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Direction des Études et Synthèses Économiques

G 2014 / 12

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Document de travail



Institut National de la Statistique et des Études Économiques

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Computing additive contributions to growth and other issues for chain-linked quarterly aggregates

Franck ARNAUD*, **Jocelyn BOUSSARD***
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NOVEMBRE 2014

Ce travail a été réalisé afin de contribuer à la discussion de la réédition du manuel du FMI sur les comptes trimestriels. Il a servi de base à la contribution des auteurs à un groupe de travail organisé par le FMI à Vienne en novembre 2014. Les auteurs remercient leurs collègues des comptes nationaux de l'Insee qui depuis 2007 ont contribué à l'accumulation des connaissances résumées ici et à leur mise en œuvre au quotidien.

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Computing additive contributions and other issues for chain-linked quarterly aggregates

Abstract

Since 2007, the French Quarterly National Accounts use a chain-linking method to measure volumes in replacement of volumes in constant prices of the reference year. This paper gathers 7 years of experience of the Quarterly National Accounts unit on this particular topic.

We first recall the annual overlap method used in France in comparison with the one quarter overlap method sometimes preferred in other countries. Based on numerical simulations, we show the distribution of two well-known effects: trend effects when elemental prices have different dynamics and non-additivity. In particular, the variance of these effects increases away from the reference year.

We also expose two new reasons to prefer the annual overlap method to the one quarter overlap: first, additive contributions to growth can be computed; second, unpleasant interactions with seasonal and trading day adjustment can be avoided.

Keywords: chain-linking, annual overlap, one quarter overlap, contribution to growth, seasonal and trading day adjustment

Calcul de contributions additives et autres difficultés des comptes trimestriels en volumes chaînés

Résumé

Depuis 2007, les comptes trimestriels français utilisent des volumes chaînés en remplacement des volumes à prix constants de l'année de base. Ce document compile 7 années d'expérience de la division des comptes trimestriels sur ce sujet.

Nous présentons la méthode de recouvrement annuel utilisée en France en la comparant à la méthode de recouvrement trimestriel parfois préférée dans d'autres pays. Sur la base de simulations numériques, nous illustrons deux propriétés des volumes chaînés : l'effet tendanciel lorsque les prix des composants d'un agrégat ont des dynamiques divergentes et la non-additivité. Notamment nous montrons que la variance de ces effets croît lorsqu'on s'écarte de l'année de base.

Nous détaillons également deux nouvelles raisons de préférer la méthode de recouvrement annuel au recouvrement trimestriel : tout d'abord il est possible de calculer précisément la contribution d'un composant à la croissance d'un agrégat ; ensuite des interactions indésirables avec la correction des variations saisonnières et des jours ouvrés peuvent être évitées.

Mots-clés : volumes chaînés, annual overlap, one quarter overlap, contribution à la croissance, correction saisonnière et des jours ouvrés

Classification JEL : C43, C82, E01

1 Introduction

One of the major objectives of the national accounts is to describe the changes in the major economic aggregates, in particular after cancelling out the effects of price variation, to analyse in volumes the growth of domestic output, consumption, etc. These volumes give a clearer idea of quantity exchanged or produced. However, simply adding up the quantities of elementary components involved is irrelevant: the quantity of cars is not directly comparable with the quantity of bicycles. These quantities need to be made commensurate. Calculating the volume of an aggregate requires to weight the volumes of its components through prices. The choice of a reference period, which will determine this structure of the prices, is thus of crucial importance.

There are two available options:

- calculating volumes using constant prices derived from the reference year;
- calculating volumes of each year using the prices observed in the previous year and then chain-linking. The idea behind these chained-linked volumes is to cumulate the growth rates in volumes starting from the values established for a given reference year. Doing so the evolutions of volumes at previous year's prices are preserved, and the chain-linked volume accounts form time series without breaks in the structure of prices every year.

The relative weight of each component in an aggregate in volume depends on the prices of a particular *weight period*. These prices can be markedly modified with time. Estimating chained volumes based on previous year's prices thus offers the dual advantage of providing data suitable for constructing time series and also accounting for any change in the relative price structure: simply put, they provide a more satisfactory description of the economic reality when the prices of some products evolve very differently than others.

However, these chained volumes do pose specific problems. They can prove misleading when prices tend to oscillate rather than evolve following a coherent trend. This may be the case, for example, with agricultural and energy prices [Berthier, 2002]. Furthermore, these volumes lose their additivity with regard to volumes calculated more simply at constant prices of the reference year.

Faced with these complex problems, until 2007, the French quarterly accounts used volumes calculated at constant prices of the reference year. In France, the difference between chain-linked volumes and the volumes obtained by using constant prices of the reference year was relatively minor.

However, European harmonisation, and the increasing disparity observed between the chained volumes and volumes in reference year prices for some product-operation pairs, led to a methodological change: since 2007 the French quarterly accounts are published in chain-linked volumes at the previous year's prices, using the annual overlap method.

With the one quarter overlap method, the annual overlap method is one of the most widespread technique to chain-link the QNA (see Table 2 in appendix). For both techniques we recall the algebra (section 2). The formulae theoretically show that QNA in annual overlap exactly coincide with the corresponding annual accounts but there is a residual price effect every first quarter. With the one quarter overlap method the opposite is true: the price effect every first quarter is controlled for but consistency with annual chained volumes must be restored through benchmarking.

We display on a simulation exercise (section 3) the common features of these chain-linking techniques: both produce non additive volumes and a trend effect appears when prices of component have diverging dynamics. Simulated variances of these two effects increases away from the reference year and can be sizeable on both ends of time series. These simulations allow us to compare the two techniques and analyse the effect of benchmarking on the one quarter overlap.

With respect to its one quarter overlap alternative, the annual overlap method has two advantages that, to the best of our knowledge have not been put forth until now in the literature on chain-linking.

First in section 4 we show how chain-linking can interact, with some unpleasant outcome, with trading day or seasonal adjustment. With the annual overlap, which uses an annual link factor, it is possible to avoid these issues. With the one quarter overlap, which uses a quarterly chain-link factor, these issues can not be circumvented. The one quarter overlap hence raises additional issues of revisability, precision and quality.

Second, in the case of the annual overlap method, additive contributions to the growth rate of an aggregate can be computed (section 5). The lack of

additivity makes drawing up and publishing the accounts a complex operation as some aggregates are unsuitable for chain-linking. Computing additive contributions of a component to the growth rate of an aggregate overcomes this difficulty. But, for one quarter overlap volumes, these contributions are only approximative, which does not allow to accurately compute the contribution of the trade balance to GDP growth for instance.

2 Computing chain-linked estimates

In this section we recall the algebra for chain-linking, first in the case of annual accounts, then for quarterly accounts in annual overlap and one quarter overlap.

2.1 Volume indexes in annual accounts

For sake of clarity, we introduce concepts of volume with elementary goods or services, for which there exists a price and can be measured a quantity (e.g. potatoes, books, haircuts...). Let X denote an aggregate, p a price, q a quantity. Hereafter a shall refer to a generic year while 0 refers to the reference year. Later on, a, t refers to quarter $t \in [1, 2, 3, 4]$ of year a .

Let Val refer to values (i.e. current prices). We denote volumes as follows:

- Volumes at constant prices of the reference year (Cst): $X_a^{Cst} = p_0 q_a$
- Chain-linked volumes at previous year's prices (Ch): $X_a^{Ch} = I_a^{Vol} X_{a-1}^{Ch}$, where $I_a^{Vol} = \frac{X_a^{Pyp}}{X_{a-1}^{Val}}$ is the growth rate index of volumes at previous year's prices and volumes at previous year's prices (Pyp) are defined by $X_a^{Pyp} = p_{a-1} q_a$

Volumes at previous year's prices can not be treated as standard time series since there is a change of prices and volumes every period. Chain-linking overcomes this difficulty by *chaining* the growth rates measured at previous year's prices.

Elementally, volumes coincide:

$$I_a^{VolCst} = \frac{X_a^{Cst}}{X_{a-1}^{Cst}} = \frac{q_a}{q_{a-1}} = \frac{X_a^{Pyp}}{X_{a-1}^{Val}} = I_a^{VolCh}$$

Imposing the reference year at current prices as the reference for all volumes, we have:

$$X_a^{Cst} = X_0^{Cst} \prod_{k=1}^a I_k^{VolCst} = X_0^{Ch} \prod_{k=1}^a I_k^{VolCh} = X_0^{Val} \prod_{k=1}^a I_k^{Vol}$$

that is chained-linked volumes and volumes at constant prices are equal.

Individual products hardly exist (potatoes come in different varieties, haircuts differ from one hairdresser to another...) and such a data collection would be impossible. In practice, National Accounts work on detailed levels which are already aggregates of goods or services but the previous concepts can be generalized to aggregates measured at current prices and trends in average prices measured by price indexes. One simply has to choose the most detailed levels he is willing to work on and define volumes as the ratio of values with the corresponding price index. By construction, there is no ambiguity of volume concept at this level, and the issue of measuring quantities is then overcome.

On aggregate, volume growth indexes differ due to their weights...

Let \mathcal{E} denote an aggregate and i its components. The growth index in volumes at constant price of an aggregate is a weighted sum of the growth indexes of the components, with weights at constant price volumes (hereafter the weight of i in \mathcal{E} for year a in the concept V is denoted $\omega_a^V(i, \mathcal{E})$).

$$I_a^{VolCst}(\mathcal{E}) = \frac{\sum_{i \in \mathcal{E}} X_a^{Cst}(i)}{\sum_{i \in \mathcal{E}} X_{a-1}^{Cst}(i)} = \sum_{i \in \mathcal{E}} \frac{X_{a-1}^{Cst}(i)}{X_{a-1}^{Cst}(\mathcal{E})} I_a^{Vol}(i) = \sum_{i \in \mathcal{E}} \omega_{a-1}^{Cst}(i, \mathcal{E}) I_a^{Vol}(i)$$

The growth index in volumes at previous year's prices on aggregate is a weighted sum of the growth indexes of the components, with weights at current prices for the previous period.

$$I_a^{VolCh}(\mathcal{E}) = \frac{\sum_{i \in \mathcal{E}} X_a^{Pyp}(i)}{\sum_{i \in \mathcal{E}} X_{a-1}^{Val}(i)} = \sum_{i \in \mathcal{E}} \frac{X_{a-1}^{Val}(i)}{X_{a-1}^{Val}(\mathcal{E})} I_a^{Vol}(i) = \sum_{i \in \mathcal{E}} \omega_{a-1}^{Val}(i, \mathcal{E}) I_a^{Vol}(i)$$

...and volumes in level no longer coincide

$$X_a^{Ch} = X_0^{Ch} \prod_{k=1}^a I_k^{VolCh} \neq X_0^{Cst} \prod_{k=1}^a I_k^{VolCst} = X_a^{Cst}$$

Chain-linked volumes at the previous year's prices are also initialized $X_0^{Ch} = X_0^{Val}$. Since $X_0^{Cst} = X_0^{Val}$ as well, Ch and Cst only differ by the structure of weights in their respective growth index. In Ch weights evolve with time according to both volume and price changes. For this reasons, in comparison with Cst , Ch are said to better account for the change in the structure of the economy.

2.2 Volumes in quarterly accounts

Current prices, constant prices and previous year's prices can be generalized to higher frequencies (quarterly or monthly). However, there are several chain-linking techniques. We do not treat in this document the cases for *over the quarter overlap* and *over the year overlap* because these techniques are seldom used and not recommended ([Eurostat, 2013], [Bloem et al., 2001]). We consider the two cases of *annual overlap* and *one quarter overlap* which are most commonly used (see Table 2). Contrary to the former two techniques, these two cases yield aggregates which are additive within a year.

2.2.1 The annual overlap method X^{Ch}

To compute quarterly aggregates in annual overlap (hereafter denoted X^{Ch}), one shall:

1. Compute quarterly volumes at previous year's prices for elementary components: $X_{a,t}^{Pyp}(i) = X_{a,t}^{Cst}(i) \frac{X_{a-1}^{Val}(i)}{X_{a-1}^{Cst}(i)}$
2. Then by sum, compute all aggregates at previous year's prices $X_{a,t}^{Pyp}(\mathcal{E}) = \sum_{i \in \mathcal{E}} X_{a,t}^{Pyp}(i)$
3. For each aggregate, chain-link from the reference year (for which Val=Cst=Ch, currently 2010 for France):

$$X_{a,t}^{Ch} = X_{a,t}^{Pyp} \frac{X_{a-1}^{Ch}}{X_{a-1}^{Val}} = \frac{X_{a,t}^{Pyp}}{X_{a-1}^{DefCh}} \quad (1)$$

with X_a^{DefCh} the annual chained deflator, also called annual link factor. Note that the link factor is based on annual accounts so that in particular seasonal

adjustment has no effect on chain-linking.¹

Comparison with annual computations shows that previous year price estimates can be summed to retrieve their annual counterpart: $X_a^{Pyp} = \sum_{t=1}^4 X_{a,t}^{Pyp}$. It directly follows that chain-linked estimates can also be summed to retrieve their annual counterpart: $X_a^{Ch} = \sum_{t=1}^4 X_{a,t}^{Ch}$.

Change of year effect

Between Q4 and Q1, the transition from volumes at previous year's prices to chain-linked volumes entails a price correction to the chain-linked volume growth rate corresponding to the growth of the annual link factor:

$$\begin{aligned} \frac{X_{a,1}^{Ch}}{X_{a-1,4}^{Ch}} &= \frac{X_{a,1}^{Pyp}}{X_{a-1,4}^{Pyp}} \frac{X_{a-1}^{Ch}}{X_{a-1}^{Val}} \frac{X_{a-2}^{Val}}{X_{a-2}^{Ch}} \\ &= \frac{X_{a,1}^{Pyp}}{X_{a-1,4}^{Pyp}} \frac{X_{a-1}^{Pyp}}{X_{a-1}^{Val}} \frac{X_{a-2}^{Val}}{X_{a-2}^{Val}} \quad \text{since} \quad \frac{X_{a-1}^{Ch}}{X_{a-2}^{Ch}} = \frac{X_{a-1}^{Pyp}}{X_{a-2}^{Val}} \\ &= \frac{X_{a,1}^{Pyp}}{X_{a-1,4}^{Pyp}} \frac{1}{I_{a-1}^{DefCh}} \end{aligned}$$

with $I_a^{DefCh} = \frac{X_a^{Val}}{X_a^{Pyp}} = \frac{X_a^{DefCh}}{X_{a-1}^{DefCh}}$ the annual deflator. This price correction eliminates the change in prices every year incorporated in previous year's prices estimates. However, in this price correction, there is a weighting effect:

$$\begin{aligned} \frac{X_{a,1}^{Ch}(\mathcal{E})}{X_{a-1,4}^{Ch}(\mathcal{E})} &= \frac{X_{a,1}^{Pyp}(\mathcal{E})}{X_{a-1,4}^{Pyp}(\mathcal{E})} \frac{X_{a-1}^{Pyp}(\mathcal{E})}{X_{a-1}^{Val}(\mathcal{E})} = \frac{\sum_{i \in \mathcal{E}} X_{a,1}^{Pyp}(i)}{\sum_{i \in \mathcal{E}} X_{a-1,4}^{Pyp}(i)} \frac{\sum_{i \in \mathcal{E}} X_{a-1}^{Pyp}(i)}{\sum_{i \in \mathcal{E}} X_{a-1}^{Val}(i)} \\ &= \frac{\sum_{i \in \mathcal{E}} \omega_{a-1}^{Val}(i, \mathcal{E}) \frac{X_{a,1}^{Pyp}(i)}{X_{a-1}^{Val}(i)}}{\sum_{i \in \mathcal{E}} \omega_{a-1}^{Pyp}(i, \mathcal{E}) \frac{X_{a-1,4}^{Pyp}(i)}{X_{a-1}^{Pyp}(i)}} \end{aligned}$$

One part of the growth rate of the first quarter is therefore due to the difference in weights between Q1 and Q4. This issue is specific to the first quarters since for the following quarters, the weights are identical.

¹Provided that seasonally adjusted accounts are benchmarked on their non-adjusted counterparts as recommended by international standards [Eurostat, 2013].

2.2.2 The one quarter overlap method \tilde{X}^{Ch}

One may want to have no ponderation effect in the price correction between Q4 and Q1. This is the purpose of the one quarter overlap method (hereafter denoted \tilde{X}^{Ch}).

To do so, one *simply* has to redefine the annual link factor. The new link factor is another annual chained price deflator using Q4 ponderation at previous year's prices (\tilde{X}_a^{DefCh}).

Its growth differs from that of the previous link factor as follows:

$$\tilde{I}_a^{DefCh} = \sum_{i \in \mathcal{E}} \omega_{a,4}^{Pyp}(i, \mathcal{E}) \frac{X_a^{Val}(i)}{X_a^{Pyp}(i)} \quad (2)$$

instead of $I_a^{DefCh} = \frac{X_a^{Val}}{X_a^{Pyp}} = \sum_{i \in \mathcal{E}} \omega_a^{Pyp}(i, \mathcal{E}) \frac{X_a^{Val}(i)}{X_a^{Pyp}(i)}$

One can then compute the chain-linked volumes identically using \tilde{X}_a^{DefCh} instead of X_a^{DefCh} . The chain-linking formula (1) becomes:

$$\tilde{X}_{a,t}^{Ch} = \frac{X_{a,t}^{Pyp}}{\tilde{X}_{a-1}^{DefCh}} \quad (3)$$

Proof that this correction is correct

$$\begin{aligned} \frac{\tilde{X}_{a,1}^{Ch}(\mathcal{E})}{\tilde{X}_{a-1,4}^{Ch}(\mathcal{E})} &= \frac{X_{a,1}^{Pyp}(\mathcal{E})}{X_{a-1,4}^{Pyp}(\mathcal{E})} \frac{1}{\tilde{I}_{a-1}^{DefCh}(\mathcal{E})} \\ &= \frac{\sum_{i \in \mathcal{E}} X_{a,1}^{Pyp}(i)}{X_{a-1,4}^{Pyp}(\mathcal{E}) \sum_{i \in \mathcal{E}} \omega_{a-1,4}^{Pyp}(i, \mathcal{E}) \frac{X_{a-1}^{Val}(i)}{X_{a-1}^{Pyp}(i)}} \\ &= \frac{\sum_{i \in \mathcal{E}} X_{a,1}^{Pyp}(i)}{\sum_{i \in \mathcal{E}} X_{a-1,4}^{Pyp}(i) \frac{X_{a-1}^{Val}(i)}{X_{a-1}^{Pyp}(i)}} = \frac{\sum_{i \in \mathcal{E}} X_{a,1}^{Pyp}(i)}{\sum_{i \in \mathcal{E}} X_{a-1}^{Val}(i) \frac{X_{a-1,4}^{Pyp}(i)}{X_{a-1}^{Pyp}(i)}} \\ &= \frac{\sum_{i \in \mathcal{E}} \omega_{a-1}^{Val}(i, \mathcal{E}) \frac{X_{a,1}^{Pyp}(i)}{X_{a-1}^{Val}(i)}}{\sum_{i \in \mathcal{E}} \omega_{a-1}^{Val}(i, \mathcal{E}) \frac{X_{a-1,4}^{Pyp}(i)}{X_{a-1}^{Pyp}(i)}} \quad \blacksquare \end{aligned}$$

Contrary to the annual overlap method, with the one quarter overlap method, the sum of the four quarters do not match the annual estimate of chain-linked volumes because the link factor is different. For this reason one quarter overlap estimates are usually benchmarked *ex-post* on their annual

counterpart. In the present paper, we do not compare or expose the different techniques to do so: this is done for instance in [Eurostat, 2013].

3 A simulation exercise

To assess the properties of chain-linking, we perform a simulation exercise.² We simulate data sets for two elementary accounts which we aggregate using the different concepts of volume. The parameters of the simulation are calibrated to replicate standard elements of national accounts in developed economies.³ The data are simulated over a time period consistent with Eurostat’s minimal request, that is since 1995.

The simulations exemplify the following properties:

- the non additivity of chain-linked volumes
- how chain-linking can modify the trend of volume estimates compared to volumes at constant prices of the reference year
- the differences between annual and one quarter overlap
- the ex-post benchmarking of one quarter overlap

Loss of additivity

The non-additivity associated with chain indices has been a major point of criticism [Schreyer, 2004]. Either in annual or quarterly accounts, with any concept of chain-linking, chain-linked volumes of 2 aggregates can not be added.

To aggregate (or subtract) 2 accounts, one must first *unchain* them, i.e. compute the previous year’s prices which are additive before chain-linking the aggregate.⁴

When bluntly adding up two chain-linked volumes, one makes an error which we exemplify on Figure 1. In annual overlap, the error is null the

²The corresponding R code is available upon request.

³The growth rates in volume and prices are equal to 2% in annual in the standard case, the standard deviation is quarterly is 0.5%.

⁴A practical advantage of the annual overlap over the one quarter overlap technique is that since the former are not benchmarked ex-post on their annual counterpart, final users of the data can perform this operation themselves.

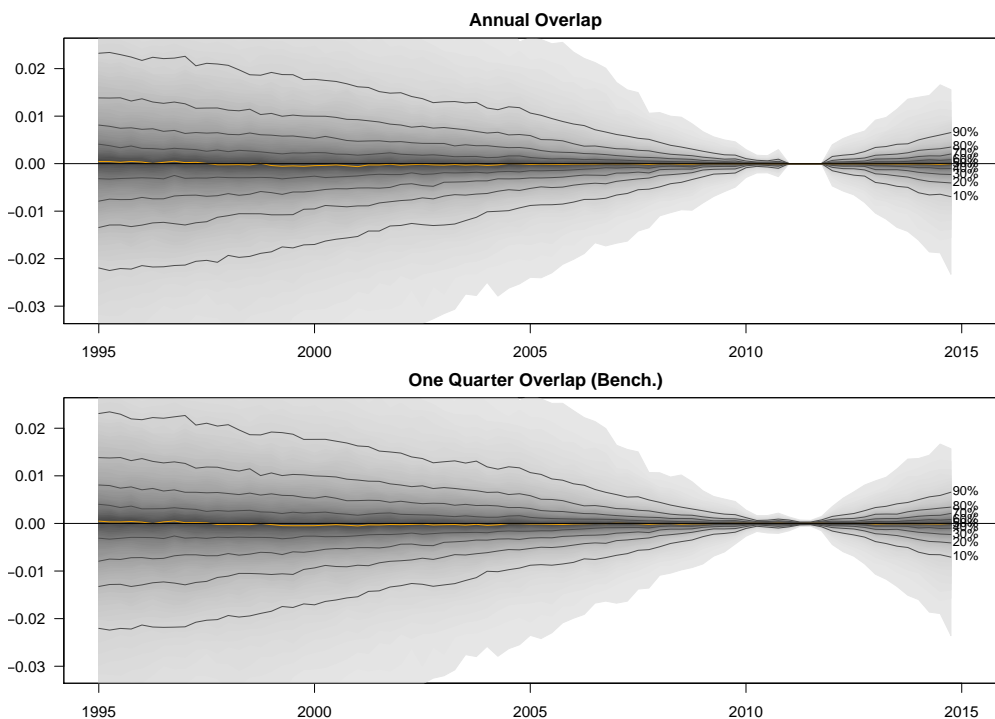


Figure 1: Error made when adding up chain-linked volumes directly

year after the reference year (2010). Indeed, this year chain-linked volumes are equal to volumes at previous year's prices which are additive (that year the chain-linking factor in equation (1) is equal to one by definition of the reference year). The variance of the error increases away from that date. A decade before (or after) the reference point, the error has roughly a 50% chance to be larger than 0.01% in absolute terms. The same diagnostic holds in one quarter overlap, although the error is not null the year after the reference year.

Trend correction of chain-linking

Because the weights of the growth index of chain-linked volumes account for both changes in prices and volumes, compared to volumes at constant prices, chain-linked volumes can display sizeable trend differences. To better exemplify this trend difference, we simulate two aggregations:

- a *symmetric* one, where both of its components grow on average at a 0.5% quarterly rate in volume and prices,

- an *asymmetric* one, where one component grows at 0.5% quarterly rate in volume and prices and the other increases faster in volume (+0.75% quarterly rate) and decreases in prices (-0.25% quarterly rate).

This asymmetric aggregation mimics the case of durables and new technologies aggregated with otherwise standard goods and services, which is a characteristic example of the trend effect.

In level for the symmetric case (Figure 2, top left and right), the effect of chain-linking is centered around 0 with both methods but its variance increases away from the reference year. Roughly speaking, a decade away from the reference year, chain-linked volumes have a 50% chance of being in absolute terms 0.5% away from volumes at constant prices, whether it is a positive or negative discrepancy. At the same time, the effect of chain-linking on growth rates (Figure 3) has a 50% chance of being larger than 0.01% in absolute term. It is noteworthy that our simulations are calibrated on standard deviations observed on French data. Other simulations with higher variances show that for energy, commodities, or developing countries the distribution effects exposed throughout the present paper can be magnified more than tenfold.

In the asymmetric case the consequence of chain-linking is also heteroskedastic, but there is an additional trend correction. Chain-linked volumes grow more rapidly than volumes at constant prices before the reference year and the opposite is true after this year. The median of this trend correction is 0.5% a decade away from the reference year.

Comparison of annual and one quarter overlap

As expected from the theory, the difference between the two chain-linking method in growth rate appears only on the first quarters of every year (Figure 3, bottom left).

In level, this difference between the two chain-linking methods are smaller than the difference between constant prices and chained linked aggregates (Figure 2, bottom left). This difference derives from the difference between the chain-link factors of the two techniques which are cumulated by the chain-linking process. Also, since the annual overlap method is consistent with the annual chain-linking, this difference, in annual terms, is equal to the benchmarking residual which can be eliminated *ex-post* to impose consistency with

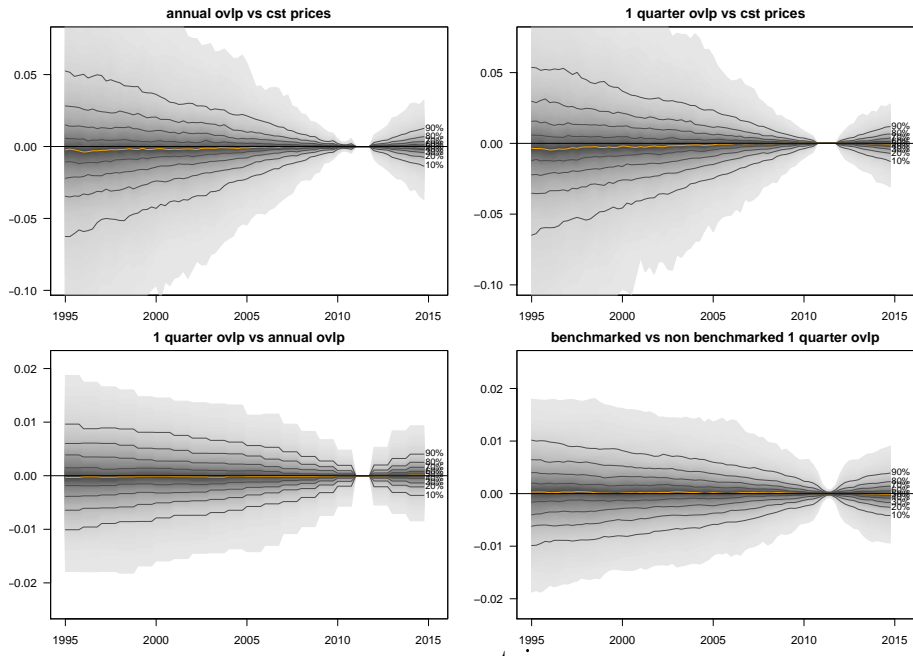
annual accounts in the one quarter overlap case.

Benchmarking the one quarter overlap

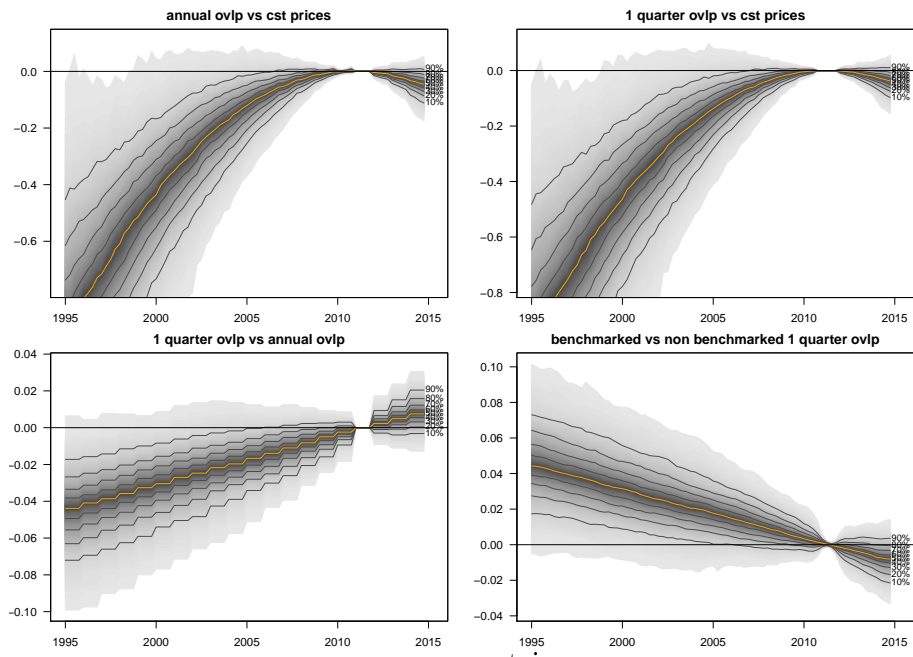
Benchmarking one quarter overlap has, with the method used here,⁵ a limited effect on growth rates (Figure 3, bottom right).

It is however noteworthy that in level this *ex-post* benchmarking is a first order integrated correction. As for the other effects we exemplify with our simulations, the variance of the correction increases away from the reference year (Figure 2, bottom right). On both ends of chain-linked volume time series, possible sizeable level correction may ensue. In this case the correction in level will necessarily modify the short term fluctuations either in delta or in growth rates, magnifying or lessening them depending on the direction of the level correction and the use of an additive or multiplicative benchmarking method. Because they modify the homogeneity of the variance one may extract from the QNA, the choice of one benchmarking technique or another is not neutral for economic analysis, whether one wishes to analyse the business cycle, run statistical tests...

⁵Benchmarking is based on additive Denton method [Denton, 1971].



symmetric



asymmetric

Figure 2: Comparison of volumes in levels

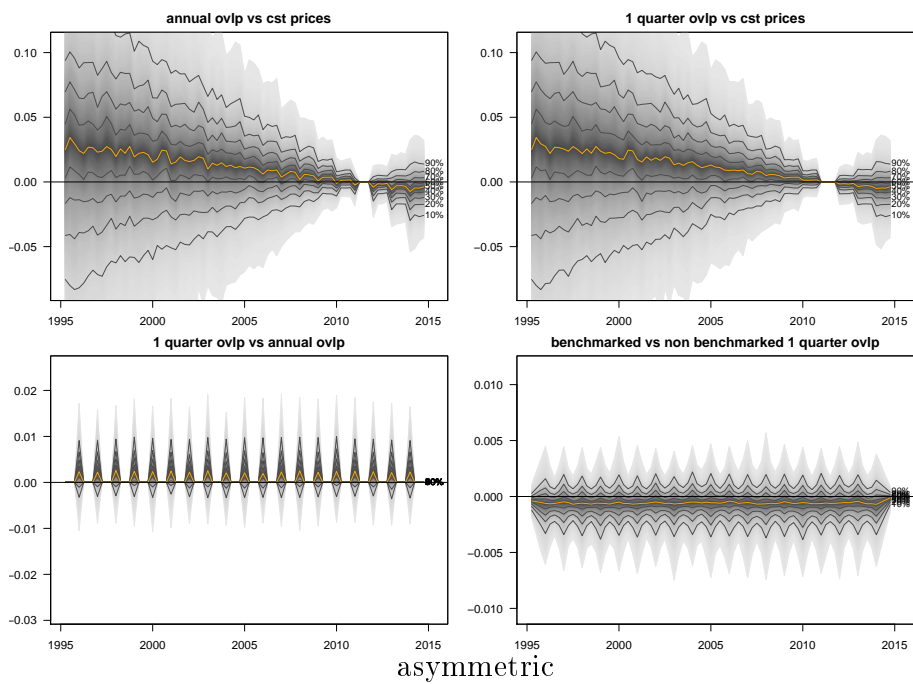
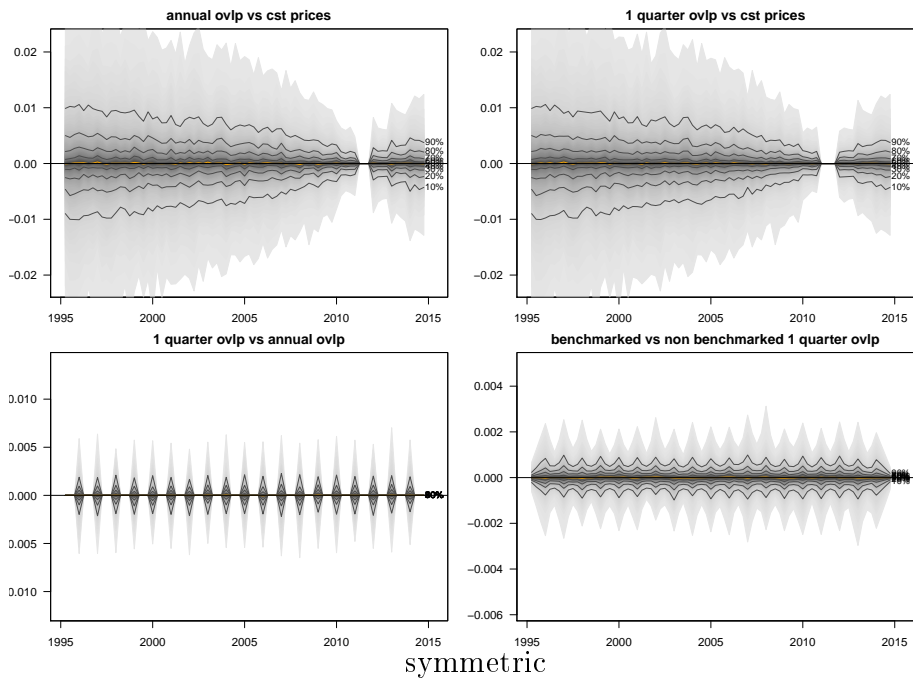


Figure 3: Comparison of volumes in growth rates

4 Chain-linking and seasonal or trading day adjustment

With annual overlap, chain-linking and seasonal adjustment do not interact if quarterly accounts are assumed to be benchmarked on their annual counterpart (as recommended by international standards). Indeed, the chain-link factor in annual overlap is based on annual estimates so is identical whether it is computed with raw or seasonally adjusted data (see eq (1)).

However, in equation (1) the question arises of using a trading day adjusted chain-link factor in addition to trading-day adjusted previous year's prices quarterly estimates.

Using a trading day adjusted chain-link factor is rather intuitive and easy. The chain-linked aggregate is then calculated as follows:

$$X_{a,t}^{Ch,TDA}(\mathcal{E}) = \frac{X_{a,t}^{Pyp,TDA}(\mathcal{E})}{X_{a-1}^{DefCh,TDA}(\mathcal{E})},$$

with X^{TDA} trading-day adjusted series.

Trading-day adjustment introduces only a small modification of the chain-link factor but due to chain-linking, it is cumulated over the sample. This cumulated trading-day effect is not always sizeable. For example, with this naive chain-linking, the trading-day effect on French GDP was not centered on zero in 2013 (last publication with 2005 as the reference year), but there is no visible problem after the update of the data in 2014 (first publication with reference year 2010, see Figure 4). With this chain-linking method, the update of trading-day adjustment models may result in a trend modification, while trading day adjustment should be *a priori* stationary. From one update to another, trend modifications may be sizeable on different aggregates, be either upwards or downwards and of different magnitudes.

To avoid these issues, an alternative way of chain-linking uses a raw chain-link factor:

$$X_{a,t}^{Ch,TDA}(\mathcal{E}) = \frac{X_{a,t}^{Pyp,TDA}(\mathcal{E})}{X_{a-1}^{DefCh,R}(\mathcal{E})},$$

with X^R raw series. In this case, the trading-day effect on chain-linked aggregate remains stationary: it is only due to trading-day adjustment of volumes at previous year's prices.

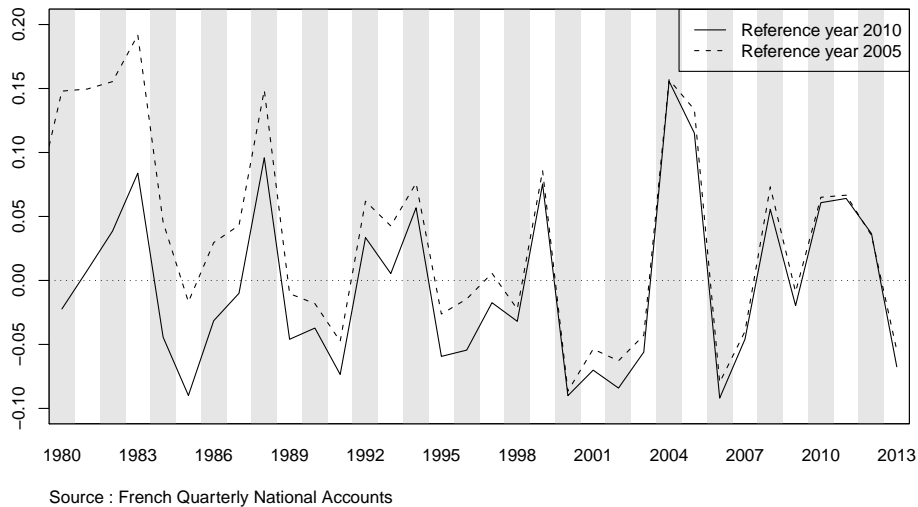


Figure 4: Comparison of trading day effects on French GDP, chain-linked volumes, naive chain-linking

To illustrate further the consequence of the choice between raw and trading-day adjusted chain-link factor, we perform a bootstrap exercise. The trading-day effect on French GDP at previous year's prices is estimated through an OLS model, and the residuals of the estimation are bootstrapped.⁶ This allows us to simulate a sample which replicates the empirical uncertainty of trading day adjustment. These trading-day adjusted series are used to calculate two samples of chain-linked aggregates: the first one using a trading-day adjusted chain-linking factor (naive chain-linking), and the second one using a raw factor (correct chain-linking). Then, the distributions of the trading-day effects on chain-linked aggregate can be plotted (Figure 5).

For the intuitive chain-linking, the variance of the trading-day effect increases away from the reference year, whereas with the alternative chain-linking, the trading-day effect is clearly stationary. A first advantage of the method based on a raw chain-link factor is that it can not introduce an undesirable drift in the trading day adjusted data. In addition, bootstrapping shows that naive chain-linking increases the uncertainty of the estimates. It does so by introducing a first order integrated correction in level. Compared

⁶The trading day effect is computed from trading-day and non trading day adjusted GDP and regressed on the calendar. The residuals (that is, 408 points from January 1980 to December 2013) are bootstrapped, and then aggregated in yearly series. In each case, a sample of 1000 simulations is created.

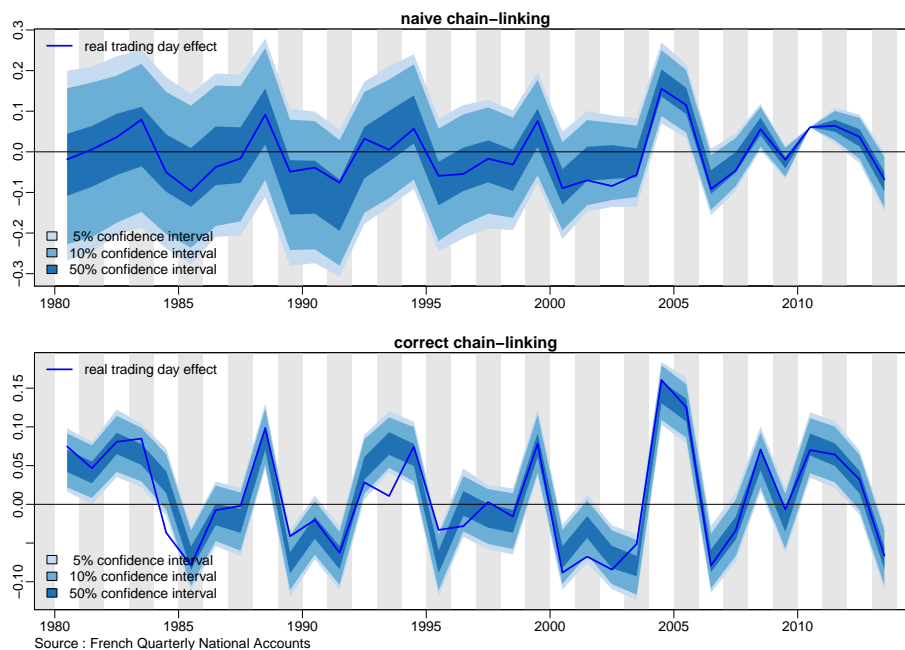


Figure 5: Simulated trading day effect on French GDP, chain-linked volumes

to the similar effect observed between the annual and one quarter overlap techniques, this correction is however much larger (tenfold) and alteration of the statistical properties of the series will be problematic if this undesired effect is corrected through benchmarking.

By construction of the chain-link factor, the one quarter overlap technique cumulates the two issues of trading-day and seasonal adjustment in the definition of the chain-link factor (see eq (2)).

First, the issue of trading-day adjustment is the same as in the annual overlap: the uncertainty of adjustment is amplified by chain-linking if a trading-day adjusted chain-link factor is used.

Second, a similar issue is added by seasonal adjustment, because the chain-link factor is quarterly and not annual. For statistical reasons, it seems better to use a non seasonally-adjusted factor, in order not to amplify the adjustment uncertainty and the alteration of the initial statistical properties. On the other hand, a raw factor may be based on a weighting structure which is not representative of the economy and affect the trend of the series (especially if seasonality is changing). None of the two options is fully satis-

fying: in both cases, the benchmarking on annual series is a trend correction which may modify the variance of quarterly fluctuations, with consequences for data users.

5 Computing additive contributions to growth

We illustrated on the simulations that chain-linked volumes are not additive. It follows that accounting equalities are not verified in chain-linked volumes which can cause some difficulties in aggregating, balancing... and most importantly for users. Moreover, chain-linking misbehaves for aggregates which change signs or are temporarily equal to zero. Hence, changes in inventories or trade balance are usually not chain-linked. To overcome these difficulties, it is possible to compute accurately contribution to the growth rate of a larger aggregate.

5.1 Annual

As we noted earlier (subsection 2.1), in chain-linked volumes ponderations are based upon **current prices** where they are based upon volumes at constant prices for this other concept of volumes. This property shows in the computation of contributions to growth.

Let $ev()$ denote the growth rate operator. For additive concepts (e.g. values and volumes at constant prices) the contribution of the component i to the aggregate \mathcal{E} can be computed easily:

$$\text{Contrib}_a^{Val}(i, \mathcal{E}) = \frac{X_{a-1}^{Val}(i)}{X_{a-1}^{Val}(\mathcal{E})} ev(X_a^{Val}(i)) = \omega_{a-1}^{Val}(i, \mathcal{E}) ev(X_a^{Val}(i))$$

For additive concepts, the contribution to growth is the component's growth rate times its weight in the aggregate in the same additive concept at the previous period.

For chain-linked aggregates, contributions to growth are slightly more complex. The growth rate of a chained-linked aggregate can be written as follows:

$$ev(X_a^{Ch}(\mathcal{E})) = \frac{X_a^{Vol}(\mathcal{E})}{X_{a-1}^{Vol}(\mathcal{E})} - 1 = \sum_{i \in \mathcal{E}} \frac{X_a^{Vol}(i) - X_{a-1}^{Vol}(i)}{\sum_{i \in \mathcal{E}} X_{a-1}^{Vol}(i)}$$

Hence the contribution of i to the evolution of \mathcal{E} in annual in chain-linked volumes can be defined as

$$\begin{aligned}\widetilde{\text{Contrib}}_a^{Ch}(i, \mathcal{E}) &= \frac{X_{a-1}^{Val}(i)}{X_{a-1}^{Val}(\mathcal{E})} \left(\frac{X_a^{Pyp}(i)}{X_{a-1}^{Val}(i)} - 1 \right) \\ &= \omega_{a-1}^{Val}(i, \mathcal{E}) \quad ev(X_a^{Ch}(i)) \\ &= \text{Contrib}_a^{Ch}(i, \mathcal{E})\end{aligned}\tag{4}$$

$$+\text{Contrib}_a^{Ch}(i, \mathcal{E}) \left(\frac{X_{a-1}^{DefCh}(i)}{X_{a-1}^{DefCh}(\mathcal{E})} - 1 \right)\tag{5}$$

As said, ponderations are in values, not in volumes (see equation (4)). Contributions can also be computed by applying a correction to the additive formula which corresponds to the component's price relative drift (see equation (5)).

5.2 With annual overlap

5.2.1 For quarters 2 to 4 in annual overlap X^{Ch}

Within a year ($t \neq 1$), the growth rate of chain-linked volumes equals that of previous year's prices volumes. In addition, previous year's prices volumes are additive, so one can easily compute the contributions in chain-linked volumes as those at previous year's prices volumes:

$$\widetilde{\text{Contrib}}_{a,t}^{Ch}(i, \mathcal{E}) = \text{Contrib}_{a,t}^{Pyp}(i, \mathcal{E}) = \frac{X_{a,t}^{Pyp}(i) - X_{a,t-1}^{Pyp}(i)}{X_{a,t-1}^{Pyp}(\mathcal{E})}$$

These contributions can be written in terms of chain-linked volumes using equation (1):

$$\begin{aligned}X_{a,t}^{Vol} &= X_{a,t}^{Ch} * X_{a-1}^{DefCh} \quad \implies \\ \widetilde{\text{Contrib}}_{a,t}^{Ch}(i, \mathcal{E}) &= \frac{X_{a,t}^{Ch}(i)X_{a-1}^{DefCh}(i) - X_{a,t-1}^{Ch}(i)X_{a-1}^{DefCh}(i)}{X_{a,t-1}^{Ch}(\mathcal{E})X_{a-1}^{DefCh}(\mathcal{E})} \\ &= \frac{X_{a-1}^{DefCh}(i)}{X_{a-1}^{DefCh}(\mathcal{E})} \frac{X_{a,t}^{Ch}(i) - X_{a,t-1}^{Ch}(i)}{X_{a,t-1}^{Ch}(\mathcal{E})}\end{aligned}$$

We can then write

$$\begin{aligned} \widetilde{\text{Contrib}}_{a,t}^{Ch}(i, \mathcal{E}) &= \text{Contrib}_{a,t}^{Ch}(i, \mathcal{E}) \\ &+ \text{Contrib}_{a,t}^{Ch}(i, \mathcal{E}) \left(\frac{X_{a-1}^{DefCh}(i)}{X_{a-1}^{DefCh}(\mathcal{E})} - 1 \right) \end{aligned} \quad (6)$$

In this expression similar to the annual case, the first term is the contribution in the additive case, the second term a correction for non-additivity. This correction will be sizeable only for components for which prices departs from those of the aggregate.

5.2.2 For the first quarter in annual overlap (X^{Ch})

If $t = 1$ the change in prices between the two periods modifies the computation made above.

$$\begin{aligned} ev(X_{a,1}^{Ch}(\mathcal{E})) &= \frac{X_{a,1}^{Ch}(\mathcal{E}) - X_{a-1,4}^{Ch}(\mathcal{E})}{X_{a-1,4}^{Ch}(\mathcal{E})} \\ &= \frac{\frac{X_{a,1}^{Pyp}(\mathcal{E})}{X_{a-1}^{DefCh}(\mathcal{E})} - \frac{X_{a-1,4}^{Pyp}(\mathcal{E})}{X_{a-2}^{DefCh}(\mathcal{E})}}{X_{a-1,4}^{Ch}(\mathcal{E})} \\ &= \frac{\frac{\sum_{i \in \mathcal{E}} X_{a,1}^{Pyp}(i)}{X_{a-1}^{DefCh}(\mathcal{E})} - \frac{\sum_{i \in \mathcal{E}} X_{a-1,4}^{Pyp}(i)}{X_{a-2}^{DefCh}(\mathcal{E})}}{X_{a-1,4}^{Ch}(\mathcal{E})} \end{aligned}$$

One can then compute the contribution as

$$\begin{aligned} \widetilde{\text{Contrib}}_{a,1}^{Ch}(i, \mathcal{E}) &= \frac{\frac{X_{a,1}^{Pyp}(i)}{X_{a-1}^{DefCh}(\mathcal{E})} - \frac{X_{a-1,4}^{Pyp}(i)}{X_{a-2}^{DefCh}(\mathcal{E})}}{X_{a-1,4}^{Ch}(\mathcal{E})} \\ &= \frac{X_{a,1}^{Ch}(i) \frac{X_{a-1}^{DefCh}(i)}{X_{a-1}^{DefCh}(\mathcal{E})} - X_{a-1,4}^{Ch}(i) \frac{X_{a-2}^{DefCh}(i)}{X_{a-2}^{DefCh}(\mathcal{E})}}{X_{a-1,4}^{Ch}(\mathcal{E})} \\ &= \frac{X_{a-1}^{DefCh}(i) X_{a,1}^{Ch}(i) - X_{a-1,4}^{Ch}(i)}{X_{a-1}^{DefCh}(\mathcal{E}) X_{a-1,4}^{Ch}(\mathcal{E})} \\ &+ \frac{X_{a-1,4}^{Ch}(i)}{X_{a-1,4}^{Ch}(\mathcal{E})} \left(\frac{X_{a-1}^{DefCh}(i)}{X_{a-1}^{DefCh}(\mathcal{E})} - \frac{X_{a-2}^{DefCh}(i)}{X_{a-2}^{DefCh}(\mathcal{E})} \right) \end{aligned}$$

The first term is the same contribution as in quarters 2 to 4, the second term is a correction for the change in relative prices across the years. This

additional term can have a marked impact every first quarter and even in extreme cases modify the sign of the contribution [Arnaud, 2007].

One can correct this undesired effect neutrally over the aggregate with a simple subtraction:

$$\begin{aligned} \frac{X_{a-1,4}^{Ch}(i)}{X_{a-1,4}^{Ch}(\mathcal{E})} \left(\frac{X_{a-1}^{DefCh}(i)}{X_{a-1}^{DefCh}(\mathcal{E})} - \frac{X_{a-2}^{DefCh}(i)}{X_{a-2}^{DefCh}(\mathcal{E})} \right) & \text{ becomes} \\ \left(\frac{X_{a-1,4}^{Ch}(i)}{X_{a-1,4}^{Ch}(\mathcal{E})} - \frac{X_{a-1}^{Ch}(i)}{X_{a-1}^{Ch}(\mathcal{E})} \right) \left(\frac{X_{a-1}^{DefCh}(i)}{X_{a-1}^{DefCh}(\mathcal{E})} - \frac{X_{a-2}^{DefCh}(i)}{X_{a-2}^{DefCh}(\mathcal{E})} \right) \end{aligned}$$

Since $X_{a-1}^{Val} = X_{a-1}^{Ch} X_{a-1}^{DefCh}$ and $X_{a-1}^{Pyp} = X_{a-1}^{Ch} X_{a-2}^{DefCh}$ this new term is the differential of ponderation of i in \mathcal{E} in values and previous year's prices volumes ($\omega_{a-1}^{Val}(i, \mathcal{E}) - \omega_{a-1}^{Pyp}(i, \mathcal{E})$), which sums to zero over the aggregate. Hence, this technique minimizes the over-the-year effects on contributions as $\frac{X_{a-1,4}^{Ch}(i)}{X_{a-1,4}^{Ch}(\mathcal{E})} - \frac{X_{a-1}^{Ch}(i)}{X_{a-1}^{Ch}(\mathcal{E})}$ becomes a second order correction. In addition, these contributions are additive without any approximation.

5.3 General formula for contributions in chain-linked volumes

With annual overlap

All in all, the contribution of i to the growth of \mathcal{E} in annual overlap chain-linked volumes is:

$$\begin{aligned} \widetilde{\text{Contrib}}_{a,t}^{Ch}(i, \mathcal{E}) &= \text{Contrib}_{a,t}^{Ch}(i, \mathcal{E}) \left(\frac{X_{a-1}^{DefCh}(i)}{X_{a-1}^{DefCh}(\mathcal{E})} - 1 \right) \\ &+ \delta_{t=1} \left(\frac{X_{a-1,4}^{Ch}(i)}{X_{a-1,4}^{Ch}(\mathcal{E})} - \frac{X_{a-1}^{Ch}(i)}{X_{a-1}^{Ch}(\mathcal{E})} \right) \left(\frac{X_{a-1}^{DefCh}(i)}{X_{a-1}^{DefCh}(\mathcal{E})} - \frac{X_{a-2}^{DefCh}(i)}{X_{a-2}^{DefCh}(\mathcal{E})} \right) \end{aligned} \quad (7)$$

with $\delta_{t=1}$ a dummy for the first quarters.

In line with section 4, we point out that annual accounts in this formula stem from the annual chain-link factor, hence if this factor is not trading day adjusted, non-trading day adjusted deflators and annual chain-linked volumes must be used in this equation.

The distributions of the three terms from equation(7) are displayed on Figure 6 for symmetric simulations. The first term is the main component of

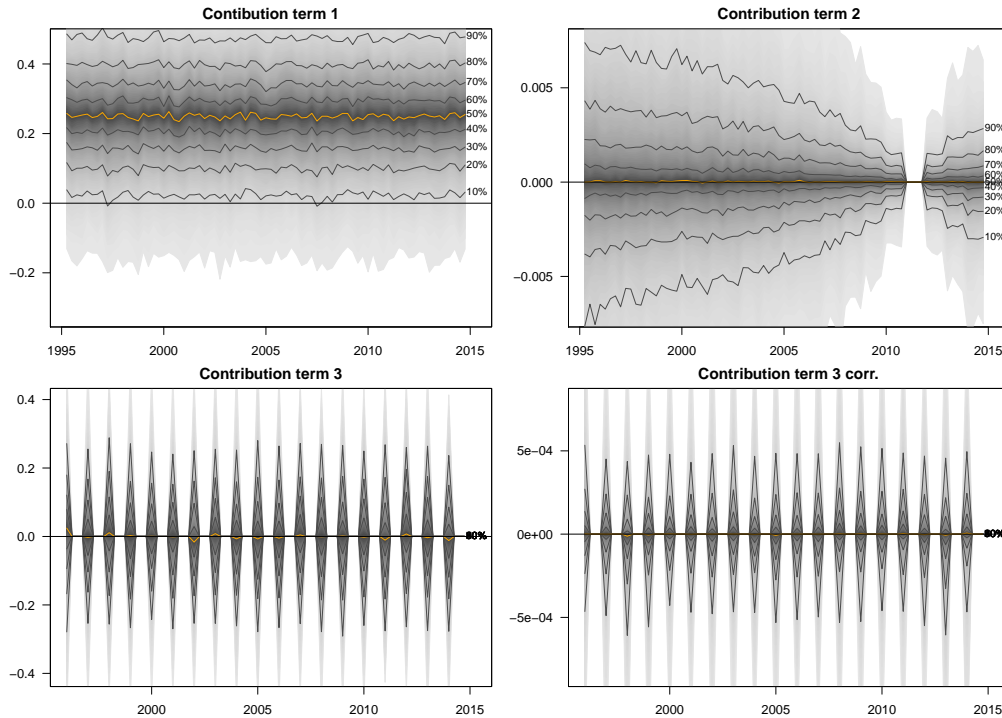


Figure 6: Three components of contribution to quarterly growth rate in annual overlap for symmetric simulations

the contribution and is on average one half of a 2% annual growth rate (0.25% quarterly contribution). The second term correspond to a trend discrepancy in deflators which resembles chain-linking effect depicted earlier. For this symmetric simulation it is very small since the prices of both components grow at the same rate on average. The third term before correction, though it is small on average, has a very large variance (comparable with the average value of the main component) but can be reduced more than a hundred fold by the correction proposed in this paper. However, contributions exactly amount to the growth rate of the aggregate with and without this correction.

Equation (7) can be adapted to compute contributions to over the year

growth rates:

$$\begin{aligned} \widetilde{\text{Contrib}}_{a,t}^{Ch,yoy}(i, \mathcal{E}) &= \frac{X_{a,t}^{Ch}(i) - X_{a-1,t}^{Ch}(i)}{X_{a-1,t}^{Ch}(\mathcal{E})} \\ &+ \frac{X_{a,t}^{Ch}(i) - X_{a-1,t}^{Ch}(i)}{X_{a-1,t}^{Ch}(\mathcal{E})} \left(\frac{X_{a-1}^{DefCh}(i)}{X_{a-1}^{DefCh}(\mathcal{E})} - 1 \right) \\ &+ \left(\frac{X_{a-1,t}^{Ch}(i)}{X_{a-1,t}^{Ch}(\mathcal{E})} - \frac{X_{a-1}^{Ch}(i)}{X_{a-1}^{Ch}(\mathcal{E})} \right) \left(\frac{X_{a-1}^{DefCh}(i)}{X_{a-1}^{DefCh}(\mathcal{E})} - \frac{X_{a-2}^{DefCh}(i)}{X_{a-2}^{DefCh}(\mathcal{E})} \right) \end{aligned} \quad (8)$$

The same precaution as for equation (7) applies on the use of non trading-day adjusted chain-link factor.

With one quarter overlap

All the computations made for annual overlap estimates apply to the one quarter overlap estimates, with one exception, the addition of a term to the first quarter correction which is neutral over the aggregate. So much so that the contribution of i to the growth of \mathcal{E} in one quarter overlap chain-linked volumes can be written:

$$\begin{aligned} \widetilde{\text{Contrib}}_{a,t}^{Ch}(i, \mathcal{E}) &= \text{Contrib}_{a,t}^{Ch}(i, \mathcal{E}) \\ &+ \text{Contrib}_{a,t}^{Ch}(i, \mathcal{E}) \left(\frac{\tilde{X}_{a-1}^{DefCh}(i)}{\tilde{X}_{a-1}^{DefCh}(\mathcal{E})} - 1 \right) \\ &+ \delta_{t=1} \frac{\tilde{X}_{a-1,4}^{Ch}(i)}{\tilde{X}_{a-1,4}^{Ch}(\mathcal{E})} \left(\frac{\tilde{X}_{a-1}^{DefCh}(i)}{\tilde{X}_{a-1}^{DefCh}(\mathcal{E})} - \frac{\tilde{X}_{a-2}^{DefCh}(i)}{\tilde{X}_{a-2}^{DefCh}(\mathcal{E})} \right) \end{aligned} \quad (9)$$

with $\delta_{t=1}$ a dummy for the first quarters. The three terms of contributions computed on one quarter overlap, benchmarked on their annual counterparts or not, have very similar distributions to the annual overlap case (Figures 7 and 8). In particular, the third term has a large variance compared to the first term. Hence, the correction of the third term seems mandatory to have interpretable contributions on the first quarters of each year. Contributions in one quarter overlap no longer add up to the growth rate of the aggregate.

Figure 9 displays the discrepancy between the sum of the contributions and the growth rate of the aggregate in one quarter overlap, with and without the correction to the third term and with benchmarked and non benchmarked one quarter overlap aggregates. Contributions given by equation (9) are additive prior to benchmarking one quarter overlap estimates on annual chain-linked aggregates (Figure 9, top left). However, the necessary correction to the third term of the contribution formula makes contributions no

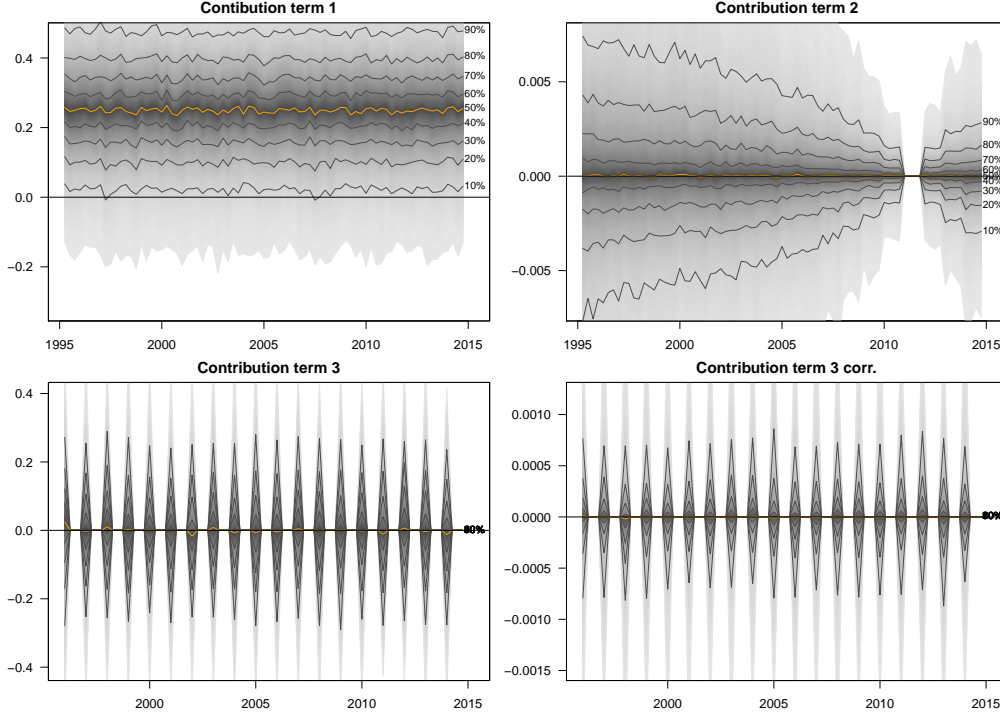


Figure 7: Three components of contribution to growth in one quarter overlap for symmetric simulations

longer additive (Figure 9, top left). When benchmarking one quarter overlap on annual chained linked volumes, because of the benchmarking residual, formula (9) is only an approximation (Figure 9, bottom left). However, the correction to the third term limits the size of this approximation (Figure 9, bottom right). Hence even for one quarter overlap, contributions are better computed with equation 7.

5.4 Comparison with an approximative formula

A common approximation for equation (7) and (9) is to apply the annual formula (4) on quarterly data:

$$\widetilde{\widetilde{\text{Contrib}}}_{a,t}^{Ch} = \omega_{a,t-1}^{Val}(i, \mathcal{E}) \quad ev(X_{a,t}^{Ch}(i)) \quad (10)$$

Figure 10 depicts the difference between the approximative formula (10) and the exact formula (7) on symmetric simulations. For the annual over-

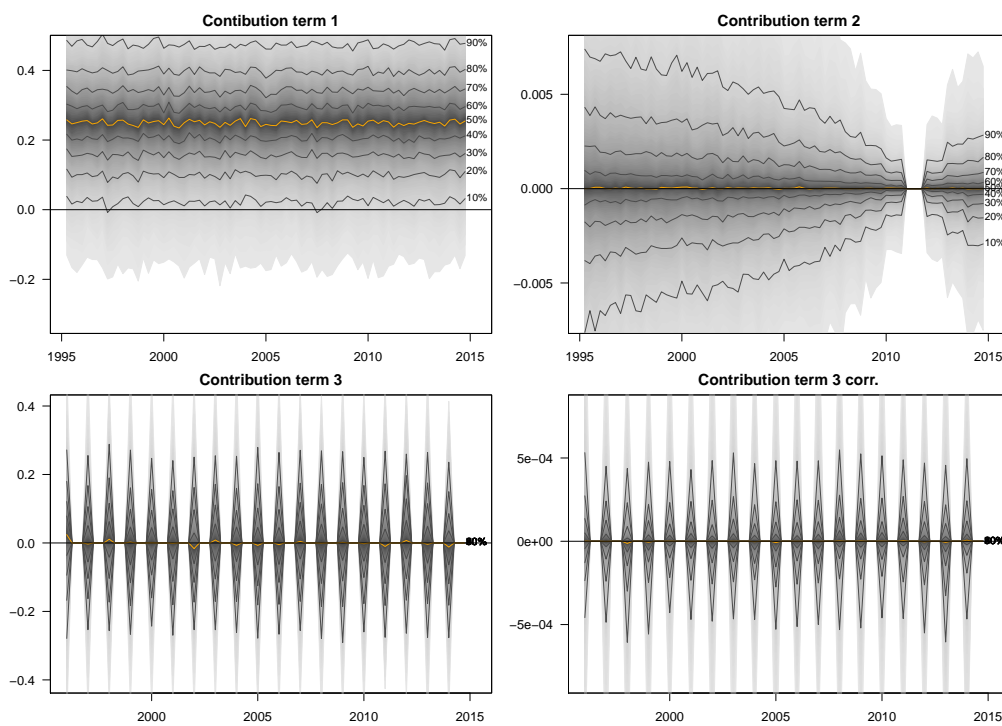


Figure 8: Three components of contribution to growth in one quarter overlap after benchmarking for symmetric simulations

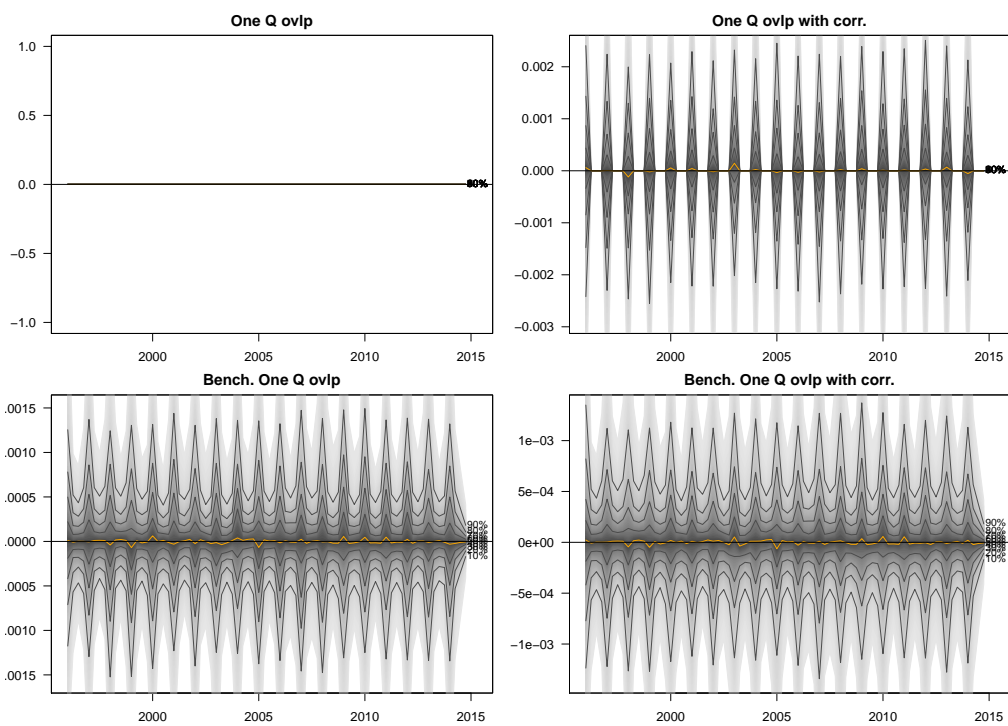


Figure 9: Residuals in contributions to growth of an aggregate in one quarter overlap for symmetric simulations

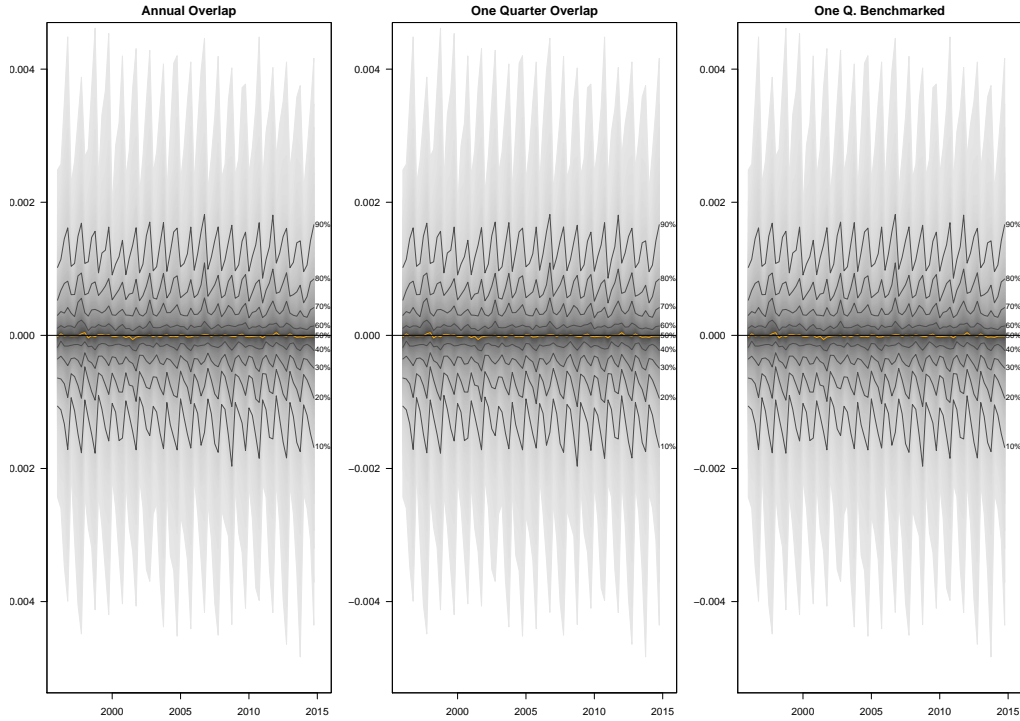


Figure 10: Comparison of approximation (10) with (7) for the computation of contribution to growth (in %)

lap and the one quarter overlap method, whether it is benchmarked or not, the approximation is quite good: the difference between the two methods is smaller than 0.002% for a contribution of 0.25% in quarterly growth rate. Hence, since formula (7) is only an approximation for the one quarter overlap case, this simpler method may be preferred. In addition to being simpler, this formula has convenient decomposition properties [Berthier, 2002].

Conclusion

With respect to one quarter overlap, the annual overlap method has the well-known advantage of naturally adding up to annual chained-linked estimates and the drawback of not correcting for a weight effect in the first quarters growth rates. We show in this paper it has two additional advantages.

First, the calculation of trading-day and seasonally adjusted series is easier with annual overlap. With both chain-linking methods, the trading-day adjustment of the chain-link factor may affect the series trend, but this issue can easily be solved by using a non adjusted chain-link factor. However, the issue of the chain-link factor seasonal adjustment, which concerns only the one quarter overlap method, is more difficult to solve. Indeed, using either a seasonally-adjusted or a raw factor is unsatisfactory, the former raises issues of revisability and precision and the trend and cycle of the series may be altered while the latter uses weights influenced by Christmas, winter temperatures...

Second, it is possible in annual overlap to compute perfectly additive contributions to growth. Our experience is that these contributions are economically relevant and the additivity enables to precisely comment the contribution of changes in inventories or trade balance to GDP for instance. This property is particularly useful for the dissemination of Quarterly National Accounts.

With one quarter overlap, calculation of contributions is plagued with more problems: exactly additive contributions can be computed but their interpretation on first quarters is doubtful. In this case, the formula proposed for annual overlap (Equation (7)) may be preferred but a simpler approximation may also be considered. Additivity is then lost even though this error is empirically small in the present simulations (generally of the order of magnitude of a first decimal rounding error on quarterly growth rates).

We can summarize the comparative advantages of the two methods in Table 1. The new properties exposed in this paper tend to tip the scales in favour of the annual overlap method, even though the relative importance of these properties remain a matter of judgement. In particular, we pointed out that benchmarking one quarter overlap chain-linked account on their annual counterpart, though it is necessary for practical reasons, should be considered with care: especially when trading-day or seasonal adjustment comes into play, this operation may substantially alter the statistical properties of

Property	Annual overlap	One quarter overlap
Additive quarter	▲	▲
Additive components	▼	▼
Consistency with annual	▲	▼
Correction of weight effect in Q1	▼	▲
Neutrality of TD-SA	▲	▼
Additive contributions to growth	▲	▼

Table 1: Comparative advantages of the one quarter and annual overlap method

the data.

We have only considered Laspeyres type indexes here as only the United States and Canada use the alternative Fisher indexes. However as they use the one quarter overlap technique for chain-linking the same issues as the ones pointed out here should apply: exactly additive contributions to growth can not be computed and chain-linking shall interact with seasonal and trading day adjustment, increasing revisability and the alteration of the statistical properties of the data through benchmarking. A thorough demonstration is left for future research.

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Appendix

Country	Ref year and volume concept	Chain-linking method
OECD Member Economies		
Australia	2011-12 Chained Vol. Est.	Quarter overlap
Austria	2010 Chained Vol. Est.	Annual overlap
Belgium	2011 Chained Vol. Est.	Annual overlap
Canada	2007 Chained Vol. Est.	Quarter overlap
Chile	2008 Chained Vol. Est.	Annual overlap
Czech Republic	2010 Chained Vol. Est.	Annual overlap
Denmark	2010 Chained Vol. Est.	Annual overlap
Estonia	2010 Chained Vol. Est.	Annual overlap
Finland	2000 Chained Vol. Est.	Annual overlap
France	2010 Chained Vol. Est.	Annual overlap
Germany	2010 Chained Vol. Est.	Annual overlap
Greece	2005 Chained Vol. Est.	Indirect method
Hungary	2005 Chained Vol. Est.	Annual overlap
Iceland	2005 Chained Vol. Est.	Annual overlap
Ireland	2012 Chained Vol. Est.	Annual overlap
Israel	2010 Chained Vol. Est.	
Italy	2010 Chained Vol. Est.	Annual overlap
Japan	2005 Chained Vol. Est.	Quarter overlap
Korea	2010 Chained Vol. Est.	Annual overlap
Luxembourg	2005 Chained Vol. Est.	Annual overlap
Mexico	2008 Fixed Ct.Pr.	-
Netherlands	2010 Chained Vol. Est.	Over the year (original values) Annual overlap (seas. adj. values)
New Zealand	1995-96 Chained Vol. Est.	Annual overlap
Norway	2011 Chained Vol. Est.	Annual overlap
Poland	2005 Chained Vol. Est.	Annual overlap
Portugal	2011 Chained Vol. Est.	Indirect method
Slovak Republic	2005 Chained Vol. Est.	Annual overlap
Slovenia	2000 Chained Vol. Est.	Annual overlap
Spain	2008 Chained Vol. Est.	Annual overlap
Sweden	2013 Chained Vol. Est.	Annual overlap
Switzerland	2005 Chained Vol. Est.	Annual overlap
Turkey	1998 Chained Vol. Est.	Indirect method
United Kingdom	2010 Chained Vol. Est.	Quarter overlap
United States	2009 Chained Vol. Est.	Quarter overlap
Non-OECD Member Economies		
Brazil	1995 Chained Vol. Est.	Annual overlap
Latvia	2010 Chained Vol. Est.	Annual overlap
Russian Federation	2004 Chained Vol. Est.	Annual overlap
Argentina	2004 Fixed Ct.Pr.	-
India	2004-05 Fixed Ct.Pr.	-
Indonesia	2005 Fixed Ct.Pr.	-
South Africa	2005 Fixed Ct.Pr.	-

Table 2: Concept of volumes and chain-linking methods in use in OECD and non-OECD countries

Source: OECD

<http://stats.oecd.org/wbos/fileview2.aspx?IDFile=479ecd3c-28ec-4b04-bf6b-a6903ce31c55>

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