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RELEVANCE AND CONSTRUCTION OF CHAINED SERIES

Invited paper submitted by the Institut National de la Statistique et des Etudes Economiques (INSEE), France*

Summary

In base 95, consistent with ESA 95, French national accounts give preference to chain volume measures. The comparisons with supporting data presented here show that the differences with constant price series may be substantial. A method of analysing the relevance of chaining is then proposed. Its numerical application to different series of French accounts broadly justifies chaining. The treatment of changes in inventories examined in the last part is, however, a very particular case.

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1. For goods and services as a whole, volume measures are the principal object of national accounting, notwithstanding the specific difficulties of the volume/price separation: consideration of the quality effect for high-technology goods, difficulty of measuring price movements for certain services, in particular for enterprises, conceptual problems and sometimes erratic results from the volume/price measures of insurance services, problem of non-market services, etc.

2. Furthermore, the fact that there are two types of volume measures, i.e. volume measures in constant prices and chain volume measures in prices of the previous year, also raises a number of questions:

- Are the divergences between the two types of series significant?

- What are the respective problems in their use?

- What is the relevance of each of the two types of volume measures?

- What policy on data dissemination should be adopted?

3. In what follows, this paper aims to shed light on these questions drawing upon French experience. This experience is quite considerable since French national accounts experts have for a long time calculated volume measures both in constant prices and in prices of the previous year. A method is, moreover, suggested here in order to examine, for a given series, the relevance of chaining. While its utility is largely confirmed by the numerical examples based on French accounts, chaining nevertheless cannot be viewed as an all-purpose technique. The problem of changes in inventories, which warrant particular treatment, serves as a reminder of that fact.

CHAINED SERIES ARE PREFERRED IN BASE 95

4. In our old base (referred to as “base 80”) volume measures were published both in prices of the previous year and in 1980 prices. The chaining of movements in prices of the previous year was not undertaken and that task was left to the user. Implicitly, the principal role of accounts in prices of the previous year was not to arrive at chained series. But they nevertheless had a dual role:

- First, these accounts made it possible to provide, for each aggregate, the best possible measure of its movement from one year to another. Thus, the economic growth discussed in the official publication on the provisional account (first complete evaluation of the accounts of the past year) was expressed in prices of the previous year;

- Secondly, they constituted a stage in the calculation of accounts at 1980 prices. These accounts were compiled from the chaining of different series of supply and use tables by product, at the finest possible level (generally at the 600 level).

Thus they were, in fact, accounts in constant prices only to the extent that the chained series could be considered as homogenous elementary series, i.e. this was only an approximation.

5. It should be noted here that while the technique of chaining was applied at the detailed level, France nevertheless did not produce chain volume measures at the more aggregated levels, and this sometimes caused confusion. The level at which the chaining is done is, of course, important:

- Chaining at the finest possible level, followed by aggregation, represents (as in base 80) a technique for compiling accounts in constant prices;

- The compilation of chain volume measures in prices of the previous year, on the other hand, involves the chaining of aggregates at all levels of classification, in particular (and this is the main advantage of the method) at a very aggregated level, starting with GDP and its principal components. The chaining must also be applied to all kinds of series, such as the consumption of manufactured products, for example.

6. The advantages and disadvantages of chained series are now well known and may be summarized very briefly as follows:

- Chained series take account of the changing structure of the economy, in particular the change in relative prices, which is significant for some outputs (data processing, energy);

- However, the chaining of series destroys, for purely mathematical reasons, the accounting equations. The accounts are thus no longer balanced (or additive, depending on the terminology used).

7. This last point may, of course, cause serious difficulties for some users, in particular for the compilers of macroeconomic models, since they are used to employing accounting equations in their models, as well as to adding the aggregates. The fact that this would no longer be possible with chained series is a fundamental criticism. The proponents of chained series may, however, reply as follows:

- It may be worthwhile to study the change in an aggregate independently of any accounting balance. For example, it seems entirely legitimate to look at household consumption over a long period, in a purely descriptive manner. In this case, it would be a shame not to have the series deemed to be the best, taken in isolation;

- Some macroeconomic models are built solely from equations incorporating growth rates. While such models are hard to build, it is tempting to think that any user, taking unbalanced chained accounts, can himself restore the accounting balances by breaking down the differences of chaining to save as best as possible the series representing the core of his field of study. For example, a model designed to analyse foreign trade will be constructed preserving the chaining of the export and import series. But it may be argued that this is a lot to ask of the user.

8. Chaining poses a specific problem, moreover, in the compilation of quarterly accounts. Compiling accounts in the prices of the previous quarter seems impractical. The proponents of chaining usually envisage quarterly accounts in the (average) prices of the previous year. But this gives rise to a certain discontinuity when moving from the fourth quarter of one year to the first quarter of the next year. Faced with these difficulties, French quarterly accounts experts are continuing to calculate accounts in constant prices. Indeed, their technique of benchmarking in respect of annual accounts series is more appropriate with annual series in constant prices.

9. With base 95, French annual accounts experts have focused on the calculation and dissemination of these chained series, without really breaking with the base 80 practice:

- The series published (on paper and on the Internet site) are chained series, at the different levels of classification (series in the prices of the previous year, chained, in 1995 francs). In this respect France works within the logic of SNA 93 and ESA 95, which favour chained series;

- Some measures in 1995 prices are nevertheless calculated and published to meet the wishes of French users. These are, however, "pseudo" constant prices inasmuch as they are derived from chaining of the input-output table for 118 items, followed by balancing and then purely additive aggregations. The 118 level represents the finest level at which such chaining can be effected automatically. At this level, the series can still hardly be regarded as homogenous. The balancing itself is done for each product by allocating the difference of chaining to the changes in inventories or, failing that, to production. This choice stems from the fact that, in compiling quarterly accounts, changes in inventories are estimated by overall balancing.

10. It should not be forgotten, however, that the fact of giving precedence to unbalanced accounts, while also offering some balanced accounts, does not simplify the task either of the users or of the producers and disseminators of the data. And it may justifiably be asked whether the exercise is worthwhile and whether we, the specialists, have not fallen into the trap of attaching too much importance to a question that, while interesting in theoretical terms, is not really vital for the quality of the published figures.

THE DIFFERENCES BETWEEN CHAINED SERIES AND CONSTANT PRICE SERIES, ALTHOUGH OFTEN SMALL, ARE NOT NEGLIGIBLE

11. For a quantitative study of the differences between the two systems of prices, we will use the base 80 accounts. This choice is above all justified by the fact that the accounts in constant prices with this base are much closer to real constant price measures than those with base 95 (see above).

12. In base 80, recent years were calculated at 1980 prices and therefore with a price structure dating back more than 15 years. An idea often put forward is that the fact of changing the reference year every five years, as envisaged in base 95, eliminates most of the differences that can be observed between the movements in the different price systems. This holds true when we look at the economic developments of recent years, where such updating of the price reference is very desirable. Nonetheless, whatever the year of reference for the prices, when we use an aggregate over a long period (20 years, for example), the first and last years are calculated with the same structure of prices even though they correspond to structures of the economy that are 20 years apart. Here, chaining is a priori the only possible answer.

13. Table 1 below indicates for some series the differences, in base 80, between the growth rates in the two price systems (in chained series, the movements from one year to another are equal to the movements obtained in the accounts at prices of the previous year, denoted here as "n-1 prices").

14. Between the two price systems, the difference of measurement for GDP growth is relatively small, although not negligible. It is usually about 0.2 and reaches 0.3 (in 1996) or 0.4 (in 1989). The impact of the reference year for the prices is greater for the gross fixed capital formation of enterprises, several times reaching half a point of growth. For energy consumption, the difference twice reaches 0.6. Lastly, the importance of the reference system is considerable for imports of capital goods, for which the difference is twice between 1 point and 1½ points and on many occasions between a ½ point and 1 point.

Table 1

Movements in 1980 prices and in prices of the previous year

n	Gross domestic product			GFCF of non-financial corporations and uninc. enterprises			Energy consumption (intermediate and final)			Imports of capital goods		
	% n-1 prices	% 80 prices	gap in points	% n-1 prices	% 80 prices	gap in points	% n-1 prices	% 80 prices	gap in points	% n-1 prices	% 80 prices	gap in points
1981	1.2	1.2	0	-2.9	-2.9	0.0	-6.8	-6.8	0.0	1.4	1.4	0.0
1982	2.5	2.5	0	0.0	-0.1	-0.1	-4.9	-4.4	0.5	7.9	7.6	-0.3
1983	0.8	0.7	-0.1	-4.2	-4.4	-0.2	-2.1	-1.9	0.2	-2.4	-2.5	-0.1
1984	1.5	1.3	-0.2	-2.6	-2.8	-0.2	2.3	2.4	0.1	1.3	1.1	-0.2
1985	1.8	1.9	0.1	4.5	4.3	-0.2	0.9	1.5	0.6	6.7	6.7	0.0
1986	2.4	2.5	0.1	6.4	6.3	-0.1	0.7	0.7	0.0	6.5	7.2	0.7
1987	2.2	2.3	0.1	5.9	5.9	0.0	1.1	0.8	-0.3	11.7	11.1	-0.6
1988	4.3	4.5	0.2	9.6	9.5	-0.1	1.1	1.4	0.3	20.1	19.3	-0.8
1989	3.9	4.3	0.4	8.5	9.0	0.5	2.1	1.9	-0.2	10.3	9.7	-0.6
1990	2.4	2.5	0.1	4.4	4.4	0.0	1.5	1.6	0.1	9.1	9.2	0.1
1991	0.8	0.8	0	-0.1	0.1	0.2	4.4	4.7	0.3	4.5	4.5	0.0
1992	1.0	1.2	0.2	-2.1	-1.6	0.5	0.1	-0.1	-0.2	-3.0	-2.7	0.3
1993	-1.3	-1.3	0	-8.4	-8.1	0.3	0.0	0.2	0.2	-7.7	-7.2	0.5
1994	2.6	2.8	0.2	1.3	1.7	0.4	-0.4	-0.4	0.0	7.4	7.0	-0.4
1995	2.0	2.1	0.1	3.1	3.3	0.2	1.4	1.3	-0.1	11.1	12.5	1.4
1996	1.3	1.6	0.3	0.4	0.6	0.2	3.0	3.6	0.6	6.5	7.1	0.6
1997	2.2	2.3	0.1	-0.1	-0.1	0.0	0.3	0.4	0.1	14.7	13.6	-1.1

15. Some more structural analyses depend more heavily on the price base selected. Thus, the contribution of the electrical and electronic equipment industries branch (FE3) to the growth of value added in 1998 increases rapidly as the price base gets older. It increases from 0.16 of a point in prices of the previous year to 0.21 in 1995 prices, reaching 0.29 in 1990 prices and 0.53 in 1980 prices.

HOW TO APPRECIATE THE RELEVANCE OF CHAINING

16. Broadly speaking, the relevance of chaining between two dates stems from the fact that it allows us to capture the change in the structure of the economy, unlike with constant price measures. However, between two dates, even far apart, the structure at the end point may be close to that of the starting point. The chaining in that case at best serves no purpose. At worst, it may be harmful if, during the intervening period, the structure diverged and then returned close to its starting point.

17. This problem is well known to specialists in price indices. Let us suppose that over time the situation passes alternately through two different states: at each even period it becomes identical to what it was at the outset, and at each odd period it passes through the second state. If we calculate a Laspeyres (or Paasche) index in each even period, the index will actually be equal to 1. On the other hand, if we calculate a chained index, the index will diverge further and further from 1 (while being limited by the even periods). This example may in theory be applied to national accounts since accounts in prices of the previous year are calculated in almost all countries, including France, by aggregating the components (outputs or branches, for example) using Laspeyres indices for volumes and Paasche indices for prices, thereby ensuring their additivity.

18. The interest of chaining therefore stems from the assumption we make that the structure of the intermediate dates is itself intermediate. The use of chaining in calculations of purchasing power parities between two countries demonstrates clearly that the object is to find intermediate points such as to ensure the greatest proximity of two successive points in the chaining.

19. This is clearly indicated in SNA 93, which states that “a chain Laspeyres, or Paasche, index should not be used if the chaining involves an economic detour ...” (cf. paragraph 16.47) and that “conversely, a chain index should be used when the relative prices in the first and last periods are very different from each other and chaining involves linking through intervening periods in which the relative prices and quantities are intermediate between those in the first and last periods” (cf. paragraph 16.48).

20. We will endeavour here to define an **“optimal” chaining** passing through, and only through, those points (the intermediate dates) which ensure that the situation develops from one point in the chain to the next in the most gradual manner towards the final state. This optimal chaining may, as appropriate, be identified with usual chaining, and termed “integral” because it passes through all the points. It may also be equated with a normal calculation without chaining (constant price calculation), when no intermediate date is selected. In many cases, however, it will pass through some dates but avoid others.

21. To proceed further in this direction, we must obviously begin by defining **a measure of the gap between one point and another**. We will illustrate the method proposed using value-added data as an example. We accordingly consider that we have for all branches (at the finest possible level of classification) information on value added in current prices and in prices of the previous year. Practically, the question to be asked is: to estimate the change in volume of total value added between two dates more or less far apart, which of the following two methods should be applied:

- calculate at each date the total value added in n-1 prices and then use chaining (chain Laspeyres index); or

- chain the value added for each detailed branch and then calculate the total? This is one method (more or less approximate, depending on the detail of the classification) of compiling constant price estimates. The movement retained is then equal to a Laspeyres index.

22. If on a first and last date of the chain the value added of each branch is the same, the gap between one date and the other must then be considered to be nil, so that no point can be said to describe an intermediate situation, and thus chaining is rejected. But we can go a little further by extending this requirement to the case where the movement of each branch is the same between the two dates. There can be no doubt that the overall movement must then be equal to this common movement, which is obtained by rejecting the chaining. We can see from this that what matters is, in fact, the permanence of the structure of the value added between branches.

23. We will therefore be concerned, at a given date, with ratios of the type va/VA, "va" being the value added of a given branch and "VA" the total value added. For VA, in fact, we will take the sum of the absolute values of the value added of the different branches so that this ratio is not too unstable in cases where the total of the aggregate is close to zero. With value added, this assumption seems entirely theoretical, although the value added of one branch may be negative (as it always is for FISIM), but the case may arise concretely for other aggregates, and particularly changes in inventories.

24. These ratios may be defined in value terms (in current prices) and in volume terms. For this purpose, we will express the value added for the starting period in volume terms at the prices of the end period (taken as the target), by chaining each series, assumed to be elementary since we are working at the finest possible level of classification. As regards the volume/price measurement, we will endeavour to define the gap between the starting point and the end point for both prices and volumes.

25. For this purpose, let us place ourselves in a mathematical space having as its origin the starting date and consisting of 2n dimensions, n representing the number of branches. The starting date will be represented by a point defined by its 2n components, n relative to volume and n to prices.

26. For a given branch, the component on the volume axis will be taken as equal to

$$(va/VA)_{t=start} - (va/VA)_{t=end} \qquad (1)$$

where va and VA are volumes as defined above.

27. To define the component on the prices axis, we will start again from expression (1). This has been calculated with volumes but may also be calculated with values. The price component will be taken as this expression in value less that in volume, with the idea that it will be for the prices to explain what has not been explained by the volumes.

28. Lastly, we have to determine the gap between the starting point, thus defined, and the end point, which corresponds to the origin of our space. Rather than taking the usual Euclidean distance (the square root of the sum of the squares), we will take as distance the sum of the absolute values. This choice stems from the fact that we want to be sure of the following property: if a branch is split into two sub-branches showing the same movements, the result of our calculation is not thereby affected (it must also be assumed that the sign of the aggregate is the same for the two sub-branches).

29. To conclude, if we have two dates, 1 and 2, an aggregate X consisting of n components (branches or products, for example), denoted as i or k, **we will determine the gap between 1 and 2 by the following formula**:

$$E_{1,2} =$$

$$\Sigma_i \left| Vol_i^1/\Sigma_k \left|Vol_k^1\right| - Vol_i^2/\Sigma_k \left| Vol_k^2\right| \right|$$

$$\Sigma_i \left| (Val_i^1/\Sigma_k \left|Val_k^1\right| - Val_i^2/\Sigma_k \left| Val_k^2\right|) - (Vol_i^1/\Sigma_k \left| Vol_k^1\right| - Vol_i^2/\Sigma_k \left|Vol_k^2\right|) \right|$$

with Val = total of the aggregate in value terms;

Vol = total of the aggregate in volume terms at date 2 prices.

30. We may note that, by design of the formula, when the change in the structure of the prices (second term) always goes in the same direction as that of the volumes (first term), then only the change in the structure in value terms comes into play because the second part of the second term is cancelled out with the first term. But this is not the case when prices and volumes change in opposite directions for at least one component. And in the economy, of course, prices and volumes often move in opposite directions.

31. It should also be noted that using this formula necessitates changing the price system as soon as we change the end date, all the volumes of the formula being calculated in date 2 prices. The symmetry of the formula between dates 1 and 2 exists in appearance only; in particular, $E_{1,2}$ is not equal to $E_{2,1}$, which is why we have not used the term distance between 1 and 2. In fact, in the space with 2n dimensions, it is only of interest to calculate the gap between a point and the origin.

32. Having thus defined the gap between any two dates, we can examine the **problem of chaining**. Let us consider an aggregate broken down into various components (branches or products, for example) over a period from t = 1 to T. We want to know how this aggregate changes between these two dates. Should we make calculations at constant prices (in T prices) or else chain the movements from 1 to T? (T may actually come before 1.)

33. We can calculate the gap between 1 and T but also the gap between any intermediate date t and T, the gap between any date t and t+1 (which obliges us to change the price system each time), and more generally the gap between any date t_1 and another date t_2. In order to determine what we called optimal chaining, the analysis conducted above leads us to adopt the following two criteria:

- the intermediate dates through which the chaining must pass have to be such that the gap between them and T is always decreasing. Intermediate dates not meeting this requirement must therefore be eliminated;

- the maximum gap between one point and the next in the chaining must be minimal. If the gap between t_1 and t_3 is smaller than that between t_1 and t_2, or between t_2 and t_3, then point t_2 must be removed from the chain.

34. In practice, applying the first criterion often leads to a solution that satisfies the second one. But it sometimes happens that the second criterion may again entail removing some points in the chain: the situations at two successive dates may be very far from one another, even if moving closer to the situation at T.

35. This step cannot absolutely resolve the question of whether or not to chain. Because they are hard to optimize and calculate, partial chainings as defined above seem destined to serve only for analytical purposes and it is therefore necessary to apply them to a number of varied and specific cases to draw a methodological conclusion from them. Intuitively, the more the aggregate changes regularly, the more worthwhile it is to use chaining. This is confirmed by the following examples.

APPLIED TO DATA OF BASE 95, THIS METHOD BROADLY CONFIRMS THE RELEVANCE OF INTEGRAL CHAINING BUT DEFINES ITS LIMITS

36. The main volume series were available, at the time of writing of this paper, for the period 1978-1998. Apart from the 1990s, these are series retropolated directly at the F level of the accounts (for 41 items). We will therefore work from the corresponding series, published in value terms and in chained series at 95 prices, and try to ascertain whether or not chaining should be used to calculate volumes for the aggregated series taking 1995 as reference year. In particular, we will be interested in the calculation of changes over the entire period 1978-1995.

37. Of the aggregates for which chaining is actually done (and available on INSEE's Internet site), four were tested, being chosen so as to have more or less regular series. Table 2, in box 1, summarizes the results obtained.

38. **Household consumption expenditure** is traditionally one of the series that change most regularly. It is gratifying to note that the optimal chaining, in the meaning we have given it above, represents an integral chaining. Table 2 shows, in the first column, that the gap between each year and 1995 is reduced continuously from 1978 to 1995. In the second column, none of the "links" from one year to the next appears to be very significant. Logically, the calculations would allow the optimal chaining to include all the years, as indicated in the third column. **Value added** is in principle a little less regular. Table 2 shows, however, that even if the gaps are greater than with consumption, the optimal chaining still represents integral chaining.

39. The **gross fixed capital formation** (GFCF) of non-financial corporations and unincorporated enterprises is subject to more significant fluctuations. Table 2 shows that the optimal chaining diverges from integral chaining. In the first column, we note that the gradual convergence towards 1995 is not observed for 1992 and 1993, both years being further removed from 1995 than is 1991. The calculations (third column) mean that the optimal chaining passes through all years except for 1992 and 1993, the year 1991 being only 0.77 from 1994 (actually 0.077 since the table shows 10 times the difference). Studying these years helps us understand their particularity: in 1992, the GFCF of non-financial corporations and unincorporated enterprises in the building sector rose extremely strongly (+18% in volume terms) because of the shifting of real-estate assets from financial to non-financial corporations. This phenomenon, for which the GFCF accounting may itself be criticized, also disturbed 93/92 patterns of GFCF by institutional sectors, when the building sector was already affected by the recession. Broadly speaking, table 2 nevertheless gives the impression that it is preferable, over a long period, to chain in an integral manner rather than not to chain at all. This is confirmed by the fact that, over the period 1991-1994 in question, chaining by passing through all the years leads to a result (-5.0%) that diverges only very slightly from the direct calculation of the change for 1994 relative to 1991 (-4.9%). Over the entire period 1978-1995, the result of integral chaining (+70.5%) is then very close to that of the optimal chaining (+70.6%), whereas the result without chaining (+86.6%) is very far removed from it.

40. The last aggregate is **household energy consumption expenditure**. Whereas the previous aggregates were broken down for 41 activity/product classification items, here there are only two components: consumption of fuel and consumption of water, gas and electricity. These series have experienced very marked fluctuations, particularly at the time of the oil price shocks and counter-shocks. Table 2 shows that chaining is justified only outside of the periods 1985-1989 and 1991-1994. But there, too, the differences are minimal over these periods between the two methods: for 1985-1989, +3.1% without chaining, +3.2% with chaining; for 1991-1994, -0.7% in both cases. Overall, for 1978-1995, we still find that integral chaining (+21.4%) is markedly closer to optimal chaining (+21.2%) than is the result obtained without chaining (+22.2%).

Box 1

How to interpret tables 2 and 3

For each of the aggregates, the first column, "n to 1995", indicates the gap, obtained with the formula presented in paragraph 29, between each year and the year 1995 (since we want to express volumes in 1995 francs). In the "good" cases, such as household consumption and value added, this gap narrows consistently as we approach 1995. The other aggregates of the tables, however, provide counter-examples: thus, for the GFCF of non-financial corporations and unincorporated enterprises, the gap relative to 1995 increases from 1.18 in 1991 to 1.53 in 1992.

The second column, "n to n+1", indicates the gap between each year and the next. This is the length of each link in the case of integral chaining. The values indicated for the different years have no reason to constitute a monotonous series. Their relative constancy for household consumption shows that the speed of change in the pattern of consumption is regular. That for value added is a little less regular, which does not prevent the optimal chaining from being integral chaining, since the change in the structure of value added is always in the same direction.

The third column, "optimal chaining", is not always completed. The entries given correspond to the years selected for optimal chaining. The values indicated represent the gap between each chosen year and the next. This is, therefore, the length of the links in the optimal chaining. It can be verified that each time the gap relative to 1995 increases (in the first column, for example, GFCF in 1992) the corresponding cell in the third column is empty, and hence the optimal chaining does not include that year. The information given in these tables is not sufficient, however, to determine at what date the next point of chaining will be situated. For that purpose, in view of the second criterion indicated in paragraph 33 (minimize the maximum length of the links), we need to have all the gaps between the links, and to look for the optimal path.

The different values of these tables are mutually comparable provided that the classifications used are the same. This is the case as between consumption, GFCF, value added and changes in inventories since each time we have used the 41 levels of the common activities/products classification (even if some minimal differences persist, such as the grouping of trade into a single product comprising three branches, the adjustment for domestic consumption, or FISIM for value added). By contrast, energy consumption and the foreign trade balance are broken down only into two components proper to each of the two aggregates (cf. body of the paper), and the gaps obtained in each case are not comparable with those obtained for the other aggregates.

Table 2

Data on gaps

Date n	Household consumption expenditure			Value added			GFCF of non-financial corporations and uninc. enterprises			Household energy consumption expenditure		
	n to 1995	n to n + 1	optim. chain n_i to n_{i+1}	n to 1995	n to n + 1	optim. chain n_i to n_{i+1}	n to 1995	n to n + 1	optim. chain n_i to n_{i+1}	n to 1995	n to n + 1	optim. chain n_i to n_{i+1}
1978	3.65	0.39	0.39	5.56	0.75	0.75	6.24	0.88	0.88	3.18	0.66	0.66
1979	3.45	0.55	0.55	5.05	0.92	0.92	5.59	0.92	0.92	2.52	0.30	0.30
1980	3.27	0.42	0.42	4.44	0.75	0.75	5.05	0.61	0.61	2.22	0.26	0.26
1981	3.05	0.41	0.41	3.90	0.63	0.63	4.68	0.51	0.51	2.05	0.19	0.19
1982	2.96	0.42	0.42	3.58	0.80	0.80	4.35	0.77	0.77	1.87	0.37	0.37
1983	2.64	0.44	0.44	3.20	0.65	0.65	3.88	0.78	0.78	1.77	0.36	0.36
1984	2.45	0.31	0.31	2.96	0.43	0.43	3.61	0.80	0.80	1.47	0.59	0.59
1985	2.32	0.49	0.49	2.83	0.67	0.67	3.06	1.00	1.00	1.00	0.65	0.27
1986	2.06	0.47	0.47	2.55	0.52	0.52	2.60	0.59	0.59	1.42	0.48	
1987	1.79	0.38	0.38	2.27	0.48	0.48	2.27	0.39	0.39	0.94	0.21	
1988	1.58	0.38	0.38	1.97	0.46	0.46	1.95	0.43	0.43	1.15	0.35	
1989	1.42	0.37	0.37	1.86	0.51	0.51	1.73	0.51	0.51	0.80	0.39	0.39
1990	1.22	0.39	0.39	1.58	0.48	0.48	1.41	0.44	0.44	0.72	0.39	0.39
1991	0.93	0.37	0.37	1.29	0.53	0.53	1.18	0.92	0.77	0.32	0.33	0.24
1992	0.72	0.36	0.36	1.00	0.65	0.65	1.53	0.63		0.46	0.20	
1993	0.51	0.37	0.37	0.82	0.48	0.48	1.37	0.61		0.26	0.10	
1994	0.26	0.26	0.26	0.59	0.59	0.59	0.87	0.87	0.87	0.23	0.23	0.23
1995	0.00		0.00	0.00		0.00	0.00		0.00	0.00		0.00

Note: The values indicated are 10 times the gap calculated.

41. **In conclusion**, it is gratifying to note that for each of the series examined, even the most irregular, the chaining is broadly justified, at least for the aggregation of amounts determined at the 41 level (no study at a finer level having been possible). In particular, we note that the oil price shocks (over the period considered: second shock and counter-shock of 1986) have no impact on the validity of the chaining. In a particular case, we may still have doubts about the relevance of the chaining of a series. If so, we can apply the method proposed to decide whether or not to chain, or to use the partial chaining deemed optimal. But we must then keep in mind that this depends on the starting and end points: the "optimal" movement between two dates is not given by the quotient of the "optimal" movements between each of the two dates and the year 1995, for example. Thus, the change in GFCF for non-financial corporations and unincorporated enterprises between 1990 and 1993 is not equal to the change between 1990 and 1995 divided by that for 1993-1995 because the optimal chaining does not pass through 1993. The concept of series is thus somewhat blurred.

THE PARTICULAR CASE OF THE FOREIGN TRADE BALANCE AND CHANGES IN INVENTORIES

42. Certain aggregates are generally regarded as unsuitable for chaining (and hence are **not** chained in our accounts). We will look at the case of the foreign trade balance (exports minus imports), which is not explicitly calculated in our accounts, and changes in user inventories (or stocks of materials). These two examples have, of course, the particularity of corresponding to the difference between two terms of broadly the same order and therefore show very large fluctuations that entail frequent changes of sign.

43. The **foreign trade balance**, in the method proposed earlier, may be regarded as having two components: one positive, equal to exports, and the other negative, equal to minus imports. With this method, the application of an unchained Laspeyres index corresponds to the calculation of the balance of chained exports minus chained imports. This is generally the solution adopted. The use of chaining does, however, mean calculating the balance for each year before chaining.

44. Table 3, produced on the same model as table 2 above, shows that until the early 1990s chaining is not desirable, notably because the difference with 1995 fluctuates and in general the intermediate years do not correspond to intermediate situations. Misgivings about chaining are therefore justified and this option has in principle to be rejected. However, as of 1990 France entered into a period of quite regular growth in its foreign trade, which would allow the trade balance to be chained directly: integral chaining is close to optimal chaining.

45. The case of **changes in inventories** is even more delicate and also of much greater practical importance. Here we will pursue the analysis for 41 products. As might be expected, the gap between two dates does not appear to depend on their temporal difference, as can be seen from the first column of table 3. Chaining is therefore to be ruled out per se and the compilation of constant price series is preferable.

46. The compilation of volume series for changes in inventories in fact poses specific problems of at least two orders:

- very strong fluctuations, with changes of sign and possibly some periods with totals close to zero. This first point is, at least in part, to be related to what has been noted above;

- the difficulty of controlling the price indices, product by product, because changes in inventories are preferred items of adjustment, in terms of value and of volume in the prices of the previous year. We may thus have certain years with changes in inventories close to zero in value and volume terms but with opposite signs. At the aggregated level, the implicit price of changes in inventories is even more problematical. Aggregating the changes in inventories of two products may result in a negative implicit price whereas each of the two prices appears to be completely normal. (For example: 10 in value and 10 in volume terms for product 1; -10.1 in value and -9.9 in volume terms for product 2.)

Table 3

Data on gaps

Date N	Foreign trade balance			Changes in user inventories		
	n to 1995	n to n + 1	optim. chain n_1 to n_{i+1}	n to 1995	n to n + 1	optim. chain n_1 to n_{i+1}
1978	0.54	0.23	0.31	15.80	10.87	12.71
1979	0.62	0.45		19.13	9.29	
1980	0.88	0.53		17.38	13.55	
1981	0.86	0.17		20.41	12.48	
1982	1.03	0.40		18.86	8.00	
1983	0.63	0.22		20.82	9.37	
1984	0.73	0.15		15.93	8.77	
1985	0.58	0.80		17.35	12.94	
1986	0.38	0.23		17.33	13.53	
1987	0.56	0.05		18.25	7.30	
1988	0.52	0.18		17.76	8.36	
1989	0.52	0.05	0.10	12.36	11.55	12.36
1990	0.54	0.15		16.28	11.97	
1991	0.42	0.24	0.24	18.60	14.69	
1992	0.18	0.24	0.24	27.23	24.09	
1993	0.06	0.06	0.06	16.51	13.57	
1994	0.02	0.02	0.02	16.64	16.64	
1995	0.00		0.00	0.00		0.00

Note: The values indicated are 10 times the gap calculated.

47. Together, these two problems may have explosive effects in chaining. Box 2 illustrates this question using real figures

Box 2

The risks of chaining for changes in inventories

We will present here the example - which is in no way exceptional - of output T07 with base.

80. This item corresponds to level 40 of the classification. It groups together three outputs of level 90 (denoted S): S09 - iron ore; S10 - iron and steel products; and S11 - primary treatment of steel.

Table 4 below shows the amounts of changes in user inventories (stocks of materials) over the period 1990-1993. We will seek here to measure volumes in 1990 prices. For each output, the table indicates the amounts in value terms (current prices) and in volume terms in prices of the previous year. These were used to calculate chained series (denoted CI 90 prices chaining) and series (denoted CI base 95) obtained by applying the formula used with base 95 as in the body of the text (with 90 and not 95 prices). This was done for outputs S09, S10 and S11, as well as for output T07 taken as a whole (heading “T07 direct”). The heading “T07 = S09+S10+S11”, which corresponds to base 80 accounts, enables us to compare the chaining at level S, then aggregated with direct chaining at level T.

Lastly, the heading “alternative S09” presents the results that would have been obtained if in 1991 the amount in value terms had been taken as equal to 1 million francs instead of 3, without a change in the volume at prices of the previous year. That change is in itself extremely small and might come from a slight adjustment of the output balance in value terms.

Two problems appear with the usual chaining (lines CI 90 prices chaining):

- Phenomenon of explosion: in 1993, for S09, we arrive at -140 MF, but at 419 MF with the alternative having changed the value in the amount of 2 MF in 1991;

- Sensitivity to the level of chaining: direct chaining provides an estimate of -6,003 MF for T07 in 1993, whereas chaining at level S, for T07, gives -4,314 MF.

Box 2 (continued)

Table 4

Changes in user inventories

	1990	1991	1992	1993
S09				
C1 value	175	3	- 78	- 128
C1 n-1 volume	186	3	- 82	- 133
C1 90 prices chaining	175	3	- 82	- 140
C1 90 prices base 95 formula	175	3	- 73	- 125
S10				
C1 value	- 2 173	- 681	- 701	- 1 411
C1 n-1 volume	- 2 261	- 761	- 719	- 1 428
C1 90 prices chaining	- 2 173	- 761	- 803	- 1 637
C1 90 prices base 95 fomula	- 2 173	- 761	- 803	- 1 637
S11				
C1 value	1 752	493	- 2 718	- 2 407
C1 n-1 volume	1 780	491	- 2 820	- 2 456
C1 90 prices chaining	1 752	491	- 2 809	- 2 538
C1 90 prices base 95 formula	1 752	491	- 2 907	- 2 628
T07 direct				
C1 value	- 246	- 185	- 3 497	- 3 946
C1 n-1 volume	- 295	- 267	- 3 621	- 4 017
C1 90 prices chaining	- 246	- 267	- 5 226	- 6 003
C1 90 prices base 95 formula	- 246	- 267	- 3 998	- 4 579
T07 = S09+10+11				
C1 90 prices sum of chainings	- 246	- 267	- 3 694	- 4 314
C1 90 prices base 95 formula	- 246	- 267	- 3 783	- 4 390
Alternative S09				
C1 value	175	1	- 78	- 128
C1 n-1 volume	186	3	- 82	- 133
C1 90 prices chaining	175	3	- 246	- 419
C1 90 prices base 95 formula	175	3	- 71	- 123

With the base 95 formula, these problems are eliminated:

- The alternative for S09 results in a change only from -125 MF to -123 MF;

- The direct chaining at level T (-4,579 MF) is not very different from the sum of the chainings of level S (-4,390 MF).

We may note also that when there is no particular problem (as with products S10 and S11) the results obtained are quite close to the usual chaining: in 1993, -2,628 MF as against -2,538 MF for S11; -1,637 MF in both cases for S10. With the latter, we can see that the base 95 formula is equivalent to that of the usual chaining if the changes in inventories in value terms and in volume terms in prices of the previous year correspond to the prices of intermediate consumption of the same product. Lastly, we may note that in 1991 the base 95 formula arrives at the total volume in prices of the previous year.

48. In base 95, these problems have been tackled using an original method that may be described as additive chaining, with a check on the price indices.

49. The formula adopted in base 95, for the various levels of classification, is as follows:

$$CI_{95}(n+1) = CI_{95}(n) + [Ci_{vol}(n+1) - CI(n)]/Prices(n/95)$$

where CI_{95} is the series in 95 prices we wish to compile (we take $CI_{95}(95) = CI(95)$);

CI (n) represents changes in inventories for the year n in current prices;

$CI_{vol}(n+1)$ represents changes in inventories for the year n+1 in volume terms in prices of the previous year;

Prices (n/95) represents the movement of prices between the year 95 and the year n, for intermediate consumption of the same item of the classification for products if changes in user inventories are to be calculated, production for producers' inventories and work in progress, and all final uses, excluding inventories for sales outlets.

50. For total changes in inventories (users, producers and sales outlets), the series is calculated (in base 95) as the sum of the series compiled for each of the types of inventories.

51. If the prices used were the prices of changes in inventories, the formula employed would be equivalent to the formula for usual chaining. The formula is not explosive, therefore, and this provides a check on the indices of the prices taken. The formula $CI_{95}(n) = CI(n)/Prices\ (n/95)$ with these prices would from this point of view offer the same advantage and would be simpler. However, it does not bring into play changes in inventories at the prices of the previous year, contrary to the one retained. In particular, it would not enable us to find for 1996 the amount in volume terms at prices of the previous year, whereas with the formula adopted using base 95, we do indeed have CI_{95} (96) equal to $CI_{vol}(96)$.

52. Table 5 allows us, for all the changes in inventories, to compare the series using base 95, calculated as indicated above, with a series obtained by (integral) chaining. The series in value terms (current prices) also appears here. Integral chaining results, for the beginning of the series (years 78 to 80), in changes in inventories of unreasonable size (320 billion francs, or 5.6 per cent of GDP in 1979), whereas the base 95 series seems much more logical.

Table 5

Total changes in inventories

Years	Volume in 1995 prices (base 95 measures)	Volume in 1995 prices, integral chaining	Value (base 95 measures)
1978	34 312	180 072	16 275
1979	60 086	319 550	31 577
1980	58 525	302 184	33 987
1981	- 13 408	- 60 051	- 6 424
1982	17 763	115 979	13 194
1983	- 11 342	- 63 150	- 7 595
1984	- 5 070	- 16 164	- 2 130
1985	- 16 314	- 85 349	- 11 913
1986	- 3 487	- 5 072	4 653
1987	- 2 357	- 6 697	6 027
1988	25 921	- 33 494	30 456
1989	39 314	- 46 228	43 676
1990	41 418	- 48 331	45 994
1991	25 430	- 32 639	27 753
1992	2 665	- 6 868	- 11 042
1993	- 83 612	- 58 487	- 88 427
1994	- 14 658	- 14 236	-14 142
1995	28 910	28 910	28 910
1996	- 16 858	-16 858	-19 367
1997	- 196	- 2 129	- 1 530
1998	29 759	40 512	27 847

53. Ultimately, the problem of volume measures of changes in inventories is still a grey area in international recommendations and practice. French national accounts experts have tried, using base 95, to provide some new thoughts on the matter. But they are well aware that the question remains open. A special study of the problem would be justified in view of its acuteness and practical importance.
