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Aggregation and Seasonal Adjustment
Empirical Results for EMU Quarterly National Accounts

by
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Empirical Results for EMU Quarterly National Accounts[1]

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Abstract:

This paper investigates the differences between directly and indirectly seasonally adjusted aggregates. This difference is derived analytically for linear seasonal adjustment methods. GDP data for five European countries and three classes of seasonal adjustment methods are used to show empirically the differences between both approaches. For this purpose cointegration methods and cross-spectral analysis are applied. The analysis shows that there are no differences in the long-run components of directly and indirectly adjusted aggregates, whereas differences in the short-run components depend strongly on the seasonal adjustment methods applied in the indirect and direct approaches.

JEL classification: C49

1. Introduction

With the ongoing European integration the interest in European data is steadily growing. Especially for business cycle research seasonally adjusted data is used. For an empirical analysis of the Euro area time series from the individual member states have to be aggregated. To obtain seasonally adjusted data, in principle there are two possibilities. The first one – the so-called direct method – seasonally adjusts the aggregated unadjusted series. The second one – the so-called indirect method – aggregates seasonally adjusted individual time series. The question is whether there are any important differences between these two approaches. If so, are there general rules to choose one or the other method?

For the time being the practice to obtain seasonally adjusted time series in the European Monetary Union (EMU) has not yet been settled. Currently Eurostat compiles quarterly national accounts for the Euro area by aggregating national seasonally adjusted data. Thus, all

[1] Paper to be presented at the conference *Seasonality in Economic and Financial Variables* on October 6/7, 2000 at the Universidade do Algarve. The material in this paper is based on an expertise of the German Institute for Economic Research, Berlin (DIW) for the German Federal Ministry of Finance: Rietzler, Stephan, Wolters (2000). We thank Gustav Horn (DIW) and Uwe Hassler (FU Berlin) for helpful comments and suggestions.

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the methods mentioned in Table 1 (below) are applied simultaneously. The result of this methodological diversity is a very heterogenous data base for the Euro area.

TABLE 1: Seasonal adjustment methods used for quarterly national accounts in EMU member countries

Country	Concept[a]	Seasonal adjustment method used
Germany	ESA95	BV4; X12-ARIMA, adjusted for calendar effects
France	ESA95	X11-ARIMA, adjusted for calendar effects
Italy	ESA95	TRAMO/SEATS
Spain	ESA95	TRAMO/SEATS, adjusted for calendar effects
Netherlands	ESA95	X12-ARIMA, adjusted for calendar effects
Belgium	ESA95	X11 (TRAMO/SEATS - planned)
Austria	ESA95	TRAMO/SEATS
Finland	ESA95	X11 ARIMA
Portugal	ESA79	X11-ARIMA
Ireland	ESA95	insufficient number of observations
Luxembourg	(no quarterly data available)	(none)

[a] ESA: European System of National and Regional Accounts

This paper deals with the interaction between seasonal adjustment and aggregation. Data from the national accounts of EMU members will be the empirical background. Comparing different approaches of seasonal adjustment and aggregation we will focus on the general stochastic properties of the time series. In the time domain we will compare the cointegration properties of adjusted and unadjusted data as well as the cointegration properties of directly and indirectly adjusted data. Furthermore, in the frequency domain we will investigate whether differences at specific cycles of differently adjusted time series exist or not.

The paper is organised as follows. In the next chapter we will present some theoretical considerations. Then the empirical results will be shown. At the end we will summarise our main findings and present some conclusions.

2. Theoretical considerations

The main question is whether there are theoretical reasons to use the direct or the indirect method. The paper by Geweke (1978) discusses the problem of aggregation and seasonal adjustment under the following assumptions. All time series are stationary and consist of two additive components: a seasonal and a non seasonal component. The multivariate distribution of all components is given. That means especially that the correlation structure of the different time series is known. The adjustment is done by minimising the mean square error (MSE). Three different approaches to achieve aggregated seasonally adjusted data are discussed:

(i) The multivariate time series process is adjusted using all available information, i.e. the common distribution. Then the time series are aggregated.

(ii) Without taking the correlation between the time series into account, these are individually adjusted and then aggregated (indirect method).

(iii) The data are aggregated and then the aggregate is adjusted (direct method).

It is shown that the general approach (i) gives the smallest MSE. The difference between the MSEs of the indirect (ii) or the direct method (iii) is minor and it depends on special circumstances whether (ii) outperforms (iii) or vice versa.

These results cannot be used in practice for the problem of seasonally adjusted aggregated time series, see also Lovell (1978) and Taylor (1978): The time series are in general nonstationary and most seasonal adjustment procedures do not optimise according to the mean square error criterion. Recently Ghysels (1997) showed that in cases where beneath linear seasonal adjustment other linear transformations of the time series are applied the optimal outcome in terms of MSE strongly depends on the sequence the transformations are applied.

Therefore, in the following we will find out the difference between the direct and the indirect approaches using given seasonal adjustment procedures. We will especially concentrate on the long-run and the short-run behaviour. Therefore, we first present the decomposition of a linear seasonal adjustment method in its short- and long-run components according to Ericsson, Hendry and Tran (1994).

2.1 Properties of linear seasonal adjustment procedures

A linear seasonal adjustment procedure can be written as a linear two-sided time invariant filter

(1) $$f(L) = \sum_{i=-n}^{n} f_i L^i$$

with the lag operator L defined as $L^k z_t = z_{t-k}$, $k = \ldots,-1,0,1,\ldots$. Such a linear approximation for the X11-ARIMA seasonal adjustment procedure is given by Ghysels and Perron (1993).

Denote the unadjusted time series by x_t , $t = 1,2,\ldots,T$, then the seasonally adjusted time series x_t^s is given by

(2) $$x_t^s = f(L)x_t = \sum_{i=-n}^{n} f_i x_{t-i} \text{ , } t = n+1,\ldots,T-n$$

For the observations $t = 1,\ldots,n$ and $T-n+1,\ldots,T$ the filter has to be adjusted. This may lead to filters with time varying coefficients for the whole sample period $t = 1,\ldots,T$. However, for our theoretical considerations we will neglect this.

The filter f as a seasonal adjustment procedure must have the following properties:

P1 : $$\sum_{i=-n}^{n} f_i = f(1) = 1$$

The weights add up to one, implying that x_t and x_t^s possess the same level.

P2 : $f_{-i} = f_i$, $i = 1,2,\ldots,n$

The filter is symmetric, implying that x_t and x_t^s are in phase.

P3 : $f(L)$ contains a factor $\left(\sum_{i=0}^{s-1} L^i\right) \Big/ s$ with s the number of observations per year.

This factor eliminates deterministic seasonality.

Filter (1) can be rewritten in such a form that the long-run properties are separated from the short-run properties:

$$f(L) = f(1) + f^*(L)\Delta$$

with $f^*(L) = \sum_{i=-n}^{n-1} f_i^* L^i$ and $\Delta = 1 - L$ the first difference operator. With P1 we get

(3) $$f(L) = 1 + f^{*}(L)\Delta$$

Decomposing $f^{*}(L)$ in a similar manner we have $f^{*}(L) = f^{*}(1) + f^{**}(L)\Delta$. With P2 it can be shown that $f^{*}(1) = 0$. Using this in (3) leads to

(4) $$f(L) = 1 + f^{**}(L)\Delta^{2}.$$

For symmetric filters (P2) the short-run fluctuations in seasonally adjusted time series are determined by the second differences of the unadjusted data. If P2 holds Ericsson, Hendry and Tran (1994) show that x_t and x_t^s possess the same sums over calendar years.

From (3) or (4) it is quite obvious that seasonally unadjusted and seasonally adjusted data have the same level:

(5a) $$x_t^s = x_t + f^{*}(L)\Delta x_t \quad \text{or}$$

(5b) $$x_t^s = x_t + f^{**}(L)\Delta^{2} x_t$$

The only differences are linear combinations of first or second differences.

In the following we assume that in accordance with the empirical results the time series are integrated of order 1 (I(1)). This means that the levels of the time series are nonstationary, but their first differences and, therefore, also their second differences are stationary. Equations (5a) and (5b) imply that x_t^s and x_t are cointegrated with a cointegration vector $(1,-1)$ in the sense of Engle and Granger (1987). The unadjusted and adjusted time series possess the same stochastic trend at frequency zero.

2.2 Linear seasonal adjustment and aggregation

In the context derived in 2.1 we will investigate the differences between the direct and the indirect method. Without loss of generality we will restrict to two time series x_{1t} and x_{2t} as well as two seasonal adjustment procedures $f_1(L)$ and $f_2(L)$ for which P1, P2 and P3 holds.

The indirect approach can be written as

$$x_{1t}^s + x_{2t}^s = f_1(L)x_{1t} + f_2(L)x_{2t}$$

and because of (3) we achieve

(6) $$x_{1t}^s + x_{2t}^s = x_{1t} + x_{2t} + f_1^{*}(L)\Delta x_{1t} + f_2^{*}(L)\Delta x_{2t}$$

It is quite clear from (6) that the indirectly seasonally adjusted data and the corresponding unadjusted aggregate are cointegrated with a cointegrating vector $(1,-1)$.

The direct approach for $i=1,2$ can be written as

(7) $$\left(x_{1t}+x_{2t}\right)_i^s=f_i(L)\left(x_{1t}+x_{2t}\right)=x_{1t}+x_{2t}+f_i^*(L)\left(\Delta x_{1t}+\Delta x_{2t}\right)$$

Again seasonally adjusted and unadjusted aggregates have the same long-run component.

Comparing (6) and (7) for $i=1,2$ we get

(8) $$\left(x_{1t}^s+x_{2t}^s\right)-\left(x_{1t}+x_{2t}\right)_i^s=f_1^*(L)\Delta x_{1t}+f_2^*(L)\Delta x_{2t}-f_i^*(L)\Delta x_{1t}-f_i^*(L)\Delta x_{2t}$$

From (8) we can conclude that directly and indirectly seasonally adjusted aggregates are cointegrated with a cointegrating vector of $(1,-1)$. They show the same long-run relations. Differences exist in the short-run fluctuations depending on the individual time series and the seasonal adjustment procedure. Using the same linear adjustment filter no difference between indirectly and directly adjusted data exists.

If we apply different filters for the indirect approach and filter 1 or filter 2 for the direct approach the difference in the short-run development is given by

$$(f_2^*(L)-f_1^*(L))\Delta x_{2t} \quad \text{or} \quad (f_1^*(L)-f_2^*(L))\Delta x_{1t}.$$

If we assume property P2 we have

$$\left(f_2^{**}(L)-f_1^{**}(L)\right)\Delta^2 x_{2t} \quad \text{or} \quad \left(f_1^{**}(L)-f_2^{**}(L)\right)\Delta^2 x_{1t} \; .$$

Whereas the choice of filter 1 or 2 for the direct method has no implication for the filter factor it has for the individual time series which is responsible for the difference.

If the seasonal adjustment filters also possess the property P2 we can reformulate f(L) according to (4). From (5b) we see immediatly that in this case even I(2) series x_t^s and x_t are cointegrated with a cointegration vector (1, -1). Therefore, this result holds also for directly and indirectly seasonally adjusted I(2) aggregates.

2.3 Nonlinear seasonal adjustment and aggregation

Whether seasonal adjustment is a linear or a nonlinear data filtering process is discussed by Ghysels, Granger, Siklos (1996). From a theoretical point of view results in the case of nonlinear seasonal adjustment procedures are negative in the following sense. Assuming $x_t \sim I(1)$ and $g(\cdot)$ a nonlinear transformation then $x_t^s=g(x_t)$, we can rely on the result by Granger and Hallman (1991, p. 223): *In theory a nonlinearly transformed series generally* *cannot be cointegrated with the original series*. This means that seasonally adjusted and unadjusted data do not show the same long-run behaviour.

For the case of aggregation to this result the fact that $g(x_{1t}+x_{2t}) \neq g(x_{1t})+g(x_{2t})$ is superimposed. Thus theoretically it is totally unclear what the differences between directly and indirectly seasonally adjusted aggregates look like.

3. Empirical results

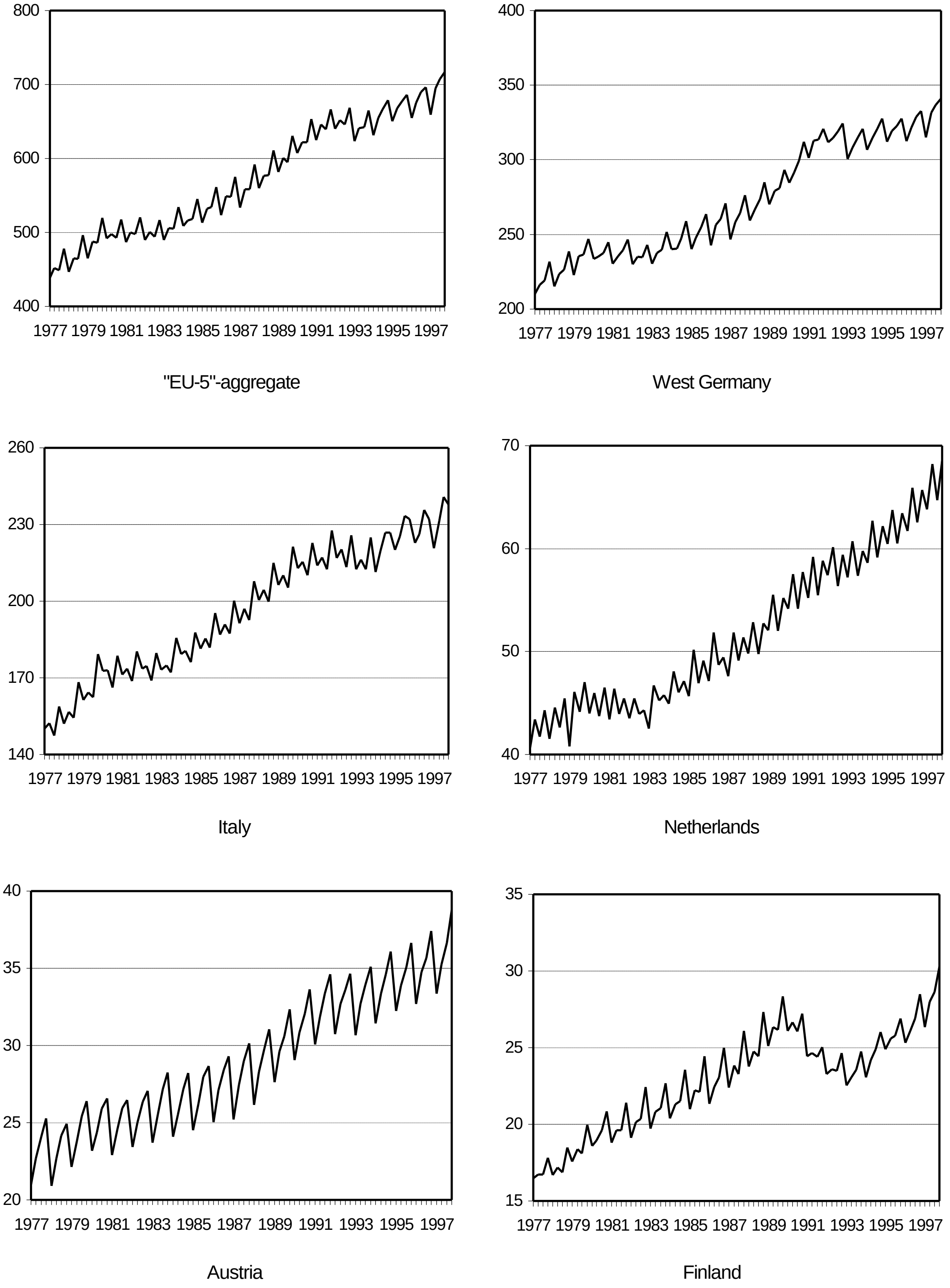
In this chapter the theoretical considerations are examined empirically. Paragraph 3.1 will provide an overview of the data base, its statistical properties, the seasonal adjustment methods applied as well as the aggregates that were formed for the analysis. It is followed by the actual empirical analysis of indirect versus direct adjustment. The analysis includes two versions of the indirect approach: 1. indirect adjustment on the basis of a single seasonal adjustment method and 2. indirect adjustment using different seasonal adjustment methods for the individual countries. The latter approach is close to the current practice in the Euro area.

3.1 Data and seasonal adjustment methods

In order to obtain sufficiently long time series without breaks national accounts data according to the ESA79 are used[4]. They are available on a quarterly basis for West Germany, Italy, the Netherlands, Austria and Finland for the period from 1977 to 1997 (84 observations). These countries cover roughly 60 % of the Euro area's GDP. They include large as well as small economies. Due to its importance for the analysis of the EMU business cycle the focus is on gross domestic product (Figure 1).[5] To examine the long-run behaviour of the time series and the kind of seasonality (deterministic, stationary, non-stationary) they contain we applied the test proposed by Hylleberg, Engle, Granger and Yoo (1990, HEGY-test). The test results show that all time series have similar statistical properties. They have unit roots and non-stationary seasonal cycles.[6] Thus, seasonality in the "EU-5"-aggregates is not artificially generated by aggregation.

[4] Data base: National Accounts (GDP by type of expenditure) according to ESA79, seasonally unadjusted data in national currency at constant prices of 1990 (West Germany, Netherlands and Austria rebased accordingly) transferred into ECU. Sources: Statistisches Bundesamt, DIW, Istat, CBS, Wifo, OECD, Deutsche Bundesbank (ECU rates)
[5] For the respective analysis of gross fixed capital formation cf. Rietzler, Stephan, Wolters (2000)
[6] Results are available on request.

Time series of GDP
billions of ECU



Source: Calculations of DIW.

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Figure 1

The analysis concentrates on three seasonal adjustment methods, which are important in a European context:

- the Berlin method (Version 4, BV4)[7]
- X12-ARIMA (or respectively its predecessors X11 and X11-ARIMA)[8]
- TRAMO/SEATS[9]

Computations are performed with the help of a specially programmed EXCEL macro using a DOS version of the BV4[10] and DEMETRA, Eurostat's seasonal adjustment package for X12-ARIMA and TRAMO/SEATS. Whereas the BV4 offers only additive seasonal decomposition, X12-ARIMA and TRAMO/SEATS each have additive and multiplicative versions. This means that actually five different methods are analysed in this paper. In contrast to X12-ARIMA and TRAMO/SEATS the BV4 program version has no user-defined options. In order to eliminate user-specific intervention, X12-ARIMA and TRAMO/SEATS were applied in their additive and multiplicative versions using default parameters. To ensure comparability with the BV4 no trading day adjustment and outlier corrections were performed. As the default options of X12-ARIMA and TRAMO/SEATS include automatic filter specification and automatic model identification, these methods treat time series individually, i.e. different filters are applied to different time series.

Subsequently, using the indirect approach the seven seasonally adjusted "EU-5"-aggregates are constructed:

- "EU-5"-aggregate indirectly adjusted (BV4)
- "EU-5"-aggregate indirectly adjusted (X12-ARIMA, additive)
- "EU-5"-aggregate indirectly adjusted (X12-ARIMA, multiplicative)
- "EU-5"-aggregate indirectly adjusted (TRAMO/SEATS, additive)
- "EU-5"-aggregate indirectly adjusted (TRAMO/SEATS, multiplicative)
- "aggregate 1": West Germany (BV4), Italy (TRAMO/SEATS, multiplicative), Netherlands (X12-ARIMA, multiplicative), Austria (TRAMO/SEATS, additive), Finland (X12-ARIMA, additive)
- "aggregate 2": West Germany (X12-ARIMA, multiplicative), Italy (TRAMO/SEATS, multiplicative), Netherlands (X12-ARIMA, multiplicative), Austria (TRAMO/SEATS, additive), Finland (X12-ARIMA, additive)

In addition the "EU-5"-aggregate formed of the unadjusted national time series is adjusted directly applying each of the five methods mentioned above.

[7] Nourney (1983)
[8] Findley et al. (1998)
[9] Gomez/Maravall (1997)
[10] The programm is available on request.

3.2 Comparison of the direct and indirect methods

3.2.1 Analysis in the time domain

It is desirable that seasonal adjustment should leave the level of the adjusted time series unchanged. Therefore, in the time domain the Johansen cointegration test[11] is applied to examine whether the five directly adjusted and the seven indirectly adjusted “EU-5”-aggregates show the same long-run behaviour as the unadjusted “EU-5”-aggregate. As can be seen in Table 2 all adjusted aggregates are found to be cointegrated with the unadjusted aggregate with the cointegrating vector (1,-1) at a significance level of 1%. For the linear approaches (additive methods) this confirms the theoretical findings, for the non-linear approaches (multiplicative methods), this means, that the non-linearities do not seem to be very significant. From the point of view of the long-run behaviour of the respective time series the direct and the indirect approaches can thus be considered equivalent.

TABLE 2: Cointegration results of the Johansen procedure. Bivariate models for "EU-5"-aggregates: unadjusted versus differently adjusted time series

Adjustment procedure	Estimated cointegration vector	Eigenvalues	Likelihood-Ratio statistic
direct: BV4	1; -1,0000	0,738 0,001	105,7** 0,1
direct: X12-ARIMA (additive)	1; -1,0000	0,717 0,000	99,7** 0,0
direct: X12-ARIMA (multiplicative)	1; -1,0000	0,585 0,000	69,6** 0,0
direct: TRAMO/SEATS (additive)	1; -1,0000	0,771 0,000	116,6** 0,0
direct: TRAMO/SEATS (multiplicative)	1; -0,9996	0,699 0,000	94,9** 0,0
indirect: BV4	1; -1,0000	0,738 0,001	105,7** 0,1
indirect: X12-ARIMA (additive)	1; -1,0000	0,701 0,000	95,4** 0,0
indirect: X12-ARIMA (multiplicative)	1; -0,9999	0,521 0,000	58,1** 0,0
indirect: TRAMO/SEATS (additive)	1; -1,0000	0,659 0,000	85,1** 0,0
indirect: TRAMO/SEATS (multiplicative)	1; -0,9995	0,563 0,000	65,4** 0,0
aggregate 1	1; -1,0000	0,696 0,000	94,1** 0,0
aggregate 2	1; -0,9998	0,537 0,000	60,9** 0,0

Note: ** indicate significance at the 1% level.

[11] Johansen (1995). We included three seasonal dummies and four lags in the vector error correction model. The determination of the number of cointegration vectors – in this case – amounts to computing eigenvalues $\lambda_1 \geq \lambda_2 \geq 0$. If λ_1 is significantly positiv (tested with the Likelihood-Ratio statistic) one cointegrating vector exists.

3.2.2 Analysis in the frequency domain

In a next step the short-run behaviour of the directly adjusted aggregates is compared to that of the indirectly adjusted aggregates with the help of a cross-spectral analysis of the quarterly growth rates of the respective aggregates[12]. The cross-spectral analysis provides information about the individual cyclical components, especially business cycles and seasonal components. The seasonal components correspond to cycles with periods of 2 and 4 quarters. For the relationship between two time series the coherence and gain for each frequency are the relevant measures. The coherence can be compared to R^2 for each frequency. The gain is equivalent to the absolute value of the regression coefficient for each frequency. If there are no differences between two time series at a certain frequency coherence and gain are equal to one. If two time series have nothing in common, the coherence is equal to zero. A coherence of one at zero frequency is an indicator of cointegration[13].

The cross-spectral analysis shows that the BV4 produces exactly the same outcome in the indirect approach as in the direct approach. The spectra are identical, coherence and gain equal one (cf. Figure 2). This result can easily be explained by the linearity of the BV4 and its fixed filters.

The aggregates, which were adjusted indirectly and directly using X12-ARIMA, show very similar spectra. Both for the additive and the multiplicative versions the coherence as well as the gain are rather close to one, which means that there are differences between the direct and the indirect approaches, but they are rather minor (cf. Figures 3 and 4). These discrepancies can be explained by the fact that the available seasonal and trend filters are geared to the individual time series. Consequently, in the indirect approach several different sets of filters are applied, whereas there is only one set of filters in the case of the direct approach. In the multiplicative version of X12-ARIMA the deviations of the coherence and gain from one are somewhat larger. This may be due to the non-linearities.

For both versions of TRAMO/SEATS the spectra differ widely between the indirect and direct approaches. These discrepancies are reflected in the large deviation of the coherence and gain from one, particularly at the seasonal frequencies (cf. Figures 5 and 6). Obviously, the discrepancies between the direct and the indirect approaches are largest, in the case of a model-based method. As each time series is modelled as an ARIMA-process, there is a wide variety of models and resulting filters, which can lead to very large discrepancies between the

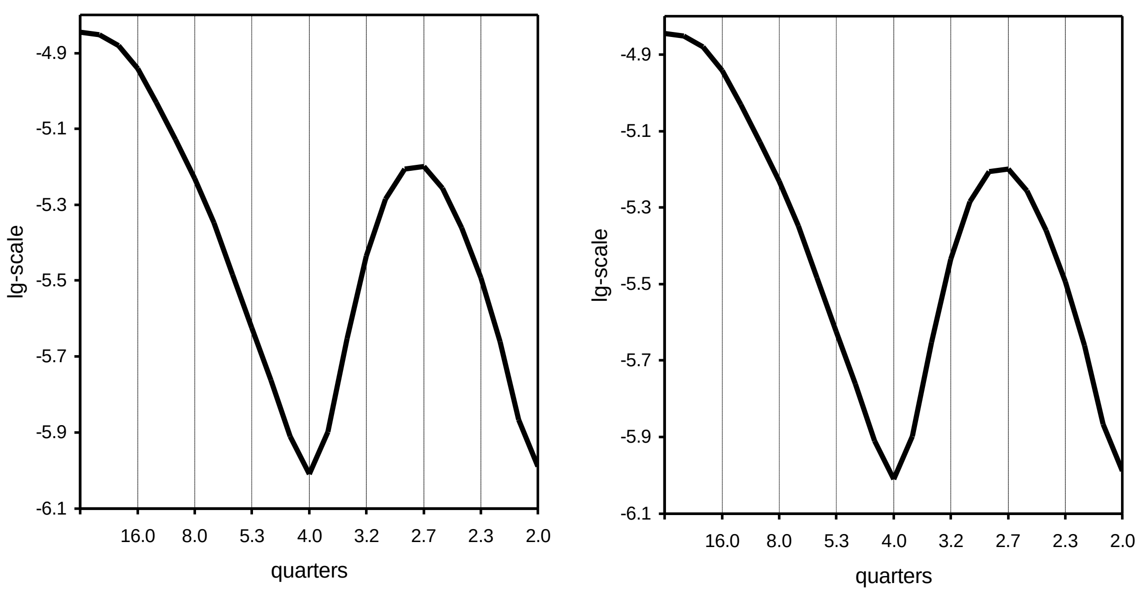
[12] See e.g. König, Wolters (1972). Spectra are estimated with a Parzen window. With a chosen truncation point of 16 and 84 observations about 20 degrees of freedom are available.
[13] Kirchgässner, Wolters (1994)

Spectral analysis of indirectly versus directly adjusted GDP-aggregates

BV4

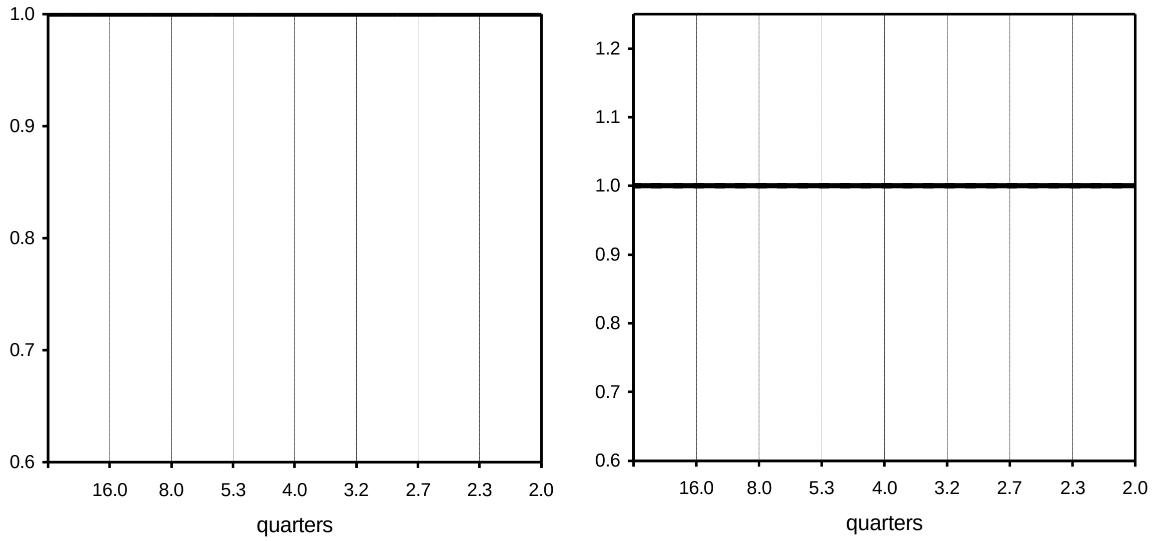
Spectra of ...

indirect seasonal adjustment　　　**direct** seasonal adjustment



Coherence　　　Gain

between indirectly and directly adjusted GDP-aggregates



Source: Calculations of DIW.

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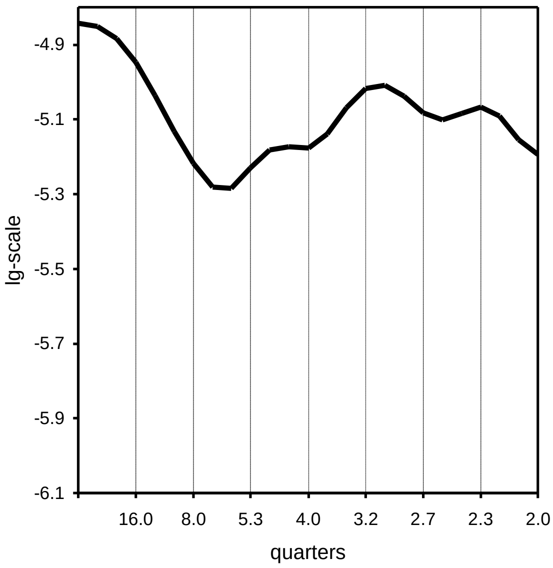
Figure 2

Spectral analysis of indirectly versus directly adjusted GDP-aggregates

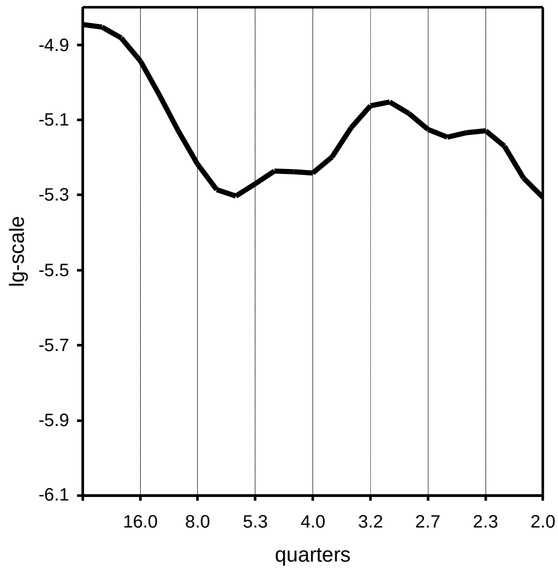
X12-ARIMA, additive version

Spectra of ...

indirect seasonal adjustment



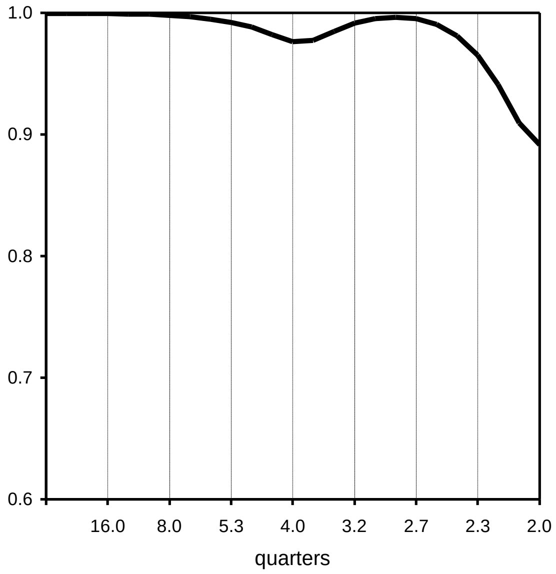
direct seasonal adjustment

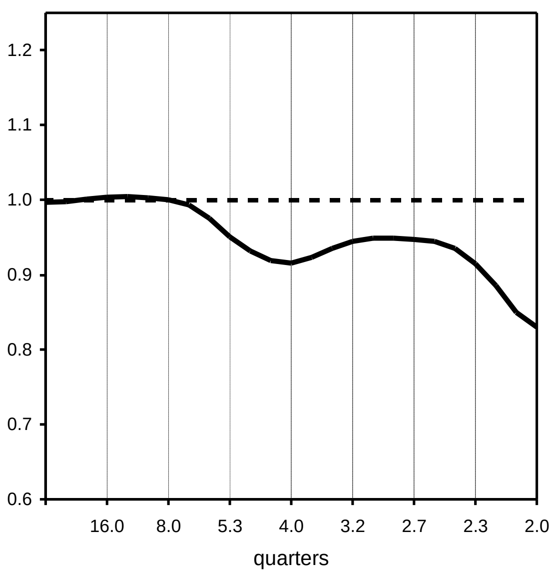


Coherence

Gain

between indirectly and directly adjusted GDP-aggregates





Source: Calculations of DIW.

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Figure 3

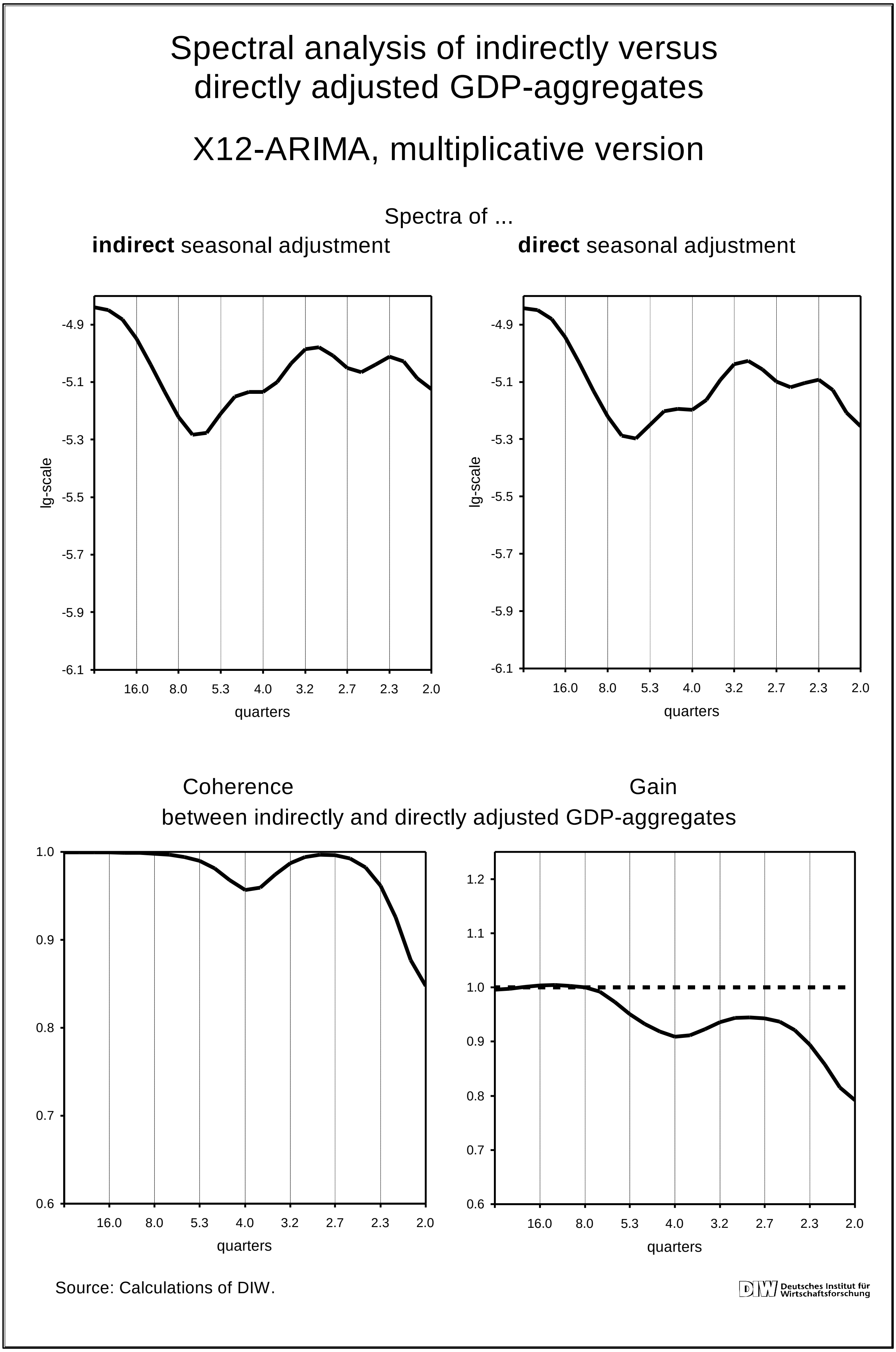
Spectral analysis of indirectly versus directly adjusted GDP-aggregates
X12-ARIMA, multiplicative version
Spectra of ...
indirect seasonal adjustment
direct seasonal adjustment
lg-scale
-4.9
-5.1
-5.3
-5.5
-5.7
-5.9
-6.1
16.0
8.0
5.3
4.0
3.2
2.7
2.3
2.0
quarters
Coherence
Gain
between indirectly and directly adjusted GDP-aggregates
1.0
0.9
0.8
0.7
0.6
1.2
1.1
Source: Calculations of DIW.
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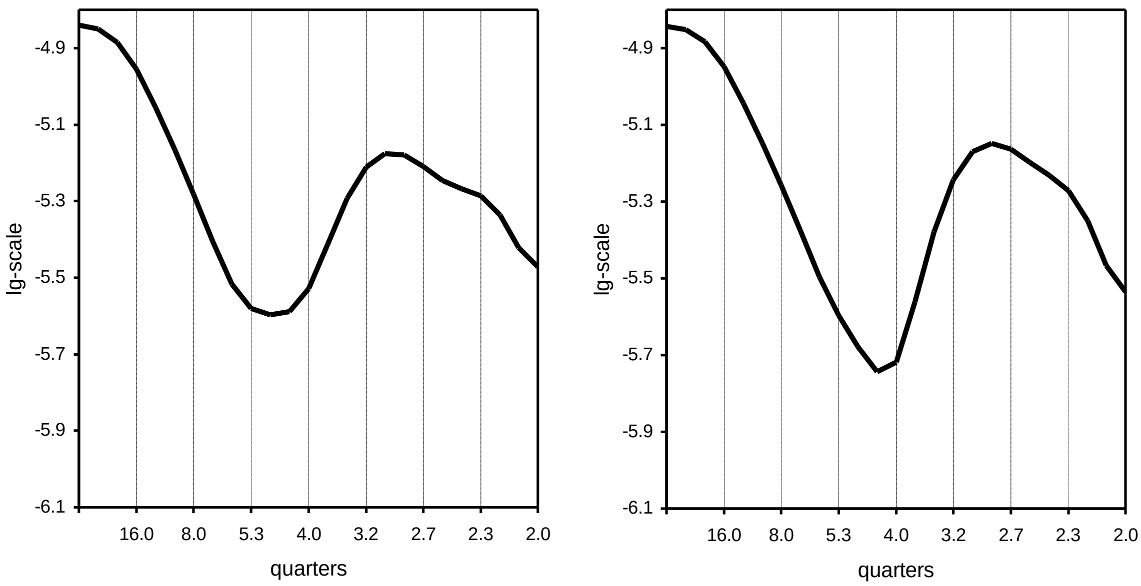
Figure 4

Spectral analysis of indirectly versus directly adjusted GDP-aggregates

TRAMO/SEATS, additive version

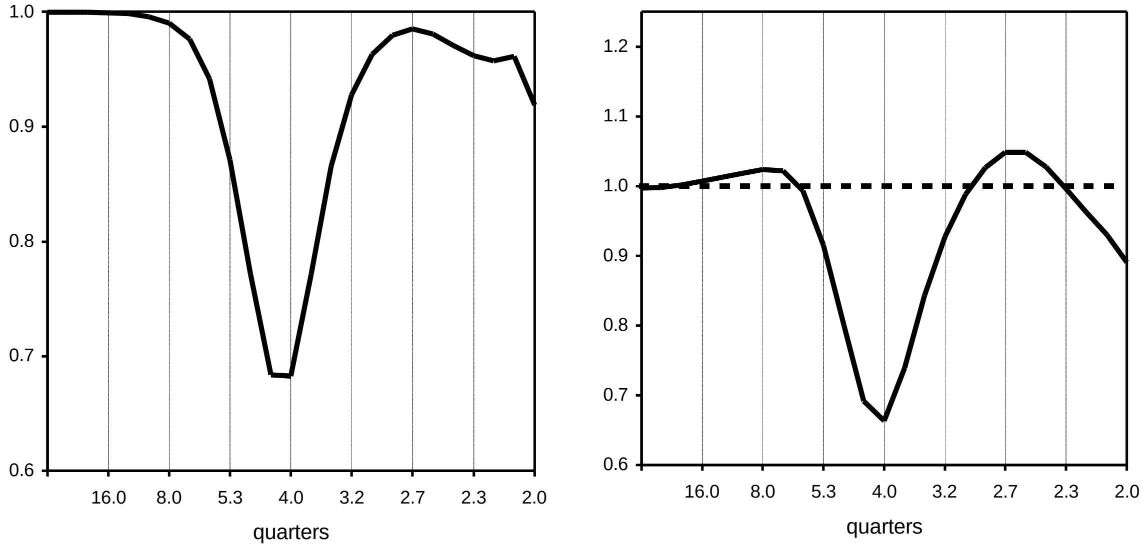
Spectra of ...

indirect seasonal adjustment | **direct** seasonal adjustment



Coherence | Gain

between indirectly and directly adjusted GDP-aggregates



Source: Calculations of DIW.

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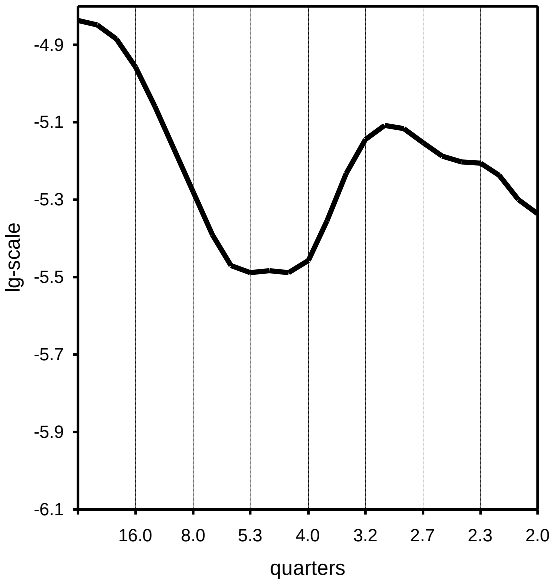
Figure 5

Spectral analysis of indirectly versus directly adjusted GDP-aggregates

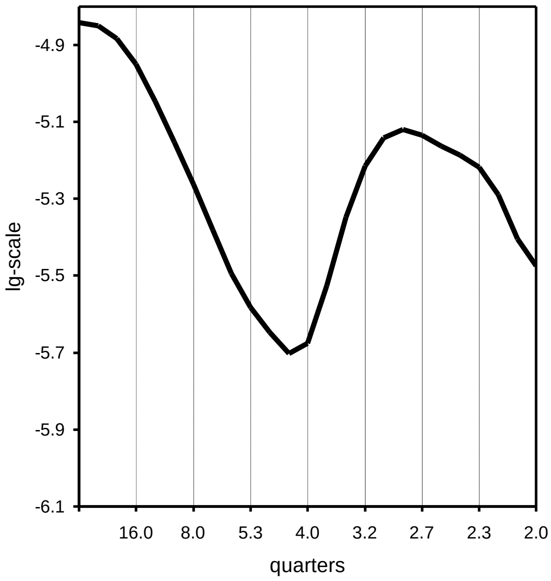
TRAMO/SEATS, multiplicative version

Spectra of ...

indirect seasonal adjustment



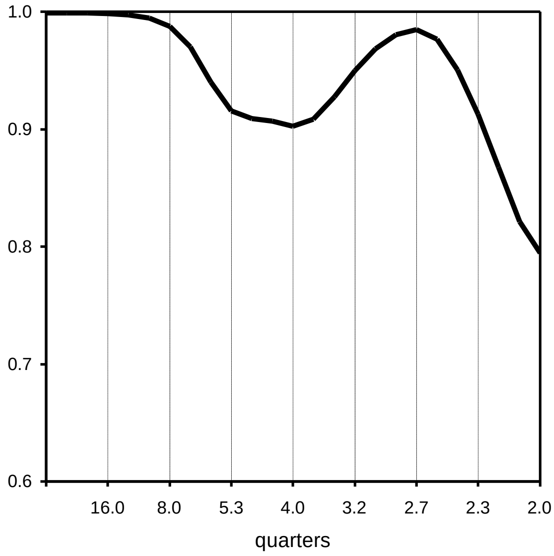
direct seasonal adjustment

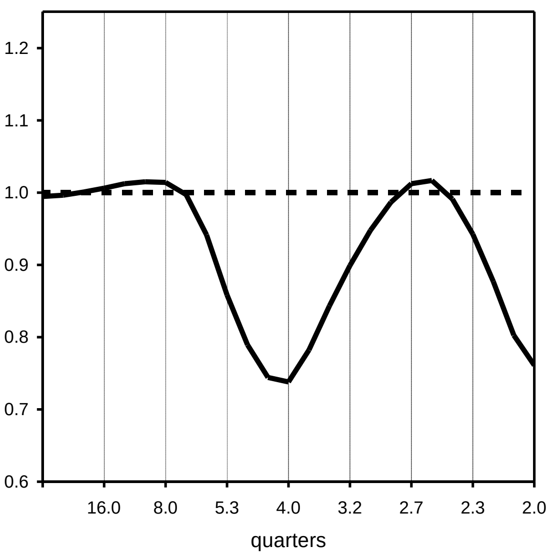


Coherence

Gain

between indirectly and directly adjusted GDP-aggregates





Source: Calculations of DIW.

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Figure 6

direct and the indirect approaches. In contrast to X12-ARIMA the largest discrepancies are not generally produced by the multiplicative version. This implies that the discrepancies due to different models and filters are decisive and not so much the non-linearities.

Generally, the analysis shows that for short-run fluctuations there are significant discrepancies between the direct and the indirect approaches for some methods. Whereas no discrepancies can be found for BV4, the model-based TRAMO/SEATS produces the largest discrepancies. The results of X12-ARIMA can be found between these two extremes.

The direct and indirect approaches thus produce different results concerning the short-run behaviour of the adjusted “EU-5”-aggregates. However, from the analysis of the discrepancies no general recommendations in favour of one of the two approaches can be derived. In practice statistical criteria are not the only basis for decisions. Practical considerations of the individual EMU member countries play an important part. Consequently, the current practice in EMU national accounts is an indirect approach, in which a number of seasonal adjustment methods are used by the individual countries. This is why in the following we look more closely at the short-run behaviour of the mixed aggregates.

The mixed aggregates 1 and 2 were formed to reflect very roughly the current practice in the EMU. Except for the West German time series the aggregates are identical. As the German statistical office (Statistisches Bundesamt) has used BV4 so far and the Deutsche Bundesbank has recently switched from X11 to X12-ARIMA, it seems sensible to compare two aggregates that use one of these methods each.

If the spectrum of Aggregate 1 is compared to the spectra of the direct approaches using BV4 and X12-ARIMA, it becomes obvious that the discrepancies are much smaller in the case of direct adjustment with the help of BV4 (cf. Figures 7 and 8). This is not surprising, because in Aggregate 1 the BV4 is used to adjust roughly half of the aggregate.

For Aggregate 2 (in which X12-ARIMA is applied for West Germany and also for the Netherlands and Finland) discrepancies between the indirect and the direct approaches are smallest, when X12-ARIMA is used in the direct approach (cf. Figures 9 and 10).

The cross-spectral analysis for the mixed Aggregates 1 and 2 thus shows that the seasonal adjustment is dominated by the method utilised for the largest country (in this case: West Germany). Thus, not surprisingly, the discrepancies between the indirect and the direct approaches are minimal, when the method of the largest country in the mixed aggregate is also applied in the direct approach. As the comparison of the direct and the indirect approaches for the five chosen methods shows, this holds in the case of methods with a limited choice of filters. For model-based methods such as TRAMO/SEATS the results vary

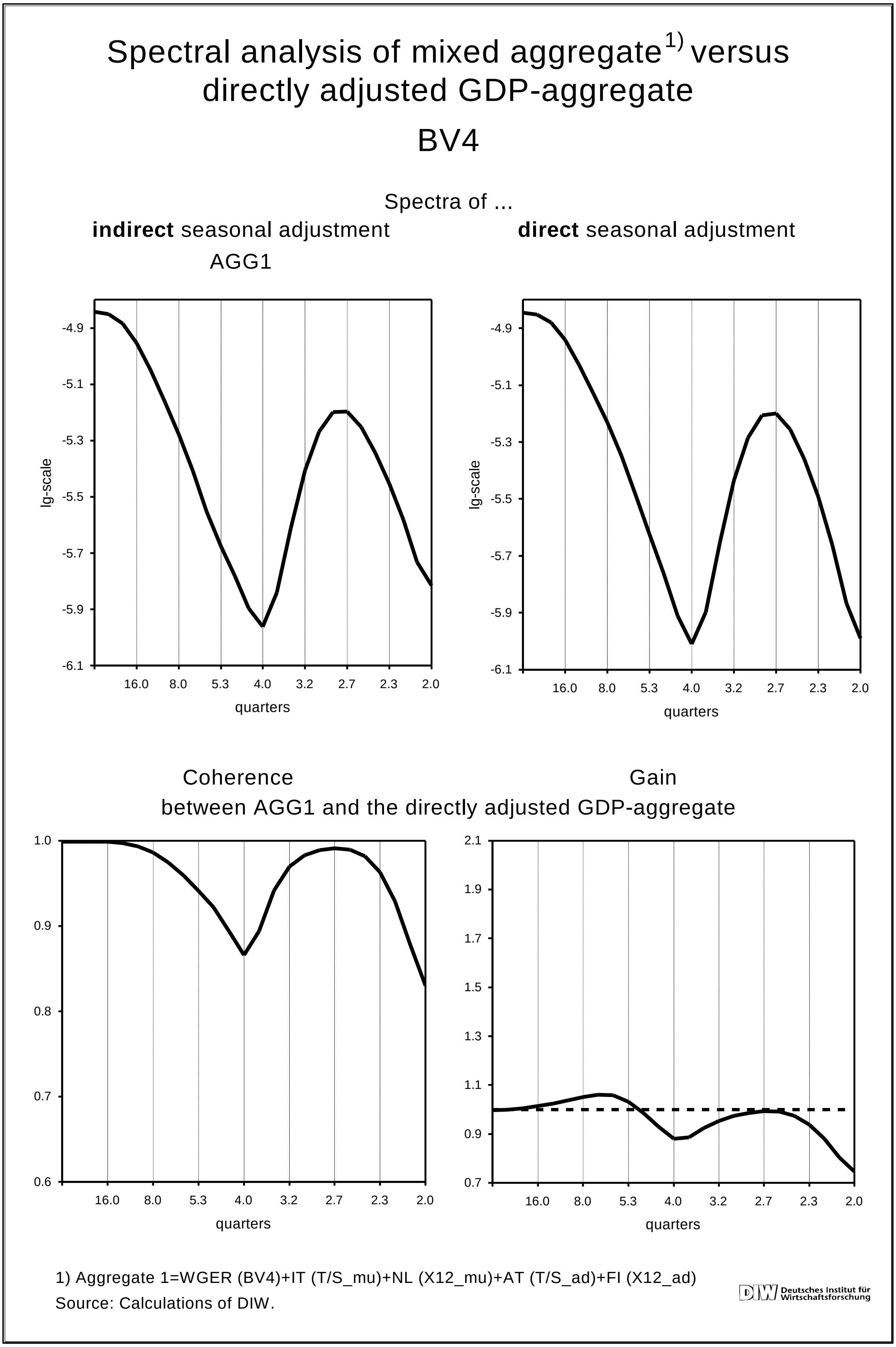
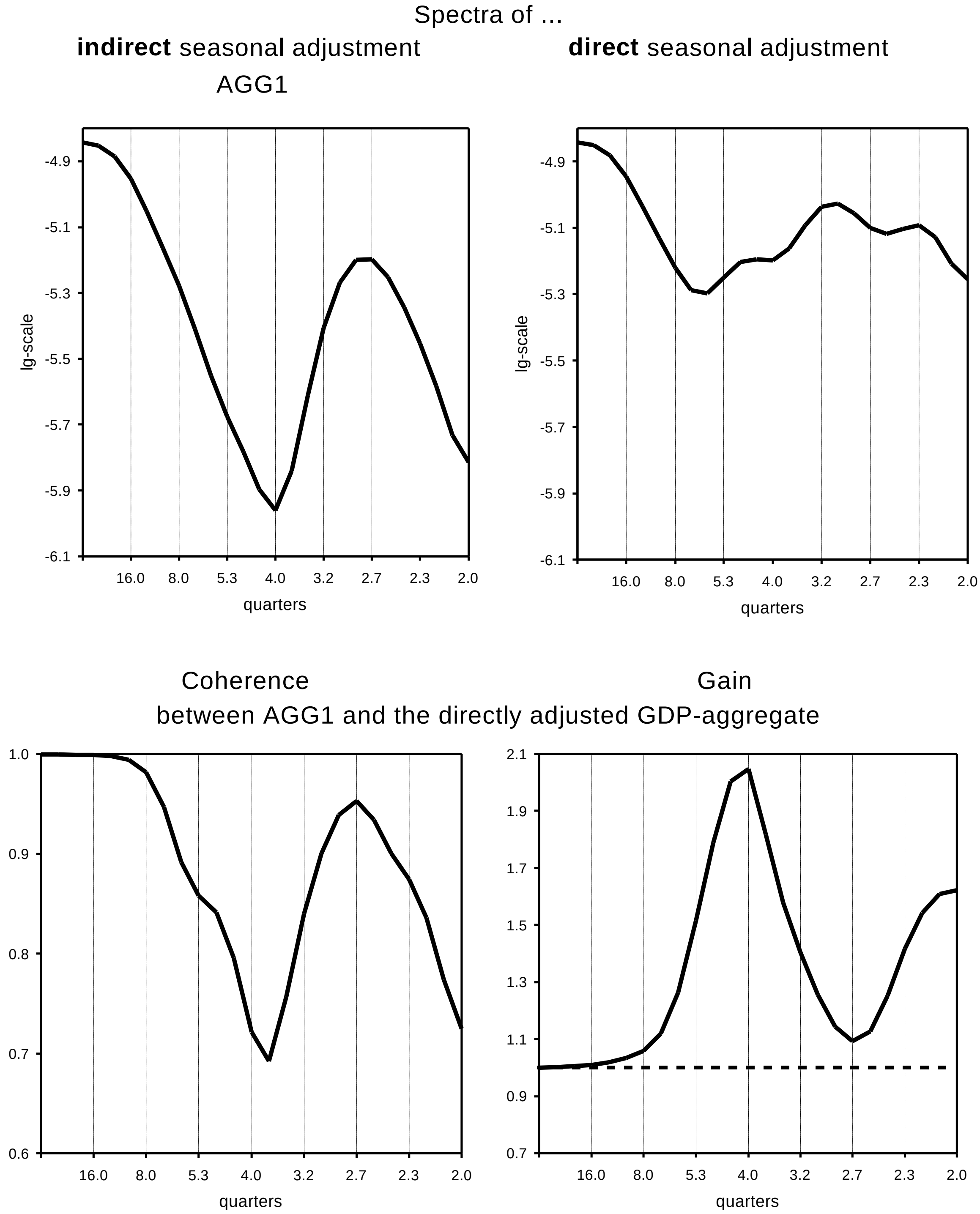

Spectral analysis of mixed aggregate1) versus directly adjusted GDP-aggregate
BV4
Spectra of ...
indirect seasonal adjustment
AGG1
direct seasonal adjustment
lg-scale
-4.9
-5.1
-5.3
-5.5
-5.7
-5.9
-6.1
16.0
8.0
5.3
4.0
3.2
2.7
2.3
2.0
quarters
Coherence
Gain
between AGG1 and the directly adjusted GDP-aggregate
1.0
0.9
0.8
0.7
0.6
2.1
1.9
1.7
1.5
1.3
1.1
0.9
0.7
1) Aggregate 1=WGER (BV4)+IT (T/S_mu)+NL (X12_mu)+AT (T/S_ad)+FI (X12_ad)
Source: Calculations of DIW.
Deutsches Institut für Wirtschaftsforschung

Figure 7

Spectral analysis of mixed aggregate[1)] versus directly adjusted GDP-aggregate X12-ARIMA, multiplicative version



1) Aggregate 1=WGER (BV4)+IT (T/S_mu)+NL (X12_mu)+AT (T/S_ad)+FI (X12_ad)
Source: Calculations of DIW.

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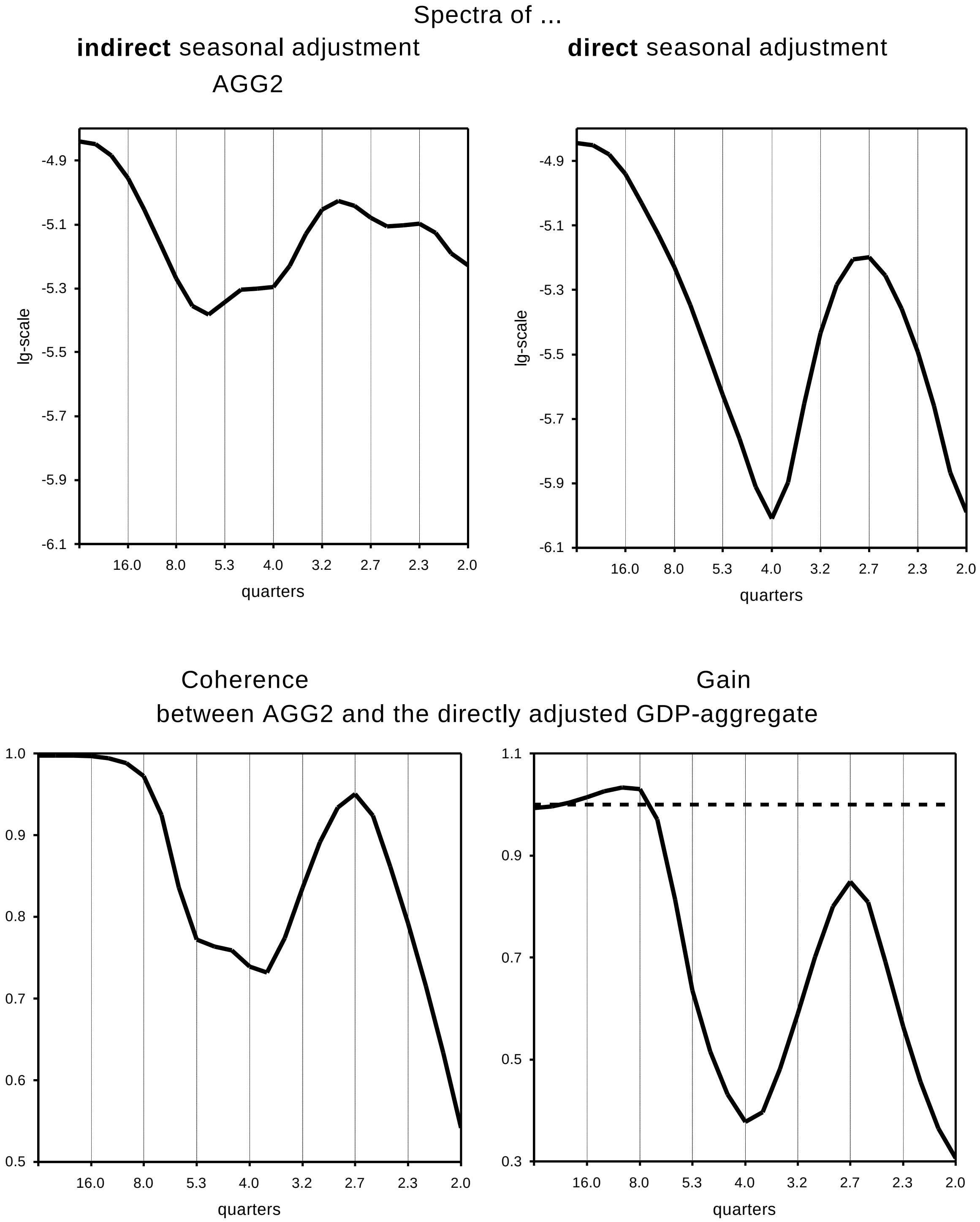
Figure 8

Spectral analysis of mixed aggregate[1] versus direct seasonally adjusted GDP-aggregate

BV4



1) Aggregate 2=WGER (X12_mu)+IT (T/S_mu)+NL (X12_mu)+AT (T/S_ad)+FI (X12_ad)

Source: Calculations of DIW.

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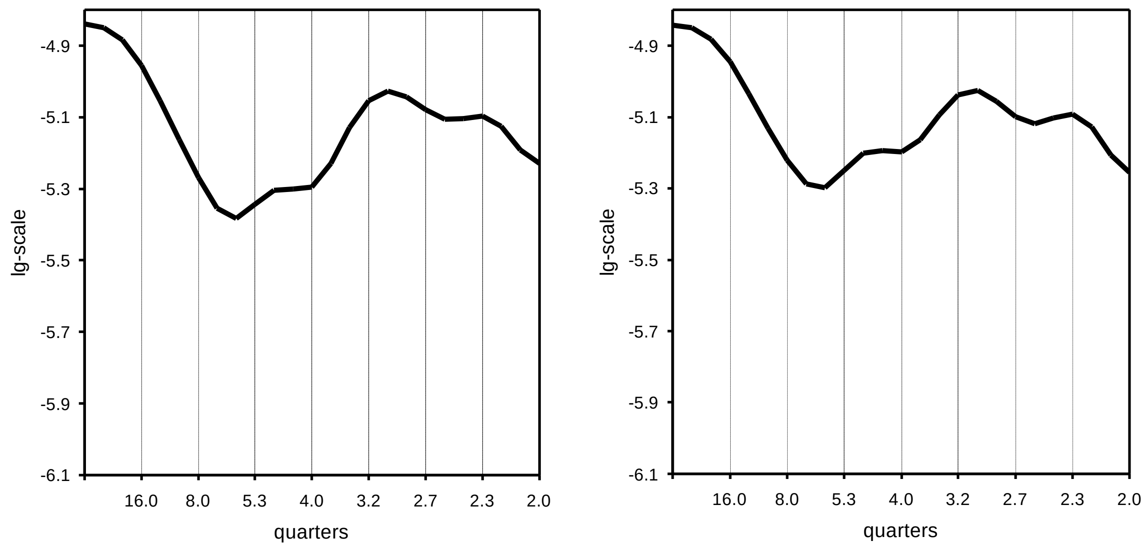
Figure 9

Spectral analysis of mixed aggregate[1)] versus direct seasonally adjusted GDP-aggregate

X12-ARIMA, multiplicative version

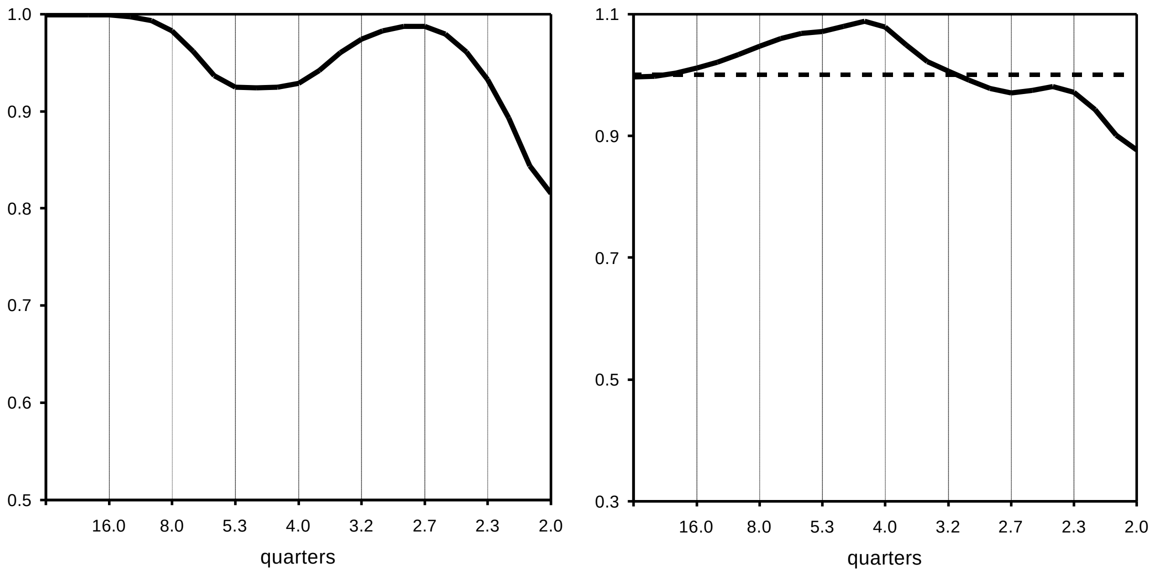
Spectra of ...

indirect seasonal adjustment AGG2 | **direct** seasonal adjustment



Coherence | Gain

between AGG2 and the directly adjusted GDP-aggregate



1) Aggregate 2=WGER (X12_mu)+IT (T/S_mu)+NL (X12_mu)+AT (T/S_ad)+FI (X12_ad)

Source: Calculations of DIW.

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Figure 10

strongly depending on the time series and no general statement can be made. However, the spectral analysis shows clearly that the differences between X12-ARIMA and TRAMO/SEATS in their default versions are much smaller than between the BV4 and each of them.

4. Conclusions

Contrary to the theoretical findings in 2.3, our empirical results show that even non-linear seasonal adjustment leaves the long-run behaviour of the time series unchanged. This holds also in the case of seasonal adjustment and aggregation. In this respect, there is no difference between the direct and the indirect approaches. Even the mixed aggregates (Aggregate 1 and Aggregate 2) were found to be cointegrated with the aggregate of the unadjusted time series.

As the cross-spectral analysis shows, the discrepancies at frequencies corresponding to four quarter cycles and lower ones between the direct and the indirect approaches can be large, particularly, if a model-based method is applied. In case of a linear method with fixed filters, no discrepancies can be found.

If aggregates are formed of time series that have been seasonally adjusted with different methods, the method used for the largest (number of) countries generally dominates. This method should therefore also be applied in the direct approach.

There is a clear trade-off between simple methods that apply one (or a few) filters to any time series and sophisticated model-based approaches that treat each time series individually. Which approach should be preferred depends largely on the objectives of the users. Thus, no general recommendation is possible. The decision, which approach should be favoured largely depends on the statistical properties of the time series and the criteria which are considered relevant.

If the time series, which are to be aggregated are very heterogenous or when the stochastic structures of the seasonal and non-seasonal components differ widely, then the indirect approach tends to be more efficient. As the HEGY-test shows, the time series analysed here have very similar properties. Thus, the choice of the approach is not restricted by the time series.

If maximum *consistency* between the individual time series and the aggregate is the main objective, a method with fixed filters (such as BV4) has to be chosen. Then the order of seasonal adjustment and aggregation will become irrelevant. Alternatively, the indirect approach can be followed exclusively.

Often the indirect approach is favoured by those who consider *optimal treatment* of the time series an important criterion. Usually the argument runs as follows: as there is more information available on the level of the individual countries, data should be adjusted using a sophisticated method by the member states of EMU. As the data-generating process and the "true" seasonal components are not known, we do not agree that indirect adjustment always produces an optimal result, this is also in line with the findings of Ghysels (1997).

With respect to the *comparability of methods* for EMU there are only two acceptable solutions: either a linear method with fixed filters should be applied or the aggregated data should be adjusted directly. As we have seen above, the use of X12-ARIMA or TRAMO/SEATS for all time series does not ensure identical treatment of all time series, as a number of different filters is applied.

As seasonally adjusted data of EMU determines the assessment of the Euro zone's business cycle and consequently influence economic policy decisions, the approach followed should be *comprehensible and easily reproduced*. This criterion points to direct adjustment and considerable automation.

For the decision between the direct and the indirect approaches the *focus* of the analysis is another important criterion. If the business cycle of the euro area is under examination, the direct approach seems preferable. Currently, national considerations are still dominating in the EMU, as monetary union is just over a year old. Most economic analyses still put the emphasis on the national levels. However, this will change dramatically in the near future, as the euro area will gain importance as a major area in the world economy. This is a clear argument in favour of the direct approach.

Independently of the ultimate decisions of official statistics, we recommend quite in accordance with Ghysels (1997, p.417) the publication of unadjusted time series along with user-friendly seasonal adjustment software, such as DEMETRA. This recommendation is made for methodological as well as practical reasons. If unadjusted time series are available to the general public, users of the data can adjust whichever period they consider relevant. On the one hand it is ensured that the methods of official statistics are open to public scrutiny, on the other hand econometricians will find the necessary unadjusted data for their estimates.

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