PRICE COLLECTION AND ESTIMATES AT CONSTANT PRICES

Note by the OECD Secretariat

Prices collection

1. The methods used to derive constant price (or volume) estimates are considered in the second part of this paper. An important issue associated with compiling volume estimates is to have a sufficiently broad range of price series available to produce deflators for all those parts of the economy for which volume estimates are required. The first part of this paper briefly discusses some issues associated with collecting information on the prices required to deflate the national accounts and obtain volume estimates.

2. Broadly, there are two methods of collecting prices regularly:

- by mailing out forms which are specifically tailored to each respondent's products;
- by having price collectors visit outlets to price lists of products appropriate for each type of outlet.

3. Ideally, all prices would be collected by trained price collectors because it is easier to control the quality of the prices being collected if field staff can be used. There are several issues involved in ensuring the quality of prices collections. First, the prices required are those that are actually charged for the goods or services sold rather than the list prices. In other words, it is not sufficient to obtain details about the prices usually charged by the business; it is essential that the prices collected are those which are actually paid by customers so any special discounts must be taken into account. For example, prices may be lower than the quoted (asking) price because of sales, or special offers available to bulk buyers, or because bargaining is a common practice in the country concerned. In some cases, particularly with motor vehicles, the extent of lower prices may be disguised and therefore difficult to assess accurately because of the varying amounts paid for trading in an old vehicle. Generally, it will be much easier to ensure that such discounts are taken into account if price collectors are used rather than if questionnaires are mailed out to collect the information. In addition, it is easier to keep track of changes in the quality of products and to obtain information on new products which are coming onto the market or on existing products which are becoming more (or less) important.

4. An added advantage of collecting prices personally is that modern technology allows the price specifications to be entered into hand-held computers. As a result, the various edits previously applied to the prices data when it was being verified in the office can now be checked readily as each price is entered which means higher quality data because edit failures can be resolved at the time of collection.

5. Obviously, though, it is very expensive to have a large team of price collectors and so it is necessary to also collect prices by mailing out questionnaires in some situations. Generally, it is less satisfactory to collect prices by mail because of the difficulties involved in ensuring that the prices reported are on the correct basis (eg, after allowing for discounts etc) and of consistent quality.

6. For any mail collection, it is essential to have an initial interview with prospective respondents to ensure that both the statistical agency and the respondent understand the specifications for the products involved and the basis on which the prices are to be reported. Given that only a small sample of all products can actually be priced, an initial visit to every respondent also enables a check to be made that the products to be priced are in fact representative (ie, they are sold in reasonably high volumes). Ideally, follow-up interviews are held with respondents every couple of years or so.

7. Most statistical agencies do not use a scientific approach to selecting the sample of products for which prices are collected, although it is common to use scientific sampling to select those businesses from which prices are to be collected. Generally, the products to be included in the prices collection are based on the judgement of experienced prices staff, taking into account all the information available on products purchased/sold. Sources such as detailed business collections and household expenditure surveys are invaluable in determining the importance of different items and in identifying those which must be priced.

8. It is important to ensure that all types of outlets are included if a judgmental approach rather than a systematic sample is used to select the outlets from which prices are to be collected. For example, if significant volumes are sold through a variety of different outlets (eg, supermarkets, corner stores and outdoor markets) then it is necessary to ensure that each type of outlet is adequately represented because they provide different levels of service, which is reflected in the prices charged.

9. The products sold within an economy change over time. For a price index to adequately represent what is happening to prices overall, it is critical to obtain ongoing information on new products, changes in existing products and changes in the importance of products. In this respect, the most important sources of information for prices statisticians are business surveys containing detailed information on products sold, surveys of household expenditures which identify all the major goods and services purchased by households, and the feedback obtained by regular programs of interviews with respondents to prices collections.

National accounts

10. An important use of national accounts data is to show the relationships between different parts of a country's economy, such as the government sector compared with the non-financial corporate sector. However, the major use of the national accounts is to assess how a country's economy is growing (or contracting) over time. Analysts are particularly interested in the behaviour of an economy at various stages in the economic cycle. For example, it is quite common to see analyses which compare the extent to which an economy has emerged from a recession compared with the stage reached at the same time following some earlier recession(s). One of the difficulties involved in interpreting these changes over time is that the observed movements are generally a combination of a change in prices and a change in the underlying volumes. Therefore, a set of tables containing estimates adjusted for the effects of price change (ie, constant price or "volume" estimates) is an important component of any national accounting system. The importance of such tables is noted in SNA93:

> "Rates of inflation and economic growth appropriately measured by price and volume indices for the main aggregates of the System are key variables both for the evaluation of past economic performance and as targets for the formulation of economic policy-making. They are an essential part of the System, especially given the emergence of inflation as an endemic economic problem in many countries." (paragraph 1.18, SNA93).

11. Most people are familiar with the concept of estimating the change over time in the production of an individual commodity by examining data on the number of units produced. However, the only

practicable means of aggregating the production of unlike goods or services is to use money values which, of course, are affected by changes in the underlying prices as well as in their volumes. In producing volume estimates in the national accounts, the aim is to remove from the money values the effects of these price changes. In concept, a volume estimate may be thought of as being derived by expressing the current price value of each component transaction as the product of a price and a quantity, and by substituting for each actual current price the corresponding price in the chosen base year. Subtotals and totals at constant prices for each period are then obtained by summing constant price values for the individual transactions. In effect, the volumes of the individual commodities involved in the transactions are aggregated using their prices in the base year as weights.

12. For any single base year, constant price measures vary only with changes in the quantities of the goods and services involved. However, the choice of base year does influence the movements in the constant price series because the underlying (relative price) weights will be different in different years since the rate of price change is not the same for all goods and services. The usefulness of constant price series depends on both the extent of the rate of price divergence for the commodities in the measure and the extent to which the relative price weights of the base period differ from the price relationships of other periods included in the series.

Volume estimation methods

13. There are two basic methods used to obtain constant price estimates. The first is to multiply the quantity of each commodity in each period by the base year price (ie, revalue the quantities at base year prices). In this paper, this method will be referred to as **quantity revaluation**. The second is to divide a price index for the commodity into the current price value in each period (referred to as **price deflation**). In each case, subtotals and totals are derived simply by aggregating the component constant price series. The formulas for different approaches are shown in Appendix 1.

14. In theory, the results will be identical provided that the "correct" index number formulas are used. If price deflation is used, it can be shown fairly simply that using a Paasche (or current-weighted) price index as the deflator will lead to the same result as that obtained by quantity revaluation. In practice, as is usually the case with national accounts, life is somewhat more difficult. While quantity revaluation is used extensively by most OECD countries in deflating foreign trade in goods, the price deflation approach is the more common method used to obtain constant price estimates for most components of the accounts. However, in practice it is virtually impossible to calculate Paasche price indexes for all parts of the national accounts because of the very detailed data, both prices and quantities, which would be required for every period. The compromise solution used for many years in most countries has been to deflate current price values at the most detailed level possible using Laspeyres deflators. The outcome is an approximation of the results which would be achieved by using Paasche deflators.

15. The results from the approach described in the previous paragraph are satisfactory provided that the relative quantities and/or relative prices of each item do not change significantly over time. However, it is rare for such conditions to be met in practice. In particular, several countries currently use hedonic price indexes to deflate expenditures on computers. These indexes record very large declines in computer prices over the past couple of decades, while prices for most other commodities have been increasing. Also, the volumes of computers purchased have been rising much more rapidly than those for most other items in the accounts. One consequence is that computers have to be revalued separately from all other commodities so that the price deflators have the most up-to-date weights possible and therefore approximate a Paasche price index formula reasonably closely. The second and much more serious consequence is that the commonly-used Laspeyres volume formula will produce distorted estimates of real growth.

16. In most countries, the price weights underlying the Laspeyres volume formula are changed only every five years. Relative prices tend to change in a way that is inversely related to changes in relative volumes (ie, the commodities for which prices become cheaper tend to have a higher volume growth). As a result, the overall measure of growth based on a Laspeyres fixed-base formula will tend to overstate the growth in years after the base year compared with the growth rate which would be calculated if a more up-to-date set of relative prices were used. When constant price estimates are rebased, the growth rates observed for major aggregates will change from those previously published. Sometimes the changes can be very significant, which can lead to problems for statistical agencies in trying to explain why the constant price GDP growth rates have been "revised" compared with those previously published. Chain volume indexes, which are discussed in more detail later in this paper, are a means of overcoming this problem.

Example of fixed-weights volume indexes

17. The example below is designed to demonstrate some of the issues associated with constant price estimates. Two items are revalued to constant prices and aggregated to obtain a total for each year using a "fixed-base" Laspeyres volume formula. The effects of using the different relative prices are shown by calculating the estimates on the basis of the relative weights in each of the five years in turn, but expressing the volume index using year 1 as the reference year. (The distinction between the "base year" and the "reference year" is that the relative prices used to compile the constant price estimates are those from the ***base year*** while the year in which the index number is set equal to 100.0 is the ***reference year***; they can coincide but, as the following example shows, it is not essential for them to do so.) All constant price estimates are calculated by quantity revaluation (see paragraph 13 above). However, it is a trivial exercise to show that the same results are obtained if price deflation is used, provided that a Paasche price index is used as the deflator.

18. The first part of the table below shows a simple set of price and quantity data. The values are obtained by multiplying the quantities each year by the corresponding prices. The quantity indexes for items A and B are shown with year 1 as the reference year so they can be compared with the total volume indexes on different base years (in the second half of the table above).

19. The constant price estimates for items A and B are calculated by quantity revaluation (i.e, by multiplying the quantities of each of item A and item B in each year by the relevant base year price). The constant price totals, expressed in turn on each of the 5 base years, are obtained simply as the sum of the constant price estimates of items A and B in each year. It is obvious that, in the example, the later the base year used, the lower is the growth in the total volume index. The reason is straightforward. The price of item A is increasing over time while the opposite is the case for item B. In addition, the volume of item B is growing more rapidly than that of item A (while the example is contrived, the pattern of more rapidly increasing volumes associated with the commodity whose price is falling is typical in the real world). Therefore, when later years are used as the base year, a smaller (price) weight is being assigned to item B than to item A, so the total volume index will grow most rapidly when the early years are used as the weighting base.

20. In practice, most countries have used a system of fixed base years on which to calculate their constant price growth rates. Generally, the base years have been changed every five years by most OECD countries and estimates for earlier years have been calculated by chaining growth rates expressed in terms of previously used base years on to the front of the latest set of estimates. The theoretically expected effects of rebasing from an earlier period to a later one have been observed in practice, with the problem

Current price and quantity estimates

Year	1	2	3	4	5
Price					
Item A	16	17	18	19	20
Item B	12	11	10	9	8
Quantity					
Item A	21	22	23	24	25
Item B	14	16	18	20	23
Quantity index (ref-erence year = year 1)					
Item A	100.0	104.8	109.5	114.3	119.0
Item B	100.0	114.3	128.6	142.9	164.3
Value					
Item A	336	374	414	456	500
Item B	168	176	180	180	184
Total	***504***	***550***	***594***	***636***	***684***

Constant price estimates (Laspeyres fixed-weight indexes

Year	1	2	3	4	5
Base = year 1					
Item A	336	352	368	384	400
Item B	168	192	216	240	276
Total	***504***	***544***	***584***	***624***	***676***
Index (ref year = year 1)	*100.0*	*107.9*	*115.9*	*123.8*	*134.1*
Base = year 2					
Item A	357	374	391	408	425
Item B	154	176	198	220	253
Total	***511***	***550***	***589***	***628***	***678***
Index (ref year = year 1)	*100.0*	*107.6*	*115.3*	*122.9*	*132.7*
Base = year 3					
Item A	378	396	414	432	450
Item B	140	160	180	200	230
Total	***518***	***556***	***594***	***632***	***680***
Index (ref year = year 1)	*100.0*	*107.3*	*114.7*	*122.0*	*131.3*
Base = year 4					
Item A	399	418	437	456	475
Item B	126	144	162	180	207
Total	***525***	***562***	***599***	***636***	***682***
Index (ref year = year 1)	*100.0*	*107.0*	*114.1*	*121.1*	*129.9*
Base = year 5					
Item A	420	440	460	480	500
Item B	112	128	144	160	184
Total	***532***	***568***	***604***	***640***	***684***
Index (ref year = year 1)	*100.0*	*106.8*	*113.5*	*120.3*	*128.6*

becoming more acute in recent years in those countries which use a hedonic price index to deflate computers. As a result, several countries have already changed their approach to constant price estimation by updating their price weights annually and a number of others are currently in the process of deciding whether to move in this direction. In addition, Eurostat released a report in 1997 recommending that all EU countries report national accounts growth rates to Eurostat on the basis of previous years' prices, as recommended in SNA93.

Chain volume indexes

21. The above example demonstrates a major practical limitation of constant price estimates. It is the fact that relative prices and relative volumes change over time and so there is no unique estimate of real growth. Generally, the further the base year is removed from the year for which growth rates are being calculated, the less relevant the price weights become (exceptions to this rule are occasionally found in areas such as agricultural exports where world conditions rather than domestic market conditions determine the prices). It follows that the best estimate of growth will generally be based on the most recent set of weights available (ie, those from the previous year for a Laspeyres volume index or those from the current year for a Paasche volume index). However, it then becomes impossible to maintain this set of weights through the whole series because they are not directly relevant to earlier years in the series. The solution recommended in *System of National Accounts*, *1993* (SNA93) is to link together (or "chain") growth rates calculated with the price weights being changed each year.

22. As is the case with the fixed-weights estimates, there are two index number formulas which are commonly used to obtain the chain volume estimates - Laspeyres and Paasche (the formulas are shown in Appendix 1). In addition, superlative index numbers, such as the Fisher or Törnqvist, can also used be used (however, only the Fisher index will be discussed any further in this paper). With a Laspeyres chain volume index, the growth rate between any year $t-1$ and the following year (t) is calculated by successively using the prices of each year $t-1$ as the weights. With a Paasche chain volume index, the growth rate between any year $t-1$ and the following year (t) is calculated by successively using the prices of each year t as the weights. The chain Fisher volume index is simply the geometric mean of the Laspeyres and Paasche chain volume indexes.

23. Conceptually, the preferred chain volume index is based on the Fisher formula. However, there are some significant practical issues involved in producing the Paasche chain volume indexes which are required as an intermediate step in calculating the Fisher chain volumes. The two main problems are that detailed data are required immediately after the end of the latest year so that the year t weights can be calculated for use in the Paasche formula and the amount of extra work needed to produce estimates based on both the Laspeyres and the Paasche formulas for the latest year. The result is that most countries preparing to adopt chain volume series seem to be favouring the Laspeyres rather than the Fisher formula for their estimates.

24. Aside from workload considerations, the major practical limitation associated with chain volume series is that, in most years, the sum of the components will not be equal to the corresponding subtotals and totals once the individual series have been linked to provide a time series. The key issue involved revolves around whether it is considered more important to maintain the "best" growth rates for the components and totals or whether it is considered essential to maintain additivity. Generally, if the divergence in relative prices and volumes is sufficient to result in significantly different outcomes for chained estimates compared with fixed-base estimates then it is advisable to use the chained estimates, despite the lack of additivity. In fact, the lack of additivity is not confined to chain estimates. In most years, time series of constant price estimates obtained using any index number formula other than the Laspeyres fixed-base formula will not be additive.

25. The following table uses the basic data in the example shown earlier in this paper but goes a step further to demonstrate how a chain series (Laspeyres) for an aggregate (total) is produced. The first step is to extract the totals for each year (*t*) in the previous year's (*t-1*) prices (see the part of the table above headed "Constant price estimates"). Notice that no data is shown with year 5 as the base year because the movement between year 4 and year 5 is being calculated at year 4 prices. The movements between year *t-1* and year *t* are then calculated and used to move forward from the index base of 100.0 in year 1.

Constant price estimates – Laspeyres chain

Year	1	2	3	4	5
Totals - fixed base					
Base year 1	504	544			
Base year 2		550	589		
Base year 3			594	632	
Base year 4				636	682
Base year 5					
Totals - fixed base (% changes)					
Base year 1		7.9			
Base year 2			7.1		
Base year 3				6.4	
Base year 4					7.2
Base year 5					
Total - chain index (reference year = year 1)					
Laspeyres	100.0	107.9	115.6	123.0	131.9
(% change)		7.9%	7.1%	6.4%	7.2%

26. The following table shows how a Paasche chain volume index is produced. As in the Laspeyres example above, the totals for each year are extracted but this time the estimates for the previous year (*t-1*) are shown in the latest year's (*t*) prices. A further difference is that no data is shown with year 1 as the base year because the movement between year 1 and year 2 is calculated at year 2 prices in a Paasche volume index. However, in each case the movements between year *t-1* and year *t* are extracted as in the previous example and used to move forward from the index base of 100.0 in year 1. The Laspeyres total index is shown for comparison, along with the corresponding Fisher chain index (the geometric mean of the Laspeyres and Paasche chains). Fixed-base estimates, with year 1 and year 5 as the weighting base years, but with both shown on year 1 as the reference year, are also presented on the following page. The differences in growth indicate that the effect of changing from an early base year to a later one is to reduce the growth rate of the aggregate (total) series. This is generally observed in practice as well because of the classical "substitution effect".

Constant price estimates - Paasche chain

Year	1	2	3	4	5
Totals					
Base = year 1					
Base = year 2	511	550			
Base = year 3		556	594		
Base = year 4			599	636	
Base = year 5				640	684
Totals (% changes)					
Base = year 1					
Base = year 2		7.6			
Base = year 3			6.8		
Base = year 4				6.2	
Base = year 5					6.9
Total - chain index (reference year = year 1)					
Paasche	100.0	107.6	115.0	122.1	130.5
(% change)		7.6%	6.8%	6.2%	6.9%

Constant price estimates - Fisher chain (reference year = year 1)

Laspeyres	100.0	107.9	115.6	123.0	131.9
(% change)		7.9%	7.1%	6.4%	7.2%
Paasche	100.0	107.6	115.0	122.1	130.5
(% change)		7.6%	6.8%	6.2%	6.9%
Fisher*	100.0	107.8	115.3	122.5	131.2
(% change)		7.8%	7.0%	6.3%	7.1%

Laspeyres fixed-weighted indexes (reference year = year 1)

Year	1	2	3	4	5
Total (base = year 1)	100.0	107.9	115.9	123.8	134.1
Total (base = year 5)	100.0	106.8	113.5	120.3	128.6

***** The Fisher chain is a geometric mean of the Laspeyres and Paasche chains

27. SNA93 considers that, in theory, chain volume estimates should ideally be produced using a Fisher formula (paragraph 16.67). However, SNA93 also recognises that, for the operational reasons mentioned in paragraph 14 above, it is likely that statistical agencies may not want to calculate constant price national accounts using the Fisher formula. Paragraph 16.67 of SNA93 states that, in such cases, "the chain Laspeyres index should provide a very close approximation to the chain Fisher". In practice, switching from a fixed-base Laspeyres formula with five-yearly rebases to a chain Laspeyres formula will achieve a large part of the effect which would result from switching to a Fisher chain index. In other words, making the move to a chain volume index is a more important decision than the actual choice of index formula. This can be seen in the above example by comparing the chain Laspeyres index with the Laspeyres fixed-weight index with year 1 as base. The movements in the Laspeyres chain index are much closer to the movements in the preferred Fisher chain index than those in the Laspeyres fixed-weight index. In practice, results with a similar pattern to these have been observed by those countries which have investigated this issue in detail (for more information, see the USA and the Netherlands' papers listed in the Bibliography).

28. The following table continues the example introduced above. In this final step it demonstrates that, while year *t* estimates expressed in year *t-1* prices are additive, once a time series of totals is formed by chaining then additivity is lost. In this example, the chain index numbers derived earlier are used to extrapolate forward from the current price value recorded in year 1 (in other words, they are expressed in terms of a year 1 reference year). The percentage changes are shown under each of the constant price values derived using each of the formulas to show that they are identical with those derived from the index numbers shown in the table on the previous page.

Non-additivity of chain estimates

Year	1	2	3	4	5
Fixed-base Laspeyres (base = year 1)					
Item A	336.0	352.0	368.0	384.0	400.0
Item B	168.0	192.0	216.0	240.0	276.0
Total	***504.0***	***544.0***	***584.0***	***624.0***	***676.0***
(% change)		7.9%	7.4%	6.8%	8.3%
Total chain values (reference year = year 1)					
Laspeyres	504.0	544.0	582.6	619.8	664.7
(% change)		7.9%	7.1%	6.4%	7.2%
Paasche	504.0	542.5	579.5	615.3	657.6
(% change)		7.6%	6.8%	6.2%	6.9%
Fisher	504.0	543.2	581.1	617.6	661.1
(% change)		7.8%	7.0%	6.3%	7.1%

29. In the first part of this table, the fixed-base Laspeyres estimates, with year 1 as base year, are summed to obtain the total constant price estimate (note that the values for item A and item B are identical for any particular reference year no matter whether a fixed-base or a chain index is calculated because they each refer to a single item and so no aggregation is involved at that level). The total chain estimates, with

one exception other than in year 1 (the reference year), are different from the total derived as the sum of the components, even though they are each derived from estimates which were additive when they were calculated in year *t-1* prices. The exception for which the chain series is additive is the Laspeyres chain in year 2. This result will always occur with a Laspeyres chain in the year after the reference year because year *t* (in this case year 2) expressed in year *t-1* (in this case year 1) prices using a Laspeyres formula is always additive by definition because of the special properties of the Laspeyres formula (see paragraph 16.55 of SNA93).

30. An apparent solution to the non-additivity problem is to allocate the differences between the totals and the sum of the components in some way (eg, by pro-rating the observed difference across the components). In this way, the growth rate of the chain total is preserved. However, the outcome with respect to the components is completely unsatisfactory. In the above example, the effect would be to change the growth rates observed for item A and item B, even though each consists of only a single item. It is clear that the growth rates of each of the two individual items concerned must remain the same as those observed in the underlying quantities and this will not be the case if discrepancies between the total chain values and the components are allocated across the components in some way.

Practices of OECD Countries

31. Most OECD countries are now moving from fixed-base volume measures to annual chained indices for their annual national accounts. Member countries of the European Union will be obliged to adopt annual chaining by 2003. Most countries use Laspeyre chain indices. These give results very similar to the preferred Fisher chain indices and require less data. OECD countries accept the non-additivity of chain indices so that there is a statistical discrepancy between the components and the totals. At the present time the following OECD countries chain their annual accounts:

Australia

Canada (for productivity analysis only)

France

Greece

Luxembourg

Netherlands

New Zealand (about to change in conjunction with their move to SNA93)

Norway

Sweden

USA (Fisher chain)

Conclusion

32. Constant price estimates expressed in terms of a fixed base year have been used for many years by most countries to derive real growth rates. However, rapidly changing relative prices are resulting in large “revisions” to published growth rates when countries move from one base year to another (generally 5 years apart). The solution which has already been adopted by some countries and which appears likely to be adopted by more in the next few years is to move to annually-reweighted chain volume indexes to maintain the integrity of recorded growth rates. However, the issue of non-additivity is a difficult one for national accountants to deal with. Those countries which have moved to chain volume series recently have

found that a large amount of user education is required before the usefulness of chain estimates is appreciated.

Appendix 1

In the following formulas, the base year is always shown as year *o*, while the current year is shown as year *n*. Prices are depicted by *P*, quantities by *Q*, current price values by *C*, a Laspeyres price index by PI^{L}, a Paasche price index by PI^{P}, a Laspeyres chain price index by PI^{LC}, a Laspeyres volume (constant price values) by V^{L}, a Laspeyres volume index by VI^{L}, and a Laspeyres chain volume index by VI^{LC}.

Current price value

$$C_n = \sum_i \left(P_{i,n} x Q_{i,n}\right)$$

Laspeyres price index

$$PI_n^L = \frac{\sum_i \left(P_{i,n} x Q_{i,0}\right)}{\sum_i \left(P_{i,0} x Q_{i,0}\right)}$$

Paasche price index

$$PI_n^P = \frac{\sum_i \left(P_{i,n} x Q_{i,n}\right)}{\sum_i \left(P_{i,0} x Q_{i,n}\right)}$$

Laspeyres volume (constant price) estimate in year *n* (base year = year *0*)

$$V_n^L = \sum_i \left(P_{i,0} x Q_{i,n}\right)$$

Laspeyres volume index in year *n* (weighting base = year *0*, reference year = year *0*)

$$VI_n^L = \frac{\sum_i \left(P_{i,0} x Q_{i,n}\right)}{\sum_i \left(P_{i,0} x Q_{i,0}\right)} x100$$

Laspeyres volume in year *n* obtained using a Paasche price deflator

$$VI_n^L = \sum_i \left(P_{i,n} x Q_{i,n}\right) \Bigg/ \frac{\sum_i \left(P_{i,n} x Q_{i,n}\right)}{\sum_i \left(P_{i,0} x Q_{i,n}\right)}$$

$$= \sum_i \left(P_{i,0} x Q_{i,n}\right)$$

Laspeyres chain volume index for year *n* (weighting base = year *t-1*, reference year = year *0*)

$$VI_n^{LC} = \left[\frac{\sum_i \left(P_{i,0} x Q_{i,1}\right)}{\sum_i \left(P_{i,0} x Q_{i,0}\right)}\right] x \left[\frac{\sum_i \left(P_{i,1} x Q_{i,2}\right)}{\sum_i \left(P_{i,1} x Q_{i,1}\right)}\right] x \ldots\ldots\ldots\ldots x \left[\frac{\sum_i \left(P_{i,n-1} x Q_{i,n}\right)}{\sum_i \left(P_{i,n-1} x Q_{i,n-1}\right)}\right]$$

Laspeyres chain price index for year *n* (weighting base = year *t-1*, reference year = year *0*)

$$PI_n^{LC} = \left[\sum_i \left(w_{i,0} x \frac{P_{i,1}}{P_{i,0}}\right)\right] x \left[\sum_i \left(w_{i,1} x \frac{P_{i,2}}{P_{i,1}}\right)\right] x \ldots\ldots\ldots\ldots\ldots\ldots x \left[\sum_i \left(w_{i,n-1} x \frac{P_{i,n}}{P_{i,n-1}}\right)\right]$$

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