Chain-linking in quarterly national accounts and the business cycle

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Abstract

In 2005 EU member countries switched their calculations of volume estimates in national accounts from a fixed base year to calculations at previous year prices. In order to get time series of absolute values for volume estimates, chain-linking of growth rates is necessary. Whereas this is a quite unambiguous procedure for annual figures, for quarterly national accounts there exist three possible methods. Despite the fact that all of them result in different output with different time series properties, countries within the EU are free to choose among them and currently are using different approaches. This can lead to differences in quarter-on-quarter growth rates - which are in the main focus of business cycle analysis – even if the same data basis is used.
In this study the properties of different chain-linking methods are shown in theory together with empirical evidence for Austrian quarterly national accounts. The resulting consequences for consecutive time-series based processing like seasonal adjustment and business cycle analysis are observed. Whereas dating turning points seem to be rather robust over different chain-linking methods, seasonal and working day adjustment and outlier detection based on time series modelling can be affected decisively. Furthermore the requirement of time consistency can interfere with outlier detection and - as a consequence – with business cycle dating, too.

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1 Introduction

Due to the usage of base years of the far past, the possibility of a bias in economic time series measuring volumes is a conventional wisdom[1]. This led to a change-over in national accounts from price adjustments related to a fixed base year to one at previous year prices[2]. As a result, only fragments of time series of a length of two years can be consistently calculated for real variables. From these fragments, growth rates in real terms can be calculated, which are not dependent on the choice of a certain base year. However, as users and the public strongly demand absolute values, these growth rates are chained together thereafter with either constructing an index series or relating them to a certain reference period.

Whereas this is a quite unambiguous procedure for annual figures, for quarterly national accounts there exist three possible methods for linking quarterly figures to a chained index. Despite the fact that all of them show different results with different time series properties, countries within the EU are free to choose among them. Currently all three types of approaches are used within the community.

In order to evaluate possible consequences, the following work wants to shed light on the question how large differences can be and whether they can interfere with successive time series based processing like seasonal adjustment or business cycle analysis.

In the second section of this paper all three different chain-linking methods (the over-the-year method, the annual overlap method and the quarterly overlap method[3]) are presented together with their theoretical properties. The magnitude of time inconsistency based on Austrian quarterly national accounts (QNA) data for all three chain-linking techniques is presented in section 3. There, also a recommendable method for benchmarking is given which adjust time series to make them time consistent. Section 4 is dedicated to the question of how the different chain-linking techniques can interfere with time series modelling. The sensitivity of dating business cycle turning points with the popular Bry and Boschan (1971) routine to the different chain-linking methods is observed in section 5. In the last section conclusions are draw.

[1] See e. g. Boskin, Dulberger, Gordon, Griliches and Jorgenson (1998).
[2] In 2003 EU member countries were obliged to deliver national accounts data from 2005 onwards on a previous year price basis.
[3] This is frequently also called "one-quarter overlap method".

2 Different methods of chain-linking for quarterly data

As analysis of economic time series draws on real output in most cases and items are often measured in monetary units, some weighting mechanism has to be found in order to construct volume estimates. This weighting scheme can either be held constant for a certain time span (base year or period) or change every year. Whereas the first method has the advantage that all volume estimates derived show additivity across their subcomponents, the latter enables to avoid a potential bias due to a possibly outdated weighting scheme. The EU regarded the problem of non-additivity as the smaller problem and member states had to switch national accounts calculations from a fixed-price basis to one of previous year prices. As the basis of calculation changes every year the results can not be regarded as a consistent time series. As for that from each pair of product *i* of calculations at current prices ($p_t q_t$) and at previous year prices ($p_{t-1} q_t$), a growth rate is calculated.

$$\Delta\% v_t = \frac{p_t^i q_t^i}{p_{t-1}^i q_t^i} \qquad (1)$$

These growth rates are either linked together in order to construct an index or to set up a series in absolute values taking a certain year as a reference (this process is called chain-linking). As growth rates are not additive, aggregates like GDP have to be constructed on a previous year price basis with a following chain-linking procedure:

$$\Delta\% v_t = \frac{\sum p_t^i q_t^i}{\sum p_{t-1}^i q_t^i} \qquad (2)$$

For aggregates for which such calculations of growth rates are not possible due to their variation of signs over time (like net exports or changes in inventories) either some workaround is done or they are not published at all.

For sub-annual frequencies the choice of the right price base is not so easy because it is unclear whether to take the average price level over last year, or the one of the respective period of last year or the foregoing period. This problem has been solved very uniformly in that the average (over all periods) has to be taken for the construction of series at previous years prices. What is left open to the countries is the decision of how to calculate growth rates and to chain them together for producing series in absolute values.[4]

There exist three different methods for doing this: the over-the-year method (OTY), the annual overlap method (AO) and the quarterly overlap method (QO). To construct all of them two "series"[5] are necessary: one which calculates each quarter at average prices of the current year and one which calculates each quarter at average prices of the previous year.

2.1 The over-the-year method

The over-the-year method calculates growth rates by comparing a certain quarter at average prices of the previous year to the respective quarter at average prices of the previous year. These growth rates are chained together analogously to an index series I[6]

$$I_{y,s}^{OTY} = \frac{\overline{p}^{y-1} q^{y,s}}{\overline{p}^{y-1} q^{y-1,s}} I_{y-1,s}^{OTY} \qquad (3)$$

where y represents the year, s the respective quarter (s=1,..,4) and $\overline{p}$ the average price level of the previous year.

From equation (3) it becomes apparent, that growth rates as well as the following chain-linking procedure relate only to the respective quarter of past years but never to the preceding. Bikker (2005) pointed out, that this method virtually constructs not one index series but four, one for each quarter, and they show no overlapping feature between each other. Therefore he stresses that "non-corresponding quarters cannot be compared in any meaningful way"[7]. In the same direction argues Kirchner (2007) showing that growth rates constructed this way depend on the entire history of these quarters.

As for all these reasons time series properties of an index produced by the over-the-year method are very poor, if such series can be regarded as a time series at all. Quarter-on-quarter growth rates, which are of exceptional importance for business cycle observations, can not be constructed in a consistent way.

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[4] Unlike annual figures QNA figures are usually not published as index series.

[5] These series cannot be regarded as time series in a narrower sense, as they show breaks at every beginning of a new year.

[6] The description of the construction of the different types of indices draws heavily on the work of Bikker (2005).

[7] Bikker (2005), p. 9

Apart from looking at time series properties, a further criterion for evaluating chain-linking methods is their time consistency feature. This is not a quality criterion but more a kind of practical requirement. Whereas it is natural to demand that quarterly series at current and previous years prices add up to their annual totals, this is not the case for chain-linked values which just represent growth rates. Nevertheless there is a strong demand for quarterly national accounts data of volume series which show time consistency with annual totals. Whereas some chain-linking methods implicitly care for that consistency others do not. For the latter case, member states are urged to make ex-post adjustments to their data.

In the case of the over-the-year method it becomes apparent from (3) that it does not fulfil this criterion because

$$\sum_{s=1}^{4} \frac{I_{y,s}^{OTY}}{I_{y-1,s}^{OTY}} \neq \frac{\sum \overline{p}^{y-1} q^{y,s}}{\sum \overline{p}^{y-1} q^{y-1,s}} \qquad (4)$$

where the left hand side of the equation gives the sum over all quarterly growth rates and the right hand side of the equation the growth rate of the annual chain indices. In practice, differences between both sides should be small, however[8].

2.1 The annual overlap method

The annual overlap method calculates growth rates by comparing a certain quarter calculated at average prices of the previous year to a quarter of the foregoing year calculated at average prices of this respective year. These growth rates are chained together analogously to an index series I

$$I_{y,s}^{AO} = \frac{\overline{p}^{y-1} q^{y,s}}{\frac{\sum \overline{p}^{y-1} q^{y-1,s}}{4}} I_{y-1,s}^{AO} \qquad (5)$$

As all quarters of the current year are related to the complete past year the index series constitutes a consistent time series until a new year becomes the next price basis. This happens each first quarter where a break occurs. The size of this break depends on the change of the fraction of the forth quarters quantities and/or prices relative to the total year between two successive years[9]. So in practice this

[8] For the Austrian case see Table 3.
[9] For a more formal explanation of this, the reader is referred to Kirchner (2007), p. 5.

"contamination" will be rather small, unless there is a large change of price or quantity structure relative to the entire year.

In respect of the criterion of time consistency of the quarters relative to the total year, the annual overlap method performs best of all three chain-linking approaches in that the quarters reach exactly the respective annual totals. This stems from the fact, that not only the annual growth rate has as its basis the index of the foregoing year but also all quarters[10].

2.2 The quarterly overlap method

This approach calculates all growth rates by comparing the current quarter at average prices of the foregoing year to the forth quarter of the previous year valued at average prices of the respective year. Again these growth rates are thereafter chain-linked in the same manner. So the index series is calculated as

$$I_{y,s}^{QO} = \frac{\overline{p}^{y-1} q^{y,s}}{\overline{p}^{y-1} q^{y-1,4}} I_{y-1,4}^{QO} \qquad (6)$$

Bikker (2005) notes that here the quarter-on-quarter growth rates represent direct quantity indices even at the first quarter of a year. Hence he concludes that "... [it] is the only technique [of all three considered ones] that leads to a proper chained quantity index". The index series constructed this way shows no frictions at the beginning of the year or in other quarters, which are due to the chain-linking technique. This is probably the reason, why the IMF[11] is strongly recommending this approach for setting up quarterly national accounts.

This good time series property comes at cost of time consistency, however. Without any formal proof[12] it seems to be logic that this type of index can not add up to annual totals. Lippe and Küter (2005) correctly noted that the quarterly overlap method performs in this respect even worse than the over-the-year method.

Table 1 illustrates all three chain-linking methods. The continuous lines represent the over-the-year method, the dashed lines the annual overlap method and the dotted the quarterly overlap approach.

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[10] To be more exact "the arithmetic average of the foregoing year" but this cancels out when summarized over all four quarters.
[11] See Bloem, Dippelsman and Maehle (2001).
[12] For this the reader is referred to Bikker (2005).

Table 1: Construction of growth rates and chain-links

Date	at average prices of the current year	at average prices of the previous year
2006Q1	55883.83	54749.82
2006Q2	58323.31	57223.87
2006Q3	60055.64	59066.67
2006Q4	61555.77	60727.75
2007Q1	57433.55	56310.32
2007Q2	60743.55	59604.40
2007Q3	62528.67	61398.34
2007Q4	64397.05	63324.27

In Table 2 an overview about the properties of all three methods is given as a summary.

Table 2: Properties of various chain-linking techniques

	time consistency	**breaks in series**
over-the-year method	approximately given	every quarter
annual overlap method	fully given	between the fourth and the first quarter
quarterly overlap method	not given	no breaks

So if national statistical offices of the EU have to decide which of these methods to use in the compilation of quarterly national accounts, pros and cons as listed in Table 2 have to be considered.[13] User oriented offices will probably give more emphasis to the time consistency criterion, while others which attach more importance to business cycle analysis may favour the ones which do not cause breaks in the series.

As time consistent quarterly series are strongly demanded by users, most countries applying methods which do not care automatically for this time consistency feature adjust their data in a second step. In national accounts procedures which force sub-annual data to show consistency with annual totals are called benchmarking techniques. These techniques range from primitive forms like the distribution of differences equally between all quarters or proportionally (pro-rata technique) to more sophisticated oriented mathematical or statistical ones.

In order to answer the question whether it is better to use the annual overlap method which implicitly respects annual totals or another method with a subsequent benchmarking

[13] A further criterion could be the amount of data to be produced and stored necessary for applying one of these methods, but as computers can be used quite well and storage cost have come down considerable in past years, this should not be taken as a criterion nowadays.

procedure it is helpful to know how the annual overlap method achieves time consistency. Bikker (2005) has shown that the annual overlap method is equivalent to the quarterly overlap method with a built-in pro-rata benchmarking process[14]. In other words, the breaks in the time series at every start of a year stem from this built-in benchmarking process. The fact that the pro-rata technique (distribution of the annual difference proportional to its unadjusted values) causes "steps" at the beginning of each year is well known as documented in the IMF's Quarterly National Accounts Manual.[15] Due to this shortcoming this benchmarking technique is regarded as "unacceptable" in this manual.[16]

[14] This can also be seen in our empirical example for Austria in Figure 2.
[15] Bloem, Dippelsman and Maehle (2001).
[16] Bloem, Dippelsman and Maehle (2001), p. 84.

3 Empirical differences due to time inconsistency

In this section the differences between the three chain-linking methods which have been discussed in section 2 are given for Austrian GDP data. It ranges from the first quarter of 1988 to the end of 1996. Table 3 gives the differences stemming from time inconsistency of all three chain-linking methods.

Table 3: Differences between quarters and annual totals

Year	OTY		AO		QO	
	in mio €	in %	in mio €	in %	in mio €	in %
1988	12.02	0.01	0.00	0.00	-128.41	-0.09
1989	12.94	0.01	0.00	0.00	-229.65	-0.15
1990	11.94	0.01	0.00	0.00	422.48	0.26
1991	12.43	0.01	0.00	0.00	761.13	0.45
1992	4.99	0.00	0.00	0.00	730.39	0.42
1993	10.23	0.01	0.00	0.00	839.55	0.48
1994	4.91	0.00	0.00	0.00	497.05	0.28
1995	7.97	0.00	0.00	0.00	266.50	0.15
1996	7.60	0.00	0.00	0.00	98.26	0.05
1997	9.34	0.00	0.00	0.00	-266.37	-0.14
1998	11.24	0.01	0.00	0.00	-721.54	-0.37
1999	9.50	0.00	0.00	0.00	-1587.38	-0.78
2000	0.00	0.00	0.00	0.00	0.00	0.00
2001	-19.63	-0.01	0.00	0.00	591.10	0.28
2002	-20.52	-0.01	0.00	0.00	1006.43	0.47
2003	-22.55	-0.01	0.00	0.00	1458.10	0.67
2004	5.57	0.00	0.00	0.00	1457.55	0.66
2005	19.59	0.01	0.00	0.00	636.15	0.28
2006	23.59	0.01	0.00	0.00	286.39	0.12

The results given in Table 3 are consistent with the expectations formed on the basis of the theoretical considerations of section 2. There are no differences with the annual overlap (AO) method. For the over-the-year approach only small differences in absolute as well as a percentage of the annually chain-linked total year arise. Only for the reference year 2000 this difference is clearly zero. The largest differences between quarterly and annually chain-linked data result from the quarterly overlap (QO) method. Whereas they are zero only for the reference year negative as well as positive deviations can be observed. In absolute values they range from -1.6 billion euro (-0.78% of annually chain-linked GDP) to +1.5 billion euro (+0.67%). There seem to be no trend but rather differences look like they evolve in a smooth auto-regressive manner.

The size of the differences arising from the QO method may suggest that this method is inferior to others. In fact the opposite is true: the larger the differences are, the more it is important to apply a benchmarking procedure which shows better properties than implied by the OTY and AO method.

As time consistency can be regarded as an important feature for some users I observe a fourth series which corresponds to the QO method but which quarters have been made summing up to annual totals. The benchmarking process used for that distributes the differences proportional to the quarters but does not allow steps between years (like the pro-rata method implied in the OTY method). This is achieved by minimizing the relative difference of the relative adjustments of two neighbouring quarters. This approach was proposed by Denton (1971) and is strongly recommended by the IMF[17].

Figure 1: Relative differences between the AO and the benchmarked QO method.

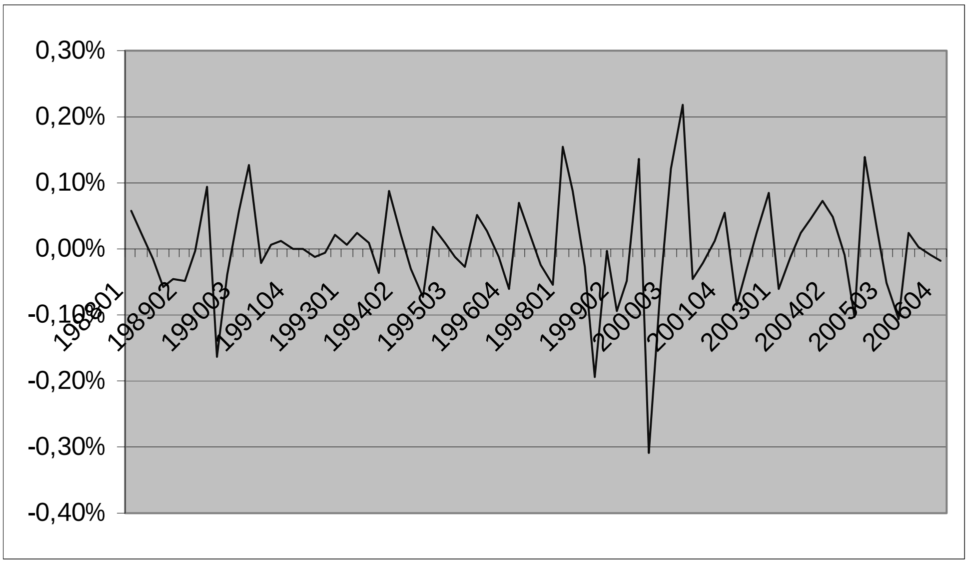
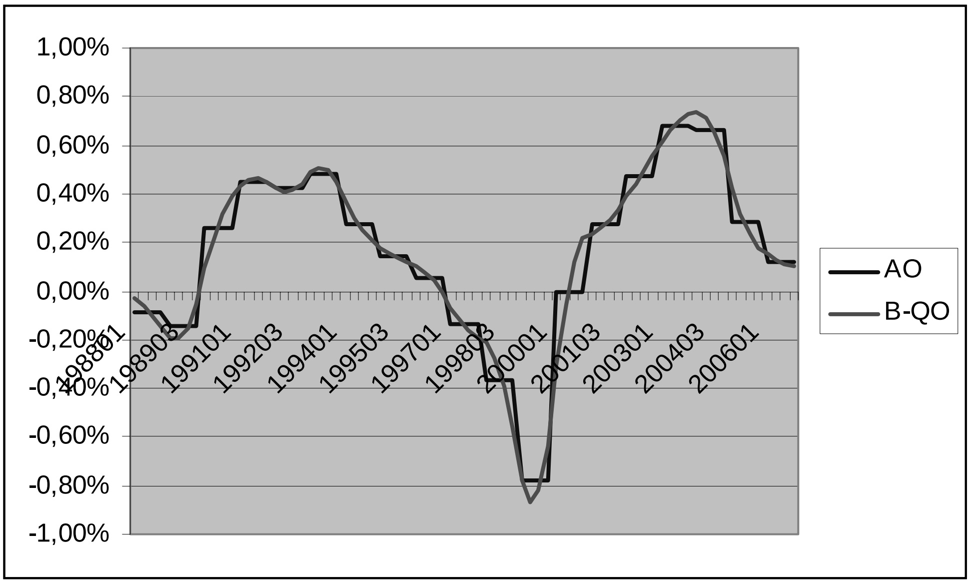


Figure 1 gives the differences between the respective quarters calculated by the AO method (which implies a pro-rata distribution of annual differences) and the QO method after benchmarking with the proportional Denton procedure. Differences are given as percentages of the arithmetic mean of the quarters as calculated by both methods. They range from -0.31% (155 mio. €) in the first quarter of 2000 and +0.22% (120 mio. €) in the last quarter of this year. It may seem odd that exactly in the reference year where all methods show automatically no deviations from annual totals the largest differences between the AO method and the benchmarked QO (B-QO) arise but it has to be noticed that the proportional Denton procedure tries to smooth adjustments between two years. If there are large steps between 1999 and 2000 and

[17] See Bloem, Dippelsman and Maehle (2001), p. 87.

between 2000 and 2001, adjustments have to be made also for the quarters of 2000. This can be shown graphically in Figure 2, where the adjustments relative to the unadjusted QO method are given, which have to be made in order to reach annual totals.

Figure 2: Distribution of annual differences by the AO and the Denton benchmarked QO method



The stepped line represents the AO method. For the reference year 2000 this line moves exactly along the X-axis which means an adjustment of 0%. The smooth evolving line represents the adjustments made by the proportional Denton procedure. As the years 1999 and 2001 require large adjustments, the Denton approach has already to adjust the year 2000 in order to avoid steps at the respective first quarters.

4 Consequences for time series modelling

In order to show possible consequences for modelling time series based on the different chain-linking methods, an automatic time series modelling software has been applied. This software fits seasonal ARIMA-models to economic time series in order to adjust for seasonal and working-day effects or possible outliers. For this the software package DEMETRA[18] has been used which includes the TRAMO-SEATS[19] module.
Tables A1 a to d in the annex show the output of the automatic modelling process for all four time series and the results differ quite substantial. For the OTY method (Table A1 a) a model has been suggested which models the seasonal part as an ARIMA (0,1,1) and the regular (trend-cycle) part as a (0,1,0) model. Furthermore an outlier in the form of a transitory component type has been detected in the first quarter of 1993 and removed automatically.

In the case of the AO method (Table A1 b) an airline model which models the seasonal part as an (0,1,1) and the trend-cycle part as an (0,1,1) process has been selected. Again an outlier has been found in the first quarter of 1993 but this time an additive outlier affecting only the respective quarter.

For the unadjusted QO (Table A1 c) method the same type of model has been chosen. Whereas the MA coefficient for the seasonal part is nearly the same as in the AO case, the one of the regular part is somewhat lower. Also in this case an outlier has been detected for the same period but this time again a transitory component as with the OTY approach.

The QO series adjusted by the proportional Denton procedure (Table A1 d) has been modelled as an ARIMA (0,1,0)(0,1,1) which is quite different to all other chain-linking methods. The parameter of the trend-cycle MA term is the smallest of all models. As in the case of the AO approach an additive outlier has been detected in the first quarter of 1993.

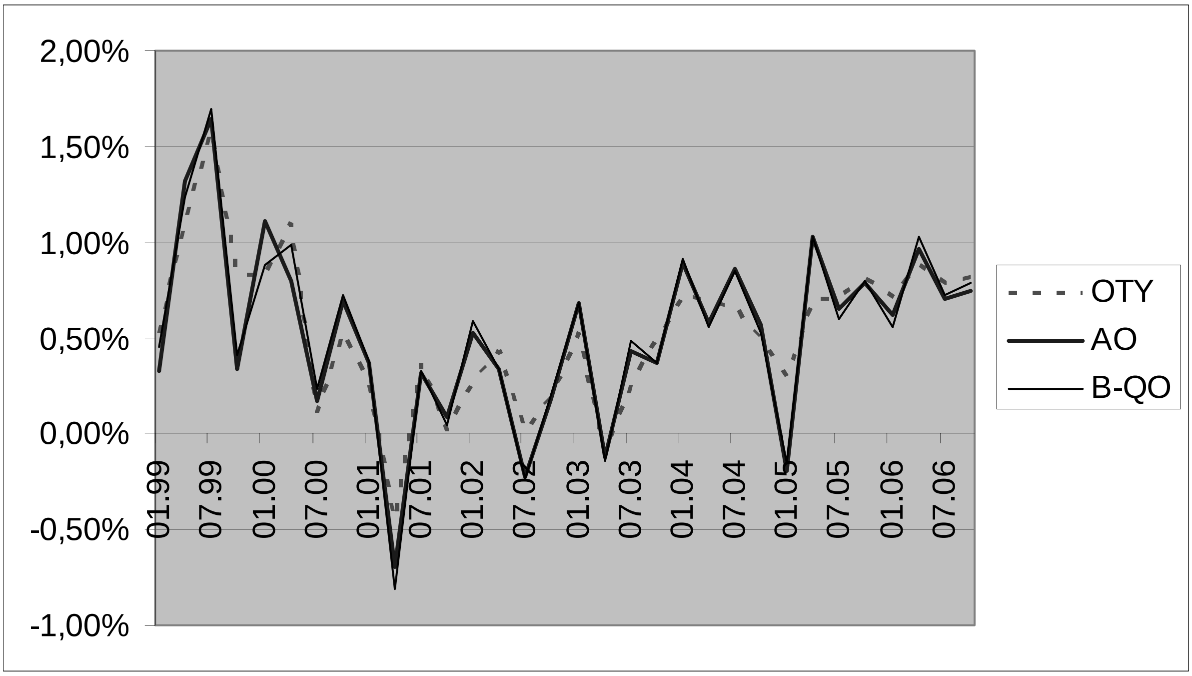
Figure 3 shows the quarter-on-quarter growth rates of the seasonally and working day adjusted series for the OTY, the AO and the Denton benchmarked QO method as they were resulting from the different time series models. Growth rates constructed this way very often serve as the basis of business cycle analysis. It can be observed that the ones derived by the AO and benchmarked QO (B-QO) methods show nearly the same pattern with highly coinciding local peaks and troughs.

[18] DEMETRA 2.1 © European Communities, 1999-2007.

[19] The TRAMO-SEATS software package used here has been developed by Gomez and Maravall (1992) and is strongly recommended by the EC for seasonal adjustment in QNA.

However, the model based on the OTY chain-linked data gives growth rates which behave quite differently in that they seem to have a lower variance. The output for the OTY series seems not to have generally a leading or lagging property if compared to the others, but the local maxima at the beginning of 2000 and 2002 are reached one quarter later in the modelled OTY series.

Figure 3: Quarter on quarter growth rates on seasonally and working day adjusted series



If the AO and the B-QO series are compared to each other, the only difference in the local maxima of growth rates can be observed for the beginning of 2000 with the B-QO method showing the peak one quarter later.

5 Extracting the business cycle

One goal of this paper is to document the consequences of different chain-linking methods for business cycle analysis. As a first step usually the trend is separated from business cycle fluctuations. For this a plethora of methods exist which all imply different theoretical views. Here only the most popular ones are used in order to show possible differences in results[20]. As the data is already seasonally adjusted the famous HP-1600 filter can be applied.

Figure 4: Differences in log of HP-1600 transformed series

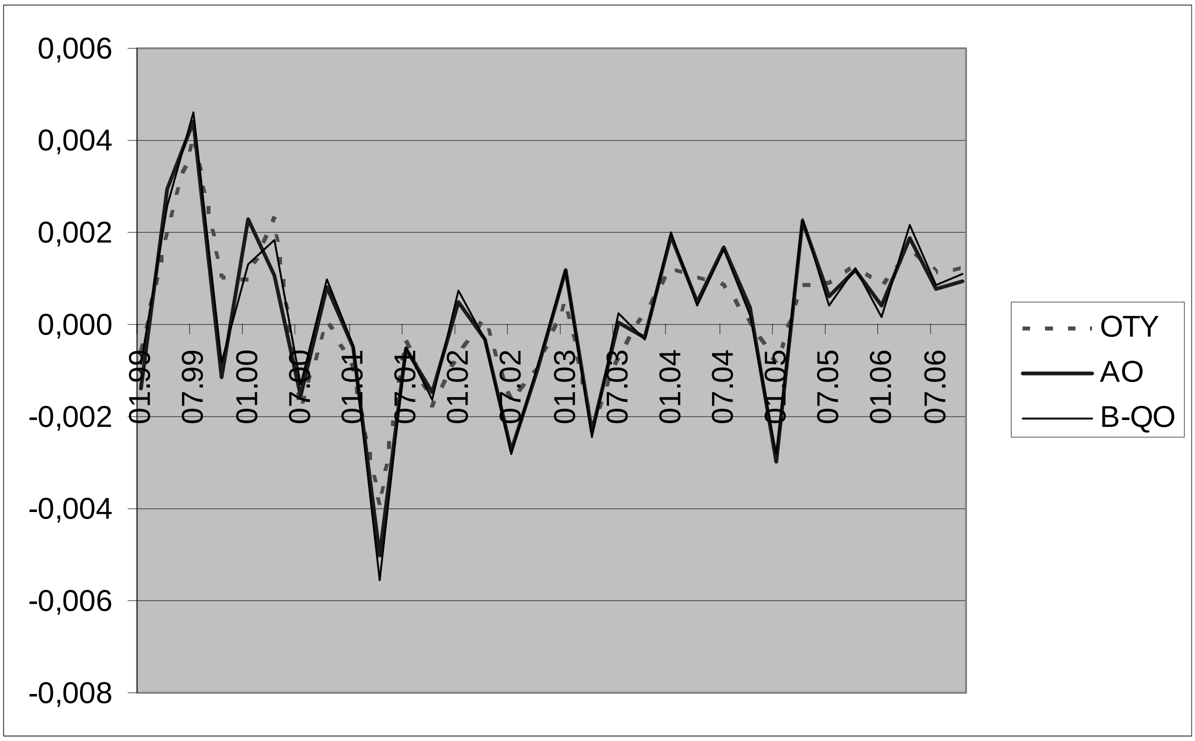


Figure 4 gives the result of log differences between consecutive quarters of the different series for which a HP-1600 trend has been eliminated. The output is quite similar to the ones where the trend has been eliminated by first-order differences of logs (this corresponds to the calculation of growth rats) as shown in Figure 3.

Table 4 gives the dates of the business cycle turning point analyses as done by the routine proposed by Bry and Boschan (1971) with demanding a minimum cycle length of 5 quarters and a minimum phase length of 3 quarters. The unbenchmarked QO series serves as the reference cycle to which all other results are compared[21].

[20] A good overview over the various approaches in this field gives Canova (1998).

[21] This is done on practical grounds and is not based on some priority reasoning.

Table 4: Turning point analysis for HP-1600 filtered series

	Peak	Trough	Peak	Trough	Peak	Trough	Peak	Trough	# of extra cycles
Reference Series	**Q3-1991**	**Q1-1993**	**Q1-1994**	**Q1-1995**	**Q1-1996**	**Q2-1997**	**Q2-2000**	**Q4-2003**	
AO	0	-	-	0	0	-1	0	0	-1
B-QO	0	-	-	0	0	-1	0	0	-1
OTY	0	-	-	0	0	0	0	-1	-1

Note : *+ (-) denotes a lag (lead) with respect to the reference series*

The reference series (QO) given in the first line shows the largest number of completed cycles between 1988 and 2006. It counts 4 cycles whereas all chain-linking methods show only 3. The one starting with a trough in the first quarter of 1993 and showing its peak in the first quarter of 1994 has not been recognized by all other chain-linked series. A possible explanation for this could be that the outlier detected in all series has not been removed sufficiently by the QO method or too much by the other methods[22].

There exists some evidence in the literature that in the first quarter of 1993 was indeed a cyclical trough. For the Austrian case Artis, Krolzig and Toro (2004) reported a trough in the third quarter of 1993 for the Austrian economy. For the Euro Area Mönch and Uhlig (2004) date a trough for the first quarter of 1993, too. The CEPR Business Cycle Dating Committee (2003) dates it in the fourth quarter of 1992, Artis, Krolzig and Toro (2004) for the second quarter of 1993, Artis, Marcellino and Proietti (2004) for the fourth quarter of 2004 and Forni et al. (2004) for the first quarter of 1994. From this it can be concluded, that the benchmarking process – either done explicitly or implicitly – can potentially interfere with the appropriated detection and estimation of outlier effects which can again hamper the detection of business cycle turning points.

The trough in the second quarter of 1997 has been indicated by the AO and the benchmarked QO method one period earlier than by the others. The same goes for the trough in the fourth quarter of 2003 which was detected by the OTY method one quarter earlier.

In order to explore whether the differences in business cycle analysis stem from the differences in time series modelling used for outlier detection and seasonal and working day adjustment or from the chain-linking process itself a further method for business cycle extraction is used. The band-pass filter a proposed by Baxter – King (1995) was applied to all four chain-linking methods as an alternative. As this filter removes not only the trend but also frequencies higher than

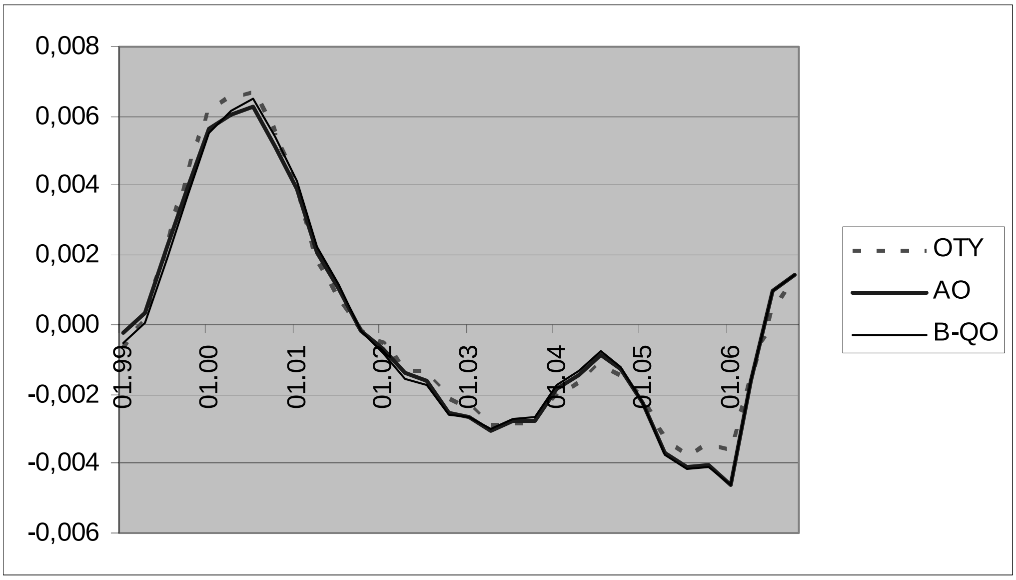
[22] The detection of a trough makes the Bry-Boschan routine look for a following peak in the series, as changing signs for business variations is a requirement for this procedure.

the business cycle like seasonal variations, it can be applied directly to the series without prior adjusting them for seasonal fluctuations[23].

In order to get sure that seasonal variations are properly extracted the filter was set to retain only variations with a frequency between 8 and 2 years (32 and 8 quarters respectively) instead of the common 8 and 1½ years. Additionally the filter length has been enlarged to 8 quarters in order to reduce the leakage of the filter, but this advantage comes at cost of a higher loss of observations at either end of the series (which have been replaced by an ARIMA forecast).

Figure 5 shows the cyclical component after applying the BK-filter in logs to the series of OTY, AO and the Denton benchmarked QO chain-linked series. They look quite similar for their ups and downs between 1999 and 2006. The only remarkable difference is that the OTY series seems to reach its lowest point two quarters before the AO and the B-QO series.

Figure 5: Baxter-King 8-2 filtered series



This result can be confirmed by looking at the turning points as detected by the Bry-Boschan dating procedure given in Table 5. The trough found by all other three series in the first quarter of 2006 is dated by the OTY series two quarters earlier[24]. This time five complete cycles have been found which

[23] It has to be mentioned that for a sensible business cycle analysis a prior adjustment for working days and outliers is indispensable but here the focus is just on the difference between methods and not on finding the correct business cycle.

[24] It has to be mentioned that this difference has to be disregarded as it concerns the margin of the time series, which has been enlarged by ARIMA forecast. That the different chain-linking methods interfere quite

can be attributed to dropping a prior outlier detection procedure. As a consequence the second quarter of 1993 has been dated as a trough with a following peak in the first quarter of 1996.

Generally the dating calendar of the BK-8-2 transformed series looks quite differently than the one for the seasonally HP-1600 filtered ones. But it is a conventional wisdom that the Bry-Boschan (1971) procedure detects less turning points in HP filtered series which are still plagued by high frequency components. This makes it difficult for this dating procedure to find turning points in such highly erratic series.

Table 5: Turning point analysis for BK-8-2 filtered series

	Peak	**Trough**	**Peak**	**Trough**	**Peak**	**Trough**	**Peak**	**Trough**	**Peak**	**Trough**	**# of extra cycles**
Reference Series	**Q4-1988**	**Q1-1990**	**Q4-1991**	**Q2-1993**	**Q1-1996**	**Q2-1997**	**Q1-2000**	**Q2-2003**	**Q3-2004**	**Q1-2006**	
AO	0	0	0	0	0	0	2	0	0	0	0
B-QO	0	0	0	0	0	0	2	0	0	0	0
OTY	0	0	0	0	0	0	2	0	0	-2	0

Note : + *(-) denotes a lag (lead) with respect to the reference series*

From Tables 4 and 5 one can conclude that the Denton benchmarked QO method and the AO method give the same business cycle turning points for the Austrian GDP between 1988 and 2006. However, the unadjusted QO method as well as the OTY method produce different dates and number of cycles with the latter showing sometimes some leading properties when compared to the QO method.

strongly with this kind of time series models has been shown already in chapter 4.

6 Concluding remarks

With the introduction of volume measurement at previous year prices for setting up national accounts, chain-linking of growth rates became necessary. While this method for calculating time series in levels is an unambiguous thing it is more complicated for sub-annual series. In principle three different methods can be used: the over-the-year method, the annual overlap method and the quarterly overlap method. Despite the fact they all produce different output EU member states are free to choose among them for their calculations.

The methods differ in respect of their time consistency (the ability of quarters summing up to annual chain-linked totals) and in view of their time series properties. Whereas the annual overlap method guarantees fully time consistency, the over-the-year method shows minor deviations. The quarterly overlap methods differences between the sum of the quarters and the independently derived annual totals are the largest. Concerning time series properties, the quarterly overlap method performs best, while the annual overlap method can show breaks at the transition from one year to another. The over-the-year method can not be regarded as a consistent time series at all.

As time consistency is strongly demanded by users, sub-annual series can be forced by benchmarking methods to meet annual totals. Transforming the output of the quarterly overlap method with the proportional Denton procedure makes it not only time consistent but also superior to the annual overlap method in terms of theoretical time series properties. Nevertheless, even this more sophisticated adjustment can make it more difficult for following time series processing to adjust for outliers. This can potentially interfere with business cycle dating procedures.

In order to adjust for seasonal variations, working day effects and potential outliers, a widespread software for modelling time series automatically was used. It has been demonstrated that the output of the over-the-year method, the annual overlap approach and the unbenchmarked and benchmarked quarterly overlap method result in quite different models and outlier detection. For showing possible consequences of this for business cycle analysis all seasonally adjusted series have been transformed by an HP-1600 filter in order to clear for trends. Furthermore the Bry-Boschan (1971) routine has been used for dating business cycle turning points. Whereas time series models differ quite substantial the different chain-linking methods proofed to be rather robust concerning the detection of turning points. Nevertheless, the well documented business cycle trough at the beginning of 1993 has been detected only in the unadjusted quarterly overlap chain-linked series.

For observing whether business cycle turning point detection is more affected by the difficult discrimination of different time series models or by chain-linking methods itself, a Baxter-King type band-pass filter has been applied to non-seasonally adjusted data. After running again the Bry-Boschan business dating procedure again detected turning points were dated quite similar. As in the HP-1600 case, once more only the annual overlap method and the benchmarked quarterly overlap method gave exactly the same dating results.

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Annex

Table A1 a: Time series model for over-the-year chain-linked series

Information on Models	OTY (Tramo-Seats)
Series Span (n° of obs.)	Q1.1988 - Q4.2006 (76)
Model Span (n° of obs.)	Q1.1988 - Q3.2006 (75)
Method	Tramo/Seats
PRE-ADJUSTMENT	
Transformation	Logarithm
Mean Correction	None
Correction for Trading Day Effects	2 Regressor(s) (holiday-corr.)
Trad1 t-value	0.86 [-1.990, 1.990] 5%
Trad2 t-value	-0.86 (derived) [-1.990, 1.990] 5%
Leap-year t-value	0.58 [-1.990, 1.990] 5%
Correction for Easter Effect	None
Correction for Outliers	Autom.:AO,LS,TC; 1 Outlier(s) fixed
Critical t-value	3.063
TC Q1.1993 t-value	-3.60 [-3.063, 3.063] crit.val.
Corr. for Missing Obs.	None
Corr. for Other Regr. Effects	None
Specif. of the ARIMA model	(0 1 1)(0 1 0) (fixed)
Non-seas. MA (lag 1) value	-0.3847
Non-seas. MA (lag 1) t-value	-3.49 [-1.990, 1.990] 5%
Method of Estimation	Exact Maximum Likelihood
DECOMPOSITION	
ARIMA Decomposition	Exact
Seasonality	Seasonal model used

Table A1 b: Time series model for annual overlap chain-linked series

Information on Models	AO (Tramo-Seats)
Series Span (n° of obs.)	Q1.1988 - Q4.2006 (76)
Model Span (n° of obs.)	Q1.1988 - Q4.2006 (76)
Method	Tramo/Seats
PRE-ADJUSTMENT	
Transformation	Logarithm
Mean Correction	None
Correction for Trading Day Effects	None
Correction for Easter Effect	None
Correction for Outliers	Autom.:AO,LS,TC; 1 Outlier(s) fixed
Critical t-value	3.065
AO Q1.1993 t-value	-3.88 [-3.065, 3.065] crit.val.
Corr. for Missing Obs.	None
Corr. for Other Regr. Effects	None
Specif. of the ARIMA model	(0 1 1)(0 1 1) (fixed)
Non-seas. MA (lag 1) value	-0.2551
Non-seas. MA (lag 1) t-value	-2.18 [-1.990, 1.990] 5%
Seasonal MA (lag 4) value	-0.2533
Seasonal MA (lag 4) t-value	-2.16 [-1.990, 1.990] 5%
Method of Estimation	Exact Maximum Likelihood
DECOMPOSITION	
ARIMA Decomposition	Exact
Seasonality	Seasonal model used

Table A1 c: Time series model for quarterly overlap chain-linked series

Information on Models	QO (Tramo-Seats)
Series Span (n° of obs.)	Q1.1988 - Q4.2006 (76)
Model Span (n° of obs.)	Q1.1988 - Q4.2006 (76)
Method	Tramo/Seats
PRE-ADJUSTMENT	
Transformation	Logarithm
Mean Correction	None
Correction for Trading Day Effects	1 Regressor(s) (holiday-corr.)
Trad1 t-value	0.99 [-1.990, 1.990] 5%
Trad2 t-value	-0.99 (derived) [-1.990, 1.990] 5%
Correction for Easter Effect	None
Correction for Outliers	Autom.:AO,LS,TC; 1 Outlier(s) fixed
Critical t-value	3.065
TC Q1.1993 t-value	-4.09 [-3.065, 3.065] crit.val.
Corr. for Missing Obs.	None
Corr. for Other Regr. Effects	None
Specif. of the ARIMA model	(0 1 1)(0 1 1) (fixed)
Non-seas. MA (lag 1) value	-0.2567
Non-seas. MA (lag 1) t-value	-2.22 [-1.990, 1.990] 5%
Seasonal MA (lag 4) value	-0.2242
Seasonal MA (lag 4) t-value	-1.83 [-1.990, 1.990] 5%
Method of Estimation	Exact Maximum Likelihood
DECOMPOSITION	
ARIMA Decomposition	Exact
Seasonality	Seasonal model used

Table A1 d: Time series model for benchmarked quarterly overlap chain-linked series

Information on Models	B-QO (Tramo-Seats)
Series Span (n° of obs.)	Q1.1988 - Q4.2006 (76)
Model Span (n° of obs.)	Q1.1988 - Q4.2006 (76)
Method	Tramo/Seats
PRE-ADJUSTMENT	
Transformation	Logarithm
Mean Correction	None
Correction for Trading Day Effects	None
Correction for Easter Effect	None
Correction for Outliers	Autom.:AO,LS,TC; 1 Outlier(s) fixed
Critical t-value	3.065
AO Q1.1993 t-value	-4.22 [-3.065, 3.065] crit.val.
Corr. for Missing Obs.	None
Corr. for Other Regr. Effects	None
Specif. of the ARIMA model	(0 1 0)(0 1 1) (fixed)
Seasonal MA (lag 4) value	-0.2720
Seasonal MA (lag 4) t-value	-2.38 [-1.990, 1.990] 5%
Method of Estimation	Exact Maximum Likelihood
DECOMPOSITION	
ARIMA Decomposition	Exact
Seasonality	Seasonal model used