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Chain Index Number Formulae in the National Accounts

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CHAIN INDEX NUMBER FORMULAE IN THE NATIONAL ACCOUNTS

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Introduction

1. An important use of national accounts data is to assess how a country's economy is growing or contracting over time. For many, if not most, analytical purposes it is the rate of change in volume, not in value that is of interest. Or more generally, what the national accountant should provide is a split of the movement of aggregates in value terms into a price and a volume component.

2. Users typically refer to two indications of volume measures: (i) what is somewhat imprecisely called 'real' growth[1], expressed in terms of percentage changes and (ii) 'constant price' measures of national accounts aggregates, expressed in monetary units of a particular 'base' year[2].

3. Users turn to (i) for indications of economic growth and movements *between periods* of national accounts aggregates that control for inflation and they turn to (ii) for information about the relative size of national accounts aggregates at constant prices *within a period* and naturally, users look for consistency between measures within a period and measures between periods: the rates of change of levels at constant prices should equal the 'real' growth rates and levels of sub-components should add up to totals within any given period. This requirement, as will be explained below, is not met by chained index number formulae and constitutes one of the reasons why chained indices have met negative reception by users. However, in many cases, this apparent inconsistency reflects more an analytical misconception than a serious drawback and communication with users is important on this point.

4. An increasing number of OECD countries has started to implement chained index number formulae into their national accounts because it is recognised that these index numbers constitute conceptually superior measures of economic growth, in particular in periods of structural change and rapid movements of relative prices. Of course, the right index number formula is only the last step in producing reliable volume measures in national accounts – without high-quality price indices at the detailed level of expenditures and/or outputs, no overall measure of economic growth will be of high quality.

A quick reminder: chained indices

5. There is a large body of theoretical literature about index numbers and the interested reader is referred to articles such as Diewert (1987) for an overview. Chapter XVI of the SNA 1993 on price and

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[1] It would be clearer to restrict the use of the adjective 'real' to those measures that have been deflated by a general price index and to use the word 'volume' growth for those occurrences where the value movement of a particular national accounts aggregate has been deflated with the price index for this aggregate.

[2] Again, this is a denomination that is often used for several different measures: a 'base' reference period is the period to which index number weights relate; an index reference period is the arbitrary period to which an index has been normalized, i.e. set to equal 100. As will be seen below, although there is a single index reference period for chained indices, there is no single base reference period.

volume measures is an excellent and more applied primer to the topic and only a very few key points will be repeated here.

6. A volume index is an average of proportionate changes in the quantities of a specified set of goods and services. While it is possible to directly observe quantities of products over time, it is much more common to use price indices, divide them into the value changes of a national accounts aggregate and so obtain a volume index of that aggregate. This should happen at the lowest level of detail available for national accounts purposes. Typically, this level of detail is still significantly higher than the level of the individual product from which price indices are constructed.

7. The reasoning about the choice of index numbers for national accounts starts at the lowest level of aggregation available in the national accounts – the price indices used at this level of aggregation have to be considered like elementary price indices and they may or may not themselves be constructed with the same index number formula as the national accounts use for higher level aggregation. For example, if the consumer price index uses fixed expenditure weights, this will affect the national accounts to the extent that CPI components are used as elementary price indices in a national accounts context. The higher the level of aggregation at which national accounts index numbers set in, the more the overall growth rate of GDP is shaped by the index number formulae that are present in the elementary price indices used in the accounts.

Box 1. A note on terminology

The term 'base period' has been used in different ways in the index number literature and in national accounts and prices work. To avoid confusion, we follow the terminology set in the *Producer Price Index Manual* (IMF et al. 2004) and call:

-*Price (quantity) reference period* the period whose prices (quantities) appear in the denominators of the price relatives used to calculate the index: for example, the implicit deflator of private consumption between the year 2003 and 2002 has 2002 as a price reference year;

-*Weight reference period* the period whose values serve as weights for the index. However, when hybrid weights are used in which the quantities of one period are valued at the prices of another period, there is no unique weight reference period;

- *Index reference period* the period for which the index is set equal to 100.

8. Given such 'elementary' prices and quantities for the national accounts, the comparison of two periods' volumes is often made by using a fixed vector of prices p. Using a particular weight reference period, say zero, and comparing the quantities of periods t and 0, amounts to using the well-known fixed-base Laspeyres volume index

$$(1)\ L^{t/0} = \frac{\sum p^0 q^t}{\sum p^0 q^0}.$$

9. If the weight reference period is set as t, on the other hand, one ends up with a Paasche volume index $\frac{\sum p^t q^t}{\sum p^t q^0}$ and the geometric average between the Laspeyres and the Paasche index yields the Fisher index. The fixed-weight Laspeyres index has been the most frequently-encountered volume index in national accounts. It yields national accounts aggregates for the year t, expressed at constant prices of year 0: $\sum p^0 q^t$. If one computes the rate of change of such a constant-price aggregate between two consecutive periods t and t-1, one obtains

(2) $$\frac{L^{t/0}}{L^{t-1/0}} = \frac{\sum p^0 q^t}{\sum p^0 q^{t-1}} = \sum \frac{p^0 q^{t-1}}{\sum p^0 q^{t-1}} \times \frac{q^t}{q^{t-1}}.$$

10. It is apparent from (2) that the year-to-year volume change of a national accounts aggregate based on a fixed-base Laspeyres index is a weighted average of the elementary volume changes, each weighted with a hybrid weight that reflects the quantities of period t-1 valued at prices of year 0. One could also say that the quantities in these weights are continuously being updated as the quantity reference period moves on.

11. The formula in (2) must be clearly distinguished from a so-called 'Sauerbeck' or 'Young' index that are also weighted averages of volume relatives but with weights that have a unique weight reference year, for example year 0:

(3) $$S^{t/t-1} = \sum \frac{p^0 q^0}{\sum p^0 q^0} \times \frac{q^t}{q^{t-1}}.$$

12. Despite its similarity to the fixed-base Laspeyres index, the Sauerbeck index can yield significantly different results. However, both of them are different from a chained Laspeyres index. Generally, a chained index compares movements between two non-adjacent periods by cumulating changes between adjacent periods rather than carrying out direct comparisons. (4) shows the chain Laspeyres index between periods t and t-1. Every volume movement between two adjacent periods is weighted by prices and quantities of the first of the two periods:

(4) $$L^{t/t-1} = \frac{\sum p^{t-1} q^t}{\sum p^{t-1} q^{t-1}} = \sum \frac{p^{t-1} q^{t-1}}{\sum p^{t-1} q^{t-1}} \times \frac{q^t}{q^{t-1}}.$$

13. The rate of volume change between period 0 and period t – done directly in (1) – would be put in place as the product of intermediate period-to-period indices: $L^{t/t-1} \times L^{t-1/t-2} \times ... L^{1/0}$. Of course, there is no reason to assume that in general, the two methods yield the same results. Only the Laspeyres volume index has been presented here but the difference between chained and direct comparisons applies equally to other index number formula, in particular the Paasche and the Fisher index.

14. The question arises: which index number formula should be preferred for the national accounts? The next section looks at this issue and discusses some of the pros and cons that are associated with this choice.

Table 1: Fixed-base and chain indices: a numerical example

		Year 1	Year 2	Year 3	Year 4	Year 5
Value	Product A	60.0	63.2	66.6	70.0	73.6
	Product B	40.0	38.8	37.5	36.1	34.6
		100.0	102.0	104.0	106.1	108.2
Price index	Product A	1.00	1.02	1.04	1.06	1.08
	Product B	1.00	0.80	0.64	0.51	0.41
Volume index	Product A	1.00	1.03	1.07	1.10	1.13
	Product B	1.00	1.21	1.46	1.76	2.11

Laspeyres fixed-base index (weight reference year = 1)						
	Product A	60.0	62.0	64.0	66.0	68.0
Value at year 1 prices	Product B	40.0	48.5	58.5	70.5	84.6
	Total	100.0	110.5	122.5	136.5	152.6
Volume index year 1=1	Total	1.000	1.105	1.225	1.365	1.526
% Change	**Total**		**10.5**	**10.9**	**11.4**	**11.8**

Laspeyres chain index (weight reference year = t-1)						
	Product A		62.0	65.3	68.7	72.2
Value at year t-1 prices	Product B		48.5	46.8	45.1	43.3
	Total		110.5	112.1	113.8	115.5
Volume index t/t-1	Total		1.105	1.099	1.094	1.088
% Change	**Total**		**10.5**	**9.9**	**9.3**	**8.8**

Paasche chain index (weight reference year = t)						
	Product A	61.2	64.5	67.9	71.4	
Value at year t+1 prices	Product B	32.0	31.0	30.0	28.9	
	Total	93.2	95.5	97.9	100.3	
Volume index t/t-1	Total		1.094	1.089	1.084	1.079
% Change	**Total**		**9.4**	**8.9**	**8.4**	**7.9**

Fisher chain index						
Volume index t/t-1	Total		1.099	1.094	1.089	1.084
% Change	**Total**		**9.9**	**9.4**	**8.9**	**8.4**

Sauerbeck index						
Volume index t/t-1	Product A		1.033	1.032	1.031	1.030
	Product B		1.211	1.208	1.204	1.200
	Total		1.105	1.103	1.100	1.098
% Change	**Total**		**10.5**	**10.3**	**10.0**	**9.8**

The arguments in favour of chaining

15. The strongest argument[3] in favor of chain indices arises in a situation where there are systematic trends in relative prices and quantities. In this situation, when a fixed-base Laspeyres index is used, it often happens that too much weight is placed on those goods and services whose relative prices have fallen and whose volumes have increased more rapidly than those of other products. A look at expression (2) shows that the weight of such a product would be too large because it combines the large quantities of the recent period t-1 with the non-adjusted, high price of period 0. This effect is known as the substitution bias. A different way of expressing the same phenomenon is to say that the spread between a fixed-base Laspeyres and a fixed-base Paasche index would be large under conditions of systematic trends in relative prices and quantities.

16. Chain-weighted indices, on the other hand, show a much smaller spread between the Laspeyres and Paasche indices and they operate with weights that are both close to the quantity reference period and where prices and quantities that constitute the weights refer to the same period. Hence, chain indices are much less prone to a substitution bias than fixed-base indices. Economically spoken, they bring closer the observed changes in behaviour, e.g. a rise in volume demand of a certain product and the relative price signals that influence this behaviour. With fixed-base Laspeyres indices, the weight reference year and the volume reference year can be far apart and so combine price weights with unrelated observations on quantities. This can yield results of modest analytical value such as negative constant-price value-added under double deflation – an economically meaningless number.

17. For example, computer volumes and prices have fallen rapidly relative to other goods while their volumes have been growing more rapidly than other goods. Therefore, price and volume indices that include computers as one item can more quite differently, according to whether they are chained or fixed-based. In the United States, the introduction of hedonic computer price indices and their rapidly falling prices into the national accounts made the need to shift to a chain-weighted index number obvious. Shortly afterwards, the United States Bureau of Economic Analysis moved from a fixed-base Laspeyres volume index to a chained Fisher formula.

18. Consider the numerical example in Table 1. It pictures a data situation that is typical for the national accounts: availability of current-price value aggregates, and availability of a price index. Two value aggregates are shown here, ‘product A’, and ‘product B’, one of which shows a moderate increase in prices (2% per year) and could be thought of as ‘services’, and the other one which shows a rapid decline in prices (-20% per year) and could be thought of as ‘computers’. The value shares of the two products shift somewhat in favour of ‘computers’ but ‘services’ continue and account for the bulk of expenditure over the simulation period which is five years. It is easy to see that after deflation, the volume indices for the two products rise at very different rates – ‘services’ production grows at an average annual rate of about 3% and ‘computer’ production at a rate of 18%. Thus, we are facing a situation of rapid shifts in relative prices and quantities here, liable to substitution bias if measured by way of a fixed-base Laspeyres index number formula.

19. Table 1 then goes on to compute a traditional fixed-base Laspeyres index number. This is done by valuing all production data at prices of year 1 – obtained by dividing the price index with year=1 into current-price data. As all data are valued in prices of year 1, they can be added up and compared across years. This gives rise to the volume growth rates under a fixed-base index number: form 10.5% between years 1 and 2 to 11.8% between years 4 and 5.

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[3] See Hill (1988) and Szulc (1983) for a more general discussion of the relative merits of fixed-base and chain-weighted indices.

20. Next, the chain-weighted counterpart is computed by expressing production values of ‘services’ and ‘computers’ in prices of the preceding year t-1. Obviously, these values cannot be compared between years because they are on a different price basis. But the production value of year 2, expressed in prices of year 1 can be compared with the production value of year 1 expressed in prices of year 1 and so on. This gives rise to a volume index between adjacent years (t/t-1) and to the annual growth rates shown in the third panel of the table. It is immediately apparent that these growth rates are significantly lower than the ones produced by the fixed-base index: for example, in year 5, the chain index grows at 8.8% as opposed to an 11.8% growth rate for the fixed-base index.

21. The numerical example also computes the chained Paasche index: here, production values for any year t are expressed at prices of the year t+1. The value of total production, expressed at prices of t+1, can then be compared with the value of total production in t+1 at prices of t+1. This gives rise to another set of volume growth rates as shown in the table. As theory would predict, if prices and quantities are negatively correlated, the chain Paasche index shows up with a slower rate of volume growth than the chain Laspeyres index. Because the chain Paasche index just as defendable as the chain Laspeyres index, theory stipulates that a Fisher-type index should be calculated as the geometric average of the Paasche and the Laspeyres index. This is done in the last panel of the numerical example.

22. For completeness, the numerical example also presents the results for a Sauerbeck index. Here, economic growth turns out to show up with a smaller rate than under the fixed-base Laspeyeres index but this is no general rule. It can be shown (Diewert 2004) that this depends on the price and volume movements and on the elasticity of substitution for particular product types.

23. Even if one favours a fixed-base index, the weight reference year cannot be used forever as it becomes less and less representative for the goods and services transacted in later or earlier periods. Thus, at one point, the base year will have to be changed imply that there is no unique rate of growth of volume of price aggregates under fixed-base index numbers – an inevitable change in the base year will have repercussions on measured economic growth. Such a dependence of the measures of economic growth on the – after all arbitrary – choice of a particular base year is not an attractive feature. It also entails more or less serious revisions of time series data following the change of base years.

24. The SNA 1993 as well as other international manuals are generally in favour of chaining, and typically for the above reasons. This does not mean that under all circumstances, chaining is the preferred option and several drawbacks will be mentioned below.

The arguments against chaining

25. There are three types of arguments against chaining:

26. First, from an index number perspective, chaining may be undesirable when it leads to index drift. Szulc (1983) made the point that when prices or quantities oscillate (‘bounce’), chaining can lead to considerable index drift: that is, if after several periods of bouncing, prices and quantities return to their original levels, a chained index will not normally return to unity. Hence, the use of chained indices for noisy monthly or quarterly series is not recommended.

27. This is shown by way of the numerical example in Table 2. The computations involved are identical to those described above for Table 1 but the base data has been changed so as to reproduce a situation where prices and volumes oscillate. ‘Services’ prices increase and then drop again to their level of period 1 whereas ‘computer’ prices first drop and then rise. Quantities are supposed to follow the opposite movements so that volume indices return to their initial values. It is then apparent that the fixed-base Laspeyres formula correctly leads back to a volume index of unity in year 5. This is not the case for the

chain indices which both end up at a level lower than unity. Nor is it the case for the Sauerbeck index that is equally subject to the phenomenon of index drift.

28. Also from an index number perspective, there has been objection to chain indices because they have no counterpart in the spatial context. In a time-series context, there is a natural ordering of the sequence of chaining: from t to t+1 and from t+1 to t+2 etc. In a spatial comparison, between countries or region no such ordering exists and, for reasons of consistency, fixed-base indices should be used in both temporal and spatial comparisons (von der Lippe 2001)

29. Second, from a practical viewpoint, the non-additivity associated with chain indices has been a major point of criticism. Non-additivity means that when the current values in the weight reference year are extrapolated backwards or forwards using a chain index, the extrapolated values of the components of some aggregate do not sum identically to the extrapolated value of the aggregate. Constant price values of components that have been constructed by way of fixed-base Laspeyres indices are additive because they are all valued with the same price vector of the weight reference period. Additivity is a feature that has been appreciated by users, in particular economic modelers in whose models interdependent variables are linked by accounting relationships between their constant-price levels. Loss of additivity due to chaining requires therefore significant interaction with users and communication about upcoming changes when a chained index number formula is introduced.

30. Third, and importantly, the implementation of chain indices into the national accounting system can be costly and/or complicated; because recent weights of period t-1 (see equation 4) may not be available when statistical offices compute volume indices for the period t/t-1. The availability of weights is an issue of particular importance in the context of quarterly accounts (see below).

Table 2: Chain and fixed-base indices with oscillating prices and volumes: a numerical example

Laspeyres chain index (weight reference year = t-1)						
	Product A		60.8	62.8	67.3	69.4
Value at year t-1 prices	Product B		47.5	48.0	25.5	25.6
	Total		108.3	110.8	92.8	95.0
Volume index t/t-1	Total		1.083	1.108	0.928	0.950
% Change	**Total**		**8.3**	**10.8**	**-7.2**	**-5.0**

Paasche chain index (weight reference year = t)						
	Product A	61.2	63.2	62.8	64.7	
Value at year t+1 prices	Product B	32.0	28.5	48.0	42.5	
	Total	93.2	91.7	110.8	107.2	
Volume index t/t-1	Total		1.073	1.090	0.903	0.933
% Change	**Total**		**7.3**	**9.0**	**-9.7**	**-6.7**

Fisher chain index						
Volume index t/t-1	Total		1.078	1.099	0.915	0.941
% Change	**Total**		**7.8**	**9.9**	**-8.5**	**-5.9**

Sauerbeck index						
Volume index t/t-1	Product A		1.013	1.012	1.051	1.051
	Product B		1.188	1.263	0.708	0.753
	Total		1.083	1.113	0.914	0.932
% Change	**Total**		**8.3**	**11.3**	**-8.6**	**-6.8**

Chaining in OECD countries

31. Over the past years, a growing number of OECD countries have implemented chain indices into their national accounts. In the European Union, implementation will be obligatory but several non-European countries have led to way in the area, in particular the United States, Canada and Australia. The table below shows the state of implementation in selected OECD countries.

Table 3 Annually chained index number formulae in selected OECD countries

Country	Index number formula annual national accounts	Index number formula quarterly national accounts
United States	Chained Fisher index	Chained Fisher index
Canada	Chained Fisher index for expenditure measure only	Chained Fisher index for expenditure measure only
Australia	Chained Laspeyres index	Chained Laspeyres index
Austria	Chained Laspeyres index (in 2005)	Chained Laspeyres index (in 2005)
New Zealand	Chained Laspeyres index	Chained Laspeyres index
Belgium	Chained Laspeyres index (from Oct 2005)	Chained Laspeyres index (from Oct 2005)
Denmark	Chained Laspeyres index	Chained Laspeyres index (from Dec 2004)
Finland	Chained Laspeyres index (in 2005)	Chained Laspeyres index (in 2005)
France	Chained Laspeyres index	Fixed-base Laspeyres index
Germany	Chained Laspeyres index (in 2005)	Chained Laspeyres index (in 2005)
Greece	Chained Laspeyres index	Fixed-base Laspeyres index
Sweden	Chained Laspeyres index	Chained Laspeyres index
Spain	Fixed-base Laspeyres index	Fixed-base Laspeyres index
Italy	Chained Laspeyres index (in 2005)	Chained Laspeyres index (in 2005)
Netherlands	Chained Laspeyres index	Chained Laspeyres index
United Kingdom	Chained Laspeyres index	Chained Laspeyres index

32. From the above table, it is apparent that there are at least four different ways how chain indices are implemented in the national accounts.

33. The first format for implementation is the one chosen by the United States and Canada: chained Fisher indices are used on an annual and on a quarterly basis, although Canada only applies Fisher indices to GDP computations based on the expenditure side. The US model is clearly the most sophisticated route towards implementation and corresponds in many respects to recommendations that arise from index number and economic theory. In particular, the use of chained Fisher index numbers over chained Laspeyres reflects the theoretical argument that on a number of criteria (index number criteria as well as economic criteria – see Diewert 1989) the Fisher index number outperforms the Laspeyres index number formula.

34. Yet, there are several practical considerations that weigh heavily in favour of the Laspeyres formulation:

- empirical analysis shows that chain Laspeyres indices often, but not always, give very similar results to chain Fisher indices;

- chain Laspeyres indices produce additive constant price data as long as only the current year (valued at t-1 prices) and the previous year (valued also at t-1 prices) are compared. For any given year, supply and use tables can then be set up at constant t-1 prices and balanced by addition and subtraction of constant price data. This is not possible for chained Fisher indices;

- to construct Fisher indices, a Laspeyres and a Paasche component have to be computed. To construct a Paasche volume index, it is necessary to value the previous period's quantities in the present period's prices and these weights may not be available at the time when the index should be computed, requiring additional estimates, assumptions and possible revisions subsequently.

35. The second format corresponds to Australian practice where chained Laspeyres indices are used for annual and for quarterly accounts. The same approach is found in the Netherlands, and in several other European countries. It corresponds to the recommended methodology by Eurostat.

36. The third format is the one currently practiced by France: the chained Laspeyres formula is used for annual accounts and the fixed-weighted Laspeyres index number for quarterly accounts. This combination has many practical advantages, in particular it helps working around complications arising with chaining in the quarterly accounts. The obvious drawback of this practice is the inconsistency injected between annual and quarterly accounts, making their reconciliation difficult if not impossible.

37. The fourth alternative is not to implement annually-weighted volume and price indices. This is still the case for several European and OECD countries and for many countries outside the OECD area. The absence of annual chaining does not normally imply no chaining at all – in many OECD countries that do not chain annually, chaining is put in place on a multi-year basis (with five years being the most frequent interval).

Does it matter empirically?

38. An important consideration in conjunction with chain index numbers is whether their implementation matters empirically. It is therefore of interest to consider examples of simulations that were carried out by statistical offices when investigating the implementation of chain index numbers. Mareska (2002), for example, shows the effect of using different index number formulae on Italian GDP growth rates (Table 4).

Table 4 Volume GDP growth under alternative index number formulae
Italy, percentages

YEARS	Laspeyres (weights 1995)	Laspeyres (chain)	Fisher (chain)	Paasche (chain)
1992-1995	1.40	1.49	1.44	1.38
1995-1998	1.64	1.59	1.58	1.56
1999-2001	2.32	2.43	2.39	2.34

Source: Mareska (2002).

Figure 1: Difference in GDP growth based on fixed-base 1995 Laspeyres index and annually chain Laspeyres index, Italy, percentage points

Source: Mareska (2002).

Table 5: Alternative growth rates from the production measure of GDP at constant prices

Year	Annually chain-linked Laspeyres % change on previous year	Annually chain-linked Fisher % change on previous year	Fixed-base Laspeyres % change on previous year
1987	*5.0*	*5.0*	*4.7*
1988	*5.2*	*5.2*	*4.9*
1989	*2.8*	*2.7*	*2.4*
1990	*0.8*	*0.7*	*0.7*
1991	*-2.2*	*-2.1*	*-2.2*
1992	*-0.4*	*-0.5*	*-0.4*
1993	*2.1*	*2.1*	*2.2*
1994	*3.6*	*3.5*	*4.0*
1995	*2.3*	*2.2*	*2.5*

Source: Tuke (2002).

39. Several conclusions arise from these two tables.

- At the level of GDP, and for the years under consideration, the growth rates based on the chain Laspeyres index are good approximations of the growth rates based on the theoretically superior chain Fisher index. In Italy, average annual differences do not exceed 0.05 percentage points per year. A similar picture emerges from the simulations for the United Kingdom.

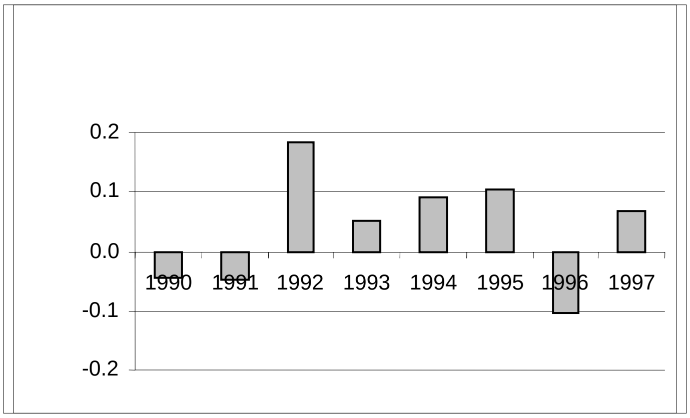
- However, and as would be expected on theoretical grounds, there are significant differences between the results from the fixed-base Laspeyres formula and the chain Fisher index or, for that matter, the chain Laspeyres index. For individual years, the difference turns out to be as large as 0.4 percentage points in the United Kingdom and close to 0.3 percentage points in Italy.

- Both country examples nicely bear out the substitution bias inherent in the fixed-base Laspeyres formula. In both cases, the fixed-base Laspeyres result overstates economic growth in years following the weight reference year and understates economic growth in years preceding the weight reference year (1995 and 1990, respectively).

40. It was mentioned earlier that one of the practical issues arising in the implementation of chain index number formulae is the availability of weights for the previous period. An obvious way to deal with this situation is to use weights not of the period preceding the volume change but of the period before that. Chained indices would continue to be chained by feature weights that relate to an earlier period. Again, some countries, including the United Kingdom carried out simulations to assess the quantitative importance of such as substitution.

Figure 2: Difference between chain Laspeyres with weight reference period t-2 and t-1
Percentage points

41.



Source: Tuke (2002)

42. It is apparent from Figure 2 that the overall effect of using t-2 instead of t-1 weights is moderate, hardly exceeding 0.1 percentage points. However, Tuke (2002) also demonstrates that this comparatively small difference hides larger discrepancies at lower levels of aggregation. For total manufacturing, for example, differences due to the choice of the weights can be sizable as is the case for total services. At the same time, the differences due to a one-year shift in weight are clearly smaller than the differences between a chain and a fixed-base Laspeyres formula.

Quarterly data

43. Chain-linking of quarterly national accounts requires more complex calculations than annual accounts. The SNA 1993 provides little concrete guidance on the implementation of quarterly chain indices. The main international sources on this topic are the IMF Quarterly National Accounts Manual (Bloem et al. 2001) and the Eurostat Handbook on Quarterly National Accounts (Eurostat 1999). The

following text draws on a paper produced by Eurostat (2002) as a background document to a seminar on chaining in the national accounts.

Frequency of weighting

44. When chain indices are implemented in quarterly accounts, there are two options for the choice of weights; to apply annual weights to quarterly quantity changes and to quarterly weights to quarterly quantity changes. In the first case, the average prices of the previous year are used as the weight reference period; in the second case, the previous quarter acts as weight reference period.

45. Because quarterly data are more likely subject to oscillations than annual data, there is a higher risk of generating an index drift (see above) if quarterly weights are used. On these grounds, annual weights are preferable, especially if data are not seasonally adjusted. The SNA 93 also warns against the effects of short-term volatility in relative prices and quantities on index number behaviour.

46. Annual re-weighting also makes it easier to establish consistency between quarterly and annual data. This is not the case for quarterly weights. On the other hand, in times of rapidly changing relative prices and volumes, quarterly weights may be more appropriate to counteract substitution biases than annual weights.

47. In several European countries (United Kingdom, Netherlands) and in Australia, there appears to be a preference for annual re-weighting, while the United States and Canada have opted for the quarterly approach.

Table 6 Annual and quarterly re-weighting

Annual re-weighting	**Quarterly re-weighting**
Results are less affected by short term volatility in quantities and prices: the so called “drift problem” is less likely to happen	Quicker in capturing the substitution effect.
Consistency between QNA and ANA can be automatically reached (without applying any benchmark).	It can lead to the so called “drift” effect.
	It should preferably applied to time series that do not show a seasonal behaviour
	If applied together with superlative index formula (Fisher) then the “drift effect” is less evident
Applied in UK, the Netherlands and Australia	***Applied in US and Canada.***

Source: Eurostat (2002).

48. Akin to the construction of annual growth rates, there is a question about the choice of the right index number formula in the construction of chain quarterly growth rates. In practice, the two candidates are again the Laspeyres and the Fisher index number formula and similar arguments for and against each of them apply as in the case of chaining annual data (see also Eurostat 2002).

49. Once the decision about the type of index number formula has been taken, further considerations enter as to the specific methodology to be applied to construct annual chain-linked data. For example, “annual overlaps” could be used, i.e., the average price data from the previous year are used as weights for each of the quarters in the current year, or the “one quarter overlap” technique: one quarter of the year (e.g., the fourth quarter) is compiled at both the average prices of the current year and the average prices of the previous year, which then provide the linking factor for the current year.

50. A detailed treatment of these techniques is beyond the scope of the present overview but can be found in Chapter IX of the the IMF manual on quarterly national accounts (Bloem et al. 2001) to which the reader is referred.

Conclusions

51. Economic and index number theory as well as international statistical standards (e.g., the SNA 1993, CPI Manual, PPI Manual) recommend the usage of chained index number formulae. The main reason is that when there are systematic shifts in relative prices and quantities, the application of a fixed-weight index number leads to biased measures of economic growth.

52. Chain index number formulae are all the more important when economies undergo important structural changes because any past vector of prices that is used for weighting will be quickly out of date and either reflect the wrong relative price and/or relate to products that are no more representative of individual markets.

53. Implementing chain indices brings with it several complications, though: (i) computations are somewhat more complex than in the case of fixed-base index numbers; (ii) the necessary data to establish weights that are close to the volume reference period may not be easily available, in particular when current weights are required as is the case for the Paasche and Fisher index number formulae; (iii) with chain indices, constant-price level data of national accounts aggregates ceases to exist or is not comparable across more than two adjacent years. ‘Constant-price’ data in level form that are generated by benchmarking volume growth rates to an arbitrary benchmark period are non-additive. Non-additivity is a feature that requires significant explanations and communication with users; (iv) choices need to be made for the treatment of quarterly data – and there is no single best method to deal with this.

54. Although these complications exist, experience has shown that they are manageable in practice and that the advantages of generating more accurate measures of economic growth clearly outweigh the complications associated with the introduction of chain indices into the national accounts.

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