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JDemetra+ 3.0
New (R) tools for (high-frequency) time series analysis

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JDemetra+ a versatile tool for time series analysis (1/2)

JDemetra+ is an open source software for time series analysis developed in the framework of Eurostat's "Centre of Excellence on Statistical Methods and Tools (TSACE)" by the National Bank of Belgium with the support of the Bundesbank and Insee.

It provides algorithms on:

- Seasonal Adjustment
- Trend and cycle estimation
- Benchmarking and temporal disaggregation
- Nowcasting

(Widely used in NSIs and central banks, JDemetra+ has been officially recommended by Eurostat to the European Statistical System members since 2015, as it allows to implement Eurostat guidelines on seasonal adjustment)

JDemetra+ a versatile tool for time series analysis (1/2)

These algorithms can be accessed

- with a graphical user-interface (GUI)
- directly in R

This presentation will give an overview of the software, highlighting selected new features from version 3:

- extended SA in R and general purpose Toolbox
- SA of High-Frequency data

JDemetra+ and R: some historical landmarks

Before 2019: core routines were available only via GUI and plug-ins.

Why add an R access ?

Allows to immerse JD+ algorithms in the R universe, with all its pre-existing statistical functions and user-community.

In March 2019, `RJDemetra` (containing X-13 Arima and Tramo-Seats) was published on CRAN and presented at NTTS:

- first R package that enables to use Tramo-Seats
- faster than existing R packages on seasonal adjustment

Ever-growing R ecosystem

Since, many more packages have been developed as JDemetra+ Core was upgraded from version 2 to version 3

Extension of scope:

- High-frequency data (`rjd3highfreq`)
- Trend cycle estimation and filters manipulation (`rjd3highfreq` and `rjd3filters`)
- STL algorithm added (`rjd3stl`)
- Refresh policies for Seasonal Adjustment (see part 2)
- New tools for time series analysis

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Multi-purpose time series tools

JDemetra+ v3 offers stand-alone tools for time series analysis:

- Tests (seasonality, auto-correlation, normality, randomness...)
- (Fast) Arima Modelling
- Calendar regressors generation
- Auxiliary variables for pre-adjustment
- Spectral analysis

Let's see to quick examples

(For more details: https://github.com/annasmyk/Tsace_RJD_Webinar_Dec22)

Fast Arima estimation

Arima estimation faster than R native `arima()` function

```
serie <- log(rjd3toolkit::ABS$X0.2.09.10.M)

# JD+
print(system.time(
    for (i in 1:1000) {
      j <- rjd3toolkit::sarima_estimate(
        x = serie, order = c(2, 1, 1), seasonal = list(order = c(0, 1, 1), period = 12))
    }))
#    user    system   elapsed   (time in seconds)
#   13.22      0.63      9.84

#R-native
print(system.time(
  for (i in 1:1000) {
    r <- arima(
      x = serie, order = c(2, 1, 1), seasonal = list(order = c(0, 1, 1), period = 12))
  }))
#     user    system   elapsed   (time in seconds)
#   225.72      1.72    232.61
```

Example: Canova-Hansen test to identify multiple seasonal patterns

```
rjd3toolkit::seasonality_canovahansen(data = df_daily$births,
    p0 = min(ch.sp), p1 = max(ch.sp), np = max(ch.sp) - min(ch.sp) + 1)
```

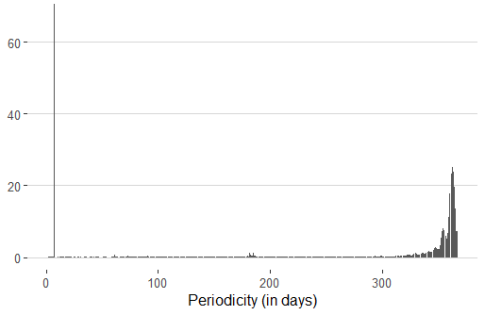

Figure 1: Canova Hansen seasonality test

Seasonal Adjustment Algorithms available in JDemetra+ v3

Algorithm	Access in GUI	Access in R (v2)	Access in R v3
X-13 Arima	yes	`RJDemetra`	`rjd3x13` / `rjd3highfreq`
Reg-Arima only	yes	`RJDemetra`	`rjd3x13` / `rjd3highfreq`
X11 decomposition only	yes	`RJDemetra`	`rjd3x13` / `rjd3highfreq`
Tramo-Seats	yes	`RJDemetra`	`rjd3tramoseats` / `rjd3highfreq`
Tramo only	yes	`RJDemetra`	`rjd3tramoseats` / `rjd3highfreq`
STL	no	no	`rjd3stl`
STS	no	`rjdsts`	`rjd3sts`

New features for production in R

In a production process of seasonally adjusted series

- it is not recommended (see Eurostat Guidelines on SA) to fully re-estimate between annual reviews
- hence the need to partially revise estimations as new raw data points become available
- JDemetra+ v3 allows to implement refresh policies (partial re-estimations) directly in R
- specific functions available in `rjd3x13` and `rjd3tramoseats` R packages

Available refresh policies

In JD+ v3, the user can re-estimate its current "result_spec" inside a domain of constraints ("estimation spec"), freeing restrictions on selected parameters, for example :

- Reg-Arima model for pre-adjustment is kept fixed (`policy="fixed"`)
- Reg-Arima variables and arima orders are kept identical but "Outliers" are re-identified (`policy="Outliers"`)

Steps for refreshing data in R

```
library("rjd3x13")

current_result_spec <- sa_x13_v3$result_spec
current_domain_spec <- sa_x13_v3$estimation_spec

# generate NEW spec for refresh
refreshed_spec <- x13.refresh(current_result_spec, # point spec to be refreshed
            current_domain_spec, #domain spec (set of constraints)
            policy = "Outliers",
            period = 12, # monthly series
            start = "2017-01-01",
            end = NULL)

# apply the new spec on new data : y_new= y_raw + 1 month
sa_x13_v3_refresh <- x13(y_new, refreshed_spec)
```

This feature allows to build SA production chains directly in R using X13-Arima or Tramo-Seats.

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SA of High-Frequency data (1/2)

- Probably most significant feature of version 3: Seasonal adjustment of High Frequency data
- Specificity: high-frequency data can display **multiple** and **non integer** periodicities

For example for a daily series:

- weekly ($p = 7$)
- intra-monthly ($p = 30.44$)
- yearly ($p = 365.25$)

Classical Seasonal adjustment algorithms cannot tackle such features

SA of High-Frequency data (2/2)

Two classes of solutions are currently available:

- use approximations for fractional powers of the backshift operators ($B^{s+\alpha} \approx (1-\alpha)B^s + \alpha B^{s+1}$) implemented Extended X13-Arima and extended Tramo-Seats
- round periodicities (might involve imputing data) implemented in extended STL, SSF Framework..

(For more details and consequences of the approximation, see "Towards Seasonal Adjustment of Infra-Monthly Time Series with JDemetra+", Webel and Smyk (2023), up-coming)

=> JDemetra+ offers a wide array of solutions

Solutions with approximation: `rjd3highfreq` package

Methods relying heavily on the approximation of the seasonal backshift operator:

- Pre-adjustment with Extended Fractional Airline Model Estimation, including
  - automatic outlier detection
  - calendar correction with specific regressors
- Moving average based decomposition with extended X-11 (also featuring kernel-based trend cycle filters)
- AMB decomposition with Extended Fractional Airline Model Estimation (Seats)

Solutions with rounded periodicities

Methods relying on periodicity rounding:

- extended STL with `rjd3stl` package (X-11 like treatment based on Loess filters)
- extended Basic Structural Models (BSM) with `rjd3sts` package

Graphical user interface for High-Frequency data

For the time being access to extended airline linearization and decomposition

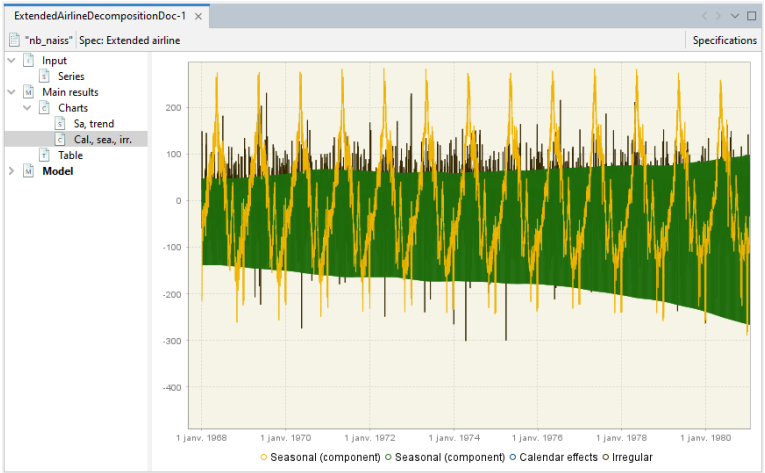

Figure 2: High frequency decomposition

Graphical user interface for High-Frequency data

Same layout, output and specification window (right) as for low frequency data in version 2:

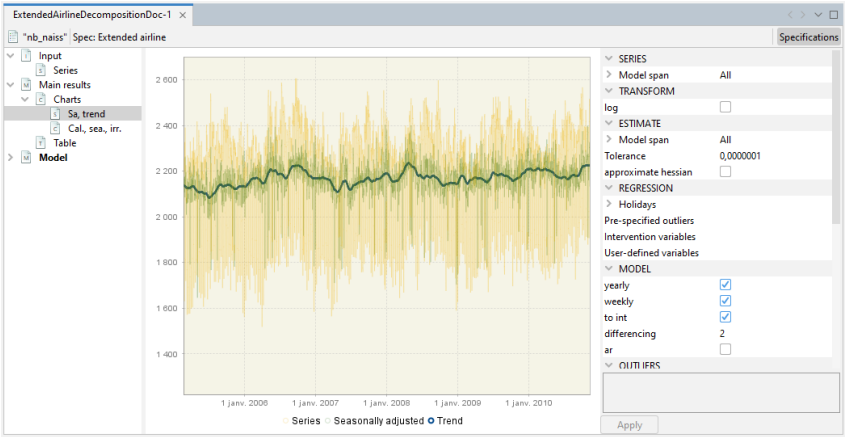

Figure 3: Raw, SA and trend

Conclusion

The latest version of JDemetra+ (3.0) offers :

- extended capabilities for SA of High Frequency data
- improved R tools for production and analysis

It combines fast java routines, user-friendly graphical interface and direct access in R.

Further developments are underway, especially on High Frequency data

- improve user's experience (GUI and R functions)
- develop filters selection criteria and seasonality tests

THANK YOU FOR YOUR ATTENTION

Resources

- Packages rjd3highfreq: https://github.com/palatej/rjd3highfreq
- GUI v3 (for High-Frequency data): https://github.com/nbbrd/jdemetra-app-snapshot/releases/tag/latest
- Online documentation: https://jdemetra-new-documentation.netlify.app/
- Blog: https://jdemetra-universe-blog.netlify.app/
- YouTube channel: https://www.youtube.com/@TSwithJDemetraandR

Our Githubs:

- Anna SMYK https://github.com/annasmyk
- Tanguy BARTHELEMY https://github.com/TanguyBarthelemy