficient detail to make judgments about replacements.

121. For direct quality adjustment, consider the example in Box 4 (commodity item number 4 of Box 3) and assume that the quality of commodity B, the paint booth, changed. Accordingly, an option was added that was valued as being worth 5 in the market. In the example, commodity C now sells for 30. As a result of this new information, its price relative decreases from $300.00 = 30/10 \times 100$ to $280.00 = (30 - 2)/10 \times 100$.

Unique and infrequently traded commodities

122. Unique goods have characteristics that are unlikely to be repeated in future production at the (usually monthly) frequency of the index, if at all. These tend to be capital goods such as ships, aircraft, and equipment made to order. Such goods are difficult to describe for pricing purposes. This is because of the difficulty of identifying a proper list of price-determining characteristics, since this exercise implies a thorough review of all the functions of the equipment and their operating characteristics. Also, attempts aimed at attributing a value to a particular configuration of components often are very subjective. Exports and imports are not affected in the same way by the difficulties involved in pricing a unique good. While an individual exporter usually provides guidance on the characteristics and pricing of his unique good, an importer may not be able to do so because he generally must depend on information supplied by the foreign supplier. This information may be incomplete for describing an elementary item.

123. One approach to compiling price indices for these goods is for the compiling agency needs to reach an agreement with the respondent to establish a *model pricing* arrangement. Accordingly, a typical model of the kind of goods the trader deals in is determined and the respondent is requested to report, in each period, the price that the trader would expect to pay (importer) or receive (exporter). Some of the components of a good may not have an explicit market price, in which case proxies are often used. A proxy for the price of a component can be estimated as a combination of indices of employee compensation in the manufacture of the component in question and the prices of the materials used. For a model to be representative, its definition should be precise and include reference to trading conditions. In an import price index for telecommunications equipment, for example, one should consider such elements as the package, country of origin, level of competitive conditions, and method of payments.

Box 4. Effect of Quality Change

Commodity	Period *t-1*			Period *t*		
	Value (V) (1)	Quantity (Q) (2)	Price (P) (3) = (1)/(2)	Value (V) (1)	Quantity (Q) (2)	Unit value (P) (3) = (1)/(2)
4 – 8419899085 INDUSTRIAL MACHINERY, PLANT OR EQUIPMENT FOR THE TREATMENT OF MATERIALS, INVOLVING A CHANGE IN TEMPERATURE; Source: North Machindia. ***The following specific transactions collected from a survey sample:***	600			700		
A – Cracking tower, heavy crude oil feedstock; mfr: Petro-Equipment Corporation	500		500	500		500
B – Paint drying booth; 4mx10m; mfr: Radiant Products, Pte.	100		10	200		30

It is known that the product specification changed for elementary item B. **Features were added that are worth 2 in the market in period *t*.** To make the item specification and the associated price in period *t* comparable to that in period *t* – 1, the period *t* price is adjusted downward by the value of the quality change, and then included in the index calculation for commodity/source (destination) 4.

Price index for item 4 without quality adjustment

Laspeyres: $[500/600 \times 500/500 + 100/600 \times 30/10] \times 100 =$ ***133.33***

Paasche: $((500/700) \times (500/500)^{-1} + (200/700) \times (30/10)^{-1}\ )^{-1} \times 100 =$ ***123.53***

Price index for item 4 with quality adjustment

Laspeyres: $[500/600 \times 500/500 + 100/600 \times (\mathbf{30\text{-}2})/10] \times 100 =$ ***130.00***

Paasche: $((500/700) \times (500/500)^{-1} + (200/700) \times ((\mathbf{30\text{-}2})/10)^{-1}\ )^{-1} \times 100 =$ ***122.50***

For period *t* + 1, the price will be compared with the observed value in *t* of 30, because at that time, the new features incorporated in period *t* would also have been present in *t* + 1.

Seasonality and discontinuities

124. Some commodities move in and out of trade at regular intervals for seasonal reasons, while others move in and out at irregular intervals. The result in both cases is periodic unavailability of data on these commodities. In both cases, there is a need to impute missing data on the basis of information available for commodities on the same HS level. The imputation is important to avoid too many simultaneous disappearances that seriously affect the representativeness of the sample of commodities in question.

125. Seasonality often is associated with commodities such as food and beverages, and clothing.[35] Due to seasonal unavailability of fresh fruits and vegetables, the imports and exports of these commodities may alternate with imports of frozen products. Summer garments tend to be imported in winter and winter garments tend to be imported in summer. The imputation of missing unit values/prices data should be based on the short-term relative change of the index of the next-higher-level commodity group. An illustration of this is provided in Box 5. A similar imputation procedure can be applied for commodities that leave and enter trade flows at irregular time intervals.

126. It may be useful to produce seasonally adjusted unit-value or price indices for analytical purposes. Time-series fluctuations can be smoothed using methods such as X-12 ARIMA from the U.S. Bureau of the Census, a moving average, 12-base monthly prices instead of one, and comparison with the previous year.[36]

B. Unit Values as Elementary Aggregate Indices

Heterogeneous commodities and commodities lacking volume data

127. Heterogeneous commodities and commodities for which no quantity data are obtained by customs authorities should not be directly represented in unit-value indices. However, the movements of such commodities should be reflected in the unit-value index of the next level of aggregation (higher aggregate). An example is parts for televisions, which would likely be better represented by movements in unit values of televisions. However, if it appears that these unit values are erratic, a second-best solution would be

---

[35] The U.S. Bureau of Labor Statistics (1999) report on international trade price indices and seasonal commodities concluded that seasonality in the value of foreign trade is less than in the value of domestic sales and that evidence for price seasonality is even slimmer in foreign trade than on the domestic side (consumer price index or producer price index).

[36] The X-12 ARIMA seasonal adjustment method requires a minimum of five years monthly data (see U.S. Bureau of Labor Statistics, 1999)

Box 5. Imputation of Missing Observations

Commodity	Period t-1			Period t			
	Value (V) (1)	Quantity (Q) (2)	Unit value (P) (3)=(1)/(2)	Value (V) (4)	Quantity (Q) (5)	Unit value (P) (6) = (4)/(5)	Unit value index (7) = (6)/(3)
1 – 2616100010 SILVER ORES AND CONCENTRATES: COPPER CONTENT; Source: Orlandia; Shipping volume: metric tons	300	6	50	1200	20	60	120.00
2 – 2701200000 BRIQUETTES, OVOIDS AND SIMILAR SOLID FUELS FROM COAL; Source: Mineland; Shipping volume: metric tons	450	10	45	450	10	55	122.22
3 – 2707100000 BENZENE, WEIGHT OF AROMATIC CONSTITUENTS GREATER THAN NONAROMATIC; Source: Lubovia; Shipping volume: metric tons	1200	30	40	0		***48.89***	***122.22***
Total	1950			1650			

We wish to produce a price index aggregating three customs elementary aggregates in this example, each comprising a single elementary item. The imputed price of aromatic benzene, item 3, in the second period is calculated by multiplying the previous period price of 40 by the relative change in the unit value of the 'similar' coal briquettes item 2 or 122.22 to obtain 48.89 in the second period. Notice that similarity is determined here by the product classification, which would be the standard case in practice: briquettes and benzene are in the same three digit HS group (270), while silver ores are in another (261). The imputed price relative for benzene is then used in the price index as follows:

Laspeyres: $300/1950 \times 120.00 + 450/1950 \times 122.22 + 1200/1950 \times 122.22 =$ 121.88

Paasche: $(1200/1650 \times (120.00)^{-1} + 450/1650 \times (122.22)^{-1} + 0/1650 \times (122.22)^{-1})^{-1} =$ 120.60

It is evident from this calculation that for an item for which there is no shipment in the current period, imputation is needed for the Laspeyres calculation, but not the Paasche, since the current period weight of the unobserved item in the latter is zero.

to impute the unit values of the next higher aggregate in the HS. [37] Such an imputation procedure needs to be carefully reviewed from time to time to ensure representativeness of all commodities subject to foreign trade.

128. Heterogeneous products usually consist of manufactured products ready for final use. They typically include machinery, parts for various products such as appliances, electronics, transport equipment, furniture, toys, pharmaceutical products, and cosmetics.[38] For practical reasons, it is usually desirable to exclude such commodities from the index, and allocate their respective weights to other related commodities. For parts of dishwashers, for instance, it may be best to allocate the weight for parts to the weight of the dishwashers themselves. If the decision were made to calculate an index for a specification of a very heterogeneous commodity, it would be important that the specification be as clearly defined as possible to avoid the risk that the elementary aggregate price index would reflect quality (and hence volume) changes in addition to price changes. In specifying the elementary item, it is important to include information on quality, quantity, and most characteristics that may influence price levels.

Size of shipment

129. The size of shipment or quantity is an integral part of any unit-value calculation. Beyond this, as we suggested in the alternate method of implementing the quantity proportionality test, it can also be considered an extension of the commodity description, that is, the customs data could be stratified according to ranges of quantity shipped where this is feasible. Before computing the average quantities for the upper and lower quantiles of an HS category, it is advisable to delete the shipments with the highest and lowest unit values to eliminate the effects of obvious outliers. If a unit value approach has been deemed acceptable for a given customs elementary aggregate, rules be established so that individual shipments are excluded if they fall outside predetermined limits; for example, those that constitute more that 120 percent of the average unit value (2.2 x unit value), and less than 70 percent of the average unit value (0.3 x unit value). These ranges should be reviewed and updated from time to time to capture actual changes in prices.

130. Ideally, the process should be based on logical conditions permitting the maximum level of automation. A good example of this is the Statistics Norway system,

---

[37] In its project of compiling world trade deflators, the UNCTAD (1999) used robust regression techniques to exclude commodities for which unit values showed abnormal changes. The approach applied consisted of (1) computing logarithms of year-over-year ratios of deflator values (log ratios); (2) for a biannual set of log ratios: computing the medians of the log ratios, computing standard ranges of log ratios using a particular formula of cutoffs, and identifying log ratios lying outside the ranges, or outliers; and (3) eliminating the deflator values that cause the outliers.

[38] In a statistical sense, a class of commodity is homogeneous over time when (1) the variance of unit values are predictable over time within a reasonable tolerance on the basis of previous data; and (2) the variance between means for subcategories such as country or port/tariff breakdown within a class is small and stable over time.

which has a built-in automated process applied to every commodity at the Combined Nomenclature (CN) 8-digit level using the following rules:

- The aggregate variation in price per unit by destination/source country must be within prescribed limits.
- There must be at least 20 shipments of the good each year.
- There must be shipments of the good in at least eight months of the year.
- The value of the CN-8 commodity must exceed 100,000 Norwegian kroner per year (or about US$12,500).

Terms of transactions

131. Other terms of the transactions, such as the mode of transport or the terms of delivery, could be used to narrow the commodity/country classification. Terms of the transactions that prove to be important and can be consistently collected may vary by product and by whether the items are exported or imported.

132. In theory, any data item collected on the customs declaration form could be used to refine the lowest level of calculation. The primary goal of refining the classification system is to increase the homogeneity of the resulting calculation units. This approximates the detailed product specification that would be collected for the production of a price index.

133. In order to decide which data items should be used to refine the classification system, it is necessary to stratify the data in various ways and to verify empirically whether the breakdowns significantly increased the homogeneity of the resulting units. It also is necessary to identify the data items collected and tracked on a regular basis.

134. Of course, improvements to the unit-value indices through these refinements will become increasingly expensive. Eventually, the only cost-effective way of making further improvements would be to move toward the survey sources of price data for elementary items, as surveys can employ systematic procedures to identify elementary items that can be repriced from month to month.

C. Price Indices for Elementary Aggregates

Instability in the trader population

135. Some elementary aggregates are composed mostly of establishments that frequently enter and exit the market, say, within a year. To the extent that entry and exit are not synchronized across market participants, the imputation methods used for seasonal items and new goods can handle this.

Shipment not made in the current period

136. Some elementary items included in the index list may not be shipped in certain periods. To compile the index for the elementary aggregate to which they belong, the common practice is to impute the price changes for these products with the index for the elementary aggregate (e.g., based on the price information from the other elementary items in the elementary aggregate). There may be a case in some customs product aggregates for imputing the previous period price multiplied by the exchange rate index for the partner country. Such a case would be an elementary aggregate dominated by long term nonescalated contracts.

Prices appear not to be transaction prices

137. The calculation of trade price indices requires the use of transaction prices, which include any taxes levied on the item. In some instances, reported prices may suggest barter arrangements, transfer pricing (between related enterprises) or some other non-commercial price. To calculate price indices for the corresponding commodities, it is necessary to ask the respondent to provide a reasonable estimate of a normal transaction price.

Significant price variations within a commodity, between country of destination (or country of origin)

138. Where there are large price variations reported by different traders for the same commodity, this may mean genuine differences in quality or differences arising from different pricing structures applying to different markets, or different exchange rate effects applying to different countries. Our price dispersion testing suite would automatically identify this aggregate as requiring a survey data source, but even for the indexes produced from survey sources, the differences in level may coincide with widely divergent price *movements* over time and therefore have a significant impact on the elementary aggregate index. Weights within the elementary aggregate matter in this case, and care needs to be taken to ensure that the internal weights allocated to the different traders reasonably approximate their annual market shares within the aggregate.

VIII. DATA DISSEMINATION AND REVISIONS

A. Data Dissemination

139. Tables of the indices compiled, notes explaining movements in these series, and a technical description of compilation procedures should be disseminated to the public.

140. It is common practice to publish a summary table that includes indices representing price movements for all imports and exports. It is also helpful to publish various aggregate groupings that interest policymakers, such as manufactured and nonmanufactured goods, petroleum and nonpetroleum imports, and agricultural and nonagricultural exports. Again, a user survey might shed light on which groups would be most useful.

141. In addition to publishing the unit-value indices/true price indices, volume indices, and nominal and constant price trade flows, it is useful to disseminate relative or absolute weights of any component indices as well as detailed product categories. By publishing these weights, users of the data will be able to compute their own index groupings for analysis from the detailed data.

142. A text explanation of price movements for aggregate unit-value/price categories in terms of the contribution to change of their components, as well as any economic events directly affecting price measurements is important to include with the release of data on export and import price indices. This assists users to place movements in the indices in economic context.

143. The release should include tables listing import and export merchandise goods indices at a more detailed level of the HS or the SITC (e.g., the two-digit level of aggregation). While a fairly high level of detail may be needed for internal use, it is advisable to confine published data to indices for which there is a good level of confidence in their reliability and accuracy.

144. Finally, users should have access to a description of the methodology, limitations of the data, and future plans for improving the indices. A detailed document could be published separately from the data and updated periodically to reflect methodological changes. In addition, a short, user-friendly summary could be reproduced for each release that briefly describes the methodology and classifications employed.

B. Data Revisions

145. Revisions are an important element of good trade indices compilation practice to the extent that they ensure that users are provided with timely and accurate data. The existence of a well-established and transparent revision policy is an effective tool for reducing tensions between timeliness of data and ensuring the good quality of these data.

146. Changes in the economy often entail large variations in the prices/unit values of exported/imported commodities as a result of changes in quality, sporadic trading in some commodities, and a change in the composition of trade regarding elementary items within elementary aggregates and elementary aggregates within the higher level aggregates. This is particularly true of electronic goods, machinery, and vehicles. The reliability of export and import price indices can be maintained by revising the list of commodities and weights on a frequent basis, ideally every year. However, this requires the availability of timely annual data on expenditures and/or sales that allows systematic use of the most recent annual weights available and implementation of an index chaining methodology.

147. In addition to updates of weights and the list of elementary items covered, trade indices may be revised to reflect new information about historical periods. As needed and with adequate advance notice to users, revisions may be made to indices for the past two to three years in order to correct for trade documents processed after the index processing cutoff date or for misclassification of trade documents by month or product class. Revisions to past data are not without potential problems and may draw criticism if not properly handled. Revisions are inconvenient to users faced with updating their databases

and applications. More importantly, revisions to past data may cause users to feel uncertain about current levels of and movements in foreign trade indicators and the policy actions taken on the basis of these indicators. To alleviate these uncertainties, the reasons for the revisions, the way they were conducted, their outcome, and explanations of major differences from previous estimates should be clearly presented to users.

IX. CONCLUSIONS AND RECOMMENDATIONS

148. The calculation of export and import trade statistics in volume terms (constant prices) is an important part of national statistical data programs, particularly national accounts price and volume indicators. Macroeconomic analysis and policymaking depend essentially on the accurate, timely, and reliable production of these statistics. The most commonly compiled types of merchandise trade indices are unit-value and true price indices.

149. Both price and unit-value indices suffer from some common problems because (1) there often are significant variations in prices and quantities between periods, so that index weights and the changes in those weights matter; (2) price levels differ between elementary items within elementary aggregates due to differences in product and transaction and destination/source characteristics between transactors; (3) transactions are denominated in different currencies and require properly synchronized data on exchange rates; (4) there are problems with units of measurement, particularly regarding services; (5) there exist unique and infrequent goods; (6) there exists some instability in the population of potential reporters; (7) prices are misreported (quantities and /or values, in the case of unit-value indices); and (8) there are classification errors (mainly affects unit-value indices). By and large, the impact of these problems on the quality of the indices compiled can be greatly moderated

- By properly specifying and fully describing the product and transaction characteristics the elementary items in the index, and
- Using these data in elementary aggregate index calculation to compare the prices of exactly the same elementary items over time and to impute missing price observations.

150. For elementary aggregates of goods, the customs unit-value index has the advantages (1) the cost collection of basic information (customs data) is low, (2) goods coverage generally is comprehensive, and (3) customs is a source of actual merchandise transactions. Its drawbacks are first that the basic information from customs documents that is not directly relevant for collecting revenue or implementing export regulations may not be properly edited and is consequently inaccurate or not reported. Second, customs elementary aggregates more often than not comprise more than one elementary item, and when this is the case, the unit values produced from customs data suffer from compositional effects.

151. For both goods and services, using survey sources to identify elementary items within elementary aggregates helps insure against compositional errors, and, for services

may be the only source of price information. Properly identifying and tracking the prices of elementary items using survey sources is generally costly to design and collect and for goods should be implemented on an elementary aggregate basis, after screening the customs data for evidence of multiple elementary items.

152. This paper recommends that price information for export and import price indices of goods be obtained from both customs and survey sources. In view of the cost of survey design and data collection, this "hybrid" of data sources for prices can be more efficient than taking a purist view that survey sources should be developed for all elementary aggregates. On the other hand, elementary items should be identified correctly, regardless of the source, so as to compile an accurate price index that is free of the quantity and quality effects found in a measure of volume. There is little alternative to developing survey sources of price data for services.

153. Concerning the index formula to be used for calculating trade indices, both Paasche and Laspeyres, as well as geometric Paasche and geometric Laspeyres indices should be produced for goods, as weight data for the Paasche indices should be available on a timely basis from customs sources. Using these components, the superlative Fisher ideal or Törnqvist indices also can be compiled with little additional effort. Annually chained superlative indices will be the most accurate indicators of price movement and should be the principal headline series, with the others as analytical devices.

154. Monthly or quarterly releases should include data, description, and methodology. Less frequent bulletins should contain detailed tables of indices by product destination/source, and, possibly industry of the reporting establishment, as well as a detailed description of the compilation techniques and statistical classifications employed.

REFERENCES

Archibald, Robert, 1977, "On the Theory of Industrial Price Measurement: Output Price Indexes," *Annals of Economic and social Measurement*, Vol. 6, No. 1, Winter, pp. 57–72.1

Balk, Bert, 2002, "Price Indexes for Elementary Aggregages: The Sampling Approach," Manuscript, Methods and Informatics Department, Statistics Netherlands, P.O. Box 4000, 2270 JM Voorburg, The Netherlands.

Boskin, Michael J., Ellen Dulberger, Robert Gordon, and Dale Jorgenson, 1996, "Toward a More Accurate Measure of the Cost of Living," *Final Report to the U.S. Senate Finance Committee* (Washington: United States Congress).

Carruthers, A.G., D. J. Sellwood, and P. W. Ward, 1980, "Recent Developments in the Retail Prices Index," *The Statistician* 29, pp. 1–32.

Coggeshall, F., 1887, "The Arithmetic, Geometric and Harmonic Means," *Quarterly Journal of Economics* 1, pp. 83–86.

Commission of the European Communities, International Monetary Fund, Organization for Economic Cooperation and Development, United Nations, United Nations Conference on Trade and Development, and World Trade Organization, Forthcoming, *Manual on Statistics of International Trade in Services*, New York: United Nations (http://unstats.un.org/unsd/sna1993/introduction.asp).

Commission of the European Communities, International Monetary Fund, Organization for Economic Cooperation and Development, United Nations, and World Bank, 1993, *System of National Accounts 1993*, New York: United Nations.

Dalén, J., 1992, "Computing Elementary Aggregates in the Swedish Consumer Price Index," *Journal of Official Statistics* 8, pp. 129–47.

Diewert, W. Erwin, 1976. "Exact and Superlative Index Numbers," *Journal of Econometrics*, Vol. 4, No. 2 (May), pp. 115–45.

———, 1978, "Superlative Index Numbers and Consistency in Aggregation," *Econometrica*, Vol. 46, No. 4. (July), pp. 883–900.

———, 1983, "The Theory of the Output Price Index and the Measurement of Real Output Change," in *Price Level Measurement*, ed. by W. E. Diewert and C. Montmarquette, (Ottawa: Statistics Canada).

———, 2002, "Harmonized Indexes of Consumer Prices: Their Conceptual Foundations" European Central Bank Working Paper No. 130 (www.ecb.int).

———, and Robert Feenstra, 1999, *International Trade Indexes and Seasonal Commodities* (Washington: U.S. Bureau of Labor Statistics).

Diewert, W. Erwin, and Catherine J. Morrison, 1986, "Adjusting Output and Productivity Indexes for Changes in the Terms of Trade," *Economic Journal* Vol. 96, No. 383 (September), pp. 659–79.

Eichhorn, W., and J. Voeller, 1976, "Theory of the Price Index, Fisher's Test Approach and Generalizations," *Lecture Notes in Economics and Mathematical Systems,* Vol. 140 (Berlin: Springer-Verlag).

International Monetary Fund, 1993, *Balance of Payments Manual, Fifth Edition* (Washington: International Monetary Fund).

———, 1995, *Balance of Payments Compilation Guide* (Washington: International Monetary Fund).

Konüs, A. A., 1924, "The Problem of the True Cost of Living," translated in *Econometrica*, Vol. 7 (1939), pp. 10–39.

National Research Council, 2002, *At What Price? Conceptualizing and Measuring Cost of Living and Price Indexes* (Washington: National Academy of Sciences).

Schultz, Bohdan, 1983, "Linking Price Index Numbers," in *Price Level Measurement*, ed. by W. E. Diewert and C. Montmarquette (Ottawa: Statistics Canada).

Törnqvist, Leo, 1936, "The Bank of Finland's Consumption Price Index," *Bank of Finland Monthly Bulletin*, Vol. 10, pp. 1–8.

United Nations, 1981, *Strategies for Price and Quantity Measurement in External Trade*, Series M, No. 69 (New York: United Nations).

———, 1983, *Price and Quantity Measurement in External Trade: Two Studies on National Practices*, Series M No. 76 (New York: United Nations).

———, 1998, *International Merchandise Trade Statistics: Concepts and Definitions*, Series M, No. 52, Rev. 2 (New York: United Nations).

United Nations Conference on Trade and Development, 1999, *The HS-based World Trade Deflator System, including selected results for the period 1988–1996* (New York: United Nations, 3rd rev. ed.).

United States Customs Service, *Importing and Exporting* (http://www.customs.ustreas.gov/impoexpo/impoexpo.htm).

World Trade Organization, 1994, *Final Act of the 1986–1994 Uruguay Round, Annex 1B. General Agreement on Trade in Services* Geneva: World Trade Organization (http://www.wto.org/english/docs_e/legal_e/final_e.htm).