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The Seasonal Adjustment of Short time series

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CONTENTS

THE SEASONAL ADJUSTMENT OF SHORT TIME SERIES

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ABSTRACT

The purpose of this work consists in evaluating changes in the quality performances of two different and widely used programs for seasonal adjustment, X-12-Regarima and Tramo-Seats, when the length of time series is progressively reduced. The comparisons are carried-out by using appropriate and homogeneous quality indicators for the analysis of the adjustment performed by the two programs. A wide array of EU/Euroarea time series is analysed. Though the quality of the adjustment progressively reduces for both approaches when the sample is shortened, the deterioration in quality indicators is found to be greater for the model-based approach.

KEY WORDS: Seasonal adjustment; Quality indicators; Short time series.

1. INTRODUCTION

Tramo-Seats (henceforth TS) and X-12-Regarima (X12) are two programs for seasonal adjustment of time series based on different methods, the former using model-based and the latter empirical filters for signal extraction. Both programs have been recommended by Eurostat, the Statistical Office of the European Communities, for the seasonal adjustment of time series by European Member States.

Nowadays, a cause of major concern at Eurostat is the seasonal adjustment of short time series. A number of reasons explain why series can be defined over a short sample at the Member States level, i.e. changes in methodologies and definitions, moving to new statistical classifications, the use of new sources of information, etc.. At the Eurostat level, imminent and further future enlargements of the European Union will certainly increase the number of infra-annual statistics defined over short samples, especially if one considers estimates of European/Eurozone series obtained by Eurostat by aggregating the national available data.

The effects of shortening the sample period on the performances of seasonal adjustment procedures have been considered in various respects by previous literature.

Cholette (1979) has analysed plots of gain functions and phases of X-11 filters in estimating central and concurrent seasonal factors for series with lengths of 36, 48, 60 and 84 observations and concluded that seasonal adjustment of series shorter than five years should generally be avoided. Hood, Ashley and Findley (2000) have considered 54 simulated time series defined over 12 years and found that, when the sample is reduced to 4 years, both X12 and TS suffer from a deterioration of the quality of seasonal adjustments, defined in terms of relative root mean squared and absolute deviations from the 'true' values. However, they

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found the deterioration to be greater for TS (about 60% the average increase of statistics) rather than for X12 (about 30% of increase). Matas Mir and Rondonetti (2003) have conducted a similar exercise on X12 and on a number of simulated series. The authors conclude that the discrepancies between the adjusted short (5 years) and long (20 years) series are high at the beginning of the sample (first 2 years), whilst these become in most cases low at the end of the sample period, the most scrutinised by users, analysts and policy-makers. Finally, Findley and Martin (2003) have conducted a theoretical frequency domain comparison between TS and X12 in terms of squared gain and phase delay functions. Their results are that seasonal adjustment near the centre of the series can be more problematic than concurrent adjustment; squared gains of both TS and X12 filters are influenced by the estimated Airline coefficients; phase delays of concurrent TS filters are influenced by the estimated Airline coefficients.

In this paper we provide new and more complete empirical evidence on the effects of shortening the sample period for seasonal adjustment of time series. The comparison between TS and X12 is carried out using a wide array of homogeneous quality indicators for the seasonal adjustment (Ladiray and Mazzi, 2003). The series used are drawn from the NewCronos data-base of Eurostat. For each series; two/three alternative lengths are considered: short series (5 years of data), medium series (10 years) and full sample, or long, series.

Our main findings can be summarised as follows. In accordance with the previous literature, we find that the quality of the seasonal adjustment progressively reduces when shorter time series are considered. However, the deterioration is found to be proportionally greater passing from long to medium, than from medium to short time series. Another important finding is that X12 performs, on average, slightly better than TS when the sample is reduced, a result possibly due to the higher instability of model-based approaches when a large proportion of data in the time series is ruled out.

The scheme of the paper is as follows. Section 2 contains a brief review of methods and statistics for comparisons of performances of TS and X12. Section 3 details on results obtained. Section 4 concludes.

2. METODOLOGY FOR COMPARISON

To assess empirically the quality of the different approaches, two main problems have to be solved. The first one consists in the definition of quality indicators that should be computed for the different approaches, the second one is a computational problem, as TS and X12 do not provide the user with a common set of quality statistics.

2.1 Quality Measures

There is nowadays no theoretical consensus on the measures to be used in order to assess the quality of a seasonal adjustment, and that explains the large number of criteria proposed so far in the literature. In effect, several aspects of the seasonal adjustment can be addressed and, for each of them, different criteria can be defined. Here we follow a strategy for quality assessment derived from Ladiray and Mazzi (2003).

How different the various approaches really are? Users pay a lot of attention to the growth rates of the seasonally adjusted series. The mean and the range of the series of the growth rate differences are therefore computed and checked. Furthermore, the various seasonally adjusted series should deliver more or less the same message and their growth rates should have the same sign. To measure the degree of consistency in growth rates, a statistic is computed measuring the global percentage of concordance between the series obtained through TS and X12.

Quality of the seasonal adjustment X12 proposes a set of M and Q-statistics to assess the quality of the seasonal adjustment[3]. These statistics have been adapted - whenever feasible - to the estimates obtained with TS.

Roughness of the components Dagum (1979) has proposed two measures of roughness of the seasonally adjusted series. The first one is the L_2-norm of the differenced series: $R_1 = \sum_{t=2}^{T} (A_t - A_{t-1})^2 = \sum_{t=2}^{T} (\nabla A_t)^2$. The second one is based on the 13-term Henderson filter: the adjusted series is smoothed with the Henderson filter and R_2 is defined as the L_2-norm of the residuals: $R_2 = \sum_{t=1}^{T} (A_t - H_{13} A_t)^2 = \sum_{t=1}^{T} [(I - H_{13}) A_t]^2$. The rationale of these measures of roughness is that the involved filters (the first difference and the I - H_{13} operator) are high-pass filters that remove most of the low frequencies components corresponding to trend-cycle variations. In other words, these statistics measure the size of the deviations from a smooth trend, namely the size of an "irregular component". This is why Pfefferman et al. (1984) suggested a "natural" third measure, a measure of similarity between seasonally adjusted data and trend: $R_3 = \sum_{t=1}^{T} (A_t - TC_t)^2$. Indeed, there is no fundamental reason why a seasonally adjusted series should be smooth as the irregular, which is one of the components of the time series, is included in the seasonally adjusted series. Gomez and Maravall (1999) prefer to focus on the other components, namely the trend-cycle and the seasonality. Regarding seasonality, they use the criterion $Mar(S) = \sum_{t=1}^{T} [(1 + B + \ldots + B^{11}) S_t]^2$. The smoothness of the trend-cycle is measured by the L_2-norm of the first and the second differences: $Mar1(TC) = \sum_{t=2}^{T} (\nabla TC_t)^2$ and $Mar2(TC) = \sum_{t=3}^{T} (\nabla^2 TC_t)^2$. All these measures can be computed on the estimates obtained from TS and X12 and on the complete series or only on the last three years.

Idempotency and characteristics of the irregular component A seasonal (and trading-day and holiday) adjustment that leaves detectable residual seasonality and calendar effects in the adjusted series is usually regarded as unsatisfactory. Then, X12 and TS are run on the seasonally adjusted series and the usual tests proposed by these software are used to check for idempotency. The irregular component should not present any structure or residual seasonality. The irregulars derived from the various approaches are analysed both with the TRAMO automatic modelling module and the Regarima software. The usual tests proposed by the software are used to check for randomness of the irregular components.

Stability of the seasonally adjusted series Even if no residual effects are detected, the adjustment will be unsatisfactory if the adjusted values undergo large revisions when they are recalculated as new data become available. Frequent and substantial revisions cause data users to lose confidence in the usefulness of adjusted data. Such instabilities can be the unavoidable result of highly variable seasonal or trend movements in the series to be

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[3] For a precise definition and the interpretation of these statistics, see Ladiray and Quenneville (2001).

adjusted. In any case, they should be measured and checked. X12 includes two types of stability diagnostics: sliding spans and revision histories (see Findley et al. (1998), U.S. Bureau of Census (2002)). Some of these diagnostics are used here, in particular the mean and standard deviation of the absolute revisions after *k* periods, and the two most important sliding spans: A(%), that is the percentage of observations with unstable adjustments, and MM(%), the percentage of observations with unstable period-to-period percent changes.

2.2 Software and parameters

TS (version 98) and X12 (version 0.2.8) have been used in the applications. A dedicated SAS program manages the software and calculates all quality statistics described above. Some specific features have been implemented in order to simulate different adjustment policies: for example, the series can be cleaned from calendar effects or outliers before any adjustment is performed; the decomposition model can be, or not, fixed by the user, etc.. Software used for seasonal adjustment can be freely downloaded at the following addresses: http://www.bde.es/servicio/software/softwaree.htm and http://ftp.census.gov/pub/ts/x12a/final/pc/.

3. EMPIRICAL RESULTS

We consider as an example of our analysis monthly extra-EU15 exports defined over the sample 1989.1- 2003.2. Over this sample (long series), we define short (1999.1-2003.2) and medium (1996.1-2003.2) series. As a first step, we perform an ANOVA analysis in order to assess the presence or not of monthly seasonality in the series. An F-type test, not reported here to save space, clearly rejects the null of no seasonality, having a p-value less than 0.01% for all the three samples.

The analysis of residuals after seasonal adjustments shows a deterioration of M-statistics when the sample is reduced, as synthesised by the Q-test, with TS having larger increases in final results, especially when passing from long to medium series (Table 1). The statistics M8 and M9 obtained for the short series through TS are greater than 1. That implies the presence of seasonal evolving movements that can bias final estimation of seasonal coefficients. Consequently, the seasonally adjusted data obtained with TS should be considered with great caution.

The analysis of the irregular component reported in Table 2 shows that, for all series but the long obtained through X12, we could identify a seasonal component. For short series, the Ljiung-Box statistics give values very close to the critical ones and there seems to be autocorrelation at lag one for TS. The residuals are normally distributed and no outliers, working days and Easter effects are found for both programs.

Table 1: M-statistics for the quality of the seasonal adjustment (Exports extra-EU15)

Statistics	Long series (89-03)		Medium series (96-03)		Short series (99-03)	
	TS	X12	TS	X12	TS	X12
M1	0,484	0,609	0,054	0,889	0,668	1,171
M2	0,177	0,302	0,031	0,475	0,781	0,418
M3	0,439	0,597	0,000	0,759	0,708	0,734
M4	0,118	0,095	0,267	0,067	0,575	0,088
M5	0,276	0,333	0,000	0,376	0,334	0,352
M7	0,178	0,203	0,412	0,335	0,901	0,355
M8	0,429	0,450	4,030	0,150	2,597	0,296
M9	0,287	0,291	0,362	0,132	1,801	0,267
M10	0,416	0,442	3,907	0,137	-	-
M11	0,323	0,385	2,861	0,133	-	-
Q	0,292	0,355	0,638	0,394	0,725	0,548

Table 2: Characteristics of the irregular component (Exports extra-EU15)

Series	ARIMA model	p-Ljung	Dw	p-Norm	Ls	Tc	Ao	Working days	Easter effect
Long series TS	(0,0,1)(0,1,1)	0,064	1,944	0,734	0	0	0	N	N
Long series X12	(0,0,1)(0,0,0)	0,058	1,865	0,020	0	0	2	N	Y
Medium series TS	(2,0,3)(0,0,1)	0,124	1,964	0,527	0	0	0	N	N
Medium series X12	(0,0,1)(0,0,1)	0,079	1,857	0,000	0	0	3	N	N
Short series TS	(0,1,1)(0,1,1)	0,029	2,908	0,935	0	0	0	N	N
Short series X12	(0,1,1)(0,1,1)	0,068	2,715	0,163	0	0	0	N	N

Table 3 reports on results of revision analyses. X12 shows better results for long and medium series for all statistics considered, but the opposite situation arises for short series. In general, we have a deterioration of statistics passing from long to short time series, but not from long to medium series. This implies that a great deal of instability is concentrated on the final part of the series. Sliding spans statistics, not computed here for short series due to the lack of data, are under critical values of 25% (A) and 40% (B).

Table 3: Revisions analysis and sliding spans (Exports extra-EU15)

	Long series (89-03)		Medium series (96-03)		Short series (99-03)	
Statistics	TS	X12	TS	X12	TS	X12
Mean AR 1 month	0,561	0,299	0,594	0,239	0,787	1,352
Mean AR 2 months	0,484	0,249	0,705	0,263	1,246	1,832
Mean AR 3 months	0,651	0,242	0,676	0,257	1,497	2,029
Mean AR 4 months	0,621	0,262	0,673	0,248	1,720	2,308
Mean AR 5 months	0,628	0,362	0,574	0,310	2,074	2,611
Mean AR 6 months	0,230	0,384	0,619	0,258	2,408	2,815
Std AR 1 month	0,918	0,240	0,465	0,215	0,790	2,046
Std AR 2 months	0,825	0,206	0,455	0,234	0,851	2,138
Std AR 3 months	1,008	0,109	0,495	0,191	0,939	2,159
Std AR 4 months	1,246	0,189	0,521	0,205	1,020	1,800
Std AR 5 months	1,046	0,304	0,423	0,205	0,980	1,818
Std AR 6 months	0,258	0,354	0,421	0,159	0,783	2,079
A (en %)	4,86	3,47	0	0	-	-
MM (en %)	16,08	5,59	0	1,69	-	-

According to the indicators of smoothness shown in Table 4, there is evidence that the short series obtained with X12 is somehow smoother. A comparison between these results and those obtained for revisions clearly shows the inverse relationship between the two measures. In terms of variability, one could notice that a number of indicators here computed are very close for the two programs (see for example the MAR statistics), what reflects a certain similarity in final outcomes.

Table 4: Variability measures (Exports extra-EU15)

Statistics	Long series (89-03)		Medium series (96-03)		Short series (99-03)	
	TS	X12	TS	X12	TS	X12
R1 (SA)	1432,768	1584,931	1058,715	2489,561	3045,356	2769,479
R1 (SA), Last 3 years	1503,545	1519,512	892,519	1745,431	1619,325	2202,051
R2 (SA)	1,433	1,573	0,719	2,006	2,626	2,096
R2 (SA), Last 3 years	1,092	1,119	0,695	1,312	1,091	1,564
R3 (SA)	1,253	1,640	0,530	2,086	2,681	2,123
R3 (SA), Last 3 years	0,942	1,121	0,501	1,311	1,123	1,587
Mar (TC, 1)	626,943	614,246	807,596	791,562	1387,729	955,035
Mar (TC, 1), Last 3 years	823,227	856,533	814,771	807,746	1455,786	829,510
Mar (TC, 2)	299,962	171,331	311,315	212,825	1676,870	289,624
Mar (TC, 2), Last 3 years	417,157	247,789	353,016	243,345	1694,602	291,795
Mar (S)	0,045	0,041	0,187	0,010	0,254	0,011
Mar (S), Last 3 years	0,028	0,018	0,208	0,010	0,256	0,011

The differences in growth rates between short and long/medium series are greater for TS as far as concerns both mean and standard deviation, and concordance rates of seasonally adjusted series are again favourable to X12 (see Table 5). On average, the short series is more ‘close’ to the long series than the medium series.

Table 5: Mean and standard deviation of differences in rates of growth, concordance rates of seasonally adjusted series (Exports extra-EU15)

Statistics	TS	X12
1. Mean (Δ% short – Δ% medium)	0,0733	0,0373
2. Mean (Δ% short – Δ% long)	0,0530	0,0451
3. Standard deviation (Δ% short – Δ% medium)	4,2772	2,3007
4. Standard deviation (Δ% short – Δ% long)	4,7194	2,7303
5. Concordance rate of s.a. series (short and long series)	71%	73%
6. Concordance rate of s.a. series (short and medium series)	55%	73%

From a qualitative point of view, the same results have been obtained by considering a detailed analysis of imports for France, not reported here to save space. Again, we obtained slightly better results for X12 for almost all statistics considered, and a greater stability in the final part of the series for both methods.

We now ask whether previous results can be in some way generalised. A set of 20 time series covering four short-term data-set has been considered (see Table 6). For each series, the whole sample (long series) has been truncated and the short series obtained as the part at the end of the sample. Each data-set covers aggregates for the EU/Eurozone and the main countries.

Table 6: Data set used in empirical analyses

Series	Countries	Frequency	Sample (Long series)	Sub-sample (Short series)
Harmonised unemployment rate (%)	EU15, France, Germany, UK	Monthly	1995.01- 2003.02	1999.01- 2003.02
Industrial production index (trading days adjusted)	EU15, France, Germany, UK	Monthly	1995.01- 2003.02	1999.01- 2003.02
GDP at current prices	EU15, Eurozone, France, Germany, Italy, UK	Quarterly	1990.1-2003.1	1998.1- 2003.02
Harmonised index of consumer prices (1996=100)	EU15, Eurozone, France, Germany, Italy, UK	Monthly	1996.01-2003.02	1999.01- 2003.02

A preliminary ANOVA analysis has been conducted over the 20 series in order to assess, through an F-type test, the presence of a seasonal component at the monthly/quarterly frequencies. The results are summarised in Table 7. At both the 5% and 1% critical levels, 19 over the 20 series possess a seasonal factor for the whole sample (excluded is the series of prices for France). These become 17 for the short series (added prices for EU15 and the Eurozone) at the 5% and 13 at the 1% (added all series but UK for prices, and UK and the Eurozone for GDP). These results reflect in great part the uncertainty over the presence of a seasonal component in prices.

Table 7: Results of ANOVA analyses

	Long series	Short series
5% signif. Level	19	17
1% signif. Level	19	13

The seasonal adjustment has been carried-out using both TS and X12, the M-statistics for the quality of the seasonal adjustment computed for both programs and the number of cases in which these were greater than 1 counted for both long and short series. The results reported in Table 8 clearly indicate a decrease in quality passing from long to short series for TS (from 9 to 16 cases), and a substantial stability of results with X12. In both cases, we note a deterioration in M2 (contribution of variance of the irregular component over all variance computed on the raw detrended series), while for M8 and M9 (tests of yearly evolutionary seasonality due to short-term variations) we have a deterioration for TS and an improvement for X12.

Considering the characteristics of the irregular components (Table 9), these are modelled as non seasonal ARIMA models in almost the same degree for long and short time series, while we observe a general and equal deterioration for the seasonal part. At the same time, a high deterioration is observed in terms of autocorrelation for both programs. As it is obvious, the presence of extreme values, trading days and Easter effects is minor with short series.

Table 8: M-statistics for the quality of the seasonal adjustment (20 series)

Statistics	Number of cases with statistics greater than 1			
	TS		X12	
	Long series	Short series	Long series	Short series
M1	2	3	6	7
M2	0	3	0	2
M3	1	0	2	2
M4	1	0	1	1
M5	0	0	0	0
M7	2	2	2	1
M8	2	5	2	0
M9	1	3	1	0
TOTAL	9	16	14	13

Table 9: Characteristics of the irregular component (19 series)

Statistics		TS		X12	
		Long series	Short series	Long series	Short series
Non zero coefficients in the non seasonal part of the ARIMA model		15	16	15	15
Non zero coefficients in the AR non seasonal part		8	7	11	4
Non zero coefficients in the MA non seasonal part		17	16	12	18
Non zero coefficients in the seasonal part of the ARIMA model		13	17	10	18
Non zero coefficients in the AR seasonal part		1	0	0	0
Non zero coefficients in the MA seasonal part		13	19	8	18
Pljung < 5%		5	9	0	5
DW > 2.15		8	17	4	12
DW < 1.85		1	1	3	2
Trading days effect		0	3	2	3
Easter effect		0	1	3	1
Outliers :	Ls	1	0	1	0
	Tc	4	4	2	1
	Ao	5	2	18	3

Tables 10 and 11 show the differences obtained between short and long series in terms of revision analysis and variability of seasonally adjusted data. These differences are grouped into classes for easy of exposition.

One can notice for both revision and stability measures a greater concordance between long and short series with X12 than with TS. In effect, only 14 indicators (8,2%) over 168 (14 * 12) have a difference greater than 0,15 against 49 (30%) with TS. Globally, the differences are closer to zero with X12 than with TS, implying a greater stability of the revision process going from long to short series. The same conclusions are obtained from stability analyses. One has littler differences between long and short series with X12 as 73% of indicators are between -0,03 et 0,05 against 60% for TS.

Considering concordance of growth rates of seasonally adjusted short and long series, we obtain quite similar results but fiable favorable to X12. With TS 85% of growth rates (687 /

8064 * 100) are in the same direction, against 86 % (697 /806 * 100) for X12. On unemployment series and prices, the differences between short and long series are close to 0 with X12 (Table 7). For the other two series, TS has some advantages. Concerning standard deviation, X12 performs again slightly better as the values obtained are close to 0.

Table 10: Revisions analysis (14 series)

Statistics	TS				X12			
	Between -0,05 and 0	Between 0 and 0,05	Between 0,05 and 0,15	Greater than 0,15	Between -0,05 and 0	Between 0 and 0,05	Between 0,05 and 0,15	Greater than 0,15
Mean AR 1 month	2	6	3	3	7	5	2	0
Mean AR 2 months	2	7	1	4	4	8	1	1
Mean AR 3 months	3	5	1	5	3	7	2	2
Mean AR 4 months	2	6	1	5	6	5	1	2
Mean AR 5 months	2	6	1	5	4	6	2	2
Mean AR 6 months	2	6	1	5	6	5	1	2
Std AR 1 month	3	5	2	4	5	7	1	1
Std AR 2 months	6	3	3	2	4	7	2	1
Std AR 3 months	5	4	3	2	4	8	1	1
Std AR 4 months	2	6	1	5	4	8	1	1
Std AR 5 months	2	7	1	4	4	8	1	1
Std AR 6 months	3	6	0	5	6	7	1	0
TOTAL	34	67	18	49	57	81	16	14

Table 11: Variability measures (14 series)

Statistics	TS					X12				
	Less than -0,03	Between -0,03 and 0	Between 0 and 0,05	Between 0,05 and 0,15	Greater than 0,15	Less than -0,03	Between -0,03 and 0	Between 0 and 0,05	Between 0,05 and 0,15	Greater than 0,15
R1 (SA)	1	3	5	3	2	0	2	6	5	1
R1 (SA), Last 3 years	2	8	2	0	2	5	4	5	0	0
R2 (SA)	3	3	4	1	3	1	2	6	3	2
R2 (SA), Last 3 years	2	4	5	1	2	4	4	4	1	1
R3 (SA)	4	1	4	2	3	2	2	4	5	1
R3 (SA), Last 3 years	3	5	2	1	3	4	3	4	2	1
Mar (TC, 1)	0	4	5	2	3	0	5	5	3	1
Mar (TC, 1), Last 3 years	1	5	5	1	2	1	4	8	1	0
Mar (TC, 2)	0	7	4	0	3	0	4	9	0	1
Mar (TC, 2), Last 3 years	1	4	6	0	3	0	5	8	1	0
Mar (S)	0	8	4	0	2	0	14	0	0	0
Mar (S), Last 3 years	0	8	4	1	1	0	14	0	0	0
TOTAL	17	60	50	12	29	17	63	59	21	8

[4] The number of series is reduced for some problems occurred during the analyses due to the short number of data available for quarterly GDP.

Table 12: Mean and standard deviation of differences in rates of growth (20 series)

		TS	X12
Mean	Unemployment	-0,0106	0,0046
	Prices	0,0015	0,0007
	Ind. Production	0,0001	-0,0041
	GDP	0,0090	0,0196
Standard deviation	Unemployment	0,2935	0,3171
	Prices	0,1286	0,1835
	Ind. Production	0,6398	0,3976
	GDP	0,3075	0,2682

4. CONCLUSIONS

In this paper we have compared the relative performances of TS and X12 in adjusting progressively shorter time series. Our analysis has concentrated on the induced effects on a number of statistics for the quality of the seasonal adjustment process, after having made most of them comparable for the two programs.

Our main findings can be summarised as follows. In accordance with the previous literature, we have found that the quality of the seasonal adjustment progressively reduces when shorter time series are considered. Therefore, analysts should exert great caution when studying seasonally adjusted data defined over a short period.

However, what out limited examples have shown is that the deterioration in quality passing from long to short series is proportionally greater going from long to medium, than from medium to short time series. This result implies that instabilities in the seasonal adjustment process are greater at the beginning than at the end of the sample, a circumstance of some relevance for policy purposes.

Another important finding is that X12 performs, on average, slightly better than TS when the sample is reduced, a result possibly due to the higher instability of model-based approaches when a large proportion of data in the time series is ruled out.

The results here summarised have been obtained using real data directly drawn from the Eurostat data bases. On the contrary, most of the works appeared so far in the literature have studied the problems at hand using simulated time series.

Whilst we are fully aware that our approach could be biased by the fact that all factors affecting the final quality of the seasonal adjustment can not be taken into account, we believe that simulations often pose other relevant problems which deserve further studies, the most important being the choice of the data generation process, and the choice of the characteristics of the series (normality, relevance of the various components, …). The use of simulated time series will be the object of future research in this field by the authors.

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