2. Unit Value Indices

A. Introduction

2.1   Export and import price indices (XMPIs) are compiled by three general methods, the nature of which is largely dependant on the source data used. The first and predominant method,[1] in terms of the number of countries using it, uses unit value indices compiled from detailed import and export merchandise trade data derived from administrative customs documents. Unit value indices are not price indices since their changes may be due to price *and* (compositional) quantity changes. However, they are used by many countries as surrogates for price indices.[2] The second method is to compile price indices using data from surveyed establishments on the prices of representative items exported and imported. The surveyed prices should be of items that are defined according to detailed specifications, so that the change in price of the same item specification can be measured over time. Third, there is a hybrid approach that involves compiling establishment survey-based price indices for some product groups and customs-based unit value indices for others. It is usually the case with hybrid indices that one type of index is the exception, used when the principle type of method is considered less suitable than the alternative. For example, some oil-producing countries use unit value indices, but because detailed reliable data are readily available from the oil-producing establishments for this important sector, the unit value indices are complemented by survey-based price indices or price quotations from international markets. Alternatively, price indices may be the norm, but unit value indices exceptionally used for relatively homogeneous product groups whose composition of traded goods and services, in terms of the quality mix of items traded each period, is considered to be unlikely to change significantly.

2.2   International guidelines on choosing among these alternatives methods—*A Strategy for Price and Quantity Measurement in External Trade*— were provided by the United Nations (1981) and are briefly outlined in Section B of this chapter. The strategic case for customs-based unit value indices in United Nations (1981) was based on the relatively low cost of such data. Unit value indices were advised for countries with a tight or medium budget and well-endowed countries were advised to base their external trade price indices on establishment survey data. The preference for price survey indices was, for the large part, due to bias in unit value indices mainly attributed to changes in the mix of the heterogeneous items recorded in customs documents, but was also attributed to the often poor quality of recorded data on quantities. The former is particularly important in modern product markets

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[1] United Nations (2007) survey on country practice—see also United Nations (2005)—found that for 88.4% of countries, customs declarations remain the main source of data. However, there was a considerable difference in country practices as only 55.6% of developed countries confirmed that customs declarations are the main source of data, while 97.9% of developing and transitional countries did.

[2] It may be argued that unit value indices are not a method for compiling price indices in that they are a distinct concept. However, they are used in economic analysis as surrogates for price indices and there is no distinct conceptually useful area of analysis for which they are designed and solely used.

given the increasing differentiation of products and turnover of differentiated products. Statistical offices working with customs authorities can make some improvements in the quality of quantity data and commodity descriptions used by customs (that is the Harmonised System outlined in Chapter 4) are periodically updated in response to changes in product markets. In almost all countries both the Customs administration and the National Statistical Office make extensive use of computer equipment. Practically all customs declarations are nowadays captured electronically. This implies that customs data are verified, available in great detail and available to the statisticians in a very timely manner. Even in the least developed countries customs administrations are computerized due to The Automated System for Customs Data (ASYCUDA) project[3] of United Nations Conference on Trade and Development (UNCTAD). Yet unit value indices have suffered further in recent times due to an increasing irrelevance of the source data with first, increasing proportions of trade being in services and by e-commerce, and hence not covered by customs data. Second, countries in customs and monetary unions are unlikely to have intra-union trade data as a by-product of customs documentation. Finally, some trade may not be covered by customs controls, such as electricity, gas, and water, or be of "unique" goods, such as ships and large machinery, with profound measurement problems for unit values.

2.3   Few deny, including United Nations (1981), that price indexes based on surveys of narrowly specified products provide the best measures of relative price change and that there are potentially significant biases in using customs unit value indices to measure export and import price changes. Yet, unit value data are readily available from customs administration systems at relatively low incremental cost (compared to obtaining price surveys of establishments needed for narrow specification prices). In view of the low cost of the data, the bias in unit value was judged by United Nations (1981) to be tolerable enough that countries were advised to continue compiling them if they do not produce narrow specification price indices. Notwithstanding the putative low cost of obtaining unit values, the Manual in this chapter revisits this strategic advice. Over 25 years has passed since United Nations (1981) and there has been major developments that impose on this strategic issue of choice of method including: developments in the analytical tools by which such methods are evaluated; further evidence regarding the validity of unit value indices as surrogates for price changes; the increasing extent of product differentiation, and associated developments in the classification system and documentation upon which customs data are based; the automation of customs data records; and developments in the principles and practice of price index number methodology.[4]

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[3] ASYCUDA is functioning in about 90 developing countries. That system verifies declaration entries immediately. Declarations need to be completely filled in order to receive customs clearance. This means among others that quantity information is required. In addition, customs values are validated – to avoid undervaluation – using unit values on the declaration which are matched against a pre-determined list of commodity prices.

[4] These prompted the writing of the consumer price index (CPI) and producer price index (PPI) Manuals, ILO (2004a) and ILO (2004b) respectively.

2.4   Unit value indices as measures of price changes of imported and exported goods serve economic analysis in many important ways. They are used as short-term indicators of inflation transmission, to measure changes in a country's terms of trade (effect), and as deflators of export and import values to yield measures of changes in export and import volumes. An issue of strategic concern is whether unit value bias misleads economists in their analysis to the extent that their compilation and use for countries with resource constraints should not be deemed a sensible alternative, but the first step of a program of hybrid indices that increasingly limits, over time, any reliance on unit value indices.

2.5   Index numbers are generally calculated in two stages. The first stage is the building blocks of price indices, the measurement of price changes of similar "elementary" items exported or imported by one or more establishment (or institutional unit), say a front-loading washing machine of given quality characteristics including say size, spin speed, energy saving. The resulting indices from these elementary aggregates are referred to as *elementary aggregate indices,* or more simply, *elementary indices*. Data on weights are not available at this level of aggregation and Chapter 21 considers the issue of appropriate unweighted formulas for elementary indices. At the next stage of aggregation weights are applied to the elementary indices, and weights are again applied to the resulting indices at higher stages of aggregation, until an overall index is derived. Unit value indices derived from customs data use unit value indices to compile elementary indices, the elementary indices then being weighted at higher levels. Standard index number theory applies to the issue of weighted formulas at the higher levels, as outlined in Chapters 10, 16-18, and 20, irrespective of whether the elementary indices are compiled from unit values derived from customs data or price indices based on establishment surveys. Compilers of unit value indices as well as price indices are referred to these chapters for higher level aggregation formulas. *The concern here is with the suitability of unit value indices as measures of price changes at the lower elementary lavel.*

2.6   This chapter first, as background, in Section B briefly outlines the recommendations on export and import price measurement given in the United Nations' statistical manuals and handbooks. The nature of unit value indices and the circumstances under which they may be reliably used is next considered in Section C. If unit value indices are to be used it is essential that compilers and users have a sound understanding of their properties. Given the potential for concern arising from the conclusions of Section C, Section D considers the evidence on the suitability of such indices. Such evidence is by its nature limited to countries that compile both price indices and unit value indices. It is also limited to the fact that the deficiencies in unit value indices are not measured against a perfect benchmark, the price indices themselves having deficiencies. Yet, as will be outlined, unit value indices suffer from not comparing the prices of like with like when the commodity description used for customs purposes is too broad and the relative share of each kind of item it covers shifts over time. Establishment–based price indices by their nature are compiled by first, determining with the responding establishments detailed price-determining specifications of representative commodities, and their prices in the reference period on "price initiation," and then comparing the prices of the

same specifications in subsequent periods.[5] In this important regard the cited studies ask: how well do unit value indices stand up against price indices designed to overcome one of their major failings? In Section E strategies are outlined for the development of a country's external trade price indices.

B. International Recommendations

2.7   The potential limitations of unit-value indices were recognized in both the United Nations (1979) manual on producer price indices (PPI index) and United Nations (1981).[6] Yet the use of unit-value indices was recommended in the latter publication as a pragmatic approach for statistical authorities with resource constraints.[7] Indeed, United Nations (1983) comprised case studies on the development and implementation of the two main approaches—the survey pricing approach as used by the Federal Republic of Germany and the unit-value approach as used by Norway—to assist countries in initiating and developing their trade price change measures. The vast majority of countries produced unit value indices then, as many do today, as the only available information on trade price changes and thus as surrogates for price indices.

2.8   United Nations (1981) recognized that the budget available to statistical authorities constrains the set of feasible data sources and methods for compiling external trade price indices. Thus, countries with "tight budgets" were advised to use the unit values compiled by customs authorities to construct price relatives, provided that such unit values are defined for commodities in the narrowest sense possible (using customs documentation). Resources permitting, unit values for the same commodity should be compared across different countries of origin/destination and, if they differ markedly, they should be treated separately. Subject to the need to achieve broad representation, unit value indices that exhibit exceptional price changes should be excluded. The caveat as to the need for achieving broad representativity was dropped for "machinery and transport equipment" and "miscellaneous

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[5] There remains a problem for both types of data when a product changes, say a new improved model is introduced. Unit value indices will be biased upwards. A change in the detailed specifications will be noted when using establishments surveys and the methods in Chapters 8 and 9 are available to deal with the quality change/new good.

[6] It is stressed that the concern of this chapter is with the use of unit values derived from customs documentation to proxy price changes. Data on the traded value shares of commodity groups in total imports or exports, derived from customs documentation, are generally most suitable for use as weights for both unit value and price indices.

[7] The advice is reiterated in United Nations (2004, paragraph 150, page 97): "Two kinds of indices may be produced to reflect prices: unit value indices based primarily on customs documents and price indices based on survey data. The relative strengths and weaknesses of those two approaches to index number compilation are described in...United Nations (1981).. Although price indices are generally preferred, in practice countries may not have the resources available to compile that information. **It is recommended that all countries produce and publish volume (quantum) indices and either unit value or price indices for their total imports and exports on a monthly, quarterly and annual basis."** [Emphasis in the original].

manufactures" due to the likely widespread contamination of the unit value changes by changes in product mix.

2.9   For a country with an "average budget" the strategy advised in United Nations (1981) was for the individual statistical agency to access the individual documents of the customs authorities, legal considerations permitting. Within each product category, it was advised to study the statistical properties of detailed unit value data (for instance, exploring the arithmetic mean and dispersion of unit values from individual transactions, in addition to the unit value for the product category as a whole and other indicators such as the number of transactions). Explicit criteria should then be established to determine whether the category's unit value changes can be further considered as a suitable indicator of price changes. These criteria might require, for example, the mean and variability of unit values being inside specific limits, no reversal in the direction of change, limited deviations between the mean of the unit values of a category and the aggregate category unit value, etc. The product categories used were recommended to be broken down as far as possible to include country of origin/destination and size group of commodity. Statistical authorities on an average budget were advised to put more emphasis on the validation of transactions using specific editing criteria than statistical authorities on a tight budget. In case a unit value indicator failed the validation procedures and was rejected on further investigation, it was advised that the gap could be filled by the judicious selection of unit values from domestic or partner-country price indicators.

2.10   Two variants were suggested for the strategy of a statistical authority endowed with considerable budgetary resources. The first option was to pursue a *dual strategy*, according to which a comprehensive price survey of importers and exporters is conducted while keeping track of unit values from customs authorities. Alternatively, a *hybrid strategy* might be followed, in which the price relatives from establishment surveys and unit value indices from customs data complement each other. The dual approach involves using both methods and thus allows price relatives from a survey to be compared, at a detailed level, with the corresponding unit values and for unit value bias to be identified. It was to give insights into potential errors in coverage, leads and lags between changes in the transaction prices and flows of merchandise in and out of the country. Yet it remains highly resource intensive and it is not easy to investigate what causes the differences between the results of the two. The hybrid approach is a more useful allocation of resources. It is explained in United Nations (1981), page 58-59:

> "For the dovetailing of the two methods of collecting data, the commodity universe is divided into two portions. The first includes those commodities which are not susceptible to quality change at all, or only to small variations in quantifiable price-determining characteristics. These commodities are measured primarily by unit values. The other segment of the commodity universe corresponds to those commodities for which there are no quantity measure to speak of, to those commodities that are unique because of their size and complexity and to those commodities that are the object of significant change in their physical characteristics. This segment is dealt with primarily by direct survey. The overall index is, in effect, derived as a weighted average of the two kind of indicators."

2.11   With regard to unit value indices based on customs data, the *System of National Accounts 1993* notes that, due to the problem of compositional change in non-homogeneous units: "Unit value indices cannot therefore be expected to provide good measures of average price changes over time." (Para. 16.13).

C.   Unit value indices and their potential bias

2.12   In this section the nature of the potential bias in a unit value index, arising from changes in the compositional product mix, is first outlined in Section C.1, and then again considered more formally in Sections C.2 and C.3 when looking at the properties of unit value indices in relation to the main axiomatic tests and economic theory used in index number work to justify formulas. Section C.4 considers limitations in the coverage of their use and Section C.5 provides a summary of issues of concern in relation to unit value indices. Given that unit value indices are widely used it is important that compilers and users are fully aware of their properties, so that strategic decision to move to hybrid or establishment-based indices can be appropriately made.

2.13   The attention in this chapter to unit value bias is not to disavow the potential problems inherent to the use of price indices. The subject matter of Chapter 11 of this manual is errors and bias in price indices and much of the remaining chapters of this manual is concerned with the principles of, and good practice for, mitigating such errors and bias. However, there remains an important deficiency of unit value indices. Unlike price survey indices, where it is possible to collect matched prices over time for detailed item descriptions, the nature of customs documentation makes this problematic at best and impossible for trade within customs unions and trade in services.

2.14   A unit value index, P_U, compares the weighted average price of $m = 1, ... , M$ individual transactions that took place a given period (denoted period 1) with the weighted average price of $n = 1, ... , N$ individual transactions that took place in another reference period (denoted period 0). All the transactions in both periods are of commodities that belong to the same commodity classification, and are characterized by prices and quantity pairs $\left(p_m^1, q_m^1 \right)$ and $\left(p_n^0, q_n^0 \right)$, respectively. More specifically, the unit value index for period 1 relative to the reference period 0 at the most disaggregated commodity classification is given by:

$$(2.1)\ P_U \equiv \left(\frac{\sum_{m=1}^{M} p_m^1 q_m^1}{\sum_{m=1}^{M} q_m^1} \right) \Bigg/ \left(\frac{\sum_{n=1}^{N} p_n^0 q_n^0}{\sum_{n=1}^{N} q_n^0} \right),$$

where the prices of individual transactions are weighted by their corresponding quantities.

C.1   Unit value bias illustrated

2.15   United Nations (1981, page 15) illustrates the potential unit value bias with an hypothetical example of trade in refrigerators, which we include here—see Chapter 6, Table

6.1 for a further example. With the exception of the "size" of the refrigerator, assume that the mix of all price-determining characteristics—including brand, frost-free technology, color, energy-efficiency, possession of ice-making feature, drink dispenser, and so forth—are adequately proxied by the "size" of a refrigerator. Assume further that there is a meaningful division of "size" into the three groups of "small", "medium" and "large", and that there is a trend in purchasing patterns towards larger refrigerators. In the illustrative example below, refrigerator prices, *p*, double for each size group and there is a shift to the quantities, *q*, sold now, in proportion to 2, 3, and 5 going from smallest to largest, from what was then 5, 3, 2, though total quantity remains the same over time. The value, *v*, is given as $p \times q$.

2.16   Since prices in each size group have doubled, a weighted average of these price changes, $\sum_i w_i \left(p_i^{Now} / p_i^{Then} \right)$, over the *i* size groups is 2.0. But the change in the unit value is 4.6/1.7=2.71. Thus, *if transactions of all size categories are classified together under the same commodity description(e.g., "refrigerator")*, there will be an upwards bias in the UVI due to the change in the product mix towards more expensive refrigerators. In other words the measurement of price changes will be confounded with the effect of shift towards purchases of larger refrigerators.[8]

	Size of refrigerator											
	Small			Medium			Large			All sizes		
Period	*q*	*p*	*v*	*q*	*p*	*v*	*q*	*p*	*v*	*q*	*uv*	*v*
Now	5	2	10	3	4	12	2	6	12	10	3.4	34
Then	2	1	2	3	2	6	5	3	15	10	2.3	23

C.2   Unit value indices: the test approach

C.2.1 Homogeneous items

2.17   The test or axiomatic approach to index number formula choice is well established and is outlined in Chapter 17. If the items whose prices are being aggregated are identical—that is, perfectly homogeneous—a unit value index has desirable properties. If, for example, exporters shift some their sales of an identical item to purchasers willing to pay a higher price, then the average price paid for the item increases, as would the revenue received from exporting the same amount. A unit value index captures this shift to higher absolute price

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[8] The Harmonized System at six digits includes four subheading for refrigerators: combined refrigerator-freezers fitted with external door (8418.10); compression-type household refrigerators (8418.21); absorption-type electrical household refrigerators (8418.22); and other household-type refrigerators (8418.29)—there is no coding by size.

levels. Consider further the case where the same item is sold at different prices during the same period, say lower sales and higher prices in the first week of the month and higher sales and lower prices in the last week of the month. The unit value for the monthly index solves the time aggregation problem and appropriately gives more weight to the lower prices than the higher ones in the aggregate. If the unit value index in equation (2.1) is used as a price index to deflate a change in the value, the result is a change in total quantity which is intuitively appropriate, i.e.

$$
(2.2) \quad \frac{\sum_{m=1}^{M} p_m^1 q_m^1}{\sum_{n=1}^{N} p_n^0 q_n^0} \Bigg/ \left[\left(\frac{\sum_{m=1}^{M} p_m^1 q_m^1}{\sum_{m=1}^{M} q_m^1} \right) \Bigg/ \left(\frac{\sum_{n=1}^{N} p_n^0 q_n^0}{\sum_{n=1}^{N} q_n^0} \right) \right] = \frac{\sum_{m=1}^{M} q_m^1}{\sum_{n=1}^{N} q_n^0}
$$

2.18 Note that to be homogeneous all price determining quality characteristics, including the conditions of sale, must be the same. The summation of quantities in the top and in the bottom of the right-hand-side of equation (2.2) must be of the exact same items for the expression to make sense. Thus for example, if the very same type of item is exported by an establishment to two purchasers in the same country with similar transport charges[9] under the same conditions of sale, but one is sold at a higher price than the other, then if the quantities sold shift in favour of the higher price purchaser, the unit value index would show an increase irrespective of whether prices changed. This would be an appropriate increase.[10] However, if the items are not identical, for example the purchasers were in different countries with different terms of sale and/or qualities of items, then the unit value index would be wrong. Prices would not have changed but the index would have. It is as if they export apples to one country and pears to another with prices unchanged.

C.2.2 *Heterogeneous items*

2.19 The very nature of an index number problem is that the desired measure is the change in price or volume of an aggregate over different items, or items of different quality. Chapters 16, 17, and 18 of this Manual clearly show that the superlative class of index

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[9] From a resident's perspective exports transportation costs are not an issue, they should be excluded for export price indices because the pricing basis is the *basic price*—that is, the amount received by the producer, or distributor exclusive of any taxes on commodities and transport and trade margins, while from the nonresident's perspective the pricing basis for imports is the basic price.

[10] That this is appropriate is apparent from the economic theory of an export price index established in Chapter 18 as a ratio of hypothetical revenues over the two periods being compared that the revenue-maximizing exporting establishment could realize, where the technology and inputs to work with (and thus quantities) are fixed to be the same for both of the periods. An establishment that, for example, doubles its revenue using a fixed technology and inputs, say by shifting some output to higher-paying customers, effectively doubles its prices.

number formula, that includes the Fisher, Törnqvist and Walsh index number formulas, are appropriate.

2.20   Unit value indices *derived from customs data* cannot *a priori* be taken as being the result of an aggregation over homogeneous items. Note that to be homogeneous all price determining quality characteristics, including the conditions of sale, must be the same. The item descriptions on customs documents do not have sufficiently detailed descriptions to provide for this and the HS sub-headings used, even at a detailed level, are too broad. The axioms established to test index number formulas apply when items are not strictly homogeneous, as would be the case for unit values from customs data. They are considered in detail in Chapter 17, though their main properties with regard to unit value indices are outlined below.

2.21   The *Proportionality Test* requires that if all prices in period 1 are the result of multiplying the corresponding price in period 0 by a positive number, λ, then the price index should be equal to λ. More formally, the proportionality test requires that $P(p,\lambda p,q^0,q^1) = \lambda$ for $\lambda > 0$. The unit value index only satisfies the proportionality test in the unlikely event that relative quantities do not change (preferences are linearly homogeneous and identical— Bradley, 2005). Changes in the index can thus reflect both changes in price and changes in the product mix over the two periods compared. Since the index should only measure price changes, the index number formula has a potential bias.

2.22   It follows from the failure of the proportionality test that the unit value index also fails the *Identity or Constant Prices Test*: $P(p,p,q^0,q^1) = 1$; that is, if the price of every good is identical during the two periods, then the price index should equal unity, no matter what the quantity vectors are. It only satisfies the identity test if relative quantities, that is the composition of the products compared, do not change.

2.23   That a price index can be affected by changes in relative quantities is a serious deficiency. The essence of the fixed basket concept of price indices is the need to hold quantities constant over time. There is a very real sense in which a unit value index should not be properly described as a price index unless applied to transactions for homogeneous products and thus, by definition, the composition of products cannot change.

2.24   The unit value index, however, satisfies the proportionality in current period prices test, $P(p^0,\lambda p^1,q^0,q^1) = \lambda P(p^0,p^1,q^0,q^1)$ for $\lambda > 0$; that is, if all period 1 prices are multiplied by the positive number λ, then the new price index is λ times the old price index.

2.25   The unit value index fails the *Invariance to Changes in the Units of Measurement (commensurability) Test*: $P(\alpha_1 p_1^0,...,\alpha_n p_n^0; \alpha_1 p_1^1,...,\alpha_n p_n^1; \alpha_1^{-1} q_1^0,...,\alpha_n^{-1} q_n^0; \alpha_1^{-1} q_1^1,...,\alpha_n^{-1} q_n^1) = P(p_1^0,...,p_n^0; p_1^1,...,p_n^1; q_1^0,...,q_n^0; q_1^1,...,q_n^1)$ for all $\alpha_1 > 0, ..., \alpha_n > 0$; that is, the price index does not change if the units of measurement for each product are changed. For example, if the measurement of one of the products changed from pounds weight to kilograms, the index should not change.

2.26   In addition, where there is more than one product variety, it is necessary to have a natural unit of measurement common to both goods in order to allow for meaningful unit value calculations. For example, say an index covered two products, product A measured in terms of the number of items imported/exported and product B in terms of the weight of the items. Then a change in the units of product B, *for both periods*, from say pounds to kilograms would affect the results of the unit value index. That is, different results would arise if pounds were used to measure total quantity in each period as opposed to kilograms. That the results of the index depend on the units adopted results in a quandary as to which units are correct. Units of measurement are, however, standardized for detailed customs categories, something facilitated by the computer system, ASYCUDA, for customs documentation noted in Section A above.

2.27   However, a particular instance of the effect of the failure in the commensurability test impacting adversely on the unit value index is one in which the quality of products imported/exported changes. When this occurs, the actual units of measurement may not change, but the implicit unit of productive service or utility would change, and bias the index. Accounting for the effects of quality changes on prices is difficult enough for index number work based on price surveys (ILO *et al.*, 2004a and Chapter 8). Customs data on quality characteristics is likely to fall well short of the corresponding information that would normally be available from establishments producing for export, or purchasing as imports.

2.28   Unit value indices pass the other main index number tests, including the time reversal test, the circularity test, and the product test. However, that it is affected by changes in the composition of products, and (changes in) its units of measurement—that is, it fails the proportionality and commensurability tests—is critical to concluding that it is an inappropriate measure.

2.29   Unit value bias can be considered as the ratio of a unit value index to an acceptable number formula. Párniczky (1974) uses the Paasche index in this latter respect while Balk (1998) uses the superlative Fisher index. The notation for p and q is as price and quantity vectors respectively for a variety of m commodities where ι is a m-dimensional vector of ones $\sum_m p_m^t q_m^t / \sum_m p_m^t \equiv p^t q^t / \tau q^t$ for (t=0,1).   Following Balk (1998), the unit value bias is given by:

$$(2.3) \quad B = P_U\left(p^1, q^1, p^0, q^0\right) / P_F\left(p^1, q^1, p^0, q^0\right)$$

$$= \left[\left(1 + \mathrm{relcov}_0\left(p_m^1, q_m^1 / q_m^0\right)\right)\left(1 + \mathrm{relcov}_0\left(p_m^0, q_m^1 / q_m^0\right)\right)\right]^{\frac{1}{2}}$$

where the relative covariances are defined by:

$$\mathrm{relcov}_0\left(p_m^t, q_m^1 / q_m^0\right)$$

$$(2.4) \quad \equiv \sum_m q_m^0\left(p_m^t - p^t.q^0 / \iota.q^0\right)\left(q_m^1 / q_m^0 - \iota.q^1 / \iota.q^0\right) / \left(p^t.q^0\left(\iota.q^1 / \iota.q^0\right)\right) \qquad (t=0,1).$$

2.30   Balk (1998) draws the following conclusion: the unit value bias will be equal to zero for a comparison between periods 0 and 1 if one or more of the following conditions are met:

- all base period prices p_m^0 are equal to each other and all current period 1 prices p_m^1 are equal to each other;

- all quantity relatives q_m^1 / q_m^0 are equal to each other; and

- there is no correlation between p_m^0 and q_m^1 / q_m^0, and also no correlation between p_m^1 and q_m^1 / q_m^0.

2.31   These are all highly restrictive conditions. The first condition requires product homogeneity to an extent that defeats the purpose of a price index, in that if all prices were equal in each period, then there is no index number problem; the price change of a single product would suffice. The second condition is the assumption required above for satisfaction of the identity and proportionality tests. If all quantity relatives were equal, and this were known, the price index number problem would be solved by dividing the change in the total value by this single quantity relative. At the heart of the index number problem is that such quantity changes cannot be assumed to be the same. The third condition arises from the fact that if price relatives and quantity relatives are uncorrelated, then a change in prices would not affect quantity relatives, and vice versa, and there will be no change in the composition mix due to relative price changes. There may be some markets in which there is market failure or temporal inconsistencies, but for the large part the laws of economics cannot be assumed away.

C.3   Unit value indices: economic theory

2.32   Economic theory allows a theoretically "true" index to be defined under assumptions of (competitive) *optimizing behavior* on the part of economic agents and related (not independent) prices and quantities. Actual index number formulas can be evaluated against their theoretical counterparts and also against a class of superlative indices that have good approximation properties to a well-defined theoretical economic index. This approach is based on the theory of the cost of living index developed by Konüs (1924) and used in the consumer price index (CPI), as outlined in the CPI counterpart to this manual, ILO *et al.* (2004a), and the theory of output index developed by Fisher and Shell (1972) and Archibald (1977), as outlined in the producer price index (PPI) counterpart to this manual, ILO *et al.* (2004b), and it follows closely the exposition of the export price index (XPI) by Alterman, Diewert and Feenstra (1999), as outlined in Chapter 18 for XMPIs. Bradley (2005) takes a cost-of-living index defined in economic theory and compares the bias that results from using unit values as "plug-ins" for prices. In Chapter 18 it is shown that the economic theory of cost-of-living indices can be applied to resident economic agents purchasing imported goods

and services. As a result of this, the findings of Bradley (2005) carry over to the use of unit value indices for import price indices.[11]

2.33 Bradley (2005) finds that if there is no price dispersion in either the current or reference period compared, the unit value (plug-in) index will not be biased against the theoretical index.[12] But this is equivalent to the case of a single item and the index number problem arises because we are aggregating across more than one item. He also finds that if there is price dispersion in the current period, but not the reference period, a unit value "plug-in" would have a downward bias; if prices are dispersed in the reference period, but not in the current period, there will be an upward bias in the index; and if there is price dispersion in both periods, there is a guarantee (there is a zero probability that the condition of no bias will hold for any arbitrary data generating process) that there will be a bias in the "plug-in" unit value index, but one cannot sign that bias. Economic theory thus does not support the use of unit value indices. It does, however, support a number of index number formulas considered in Chapter 18.

C.4 Unit value indices: coverage limitations

2.34 United Nations (1981, paragraph 2.31-2, page 21) acknowledged that the balance could shift towards survey pricing if, as a result of tariff-reduction agreements, customs controls were to all extents abolished. For example, on January 1, 1993 the physical frontiers and customs checks, including the use of the single administrative (customs) document, were abolished for movements of goods between Member States of the European Union (EU). Since then, under the Intrastat system, intra-community trade data are collected directly from firms.[13] The system has a close link with the value added tax (VAT) system, under which most cross border transactions are taxed and recorded on acquisition. The coverage of the surveys is akin to a census with only a minor proportion of trade excluded due to non-response or falling below the VAT threshold. Establishment-based sources for external trade price data are the only practical option in these cases.

2.35 Furthermore, with services and e-commerce making up an increasing share of trade, customs data on merchandise trade will be unsuitable as the sole data source. Some goods such as electricity, gas and water should be included in external trade, but are excluded from

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[11] Similar conclusions could also be derived for indices defined in economic theory for revenue maximizing producers exporting goods and services. Such indices are defined in Chapter 17.

[12] The theoretical cost-of-living index is defined for homogeneous preferences that are identical across all consumers and a negative (compensated) demand and price relationship.

[13] New Intrastat legislation was introduced on January 1, 2005 (the European Parliament and Council Regulation (EC) 638/2004, the Commission Regulation (EC) 1982/2004, and amending Commission Regulation (EC) 1915/2005). The European Commission Short-Term Statistics Council Regulation 1165/98 amended by 1158/2005 introduced requirements for the compilation of import and export price indices based on price surveys.

customs documentation. United Nations (2004, paragraph 255, pages 44-5) advises that enterprise surveys be used to collect such data.

2.36 Finally, there are unique commodities, such as ships and oil-platforms, and commodities, such as personal computers, highly differentiated by quality characteristics, including brand and conditions of sale. For such commodities it is often the case that the differing characteristics are responsible for a high degree of price dispersion and there is much quality change and change in the month–to–month churn in the mix of the characteristics of the differentiated items traded.[14] For such highly differentiated commodities establishment price surveys based on tightly specified representative items are most suitable for price index number measurement[15] and unit value indices based on administrative customs documents most unsuitable.

C.5   Unit value indices: the cause for concern

2.37 The concern over bias in unit value indices is not new. Early critical studies of unit value bias as measures of import and export price changes and terms of trade include Kravis and Lipsey (1971 and 1985). The United States discontinued publication of unit value trade indices in 1989 due to concern over bias and introduced trade price indices based on establishment surveys. More recently, in a speech on statistical challenges raised by globalization, González-Páramo (2006) noted that the European Central Bank is looking forward to the moment that appropriate import and export price indices, instead of unit value changes, become available for the Euro area as a whole, in order that central banks have key information to anticipate domestic inflationary pressures.

2.38 Unit value indices derived from data collected by customs authorities are mainly used by some countries as surrogates for price changes at the elementary level of aggregation. The following are grounds upon which unit value indices might be deemed unreliable, some of which are considered in more detail in later sections of this Chapter:

- Bias arises from compositional changes in quantities and quality mix of what is exported and imported. Even with best practice stratification the scope for reducing such bias is limited due to the sparse variable list—class of (quantity) size of the order and country of origin/destination)—available on customs documents. Most promising, however, is the inclusion of establishment number on customs declarations which, when used as stratification factor should reduce the heterogeneity of items included in a unit value. However, Párniczky (1974) shows that it does not follow that such breakdowns are always beneficial to a UVI;

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[14] There is much theory and evidence in economics, based on search costs, menu costs, signal extraction models, of substantial price dispersion, even for similar items including Sheshinski and Weiss (1977),Varian (1980), Bénabou and Gertner (1993), Sorensen (2000), Silver and Ioannidis (2001) and Lach (2002).

[15] Chapters 7 and 8 of this Manual provide detailed guidelines on adjustments to prices for quality changes and incorporating the effects of new goods of different quality. Chapter 10 provides examples of how the price changes of hard-to-measure commodities, such as ships, can be measured.

- For unique and complex goods, model pricing can be used in establishment-based surveys where the respondent is asked to price each period a product, say a machine with fixed specified characteristics. This possibility is not open to unit value indices.

- Methods for appropriately dealing with quality change,[16] temporarily missing values, and seasonal goods can be employed with establishment-based surveys to an extent that is not possible with unit value indices;

- The information on quantities in customs returns, and the related matter of choice of units in which the quantities are measured, has been found in practice to be seriously problematic, though the former has improved with the adoption of ASYCUDA;

- With customs unions countries may simply have limited intra-area trade data to use;

- An increasing proportion of trade is in services and by e-trade and not subject to customs documentation;

- Unit value indices rely to a large extent on outlier detection and deletion. Given the stickiness of many price changes, such deletions run the risk of missing the large price catch-ups when they take place and understating inflation.

2.39 A main advantage of the use of unit value indices is their coverage and relatively low resource cost. However, the unit values used are drawn as non-random samples in the sense that they exclude: products traded irregularly; that have no quantity reported—something less likely now given the widespread adoption of ASYCUDA; have low-value shipments; and, where outlier detection is automatically and badly applied,[17] erratic month-to-month changes. For some commodities, the extent of such exclusions may be substantial.[18] Establishment-based surveys can be quite representative, especially if a small number of wholesalers or establishments are responsible for much of the total value of imports or exports and, with the important assumption of cooperation, will be a cost-effective source of reliable data. Further, good sampling, can, by definition, realize accurate price change measures and finally, the *value* shares of exports and imports, obtained from customs data, will form the basis of information for weights for establishment-based surveys.

2.40 Errors and biases are recognized in price index measurement. Chapter 12 of this manual outlines such sources of error and bias and Chapters 2-11 provide detailed accounts of methods to mitigate them—methods that statistical authorities are well versed in for

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[16] Von der Lippe (2007) shows that adjustments for quality change is one reason why price indices are less volatile than unit value indices.

[17] Though it recognized that the appropriate response is good outlier detection. However, this in turn requires collaboration with establishments for confirmation as to whether a large change is real or not.

[18] For an illustration of the substantial extent of unit value dispersion and outliers see World Trade Organization (WTO), United Nations Conference on Trade and Development (UNCTAD), and International Trade Centre (ITC), *World Tariff Profiles 2006* (WTO: Geneva, 2007), Technical Appendix B.

compiling consumer and producer price indices. These methods include the use of detailed specifications of representative goods and services so the prices each month of like are compared with like, something customs data does not allow for. CPI and PPI compilation practices have benefited from much research and experience since the publication of United Nations (1981) and extensive guidelines on good practice are available in the CPI and PPI Manuals (ILO *et al.*, 2004a and 2004b respectively), the benefits of which should carry over to XMPI practice—see Ruffles and Williams (2004, Chapter 5) for an example of country practice for the United Kingdom.

2.41 There is next the need for any strategic decisions as to the adoption/continued use of unit value indices by a compiler, or evaluation of such statistics by a user, to be evidence based. Since unit value indices may not be suitable surrogates for price indices, it is necessary to consider the empirical evidence available on the nature and extent of any differences.

D. Evidence of unit value bias

2.42 We briefly outline comparisons of price and unit value indices when they coexist. The evidence is presented below first at the **aggregate level**. Results at a more disaggregated level will be considered in Section E4.

2.43 Angermann (1980) compared price index number changes with unit value changes for exports from and imports to the Federal Republic of Germany. Between 1970 and 1976 the (Paasche-version, to be consistent with the unit value index) price index for exports increased by 38.6 percent compared with 34.3 percent measured by (Paasche) unit value indices. The discrepancy between such import price indices and unit value indices was greater, at 45.8 and 33.1 percent respectively. He also found that when unit value indices were used to calculate the terms of trade effect there was a gain in 1976 of 1.4 billion DM to real income, at 1970 prices, compared with a loss of 6.6 billion DM when using a Paascheized price index.

2.44 Alterman (1991) compared export and import price changes between March 1985 and June 1989 for the United States (U.S.) as measured by unit value indices and by the price indices based on establishment surveys that replaced them.[19] For imports, over this period, the price index increased by 20.8 percent and the unit value index increased by 13.7 percent. For exports, the figures were much closer, 13.0 and 12.2 percent for the price and unit value index respectively. Some of the difference between the two series may be attributed to their use of different periods for weights. However, when price indices were recalculated using the same weights as the unit value indices, the differences were exacerbated: a 20.6 percent and 16.4 percent increase for the import and export price indices respectively. The average (absolute quarter-on-quarter) unit value index change for imports and exports respectively were 27 and 70 percent larger than the corresponding price index changes. One method of considering whether such differences matter is to evaluate the implications of such

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[19] The official U.S. Unit value indices were discontinued by the Bureau of the Census in 1989 so these figures are the latest available estimates.

discrepancies for the deflation of the foreign trade component of the national accounts. Alterman (1991) found that the annualized second-quarter 1989 "real" trade deficit in March 1985 dollars would have been $128.4 billion if deflated by a unit value index, but just $98.8 billion, 23 percent less, if deflated by a price index.

2.45   A review in 1992 of the unit value methodology used by the UK led to their change in May 1996 to establishment-based trade price indices, following similar changes in methodology by the US, Japan, and Germany (Ruffles and Williamson, 1997). The annual averages of export prices in 1995, compared with 1994, increased by 6.6 percent using price indices compared with 8.1 percent using unit value indices.

2.46   Such findings are not new. Kravis and Lipsey (1971) found that the prices of manufactured goods exported by developed countries to developing countries had risen over about twenty years by 75 per cent, as compared to the l4 per cent shown using unit value indices. Kravis and Lipsey (1985) found a decrease in the terms of trade of manufactures relative to all primary products between 1953 and 1976 of over 36 per cent, using price indices, almost a quarter greater than that suggested by the unit value indices (28 per cent). With a further correction for quality change, the price data suggested a fall in manufactures terms of trade of over 45 per cent, more than 50 per cent greater than unit value indices.

2.47   Silver (2008) compared unit value indices and price indices for both Germany and Japan for exports and imports using monthly data for1996:7 to 2006:9. Unit value indices were found to seriously misrepresent price indices in the sense that discrepancies between unit value indices and price index were substantial; changes could not be relied upon to have the same sign; there was no evidence of long-run (cointegrating) relationships between price index and unit value indices; and unit value indices were of little help in predicting price index. The findings held both for month-on-month and month-on-12 month changes. The marked unreliability of unit value indices as measures of export and import price inflation was surpassed by the unreliability of the terms of trade (TOT) indices based upon them. For example, the mean month-on-month discrepancy for ToT changes for Germany was 1.3 percent compared with discrepancies of 1.1 and 0.9 percent respectively for imports and exports. A discrepancy of, for example, 1.1 percent implies that if the month-on-month change in the price index was zero, no change, then the unit value index would take a value of a 1.1 percent change on average. Such discrepancies can be regarded as seriously misleading for economists. The discrepancy for individual months can of course be much larger than this mean discrepancy, as reflected by an associated standard deviation of 1.0 percent and maximum of 7.3 percentage points for Germany's import month–on-month index changes. The problem is not just of magnitude or error, but also of direction. For about 25 percent of month-on-month comparisons the signs differed; that is in one quarter of comparisons the economist would read prices were rising (falling) when they were falling (rising).

2.48   Silver (2008) also found the discrepancy between use of unit value indices to calculate the terms of trade *effect*, as against price index, was most marked. For example, Japan's trade balance in 2005 of 6,956 billion Yen was eliminated by the adverse change in its terms of trade when using a price indices, but only halved when using unit value indices. The values of exports and imports of Germany and Japan were deflated over the period from

1999 to 2005 by corresponding unit value indices and price indices and the results compared. For example, the volume of exports by Japan increased by 50 percent when a unit value deflator was used, but the increase was halved when a price index was used.[20] He noted:

> "The evidence......is that export and import unit value indices are inadequate surrogates for their price index counterparts when used in economic analysis. Such analysis includes their use in the measurement of short- and long-run inflation, prediction, terms of trade, terms of trade effects, and as deflators. Indeed, the evidence is that they are seriously misleading." (Silver, 2008).

E. Strategic options: Compilation of hybrid indices

2.49   There is the practical matter of what should be done. Unit value indices are used by many countries and a move to price indices has resource consequences. One possibility is to identify whether there are particular commodity classes less prone to unit value bias and utilize unit value indices only for these sub aggregates in a hybrid overall index and price indices elsewhere—Chapter 6, Section C provides some distributions and summary measure to help identify commodity classes more suited to unit value indices. Hybrid indices have resource advantages, yet the efficacy of their use depends on the extent to which reliable unit value indices will be available at a disaggregated level.

E.1   The case for hybrid indices

2.50   The account given in this section identifies hybrid indices as primarily based on unit value indices with the use of alternative sources, considered in Section E.3, as the exception when unit value indices are considered to be subject to unacceptable levels of bias. However, it is the case for countries whose primary source of price change information is establishment-based price surveys, that unit value indices are exceptionally used for goods whose characteristics are considered to be homogeneous. The account here will be from the former position, external trade price indices primarily based on customs data. This is because the Manual takes the stance that there is sufficient cause for concern, established in sections C and D, to advise countries using unit value indices to move to establishment-based surveys. A strategic response to this would be a staged progressive adoption of hybrid indices with, over time, increasing proportions of unit value indices being substituted in favor of

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[20] Price index and unit value indices may be compiled using different formulas at the higher level so differences in the results may in part be due to formula differences. Some insights are available for Germany, a country that has import price indices, import deflators of the national accounts and unit value indices. The import price indices are of the Laspeyres type and refer to the year 2000. The Laspeyres principle is applied, however, only to the basket of goods, but not to the countries of origin, meaning that any shifts to low cost producers will be captured by the import price index. The national accounts deflator are annually chained Paasche indices, and the unit value indices are Paasche indices referring to the year 2000. The product specific price indices used for the compilation of the national accounts deflators are taken from the price statistics. Hence, the main difference between the import price index and the import deflator is to be found in the index formula. In the years 2000 to 2005, the UVI displayed a decline of 1.8% per annum, whereas the import price index increased slightly and the import deflator decreased less strongly (+0.3 and -0.8, respectively). Taking the geometric average of the change in the import price deflator and the import price index gives an estimate of -0.2% as the "true" annual change in import prices, implying that the German UVI is significantly distorted downwards.

establishment-based survey data and other sources outlined in Section E.3, though issues arising in the adoption of such a policy are the subject of Section F. First is the need to outline the characteristics of hybrid indices.

E.2   Using unit value sub-indices for homogeneous product groups only

2.51   Hybrid indices can be readily calculated. A worked example is given in Chapter 6 section D, Table 6.2, and the principles outlined below. Say a Laspeyres index between period 0 and 1 is to be compiled for a Harmonized System (HS) commodity code from $i=1,...,4$ lower level HS codes for which unit value indices are available. Then the unit value index given by (2.1) for a commodity group i may be defined as $P_{Ui}^{0,1}$, where the m and n prices and quantities in respective period 0 and 1 are allowed to vary with commodity classification i:

$$(2.5)\ P_{Ui}^{0,1} = \left(\frac{\sum_{m=1}^{M} p_m^1 q_m^1}{\sum_{m=1}^{M} q_m^1} \right) \Bigg/ \left(\frac{\sum_{n=1}^{N} p_n^0 q_n^0}{\sum_{n=1}^{N} q_n^0} \right)$$

2.52   However, say the unit value index is considered to be unreliable for the $i=1$ commodity group; its nature is that it is composed of say equipment whose quality varies from shipment to shipment and the resulting index is highly volatile. Then the measured price change of this commodity group $i=1$, is say the unweighted geometric mean of the matched price changes of $j=1,...,J$ representative items from an establishment survey:[21]

$$(2.6)\ P_{i=1}^{0,1} = \prod_{j=1}^{J} \left(p_j^1 \Big/ p_j^0 \right)^{1/J}$$

2.53   The overall index for the four commodity groups is then a period 0[22] weighted average of the price index and unit value indices:

$$(2.7)\ I^{0,1} = \frac{p_1^0 q_1^0 P_{i=1}^{0,1} + \sum_{i=2}^{4} p_i^0 q_i^0 P_{Ui}^{0,1}}{\sum_{i=1}^{4} p_i^0 q_i^0} .$$

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[21] In Chapter 21 the advantages of using a geometric mean of price ratios—equivalent to the ratio of geometric means—rather than arithmetic means, is outlined in the context of elementary aggregate indices, that is when there is no information on weights.

[22] As outlined in Section F.3 alternative and better formulas exist to this base period weighted Laspeyres, which is used here for illustration.

E.3   Sources of alternative measures of price changes

E.3.1 Establishment surveys

2.54   Establishment surveys are considered the most appropriate data source for the measurement of price changes. However, customs documentation can still provide contact details for the importers and exporters concerned and the amount of the shipment, so that a representative sample of major importers and exporters can be contacted. Note that this in turn raises particular challenges for price measurement, the subject of much of the remaining chapters of this manual. Chapter 6 of this manual considers issues of ensuring the establishments and items selected for the measured price changes are representative. Guidance on the collection of prices of detailed specified items over time is provided in Chapter 7, with further detail on the treatment of quality change and inclusion of new goods in Chapters 8 and 9 respectively. Price measurement is more problematic for some commodities, such as telecommunications and shipbuilding, and the issues relating to specific hard-to-measure commodities are considered in Chapter 11, along with more general problem areas. That there will be errors and biases as a result of this process is acknowledged in Chapter 12 in which is an outline of their nature, though the previously mentioned chapters have as their purpose the reduction of such errors and bias. Such issues are not new. They are for the large part similar to those that arise and are dealt with in PPI and CPI construction, guidelines on the principles and practice of which can be found in ILO *et al.* (2004a and 2004b).

E.3.2 Global and mirror price indices

2.55   An alternative to using unit value indices is to use the corresponding series from other countries, that is if your major exports (imports) are to (from) one or more identified countries and these countries have what you believe to be reliable import (export) price indices for these goods, then a weighted average of these series may be a suitable proxy. Alternatively, there may be the case where there are substantial quality changes in the goods imported and exported, for example personal computers, and unit values, measured in terms of the quantity (by number or weight) traded will provide inadequate measures of price change. However, some countries may compile detailed estimates of price and quality change and their estimates of quality-adjusted say export prices changes, in an international competitive market with little price differentiation by country, may be the most suitable measure. A further alternative is to use international commodity price indices to proxy exports or imports price changes. The assumption is that there is a global market in which countries are price takers with little to no price discrimination between countries. In advocating stratification by country of origin/destination United Nations (1981) implicitly argued against this as a general strategy. However, there may well be product areas for which this is useful.

E.3.3 Producer price indices

2.56   A country may well have a program for compiling an establishment based output (input) PPI for which the price changes of a representative sample of tightly specified outputs (inputs) are monitored and compiled into a price index. The resulting price index is a

measure of the output from (input to) the domestic economy as a whole to (from) both the resident and non-residents. In some cases the establishments may wholly sell to (buy in from) non-resident markets in which case a timely series should exist for the external trade price index. In other cases output may be to both markets, but the contact at the establishment should be able to provide information as to the proportion of output that goes to non-resident markets and whether there is any price discrimination in the prices, or price changes. If only a small proportion goes to (is bought by) the domestic market or if prices or price changes are, and are expected to continue to be, similar, then such price indices may be usefully employed for commodity groups of the external trade price indices.

E.3.4 Imputation

2.57   It may well be that data from establishment-based surveys or other sources are unavailable, in which case, in the absence of hard information, a default option would be to impute the price change for commodity group 1, in the example in Section E.2 above, from the price change of commodity groups 2-4. The measured price change from this calculation will be the same for all four groups, as that from the three groups. However, the overall index will benefit from the selective basis on which the imputations are undertaken. Imputations should be undertaken on the basis of following what are considered to be reliable price changes of groups expected to have a similar price change. The reliability will be based on the sample size, variability of price changes within the product group—less variable more reliable—and robustness of the data source. If, for example, commodity group 2 was based on measured price changes of carefully specified representative items from an establishment survey, while commodity groups 3 and 4 were based on ill-defined unit value indices, it would be better to impute the price changes of commodity group 1 from those of commodity group 2 alone. The case would be even stronger if their price changes of commodity group 1 were expected to be more similar to those of group 2, say, for export price index, because they both utilized similar raw material inputs and other inputs and targeted their output to the same markets.

2.58   Imputation also has a wider use. For unit value or price indices, should some proportion of the weight of the commodity group not be covered, say due to poor data for unit value indices or sampling for price indices, then imputation is a means by which the coverage is factored up to the weight for the commodity group as a whole. Further, as outlined in Chapter 8, imputations may be used for temporarily missing items.

E.4   Hybrid indices: The reliability of unit value sub-indices

2.59   The extent to which unit value indices are included in a hybrid index depends on the resources of the country's statistical authority (customs data from administrative sources are generally cheaper); the availability of alternative sources (establishment response may be very poor for some industries); and the reliability of the unit value indices for the goods considered. There is much of this that will require specialized knowledge of the goods and services markets concerned. The Manual cautions against uninformed judgments as to what might be deemed homogeneous. In informal discussions with unit value index compilers as to which product groups give reliable series, the anecdotal information confirmed the care required. For example, for one country, coal was initially considered to be homogeneous, but

they discovered that the unit value indices were completely unpredictable and uncorrelated with price changes. The explanation was that coal is not just coal; it varied in quality in terms of the amount of energy it produced, the extent of cleaning/filtering required, and residual use, say for road construction. Ruffles and Williamson (1997), in arguing the case for a change in the UK from unit value indices based on customs data, to establishment-survey based price indices, cite the case Adipic acid, an organic chemical that is an important precursor in the manufacture of nylon. Unit values from customs data increased from 0.74 in April 1995 to 4.06 in May 1995, to return to 0.77 in June 1995. The price returns from individual companies had average quotes of 1.56, 1.56, and 1.55 for these three respective months. Individual customs returns from different companies had a wide variation in prices with significant number of occasional traders whose unit values varied considerably from the average for the month in question, due mainly to quality differences.[23]

2.60   Silver (2008) analyzed disaggregated monthly data for Germany comparing unit value indices with their price index counterparts. The data were for export and import unit value indices and price indices for the period from January 2000 to November 2006 at the 4-digit level of the Statistical Classification of Products by Activity in the European Economic Community, 2002 version, (CPA). The relative discrepancies between month-on-month changes between the unit value indices and price indices were calculated for each of the 150 class series available for both unit value indices and price indices at this level. The 15 classes in the lowest percentile were then identified and their mean, maximum, minimum, and standard deviation month-on-month change over the period January 2000 to November 2006 calculated. These were the best product classes to use for unit value indices in the sense that they had the least average discrepancies. The results identified the magnitude of the discrepancies of what should be the most homogeneous product classes, with the intention of assessing whether they could be used in a reliable way

2.61   The best two product classes, the manufacture of motor vehicles and the manufacture of pulp, had mean month-on-month discrepancies of 2.00 percent; that is, if the price index showed no change the UVI would show a 2 percent change. At the bottom of the best percentile range was the manufacture of fertilizer and nitrogen compounds with a discrepancy on average of 4.00 percent. These averages of course have standard deviations that at 6 and 7 percent for the best two classes and 15 percent for the worst end of the best percentile, demonstrated serious cause for concern. Had the results been more favorable it would have been useful to attempt to characterize these "best" product classes for use in the compilation of unit value indices in hybrid unit value/price indices. Unexpectedly the best percentile groups included three heterogeneous classes composed of "other" and "n.e.c." products. There is also some concentration around plastic products and motor vehicle related activities, but given the size of the discrepancies these were not useful groupings.

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[23] For further information on the wide dispersion and extreme outliers in customs-based unit values see World Trade Organization (WTO), United Nations Conference on Trade and Development (UNCTAD), and International Trade Centre (ITC), *World Tariff Profiles 2006* (WTO: Geneva, 2007), Technical Appendix B.

2.62   Also of particular help in examining unit value and price index discrepancies at a disaggregated level are the extensive Reports by PLANISTAT Europe, Decoster (2003a and 2003b) commissioned by Eurostat to examine the methodology for export and import price indices by EU member states. In particular, the Second Report provided a comparative analysis of import price and import unit value indices for Finland, Germany,[24] Netherlands, and Sweden. The monthly import indices used were those provided by these countries to Eurostat. The unit value indices were extracted from the Comext database.[25] The series were available at a 3-digit level CPA and while results at aggregated levels were provided, they were unweighted and not useful. The series are monthly from January 1995 (=100) to September 2001[26]

2.63   The report found that, for example for Finland, of the 77 product groups at the 3-digit level CPA for which import data were available, 17 percent had an average discrepancy between unit value and price indices of less than 2.5 percent, and about another 40 percent between 2.5 and 5 percent. There was less difference between unit value and price indices for Sweden with about one-third of 3-digit product groups having a discrepancy of less than 2.5 percent. Bear in mind that a discrepancy of 0.025 implies that if the month-on-month change in the price index was zero, no change, then the unit value index would take a value of a 2.5 percent change on average. Such discrepancies can be regarded as misleading for economists and 83, 87, and 66 percent of 3-digit groups in Finland, Netherland, and Sweden respectively had discrepancies that on average exceeded this value. The average percentage discrepancies for the three countries were 5.3, 5.4, and 4.1 respectively and the minimum discrepancy for a 3-digit group to be between 1.5 and 2 percent—at best still significant potential to mislead economists.

2.64   The figures cited above are for the mean discrepancy over the 68 month-on-month comparisons for the period January 1995 (=100) to September 2001. The standard deviation of the discrepancy for each group were calculated for the 68 comparisons over time to quantify the volatility of the discrepancies. The average dispersion was high: for each country the mean standard deviation over the groups exceeded the mean of the groups. The very lowest dispersion over time of the month-on-month discrepancy for a 3-digit group was for Finland at 1.9 percent allowing an approximately 95 percent plus or minus range of $2 \times 1.9 = 3.8$ percentage points around the mean discrepancy—and this was the lowest dispersion.

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[24] Data were not readily available at a detailed level of aggregation for Japan.

[25] Unit value indices are subject to outlier detection and revision and the series available in Comtext may differ from those available from the individual countries in this regard.

[26]The PLANISTAT report was undertaken by Renaud Decoster. The results provided here are based on the worksheets of summary measures for the individual series, provided to the author of this chapter by Mr. Decoster. The author acknowledges Mr. Decoster's help and advice. The above tables do not appear in the report, but are based on the data series used for the report. The conclusions drawn here and in the report are very similar and differ only in that a less favorable consideration is given in the report to unit value indices than here.

2.65   The results allowed Decoster (2003a and 2003b) to conclude that for no product group was the average monthly discrepancy acceptable. Decoster (2003a) analyzed the data in considerably more detail. He found that price indices are more stable over time than unit value indices, and that unit value indices often display erratic behavior and that price indices do not; he therefore concluded in the Final Report (2003b, p.9) that:

> "Any list of CPA categories for which UVIs [unit value indices] are a priori acceptable as proxies for SPIs [import price indices] would be very short, especially as regards monthly data. It would include almost only aggregates and raw materials, even if sizable discrepancies between unit value indices and SPIs are deemed acceptable. Apparently, any list of product categories for which short-term UVIs are acceptable proxies for SPIs seems country specific. For a few low-tech products, for which quality changes are slow, UVI changes over the long term (several years) may be acceptable proxies for SPIs."

F.   Strategic options: improve unit value indices

2.66   A response to concern over the unreliability of unit value indices is to improve them. This may be undertaken first, by more detailed stratification of the customs data, and second, by better data validation routines. These are considered in turn.

F.1   Use a more detailed stratification of unit values

2.67   United Nations (1981) emphasized the need to stratify unit values to the (limited) extent possible and drew attention to doing so where possible by country of destination and size of batch, though see Párniczky (1974) on the limitations to this. Stratification is also possible for shipments by/to (major) establishments to/from given countries. The absence on customs documentation of highly detailed product descriptions by which to stratify unit values precludes any benchmark as to what is a reliable unit value index. However, such experiments can be undertaken for consumer goods using highly detailed bar-code scanner data. Bradley (2005) examined the issue in some detail and found that even for detailed data of sales of cereal in 169 selected stores by 1,369 brands, aggregating unit values that distinguish a brand of Tuna according to the week of purchase and store in which it is sold, as against simply aggregating unit values for the self-same brand and item, leads to substantial differences in the results. Silver and Webb (2002) took (brand and) model numbers for washing machines, dishwashers, vacuum cleaners, television sets, cameras and personal computers (PCs) and compared unit value changes for the same models over different store types, finding quite different result when aggregating with and without store type as a variable. Haan and Opperdoes (1999) undertook a similar study on coffee, further apportioning their data according to the week of the month the data relates to, again finding unit value bias. Given such bias at this fine level of detail for aggregating identical items it is hard to imagine disaggregated unit values based on customs returns being robust to unit value bias.

2.68   However, as noted in Section C.2.1, if a commodity, for example, exported is homogeneous, and there is price discrimination according to the country or group of countries exported then a, for example, shift in quantities to say countries in which export prices are lower, would be a fall in the average price at which the commodity is sold and stratification by country inappropriate. If the commodities are broadly comparable and the

quality difference can explicitly be stripped out using a suitable method outlined in Chapter 8, then unit values for these quality-adjusted prices would be appropriate.

F.2 Use deletion routines for unusual price changes

2.69 Of widespread use in the compilation of unit value indices are deletion routines. This is because much of the data from customs records on unit value changes are highly volatile and often discarded. Some of this volatility arises from absent or poor quantity data—something less likely now given the widespread adoption of ASYCUDA. In other cases it is due to unit value bias. Alterman (1991) estimated that the U.S. unit value indices produced in 1985 were calculated for only 56 percent of the value of imports and 46 percent of the value of exports. For capital goods the respective figures for imports and exports fell to 30.3 and 26.1 percent. The problem of such deletions are two-fold. First, is the implicit effect on the sample representativity and coverage. Price indices are based on selected items from selected establishments with the purpose in mind that they are representative. Second, is that the deletion removes signal as opposed to noise. There is much evidence in CPI compilation, for example Hoffmann and Kurz-Kim (2006), that price changes can be substantial, and irregular, with long periods of constant prices followed by relatively large catch-up price changes. The problem is aggravated with external trade statistics when price changes can become volatile as a result of exchange rate fluctuations that may—the extent will vary between commodity groups—have varying pass-through rates in terms of their extent and time lags.[27] Large catch-up price changes may be deleted by automatic outlier detection routines, resulting in unit value indices that are unduly stable, and volatile prices changes, due to exchange rate fluctuations, may lead to unduly high dispersion parameter values, used in deletion routines, and deletion rates.

2.70 Improved deletion routines are certainly advocated by the Manual when unit value indices are used. However, caution is expressed about the efficacy of such routines and the need for validation with an exporting/importing establishment or other third-party source prior to deletion. Deletion routines should be used to identify unusual price changes, which then have to be followed up to ensure that they are not real changes—large catch-up price changes under sticky price-setting—but due to wrongly entered numbers or a change in the units for quantities. However, the sheer magnitude of the task of following up the original customs documentation, and then possibly having to refer back to the exporter/importer, may well preclude detailed follow-ups with an over reliance on automatic deletion routines. Deletion routines will be based on past parameters of the dispersion, which may themselves be based on outliers. Further, the parameters may themselves be unstable and past experience not be useful for future deletion practice. Finally, there is the arbitrary nature of the cut-off values often used in practice for deletion. Routines for outlier detection are outlined in

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[27] See for example, Emi Nakamura, Accounting for Incomplete Pass-Through, Paper presented at the 2008 World Congress on National Accounts and Economic Performance Measures for Nations, May 13-17, 2008.

Chapter 6, Section 6; Chapter 10, Section D; WTO and others (2007)[28]; and specialized conferences such as those held by the UNECE.[29]

2.71   The very nature of establishment-based price surveys, for which there is well established good practice, (ILO et al. 2004a and 2004b), militates against such problems. A contact is made in an establishment on price initiation, in which the characteristics and conditions of sale of well specified representative items are established. The contact is responsible for providing a price each month for these items and is able to explain why unusual price changes take place, which in turn facilitate adjustments to prices for quality changes.

F.3   Use better formulas

2.72   Chapters 15-19 advise the use of a superlative index number formula such as the Fisher, Törnqvist, and Walsh index number formulas. These formulas make symmetric use of reference and current period quantity information, can be justified as providing a good approximation to a "true" index defined in economic theory; in particular, the Fisher index, has good axiomatic properties. Chapters 9 and 15 also provide a case for using annually chained index number formulas. Customs data benefits from the possibility of obtaining current period information to enable superlative index number formulas and/or chaining to be employed. Chaining of a say Laspeyres index has its own advantages, in terms of facilitating the introduction of new goods/establishments, but also has the advantage of reducing the gap or spread between Laspeyres and Paasche index numbers and thus more better approximating a superlative index.[30]

G.   Strategic options: move to establishment-based price surveys

2.73   Resources permitting countries should adopt establishment-based price surveys. United Nations (1981) recognized the superiority of price indices by recommending that well-endowed countries compile them, while advising countries with limited resources to compile unit value indices. Countries not only require price indices for trade flows, but for the deflation of output, intermediate and final consumption goods and services by resident units. In particular, an output producer price index (PPI) is required that measures the changes in the prices of output of resident establishments. Price indices are compiled by

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[28] Systems for outlier detection tailored to the needs of unit value indices are outlined in Technical Annex B, pages 190–198 of the World Trade Organization (WTO), International Trade Centre (ITC), and UNCTAD, 2007, *World Tariff Profiles 2006* (Geneva: WTO).

[29] The United Nations Economic Commission for Europe (UNECE) hold conferences on data editing that include papers on outlier detection. Papers for the 2005, 2006, and 2008 meetings can be found on:
http://www.unece.org/stats/documents/2008.04.sde.htm
http://www.unece.org/stats/documents/2006.09.sde.htm and
http://www.unece.org/stats/documents/2005.05.sde.htm.

[30] Chaining is not advised for high frequency, say monthly or quarterly data, subject to seasonal/volatile fluctuations.

selecting representative items from major/representative establishments and comparing the prices of like with like over time. Such output covers the domestic and export market (ILO *et al.*, 2004b). For a self-standing export price index there would be a need to identify price changes from such establishments for foreign markets as well as overall output and, as necessary, expand the sample size to ensure those establishments serving foreign markets are included in a representative manner. Similar arguments apply to imports. Establishment-based trade price indices are but an extension of establishment-based price surveys for producer prices. If a PPI program exists there are synergies and cost savings to starting a XMPI program (see Chpter13.). Poorer countries have fewer establishments serving foreign markets with large proportions of exports usually being the responsibility of a relatively small number of establishments. There are resource costs. But reliable XMPIs have their benefits which are the proper measurement of two major economic flows affecting the country, to allow for appropriate policy responses when necessary.

G.1   The gradualist approach

2.74   A gradualist approach has major resource benefits. There will be some "low-hanging fruit," establishments responsible for relatively high proportions of exports and imports, some of which may be owned by the state and may have some reporting obligation. Likely examples of such commodity groups include natural gas, petroleum, electricity, and airlines. There will also be industries in which unit values indices are *prima facie* inadequate measures of price changes, largely because of the churn in highly differentiated products, or the custom-made nature of the products, such as shipbuilding and oil platforms. Further, there may be industries which account for a substantial proportion of trade and the pay off of reliable data far outweighs the survey costs, for example, the use of surveys of fish-processing plants for major exporters of fish products and of agricultural marketing cooperatives for exports of primary products.

2.75   The gradualist approach requires as a first step a rigorous evaluation of each commodity group of the relative pay-off and cost of abandoning unit value indices. A good starting point would be a listing by commodity group that includes the weight, the perceived reliability of the unit value series, the likely source and reliability of alternative series, and a grade for the relative cost of obtaining such data. The initial aim would be to identify important commodity groups whose current series are deemed unreliable for which there are readily available alternative sources. International commodity prices and mirror prices, discussed above, may be usefully employed in some cases. For some commodities, a small number of traders/establishments, say marketing cooperatives, may be responsible for a relatively large proportion of external trade and exploratory contacts with such establishments can be initiated to obtain price data. The price data obtained may be considered to be representative of other commodity classes and imputations may be used as outlined in Section E.3 above.   A further alternative, also outlined in Section E.3, is to use sub-indices from a PPI, if compiled, in instances where the share of the market to/from non-resident producers is very high or if there is limited price discrimination or difference in price changes between output to (input from) non-resident and resident markets. In other cases, data from customs documentation may be considered, at least as a short-run expedient, to be sufficiently reliable to be used for a commodity group as whole, or for that part of the group

not covered by the establishment/ global/mirror prices. Chapter 6, Section C outlines some simple distributions and summary measures that may indicate classes for which the use of unit value indices would be less problematic. Where there is doubt, especially for groups with high weights, a coding for the priority for future change should be attributed to the group. Where unit value indices are the only available series, at least in terms of currently available resources, then the strategy must be to improve them by ensuring as detailed as possible stratification is undertaken and employing automatic outlier detection, but not automatic outlier deletion.

2.76 A potential problem with a gradualist approach is that longer-term changes in the index become problematic. The user cannot judge how much of the long run change is due to changes in the price change indicator series used. For example, say unit value indices on average had an upward bias, as the mix of items moved to better quality ones. And say in year 1 about 20 percent of the index by weight was replaced by a more reliable price index that cut the annual increase in the unit value index of say 5 per cent to 3 percent. Then the overall index would increase by only 4.6 percent; if in the next year a further 20 percent was changed under the same assumptions, the index would increase by 4.2 percent, and subsequently, with replacements of further 20 per cents, by 3.8, 3.4 and 3.0 percent when finally the whole index becomes a price index.. Such a gradualist policy would be yield misleading results. A gradualist approach should be accompanied by well signaled steps to users and, when changed, be accompanied by back data for at least the last 12 months so that 12-month changes can be identified and the new index readily linked to the old. There should be adequate meta data to explain the change.

G.2   The introduction of a new establishment-based price index.

2.77 The reason for moving to establishment-based price surveys may be outside of the control of the statistical authority. Customs data itself may become unsuitable for measuring trade flows for some countries if a country joins a customs/monetary union.

2.78 The introduction of a new external trade index, distinct from unit value indices has advantages. First, there is no confusion over the measurement of external trade prices changes over a period that encompasses both types of indices, as would be the case with a unit value index that evolves through a hybrid index to become an establishment survey based index. Second, contacts with establishments can arise from a well publicized and marketed process embedded in a legislative framework that has a response burden that is identified as fairly spread across establishments, as opposed to grace and favor requests.

2.79 The main problem with simply introducing a new program is the resource cost. This includes the training of price collectors, building of sample frames, sample selection of items and establishments, computer routines, data validations and much more that is the subject of the remaining chapters of this manual. However, if a PPI program is already established, there will be synergies with the external price index program including computer routines, price collecting manuals and training, expertise in sampling items and establishments. There will be some commodity groups for which the PPI results are alone sufficient. However, in other commodity groups for which the current PPI sample is not sufficiently detailed to allow reliable export /import indices to be compiled, the sample of items/establishments will need

to be supplemented to include items that are imported/exported. Of course, an import price index will include transactions by households mainly (cross-border shopping is an exception) through a chain of resident wholesalers and retailers who will need to be sampled. Annex 1 to Chapter 1 provides a step by step guide to developing export and import price indices. Chapter 1 itself provides an overview of this manual: the theory and practice of export and import price indices.

H. Summary

2.80   The Chapter in Section B briefly outlined the rationale for the United Nations (1981) strategy advising that unit value indices based on data from customs administrative documents be used by countries with limited resources, as surrogates for narrow specification price indices. In the absence of a systematic examination of the evidence and in view of the low cost of the data, the bias in unit value indices was judged by United Nations (1981) tolerable enough to advise their use. This manual provides an opportunity to review this strategy.

2.81   Unit value indices were evaluated against the axiomatic and economic theoretic approaches to index numbers and found to have major shortcomings (Sections C.2 and C.3). Unit values were also found wanting since they are only applicable to trade subject to customs administration, and thus can neither be compiled for trade within economic customs unions where there is insufficient documentation, nor be used for trade in services. Unit value indices also have insurmountable problems when used for "unique" goods such as ships (section C.4). The case for concern over the use of unit values was summarized (Section C.5); there were strong reasons for advising that they not be used. Evidence for the extent of the bias was then outlined (Section D). Unit value indices were found to have:

- no well-defined relationship over time to the desired narrow specification price indexes; indeed there are substantial discrepancies in direction and magnitude.

- no predictive power for narrow specification price indexes.

- For terms of trade indices the discrepancies are much worse.

- Measures of the terms of trade effect (for real national income) and deflated volume changes were vastly different when measured using unit value indices as opposed to price indices.

2.82   The evidence in Section D went beyond the fact that export and import unit value indices are inadequate surrogates for their price index counterparts when used in economic analysis; the evidence was that they were seriously misleading.

2.83   The manual turned to the question as to what can be done? Sections E, F and, G examined strategic options available in light of the conclusions of Sections C and D. Countries whose resources are limited and use unit value indices were advised to compile hybrid indices with, over time, a staged progressive program decreasing the reliance on unit value indices. The nature of hybrid indices was outlined (Sections E.1 and E.2)—a worked

example is given in Chapter 6 section D, Table 6.2—and alternative data sources to unit value indices considered including establishment-based price surveys, global/other country (mirror) price indices, producer price indices, and imputations (Section E.3). There remained the issue as to establishing which commodity groups might remain as being best served by unit value indices. Evidence on the reliability of sub-groups was presented (Section E.4), it being concluded that there is no evidence of particular sub-groups for which the unit value indices reliably represent price indices. The culmination of a program of use of hybrid indices should be an index in which unit values have little or no place.

2.84 Strategies of improving unit value indices were considered (Section F). Increased stratification, by country of origin/destination, size of shipment, and type of commodity (section F.1), and improved detection and deletion (after follow up) of outliers (Section F.2) will improve unit value indices and should be adopted— Chapter 6, Section 6 and Chapter 10, Section D contains an outline of methods a statistical office might use and Section F/2 footnotes references to other material.. However, the nature of customs documentation and natural volatility of sticky price changes and pass through rates constrain the benefits of increased stratification and unduly robust outlier detection. Better formulas (Section F.3) can be employed, particularly the adoption of chaining and use of superlative indices, but such advantages also carry over to price indices.

2.85 The strategic issue of a staged gradualist approach through hybrid indices or a one-off switch to establishment-based surveys was finally considered (Section G). A gradualist approach (Section G.1) using hybrid indices has major resource benefits. The gradualist approach requires as a first step, a rigorous evaluation of each commodity group of the relative pay-off of abandoning unit value indices. The initial aim would be to identify important commodity groups whose current series are deemed unreliable for which there are readily available alternative sources: the "low-hanging fruit." However, changes should be in a limited number of staged steps with good meta data and backdated series so that analysts do not confuse price changes with changes in methodology.

2.86 A preferable, though resource-intensive, approach is a one-off switch to an index based on establishment-based price surveys, possibly supplemented by global/mirror series as applicable (Section G.2). This may be prompted by a country joining a customs/monetary union. While the main problem with simply introducing a new program is the resource cost, there will be natural synergies between the administrative offices responsible for XMPIs and PPIs, if a PPI program is already established. Chapters 3-14 of this Manual provide practical advice on the compilation of export and import price indices based on establishment surveys, and Chapter 16 onwards, provides a detailed account of the theory of price indices and issues in their construction including choice of formula, the treatment of transfer prices, seasonal goods and services, and quality changes . Chapter 1 provided an overview of the manual and, more particularly, its Annex is a step by step account of how to start compiling XMPIs.

Annex 1: On limitations to the benefits of stratification

2.87   Consider a unit value index that is disaggregated into $k=1,....K$ sub-classes is given by:

$$(A.2.1\ P_{DU} = \sum_{k=1}^{K} w_k P_{Uk}$$

2.88   where P_{Uk} are the unit value indexes defined by equation (2.1) for each sub-class k, and w_k their respective weights. If the only limit to the disaggregation was a reduction to perfectly homogeneous commodities, then the unit value index would be ideal, as argued in section B above. There will, however, be practical limits to the extent to which a class can be broken into detailed sub-classes, as dictated by the data source. Given these limits, there is the question as to whether a strategy of disaggregation into smaller commodity groups to reduce bias should be undertaken. The analysis here follows that by Párniczky (1974). The total price variation of the unit value class can be decomposed into the variation within the sub-classes, and the variation between the sub-classes, that is:

$$(A.2.2)\ \sigma_w^2(p_0) + \sigma_b^2(p_0) = \sigma^2(p_0)$$

where the three terms are, successively, weighted[31] variances of prices in period 0 within sub-classes, between, sub-classes and overall. The weighted variances for quantities relatives, $g = q_1/q_0$ between periods 1 and 0 can be similarly decomposed as $\sigma_w^2(g)$ and $\sigma_b^2(g)$ as can weighted correlation coefficients, r_w and r_b between p_0 and q_1/q_0. The relative bias, B can be stated as an additive decomposition:

$$(A.2.3)\ Bias = \frac{\sigma_w(p_0).\sigma_w(g_0).r_w}{\overline{p}_0\overline{g}} + \frac{\sigma_b(p_0).\sigma_b(g_0).r_b}{\overline{p}_0\overline{g}}.$$

2.89   The first term in the square brackets is the component of the bias associated with using a weighted average of the unit values of disaggregated sub-classes. Only the within sub-class component generates bias; the between sub-class component is removed by the disaggregation. The sum of the two terms in the square brackets would represent the bias from using a unit value index without disaggregation. If, *a priori*, between group bias is considered to be the dominant effect—the compositional changes between the sub-classes is considered generate the largest part of the bias— disaggregation is worth pursuing. However, say the two sources of bias are considered to be of the same order of magnitude. If the *direction* of the two sources of bias is the same, then again, disaggregation is worth pursuing. However, say the direction of the bias from the two components is in the opposite direction,

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[31] The form of the weighting depends on the nature of the bias measure, that is whether the unit value index is related to a say Paasche index, Laspeyres index or an index which makes use of a symmetric mean of base and current period weights.

and they were of equal magnitude. Then the component biases in a unit value index that is *not* disaggregated would cancel. A disaggregated unit value index would be more biased. Disaggregation would not the best strategy.

2.90 The directions of bias are dictated by the correlations of prices in the base period with relative quantities; the expectation is that the price increases of lower priced commodities in period 0 would be higher—a negative correlation. But say this is true of the relationship within subclasses, but not between them. Equation (A.2.3) warns us that a strategy of disaggregation may increase unit value bias. Price and quantity data within sub-classes is often unavailable. Indeed, were it available it should be used to compile weighted unit value indices at a further level of disaggregation. As such empirical studies as to the relative signs r_w and r_b are not feasible and reliance must be put on *a priori* expectations. It is further apparent from equation (A.2.3) that if the within subclass component of bias is the dominant one, then there is less to gain from a disaggregated unit value index, which removes the between sub-class component of bias. Note the multiplicative nature of the terms in the components of bias in equation (A.2.3). If either $\sigma_b(p_0)$, or $\sigma_b(g_0)$, or r_b are close to zero, then the between sub-class component of bias will be small and there would be little to be gained from the disaggregation of a unit value index.

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