Introduction to Seasonal Adjustment and JDemetra+

ESTP course

EUROSTAT 30 January – 1 February, 2023

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Introduction

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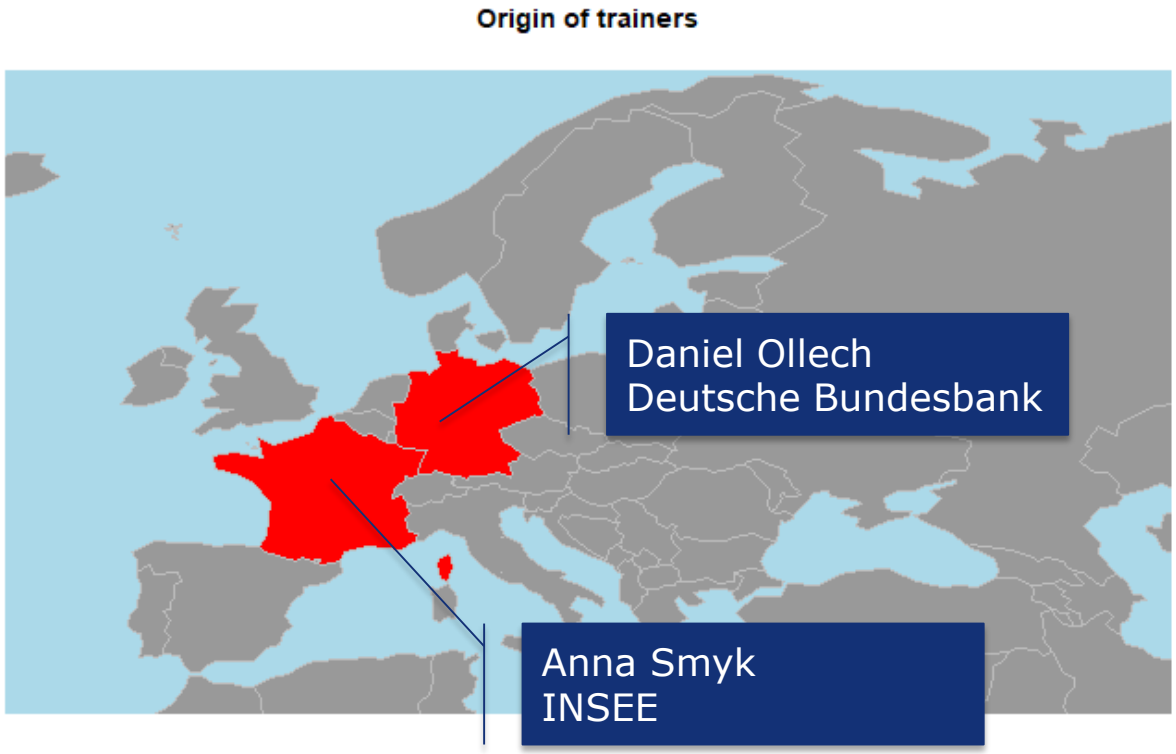
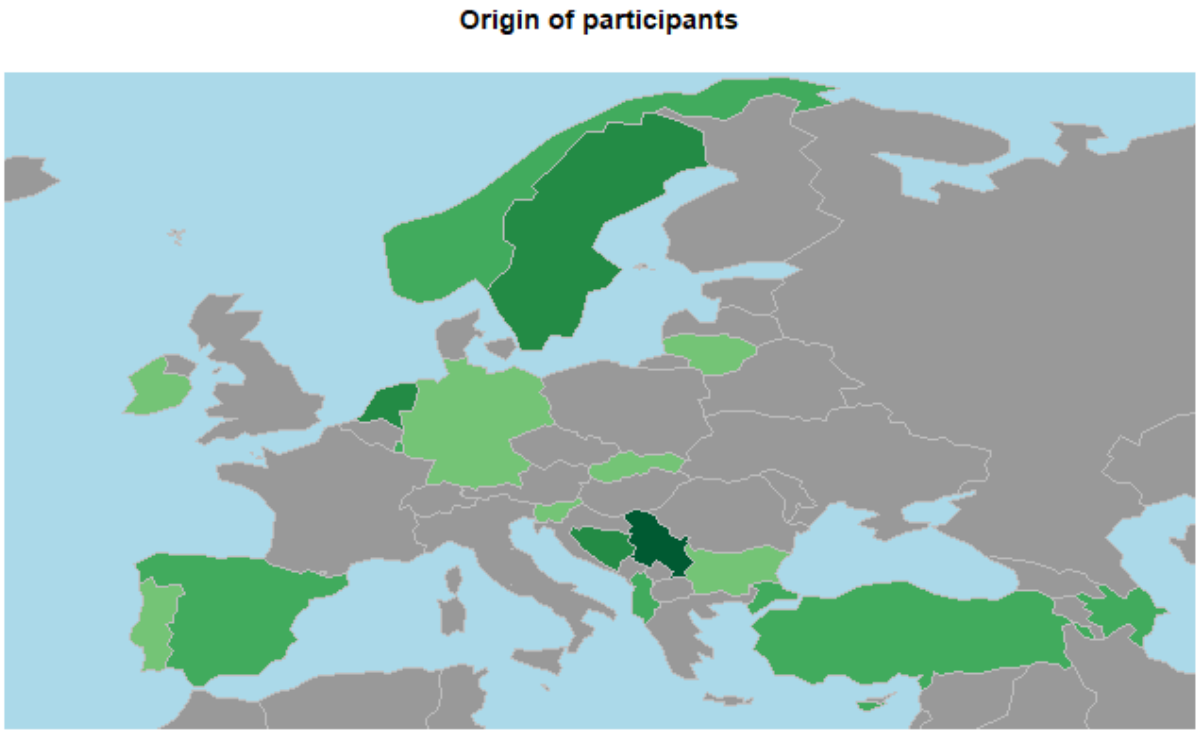
Introduction round

- Please introduce yourselves
  - Name
  - Where you work
  - Time-series and JD+ experience/background

Origins of lecturers



Origins of participants



Outline

Aims of the Course

- Basic understanding of the theory
  - Ideas and concepts
  - Seasonal adjustment approaches
    - ARIMA model based (AMB): SEATS
    - Pre-defined filter based: X-11
  - Pre-treatment (RegARIMA, TRAMO)
- Applications
  - Software JDemetra+
  - Package {RJDemetra} in the statistical software R
  - ESS-guidelines on seasonal adjustment

Schedule

Day 1

09:30	Introduction
09:45	Motivation and the unobserved component model
11:00	Coffee break
11:15	Using JDemetra+: getting familiar
12:30	Lunch break
14:00	Theory of X-11
15:15	Coffee break
15:30	Using JDemetra+: seasonal adjustment with X-11

Schedule

Day 2

09:00	Theory of Seats
10:00	Using JDemetra+: seasonal adjustment with Seats
11:00	Coffee break
11:15	Pre-treatment: outliers and calendar effects
12:30	Lunch break
14:00	Using JDemetra+: calendar adjustment
15:00	Coffee break
15:15	Using JDemetra+: outliers
16:15	Output from GUI

Schedule

Day 3

09:30	Quality assessment, seasonality tests
09:30	Cruncher and quality reports
10:00	JDemetra+ in R
11:00	Coffee break
11:15	Using JDemetra+ or R: full exercise
12:30	Lunch break
14:00	Using JDemetra+ or R: show and tell exercise
15:30	Coffee break
15:45	Conclusions and evaluation of the course

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Motivation

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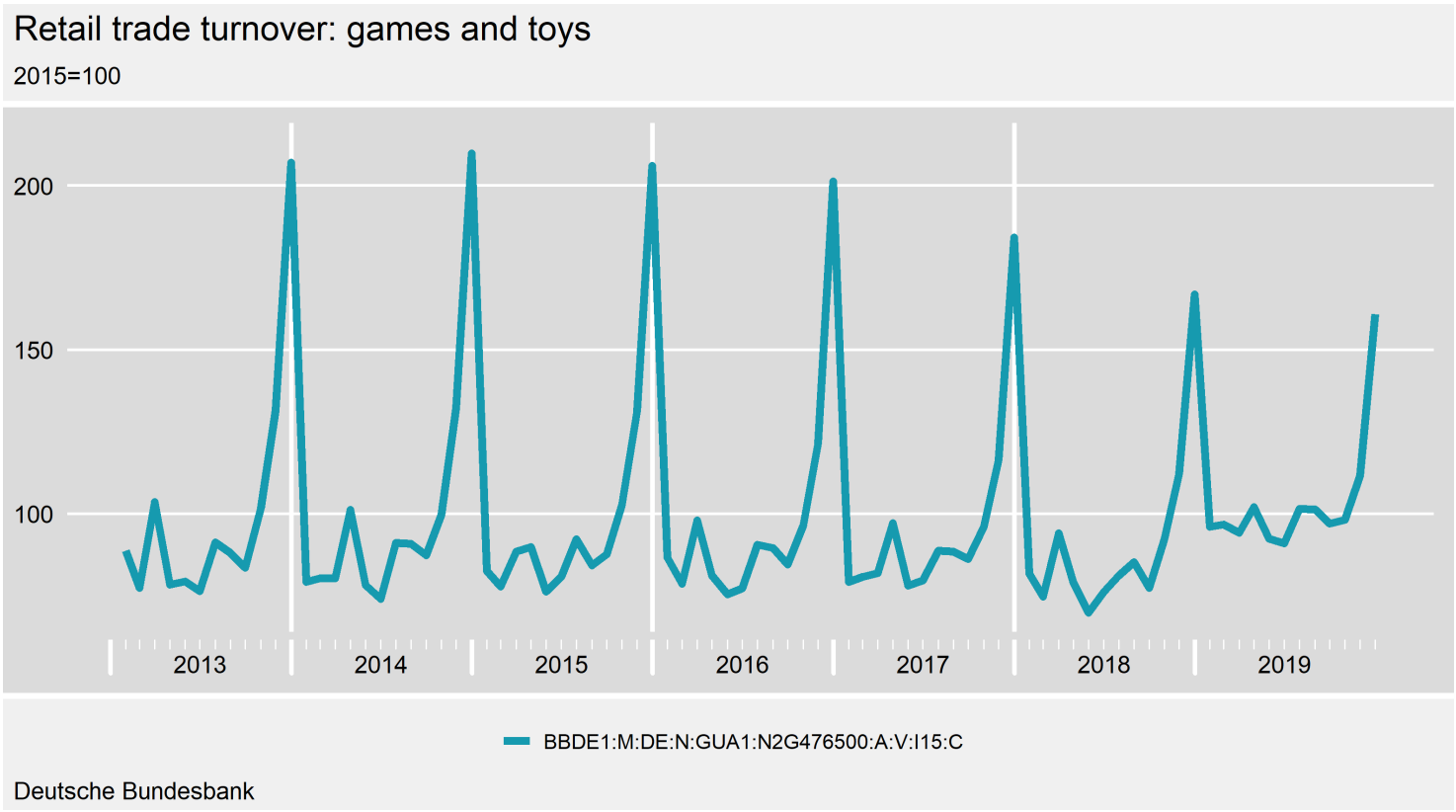
What is a time series?

Example: Retail trade of games and toys

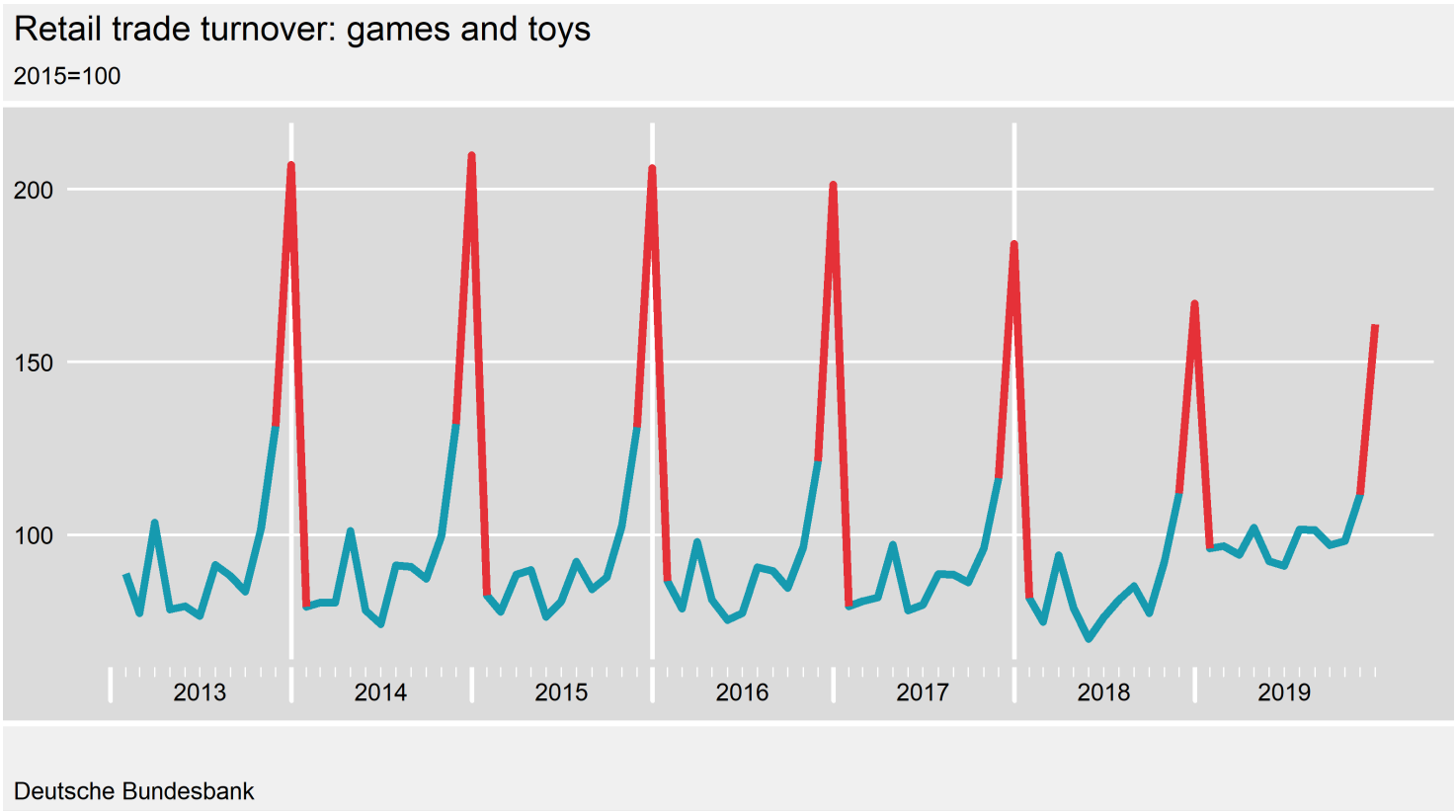


What is a time series?

- A time series is
  - a sequence of measurements
  - of a given phenomenon
  - taken at regular time intervals (hourly, daily, weekly, monthly, quarterly, annually, etc.)
- Types:
  - stock series: measurements of activity at a point in time (can be thought of as stock takes)
    - e.g. monthly currency in circulation
  - flow series: measurements of activity to a date
    - e.g. Retail, Output in industry, Balance of Payments

What is seasonality?

Example: Retail trade of games and toys



What is seasonality?
Verbal definitions (I/III)

"Usual seasonal fluctuations" means those ***movements which***

recur with similar intensity

in the same season each year

and *which, on the basis of past movements of the time series in question,* ***can****, under normal circumstances,* ***be expected to recur****."*

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Statistical Series
"Seasonally adjusted business statistics"

What is seasonality?

Verbal definitions (II/III)

"In the more general case, then, we may define seasonality as that characteristic of a time series that gives rise to ***spectral peaks at seasonal frequencies.***

Nerlove (1964)

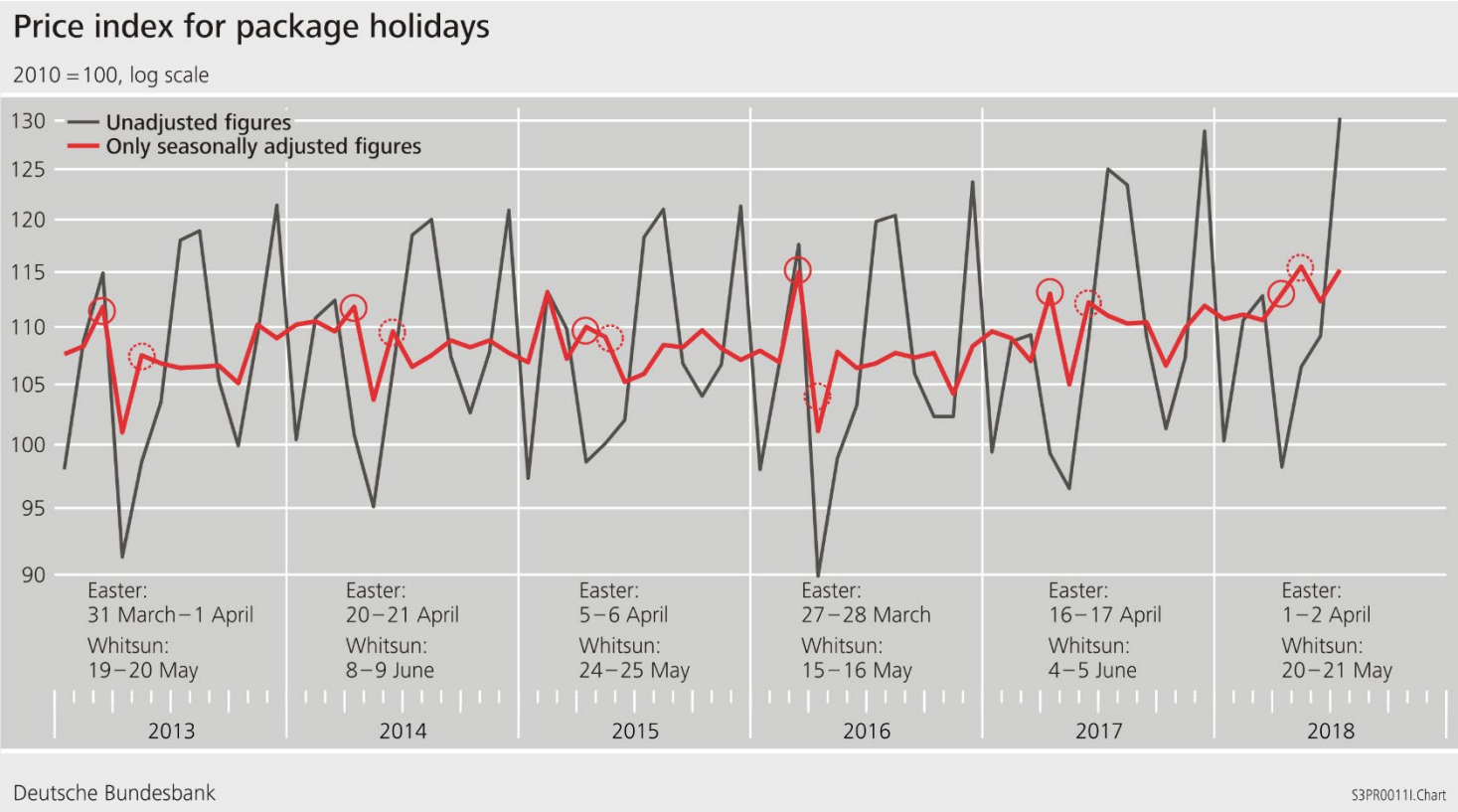
What is seasonality?
Verbal definitions (III/III)

*"**Seasonality is the systematic**, although not necessarily regular, **intra-year movement** caused by the **changes of** the **weather**, the **calendar, and timing of decisions**, directly or indirectly through the production and consumption decisions made by the agents of the economy. These decisions are **influenced by endowments,** the **expectations and preferences of** the **agents**, **and** the **production techniques** available in the economy."*

Hylleberg (1992)

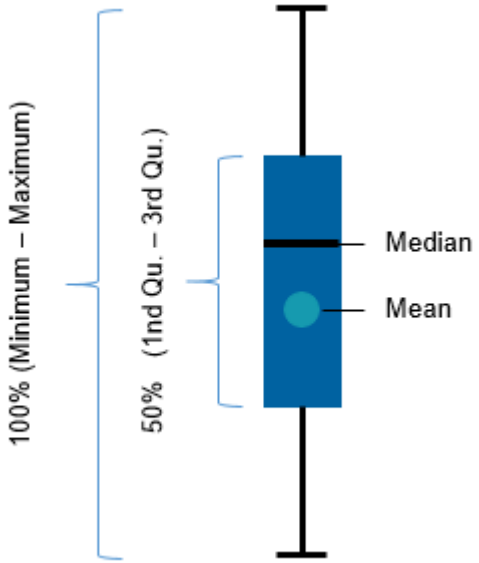
What is seasonality?

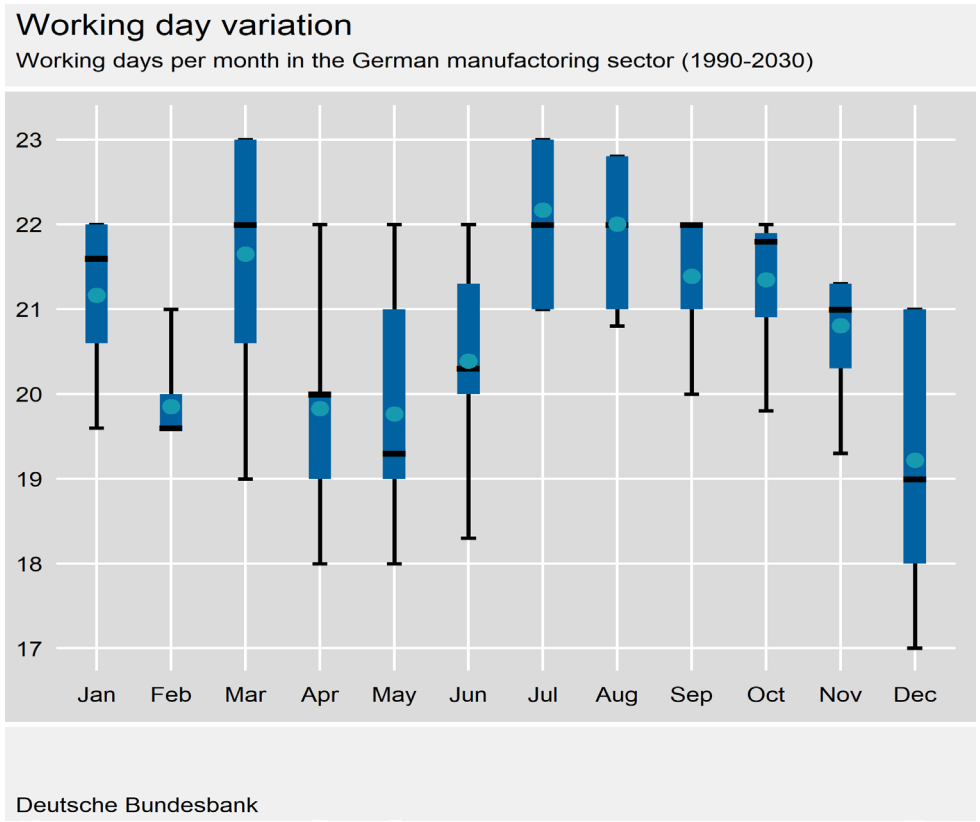
Calendar & Moving holidays



What is seasonality?

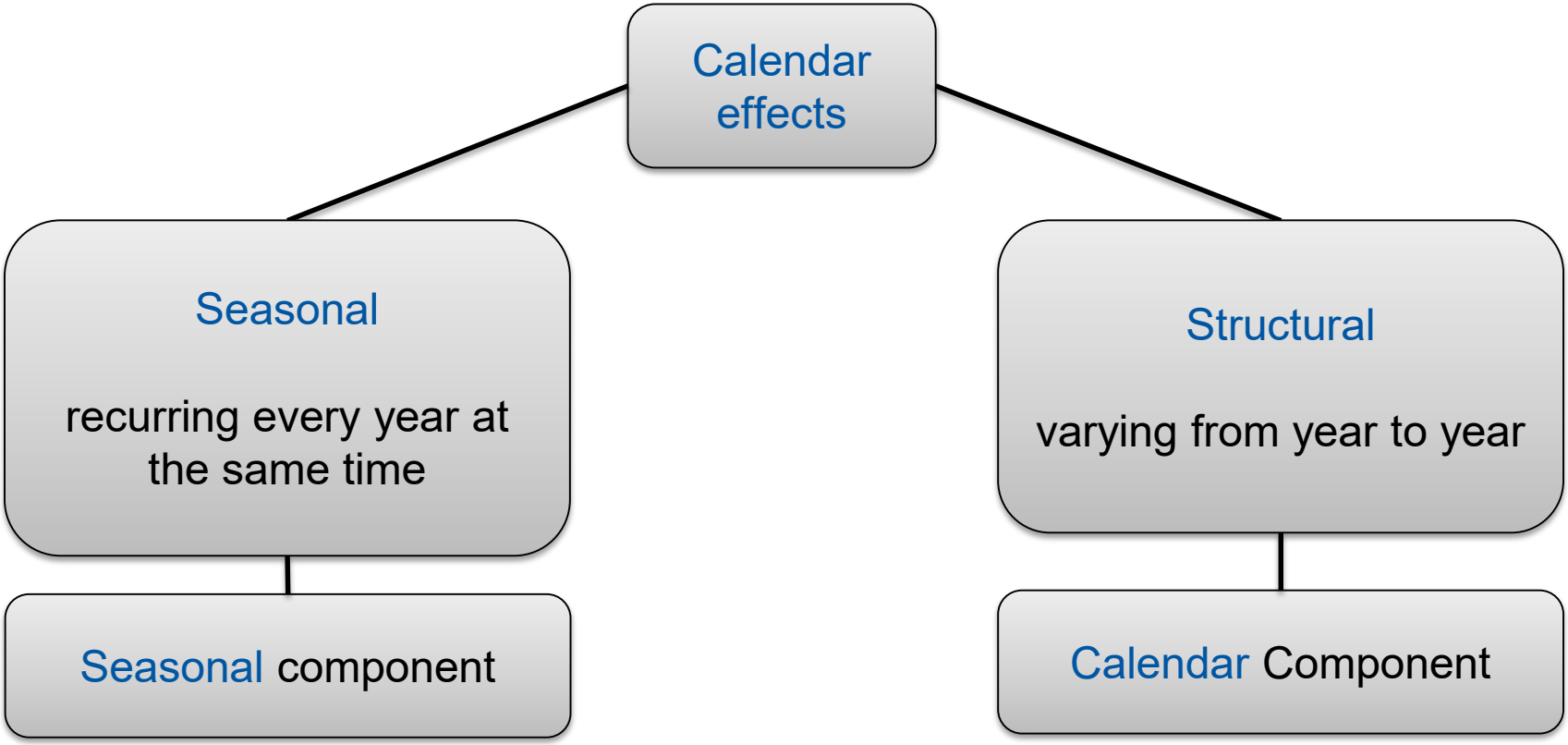
Calendar & Working day variation





What is seasonality?

Seasonal & Structural calendar effects

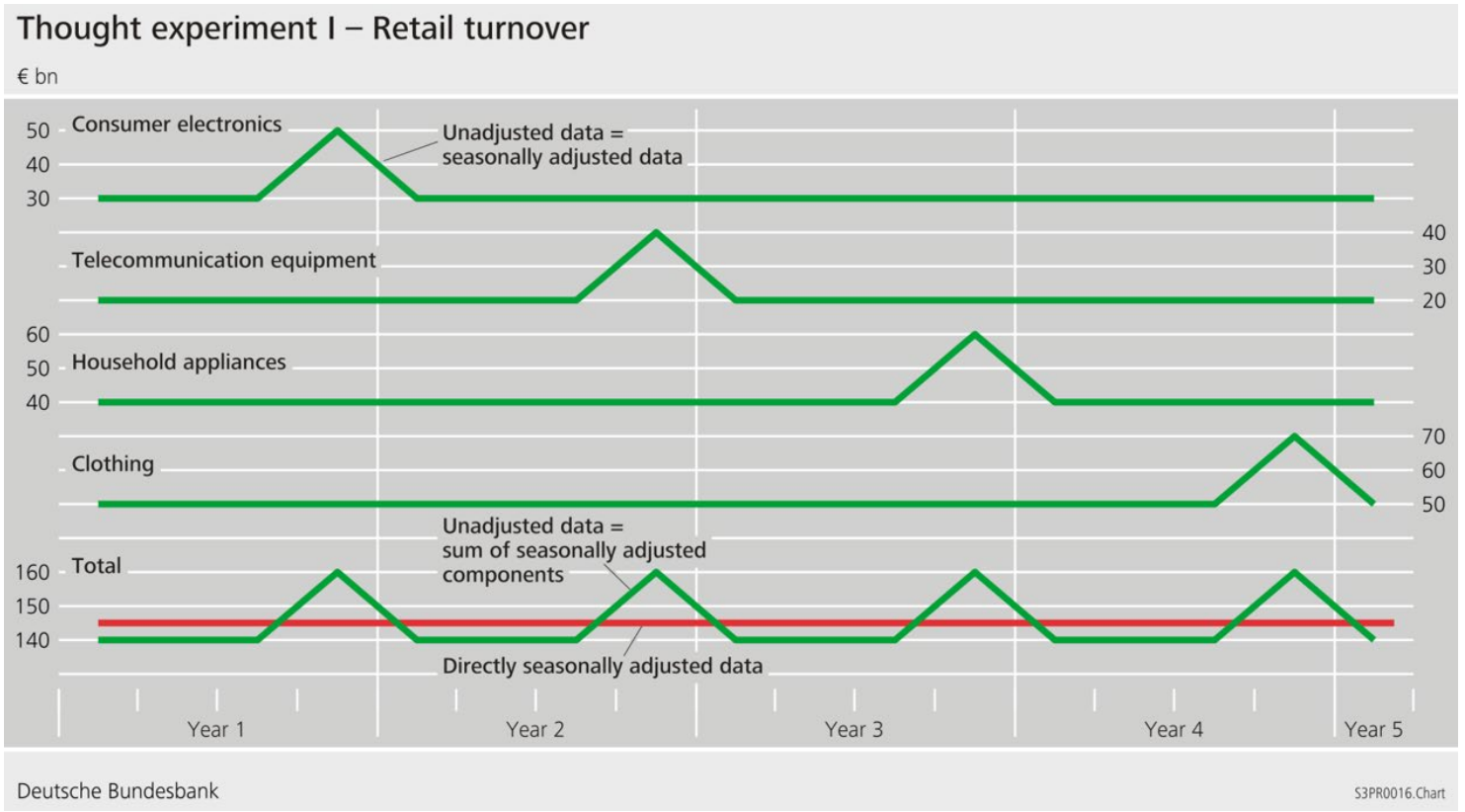


Reasons for seasonality

- Climatic seasons
- Composition of calendar
  - Number of working days or trading days per month
  - Secular or religious holidays and events
- Human interventions
  - Economic agents: social habits, expectations, preferences, profit, utility
  - Institutions: administrative rules and business practices
  - Production technique
- Data compilation
  - Cross-sectional aggregation (sub-components potentially non-seasonal)

Reasons for seasonality

Compilation of sub-components



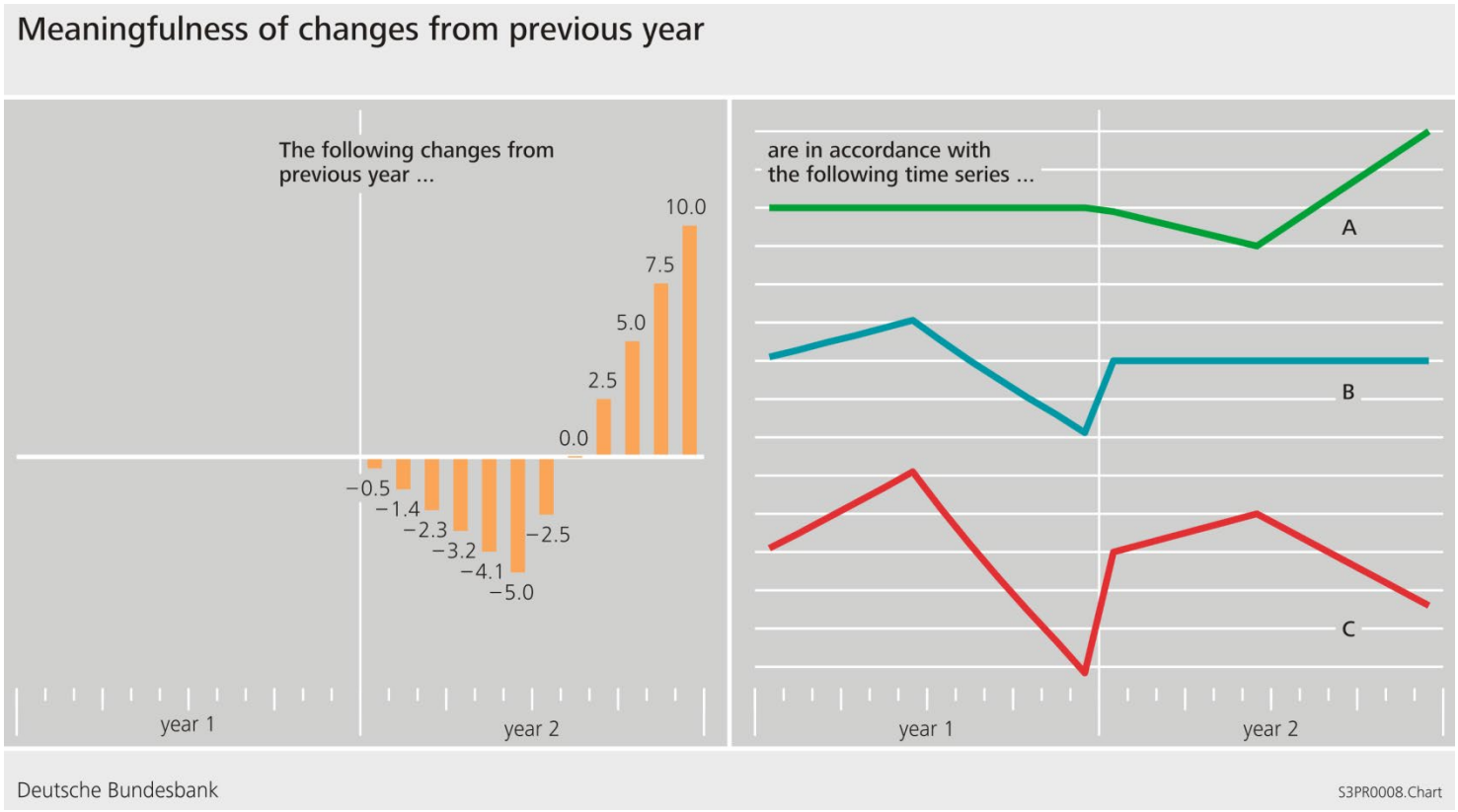
Why seasonal adjustment?

Improvement of interpretability

*"Seasonal adjustment is done to **simplify the data** so that they may be more easily interpreted by statistically unsophisticated users **without a significant loss of information**."*

Bell and Hillmer (1984)

Why not year-on-year changes? (I/II)

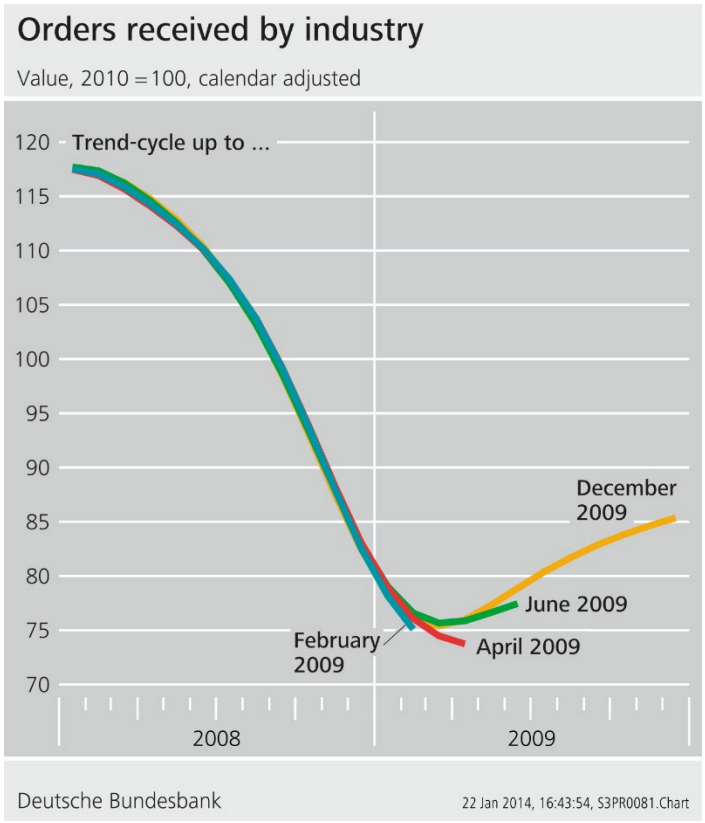


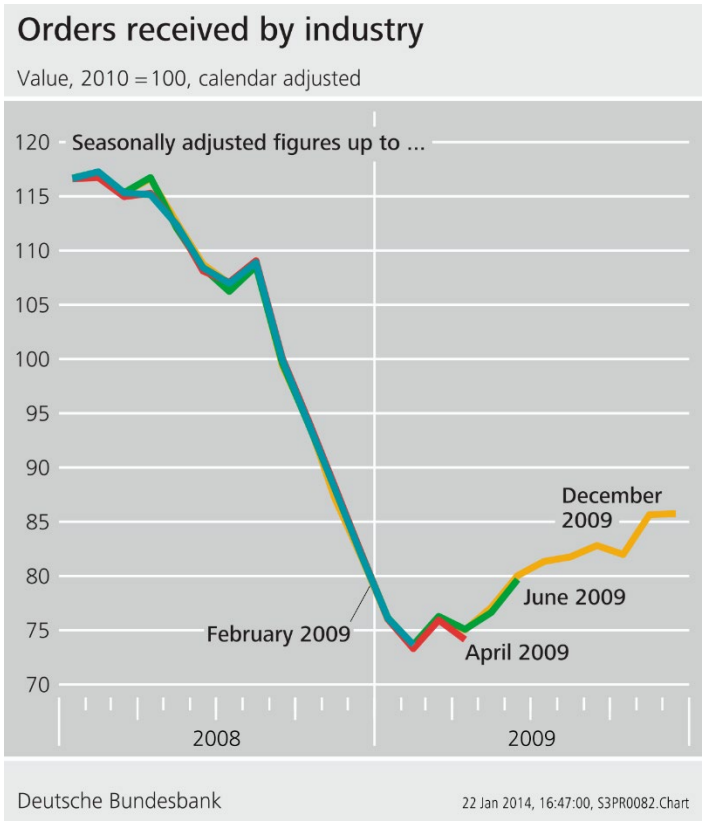
Why not year-on-year changes? (II/II)

- Current **direction** of economic development is **unclear**
- **Delayed detection** of turning points
- **Moving seasonality** can not be identified
- Does not account for **calendar variation**

Why not the trend-cycle?

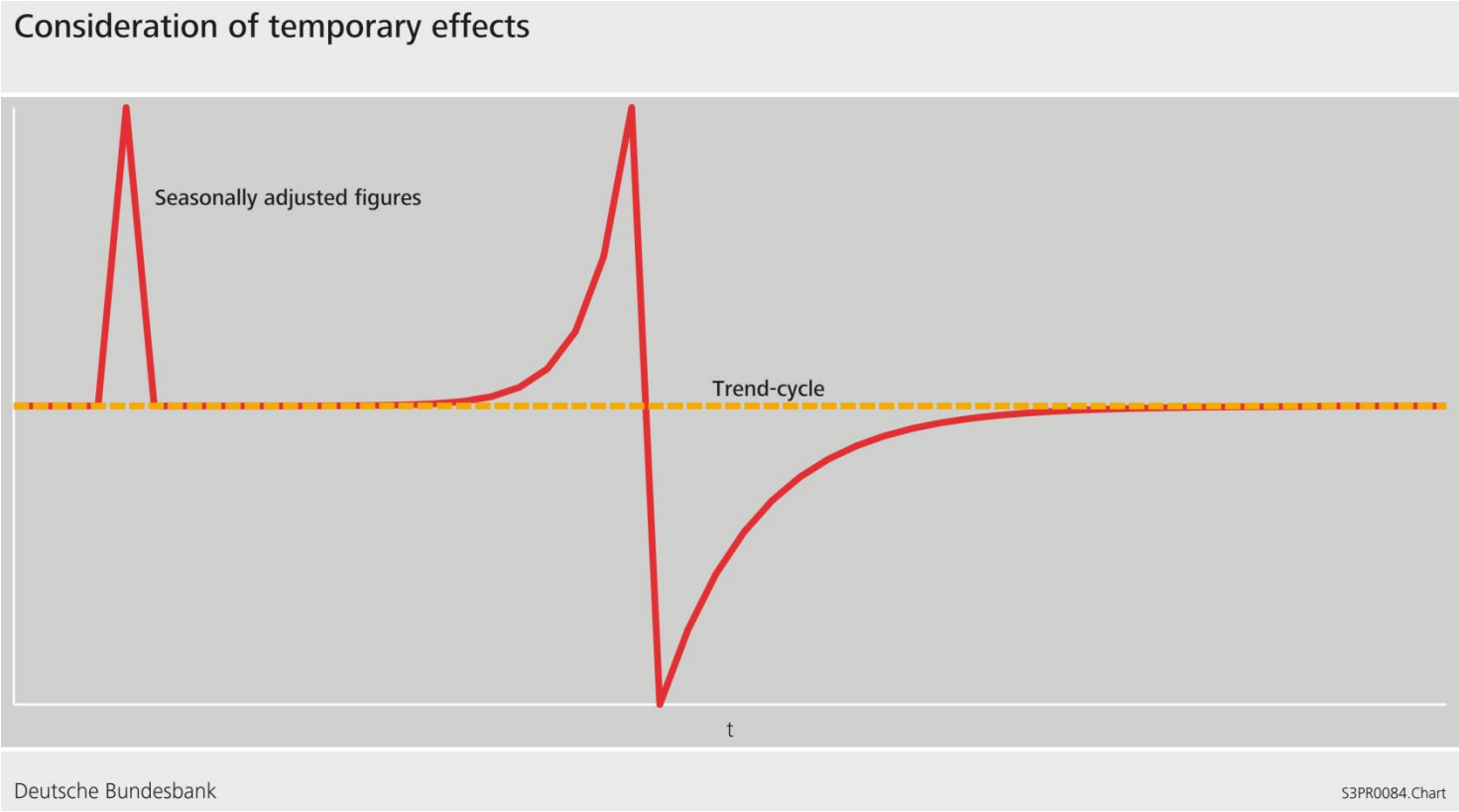
Lagged flow of information & larger revisions





Why not the trend-cycle?

Missed news in irregular



Why not the trend-cycle?

- **End point problem** due to low information value on current end of a time series
- Current values are estimated via extrapolation and are exceptionally **prone to revisions**
- **Time delay / phase shift** leads to a late detection of turning points
- **Noise** is not eliminated, but only distributed across time
- **News** belonging to the irregular component are not visible

Seasonal adjustment in a nutshell

Seasonally adjusted figures

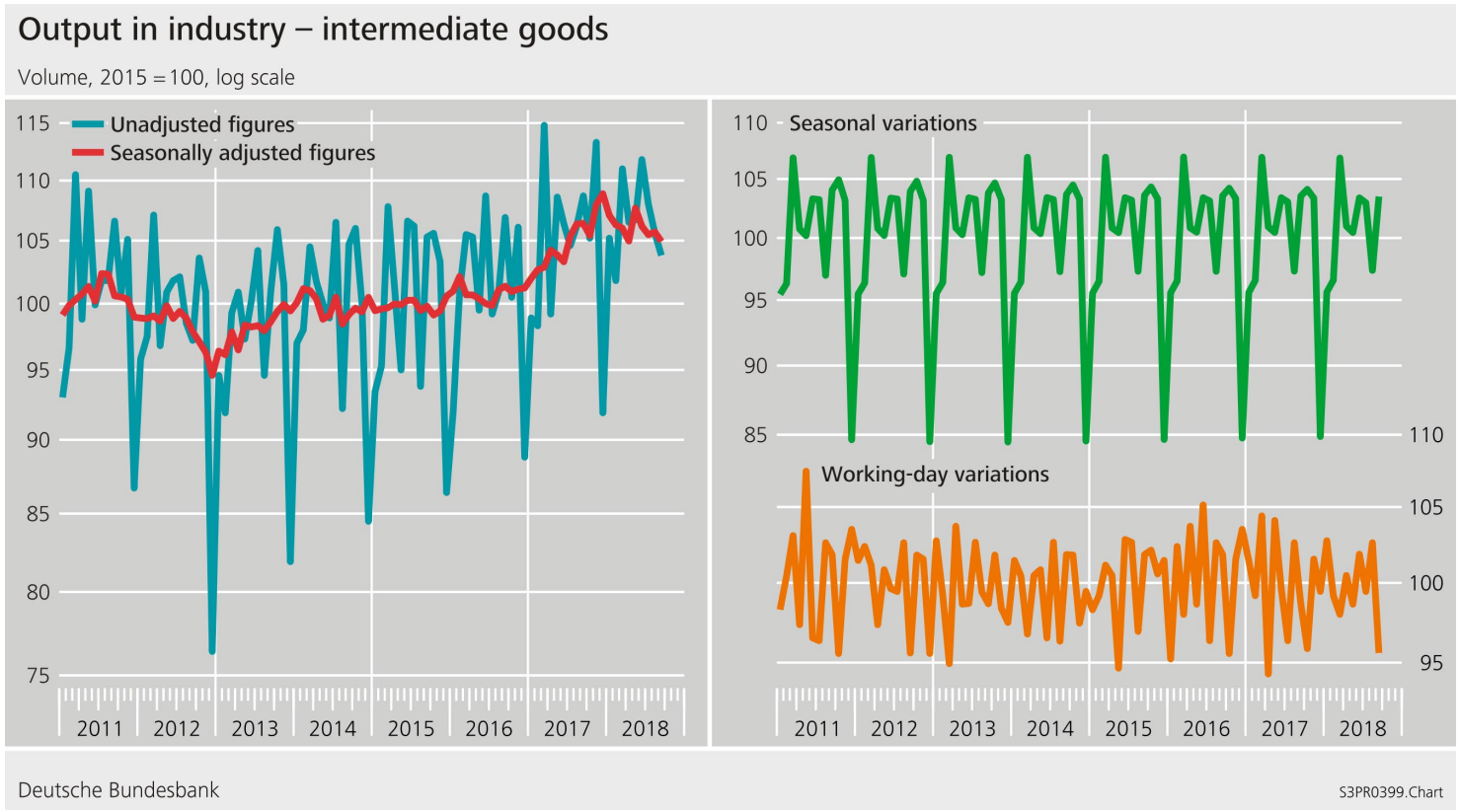
- Filter out recurring and systematic patterns that are not particularly informative ("noise")
- Are helpful for the analysis of the current economic development: revealing the news
  (seasonally adjusted series will not hide outliers because they are part of the news)
- Facilitate the comparison of the development of different time series (e.g. across sectors, across economies)
- Enable an early detection of turning points
- Are helpful as a basis for short-term forecasting

Purpose of seasonal adjustment

- What shall be **removed**?
  - **Usual seasonal fluctuations**
  - Effects that arise due to **working-day variations** or dates of particular days
- What shall **remain**?
  - **Exceptionally** strong or weak seasonal **fluctuations**
  - **Random disruptions** and unusual movements

Purpose of seasonal adjustment

German output in industry – intermediate goods



ESS guidelines on seasonal adjustment

- Developed to promote best practice in seasonal adjustment to
  - achieve harmonisation across national processes
  - enhance comparability between results
  - increase robustness of European aggregates

→ Discussed whenever important for the reasoning of some decisions

Handbook on seasonal adjustment

I. General aspects
II. Pre-treatment methods
III. Seasonal adjustment methods
IV. Improving end-point estimates for seasonal adjustment
V. Seasonal adjustment and aggregation
VI. Revision and communication
VII. Seasonal adjustment in practice
VIII. Seasonal adjustment of high frequency data
IX. ESS guidelines on seasonal adjustment

The unobserved component model

Basic idea

$$Y_t = T_t \circ S_t \circ C_t \circ I_t$$

with

- $Y_t =$ unadjusted data
- $T_t =$ trend-cycle component
- $S_t =$ seasonal component
- $C_t =$ calendar component
- $I_t =$ irregular component

$\circ = +$ → additive
$\circ = \cdot$ → multiplicative

Usual components
Definition

- Definition of the components is a "philosophical" issue

> ***"The essential idea of trend is that it shall be smooth."***
>
> ***Sir Kendall (1973)**, Time Series, p. 29.*

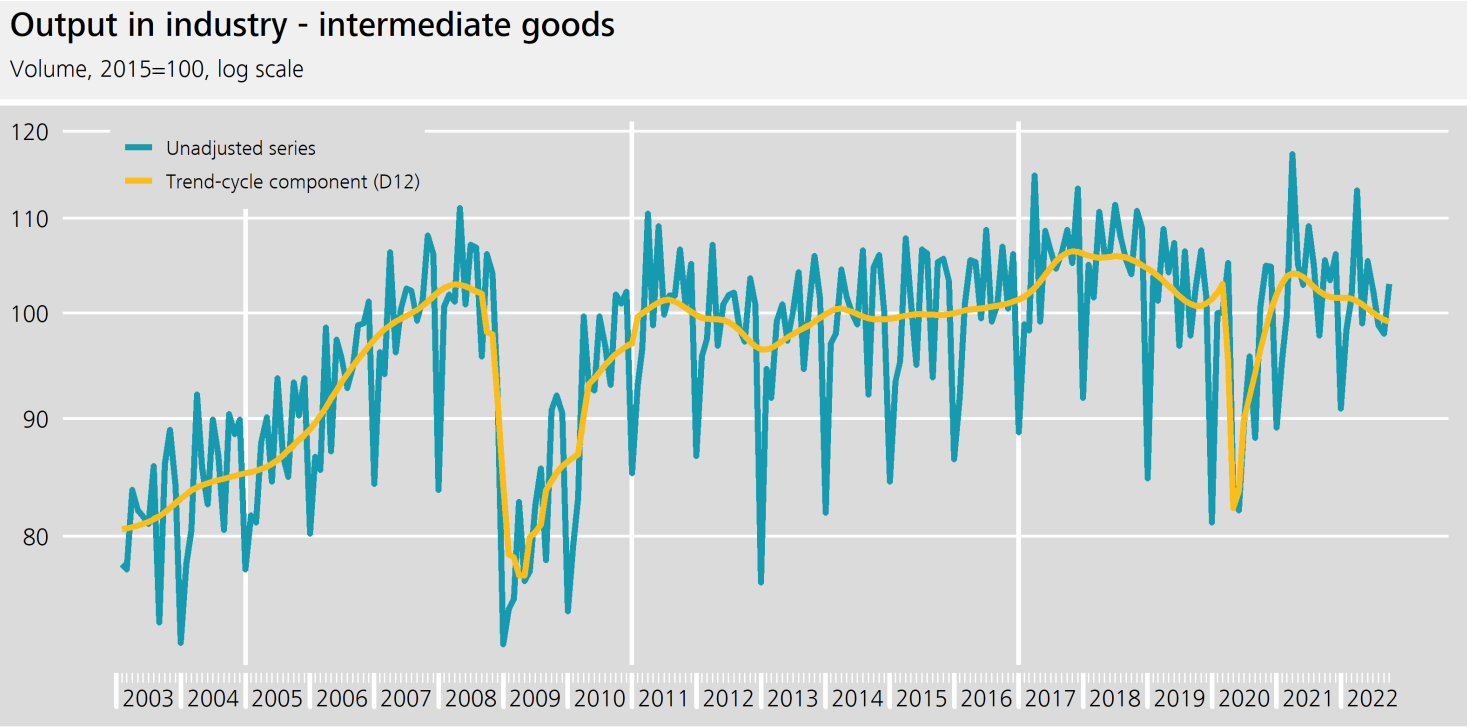
> ***"There is no fundamental reason, though, why a trend should be smooth."***
>
> ***Andrew Harvey (1989)**, Forecasting, Structural Time Series Models and the Kalman Filter, p. 284.*

Usual components

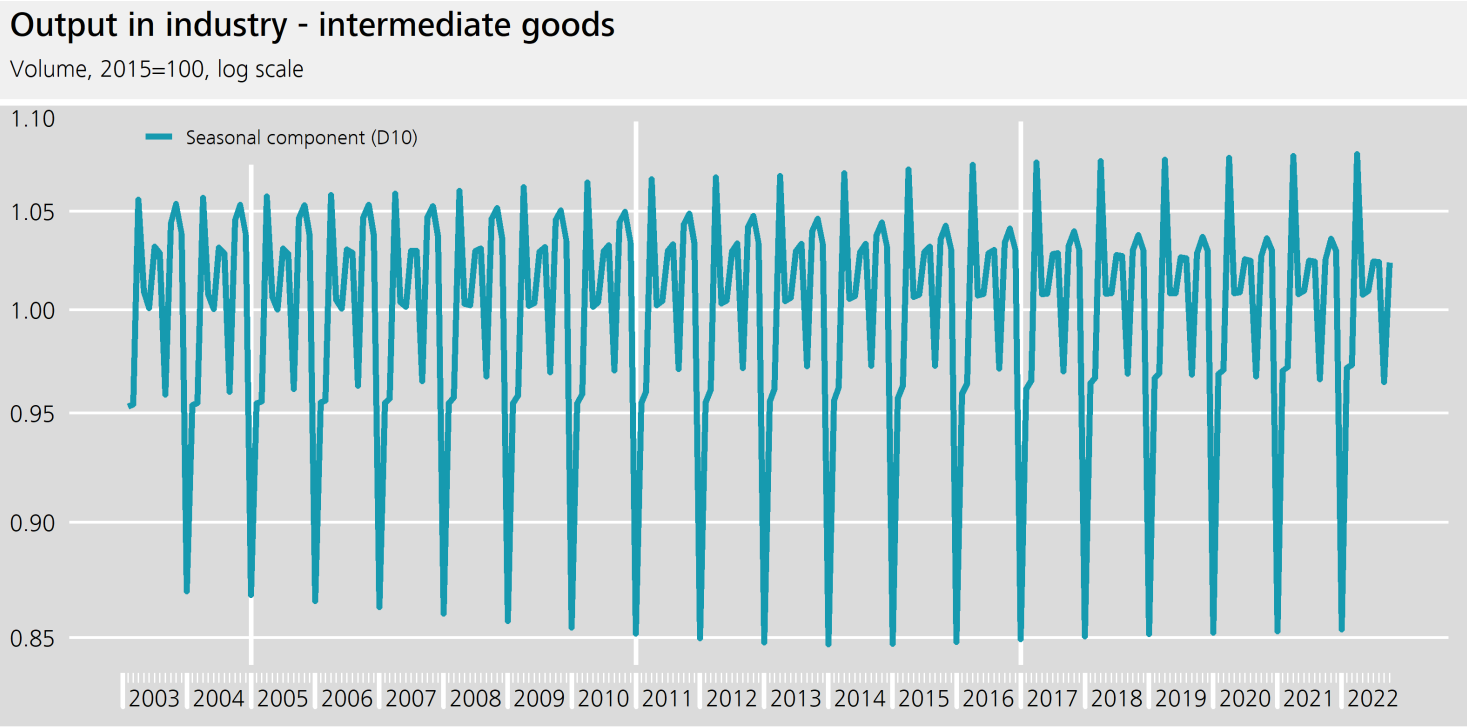
Trend-cycle

- Trend: long term evolution of the series that can be observed on several decades
  - reflection of the level
  - driven by population growth, inflation, general economic development
- Cycle: smooth and quasi-periodic movement of the series that can usually be observed around the long term trend
- Trend and cycle are often taken as a combined component, referred as trend-cycle

Usual components
Trend-cycle



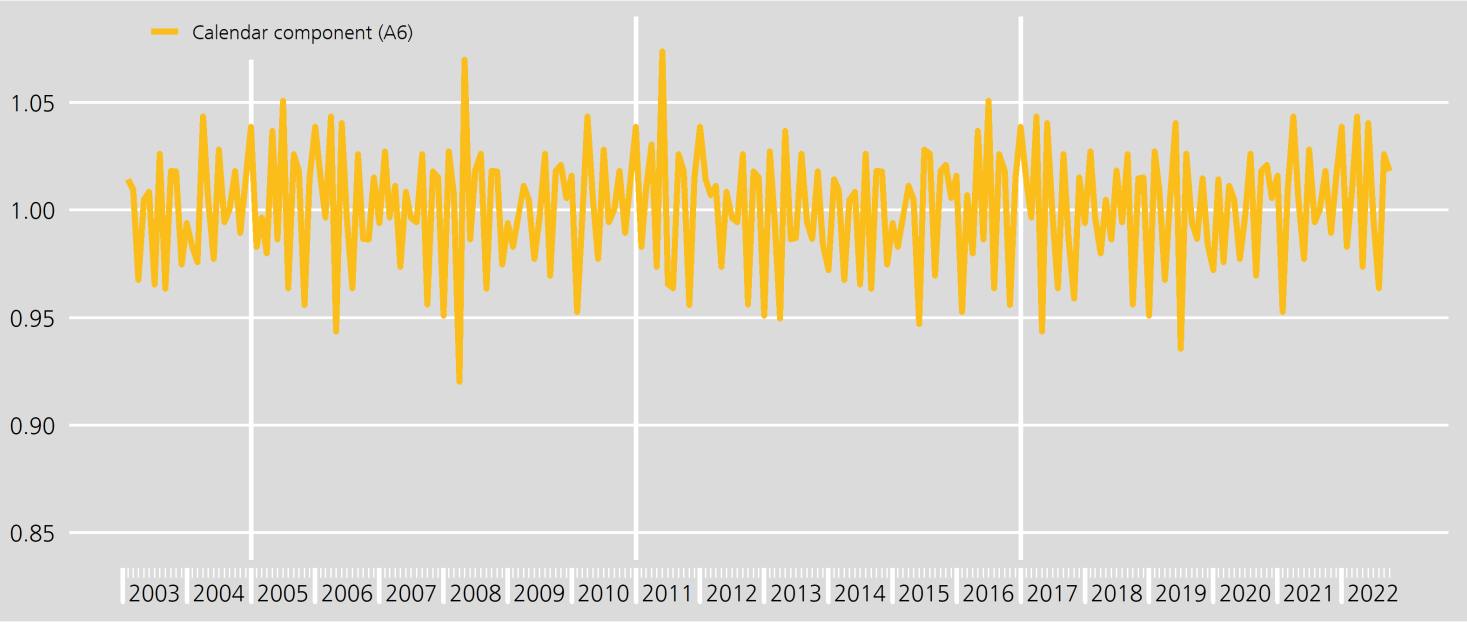
Usual components
Seasonal component



Usual components
Calendar component

Output in industry - intermediate goods

Volume, 2015=100, log scale



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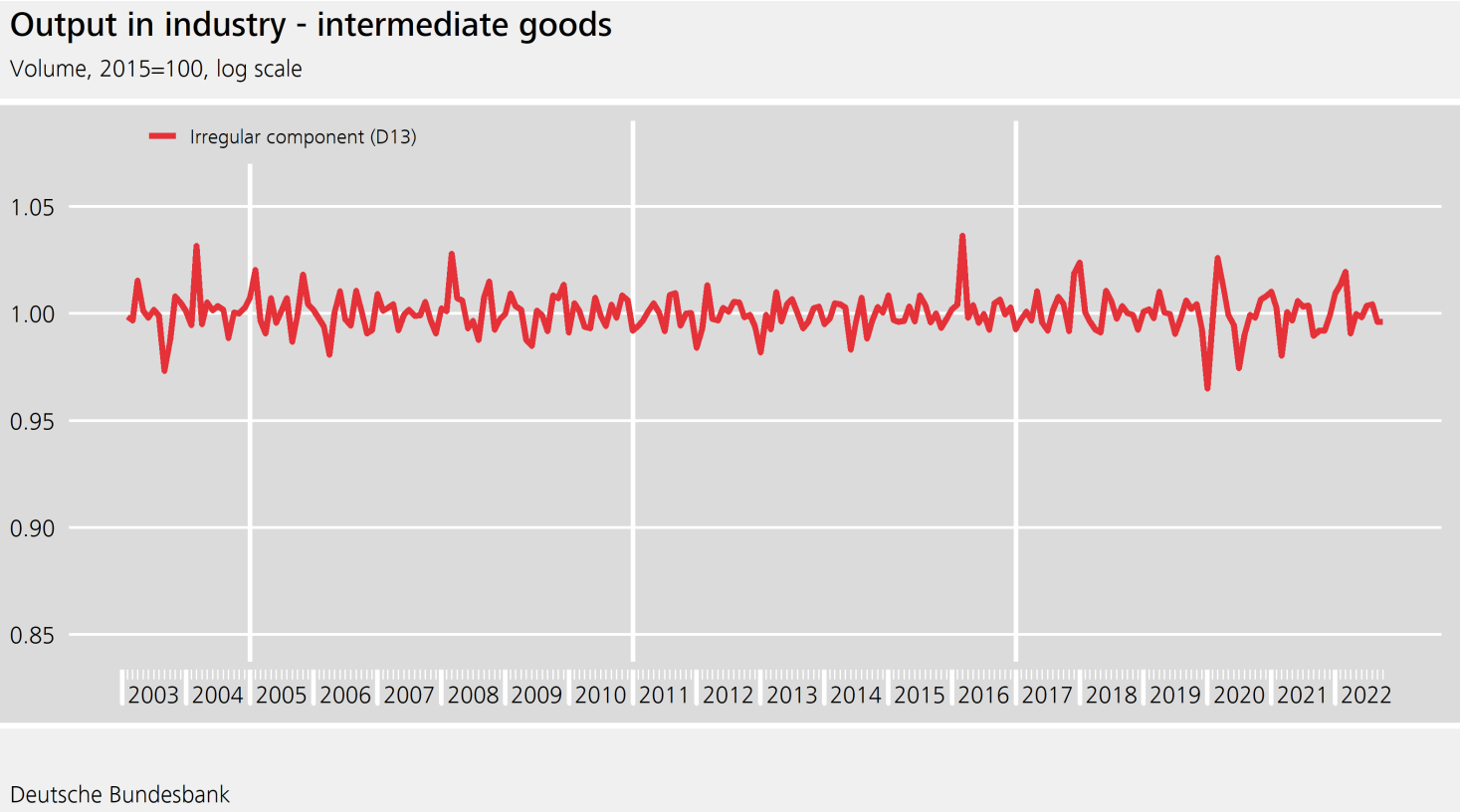
Usual components

Irregular component

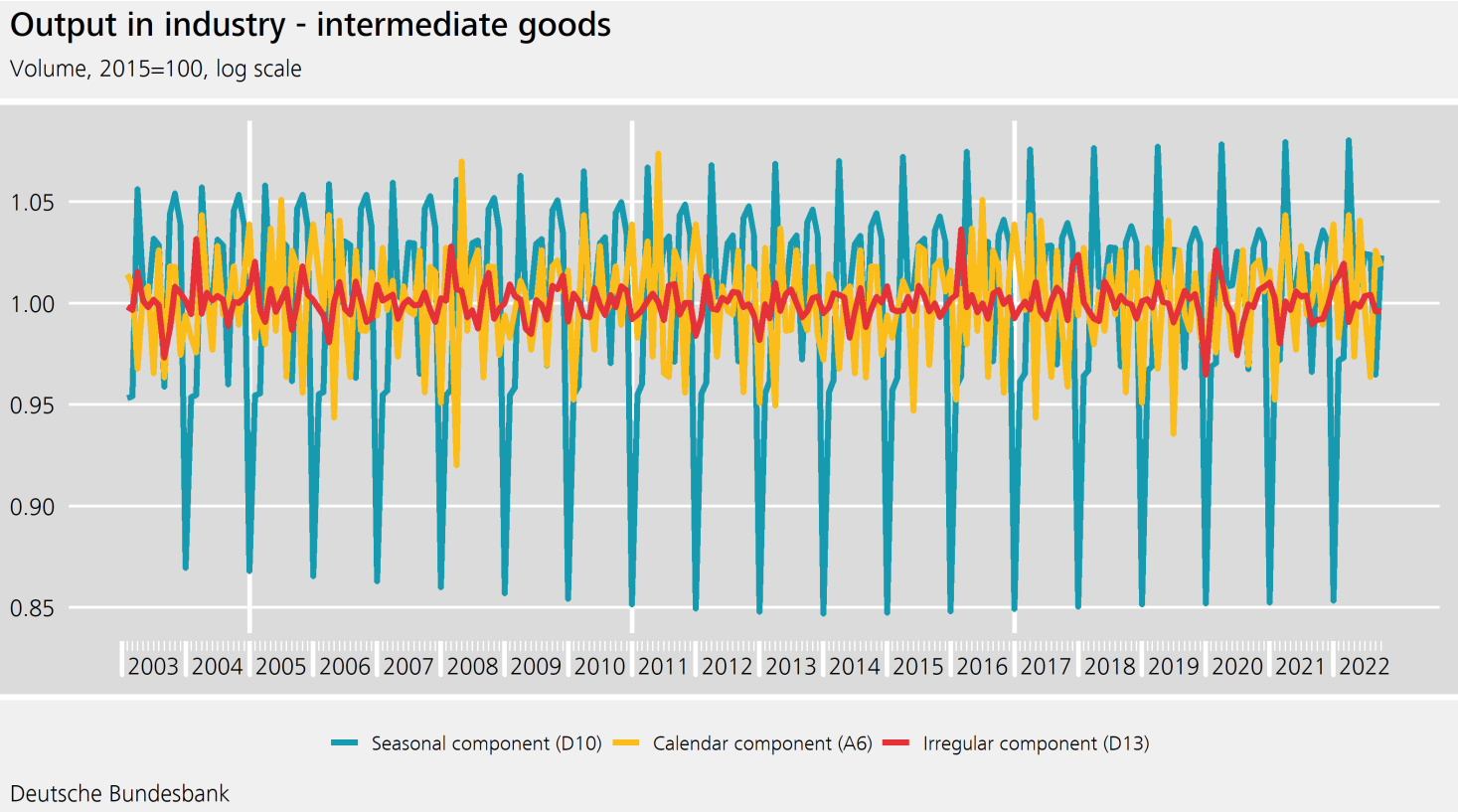
- Residual and random fluctuations that cannot be attributed to the other “systematic” components
- Captures the remaining short term fluctuations in the series which are neither systematic nor predictable
- Remaining component of the series after the seasonal and trend components have been removed from the original data
- Sometimes referred to as the residual component

Usual components
Irregular component



Usual components

German output in industry – intermediate goods



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History

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Seasonal adjustment methods and software

Classification

Seasonal adjustment methods and software

Classification

Non-parametric
Implicit Models

Parametric
Explicit Models

Seasonal adjustment methods and software

Classification

Seasonal adjustment methods and software

Classification

Robust Filters — Non-robust Filters — Implicit Modeling

Global Modeling — Modeling of Each Component — Explicit Modeling

Seasonal adjustment methods and software

Classification

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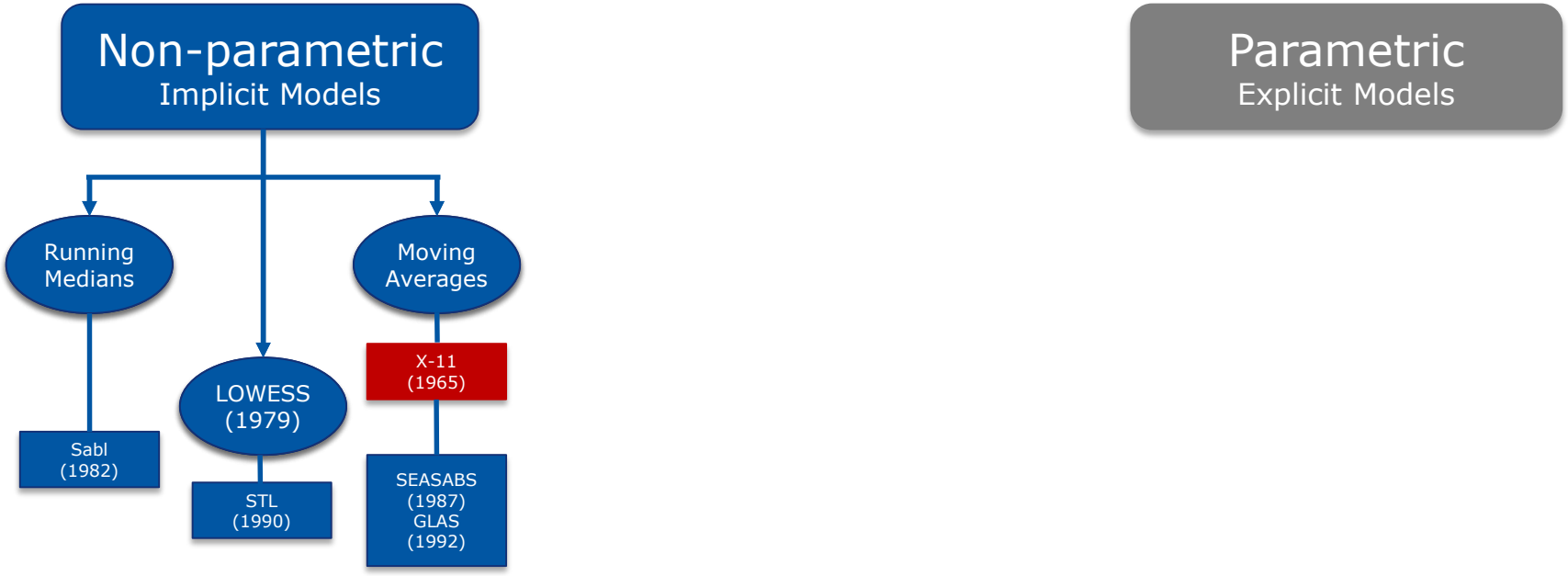

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Seasonal adjustment methods and software

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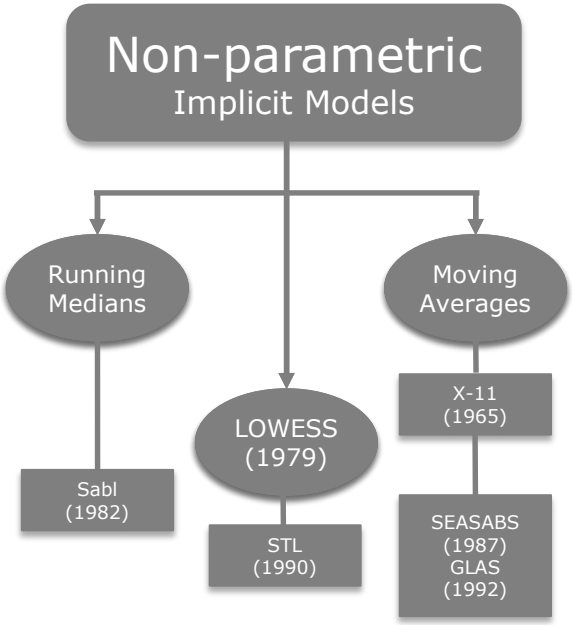
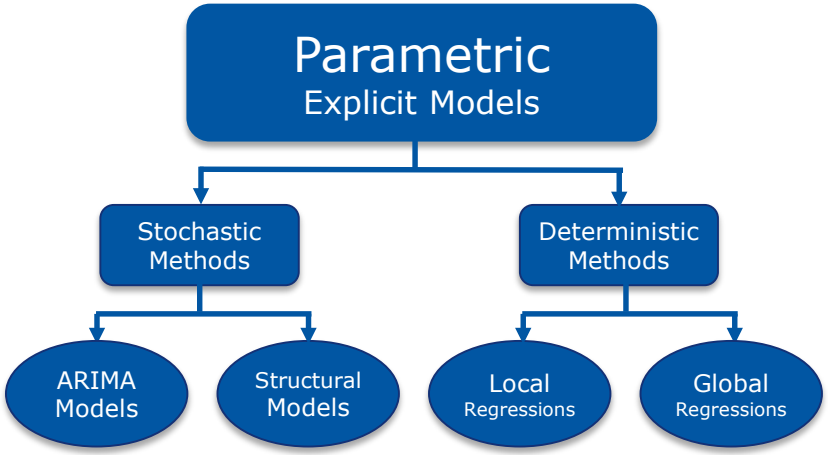
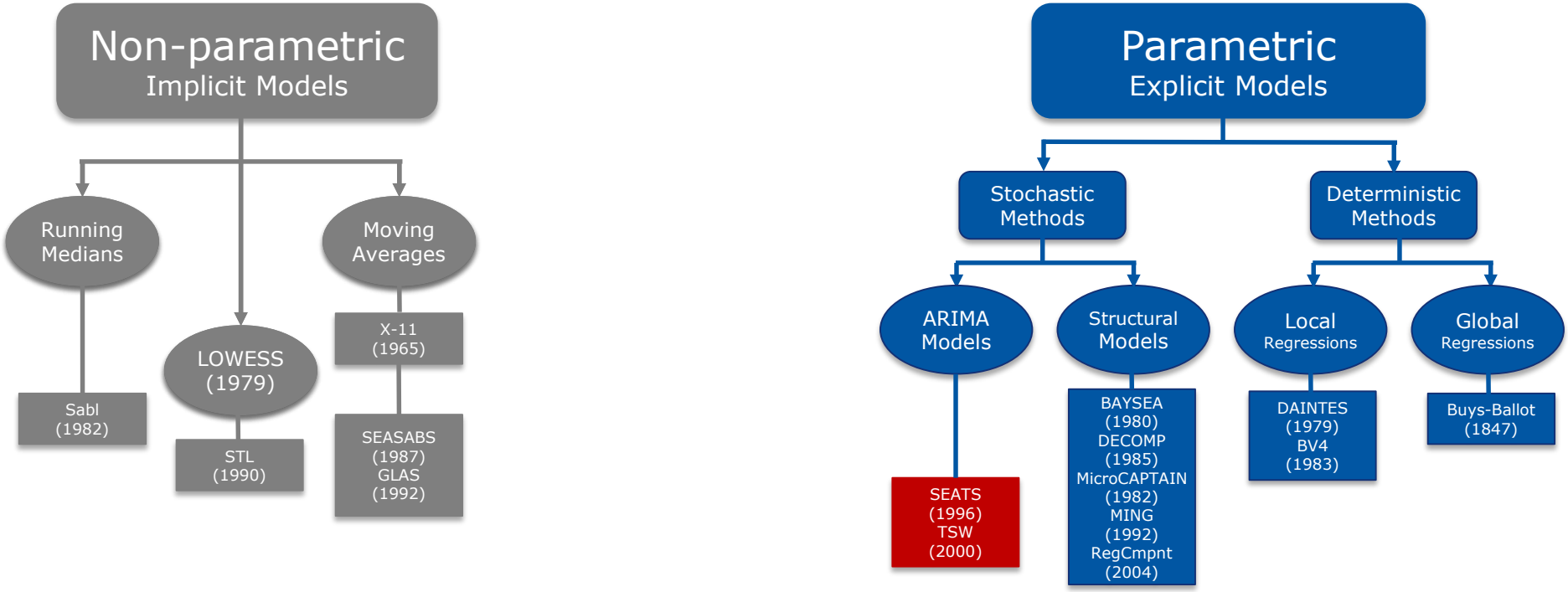




Seasonal adjustment methods and software

Classification

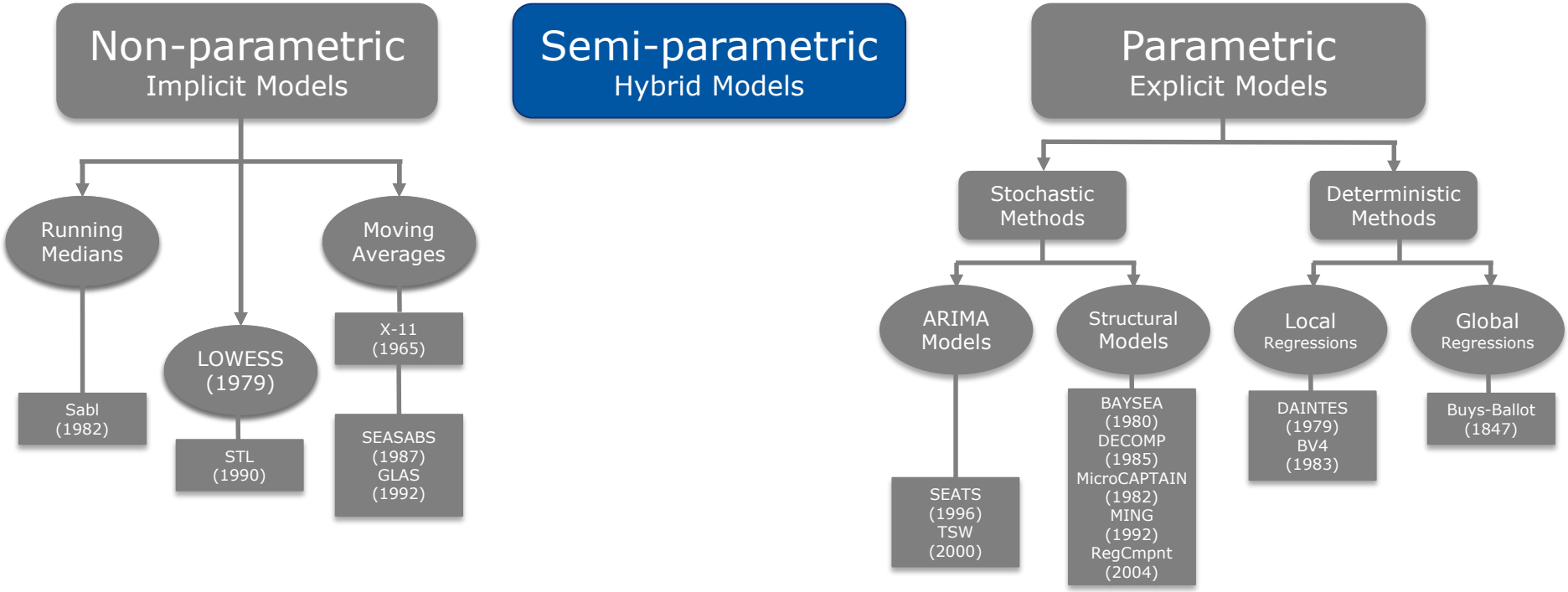


Robust Filters — Non-robust Filters — Implicit Modeling

Global Modeling — Modeling of Each Component — Explicit Modeling

Seasonal adjustment methods and software

Classification

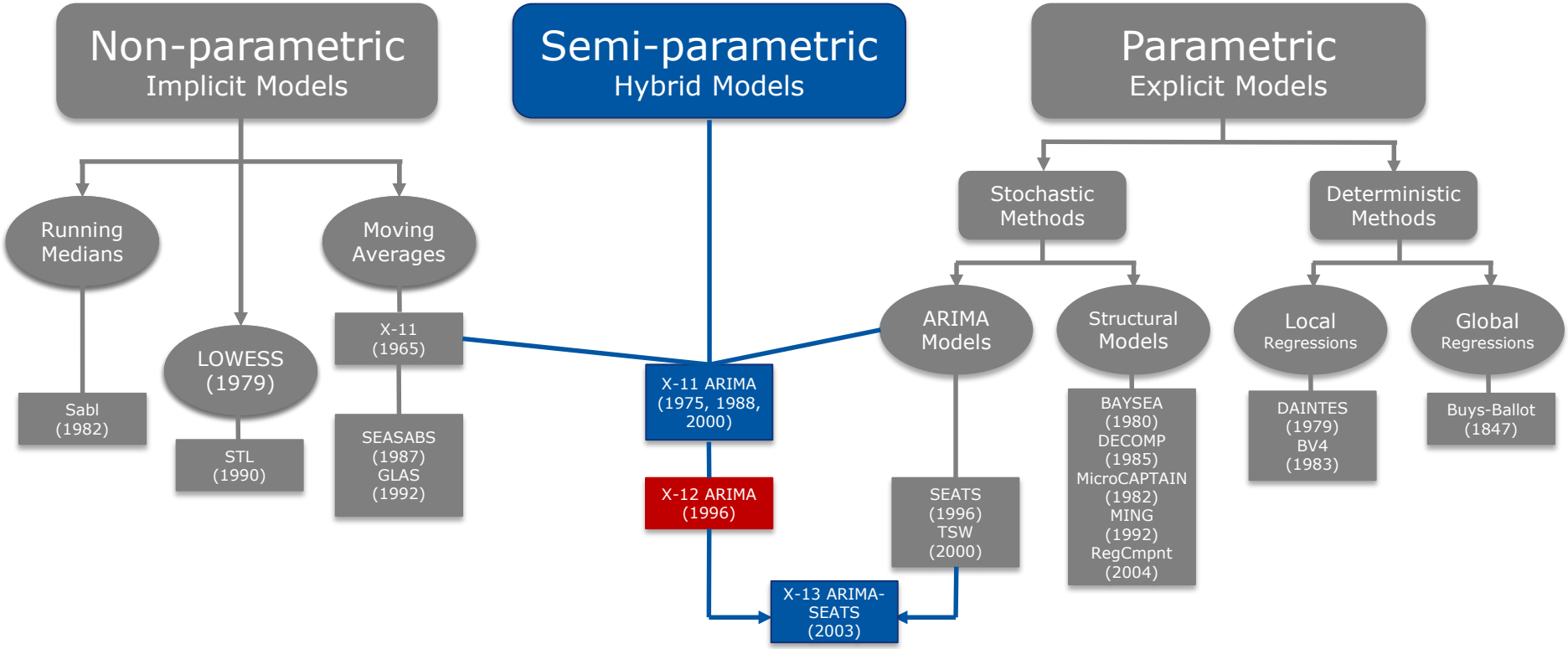


Robust Filters — Non-robust Filters — Global Modeling — Modeling of Each Component

Implicit Modeling — Explicit Modeling

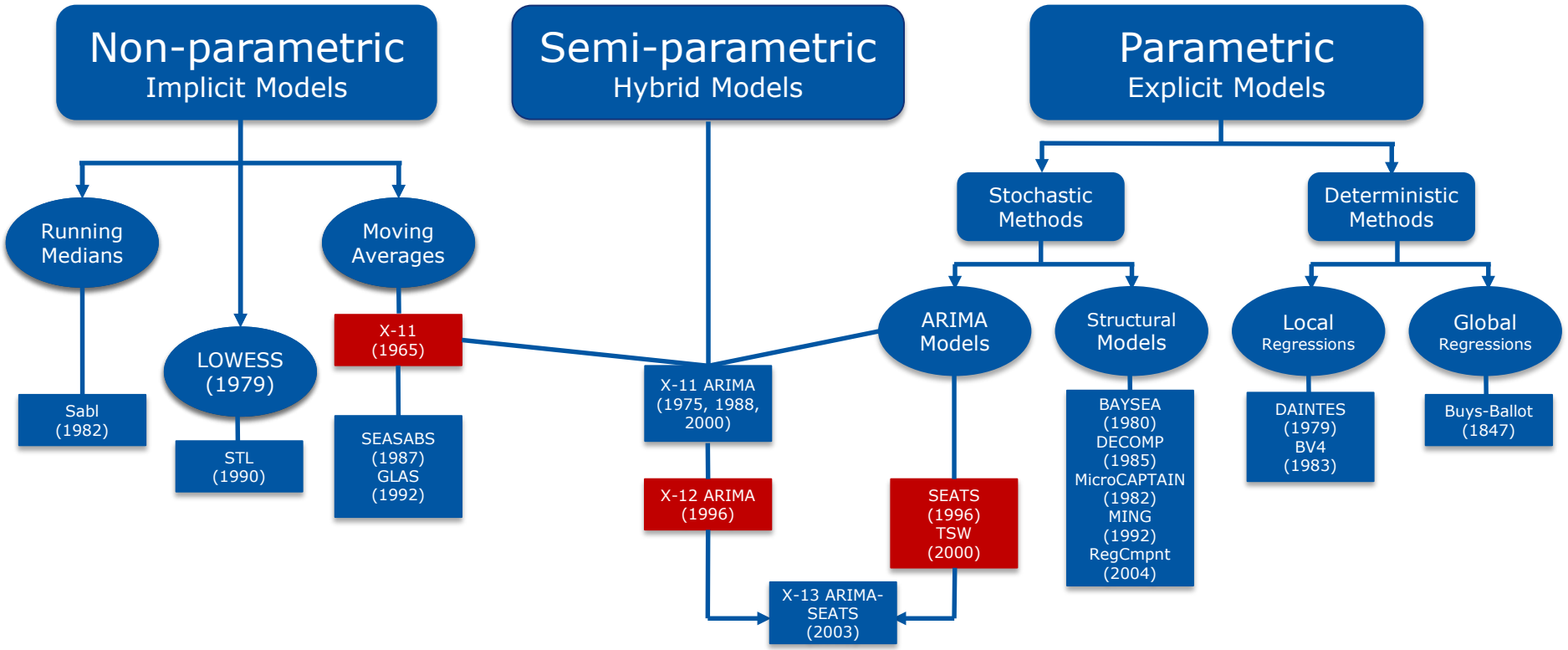
Seasonal adjustment methods and software

Classification

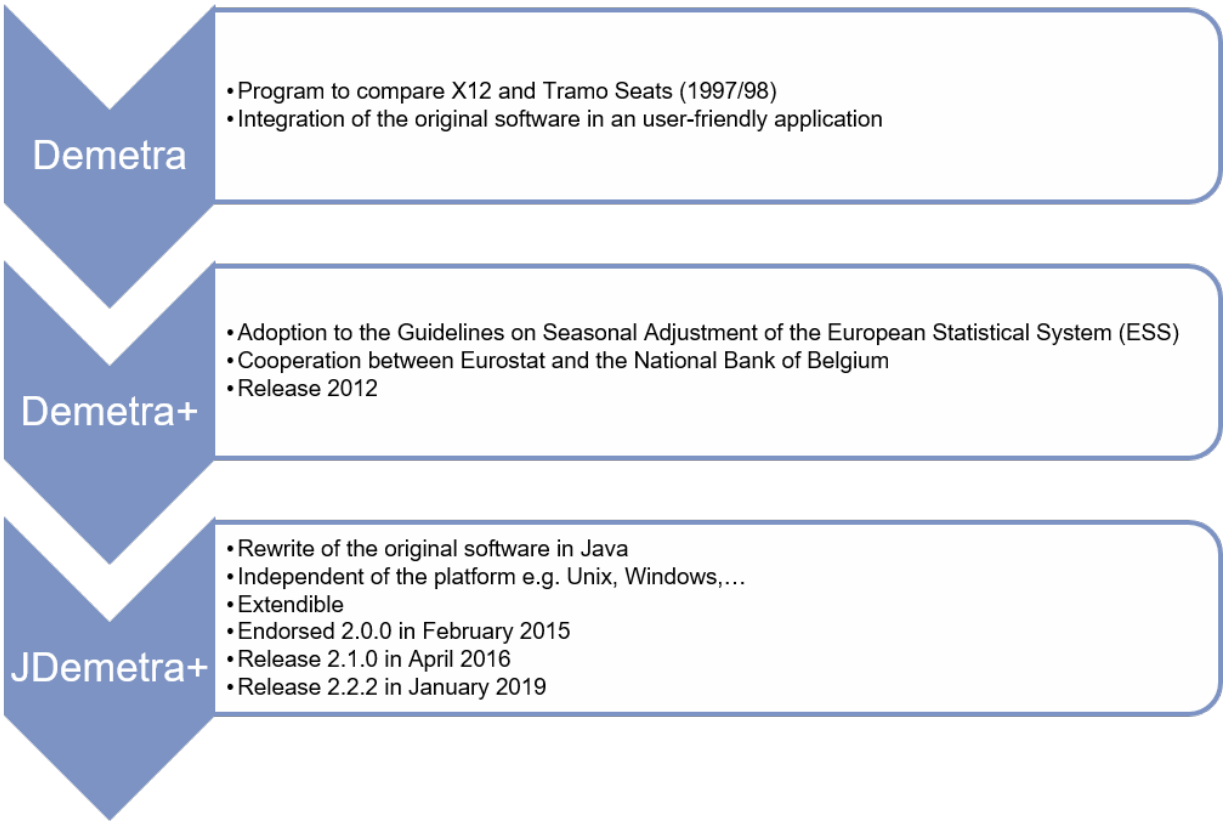


Seasonal adjustment methods and software

Classification



Jdemetra+ (I/II)



JDemetra+ (II/II)

- One extendable main application
- Open source application
- **Recommended software in the ESS Guidelines**
- Development is done by the National Bank of Belgium, supported by the Deutsche Bundesbank for the X-11 part
- The release version 2.2.3 (jdemetra-2.2.3.zip) is available for download on GitHub
  - https://github.com/jdemetra/jdemetra-app/releases
- Installation guide
  - https://github.com/jdemetra/jdemetra-app/wiki/Quick-install-guide

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Seasonal adjustment

Step by step procedure

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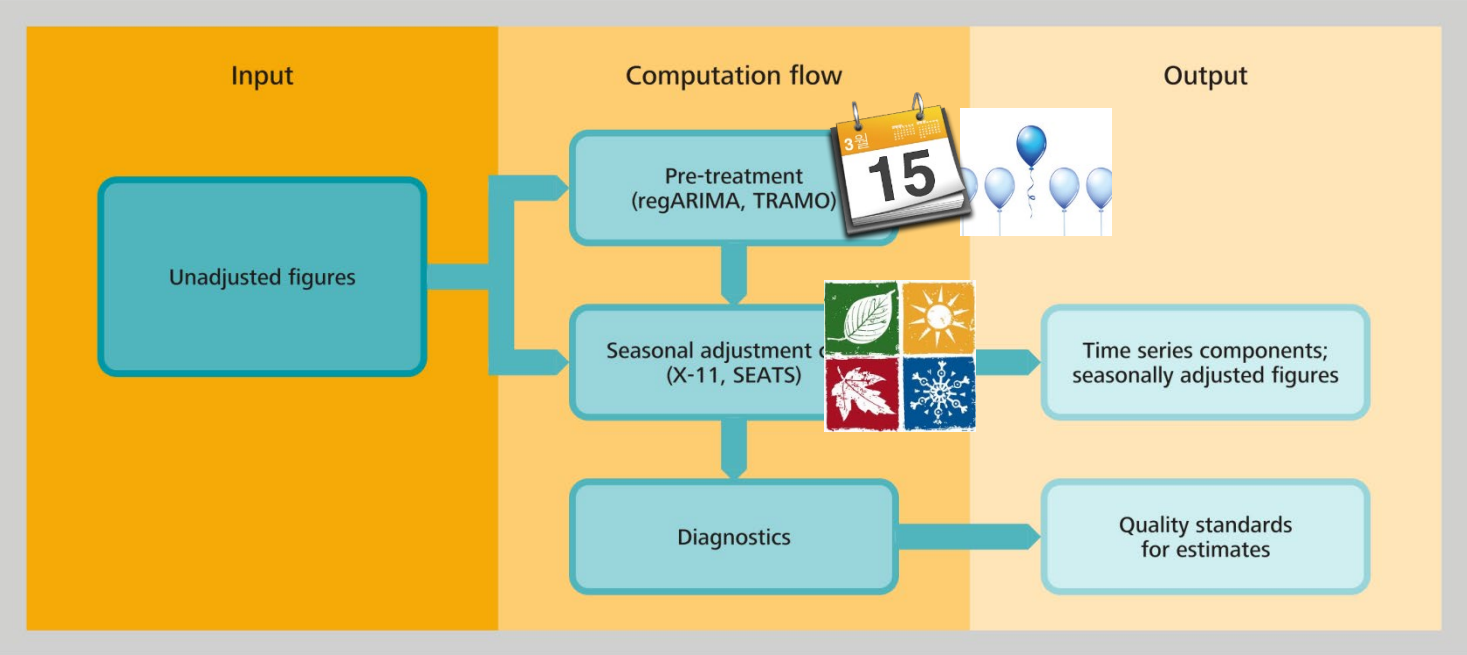
JDemetra+
Flow chart

Structure of JDemetra+



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Step 0: Number of observations

Short and very short series

- Very short series (< 3 years):
  - monthly data: minimum of 3 years (36 observations)
  - quarterly data: minimum of 4 years (16 observations)

  → Seasonal adjustment not possible due to technical constraints

  (ESS guidelines, item 6.1)

- Short series (3-7 years):

  → Seasonal adjustment possible, but stability issues might cause problems

  (ESS guidelines, item 6.1)

Step 0: Number of observations

Long series

- Longer series are **not** necessarily better
  - series might have changed the way the data is measured or defined
  - → it might be better to cut off the early part of the series to keep the series as homogeneous as possible
- The decision if a series needs to be shortened should be based on the investigation of
  - the data collection methods and
  - the economic factors associated with the series
  - → choose a length that gives the most homogeneous series possible

  (ESS guidelines, item 6.2)

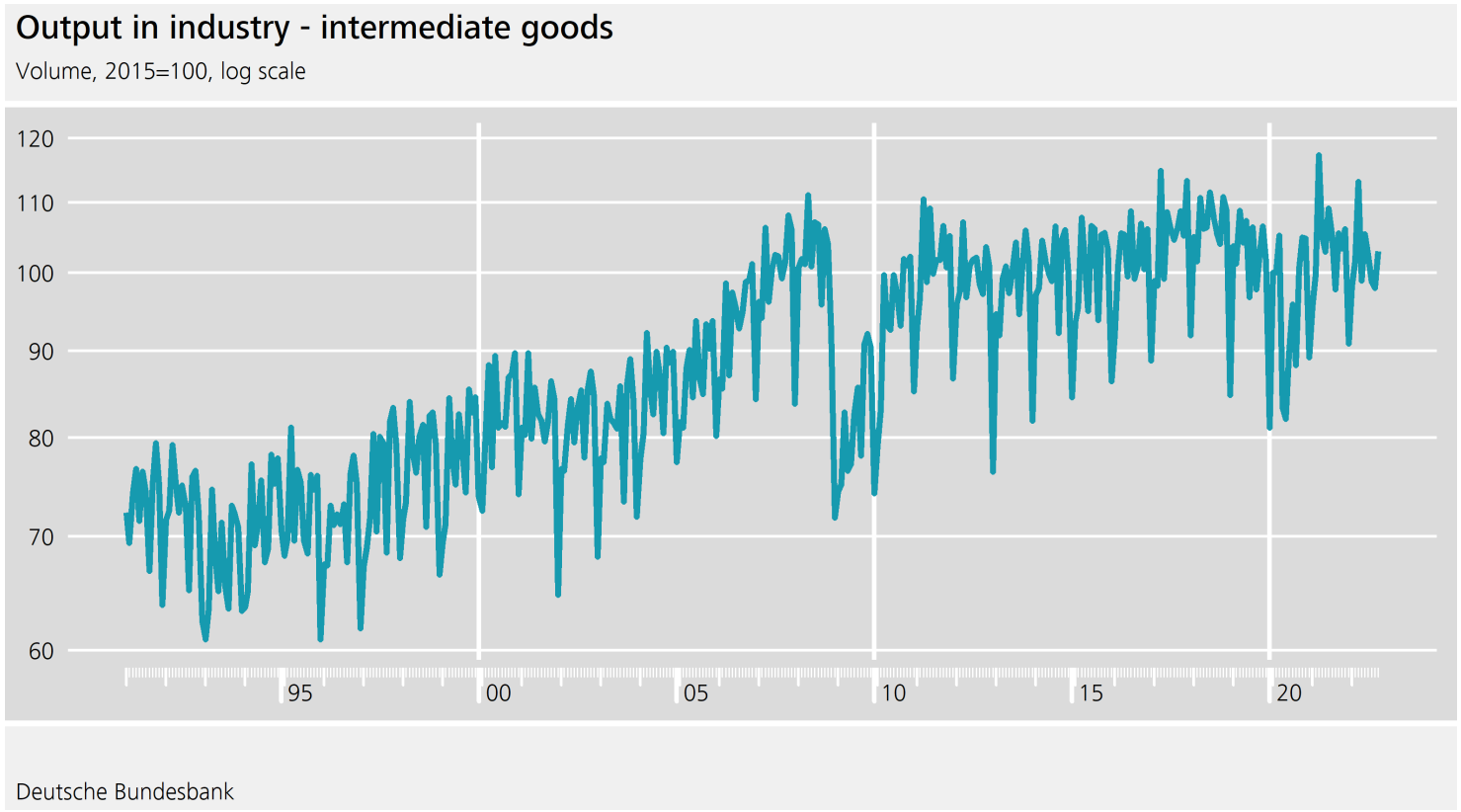
Basic exploration (graph the data)

- Prior to running any seasonal adjustment method
- Helps to …
  - detect "structures" in the series (trend, seasonality, "strange" points or behavior, structural breaks, decomposition, etc.)
  - formulate a global or time series specific decomposition model for the series
- Consider …
  - possible outliers (Are those valid and not a data error?)
  - missing observations (Can you explain them?)
    (too many missing values will cause estimation problems)
  - Aggregates (Is the series part of an aggregate?)
    → ensure same starting and ending dates for all component series

(ESS guidelines, item 2.2)

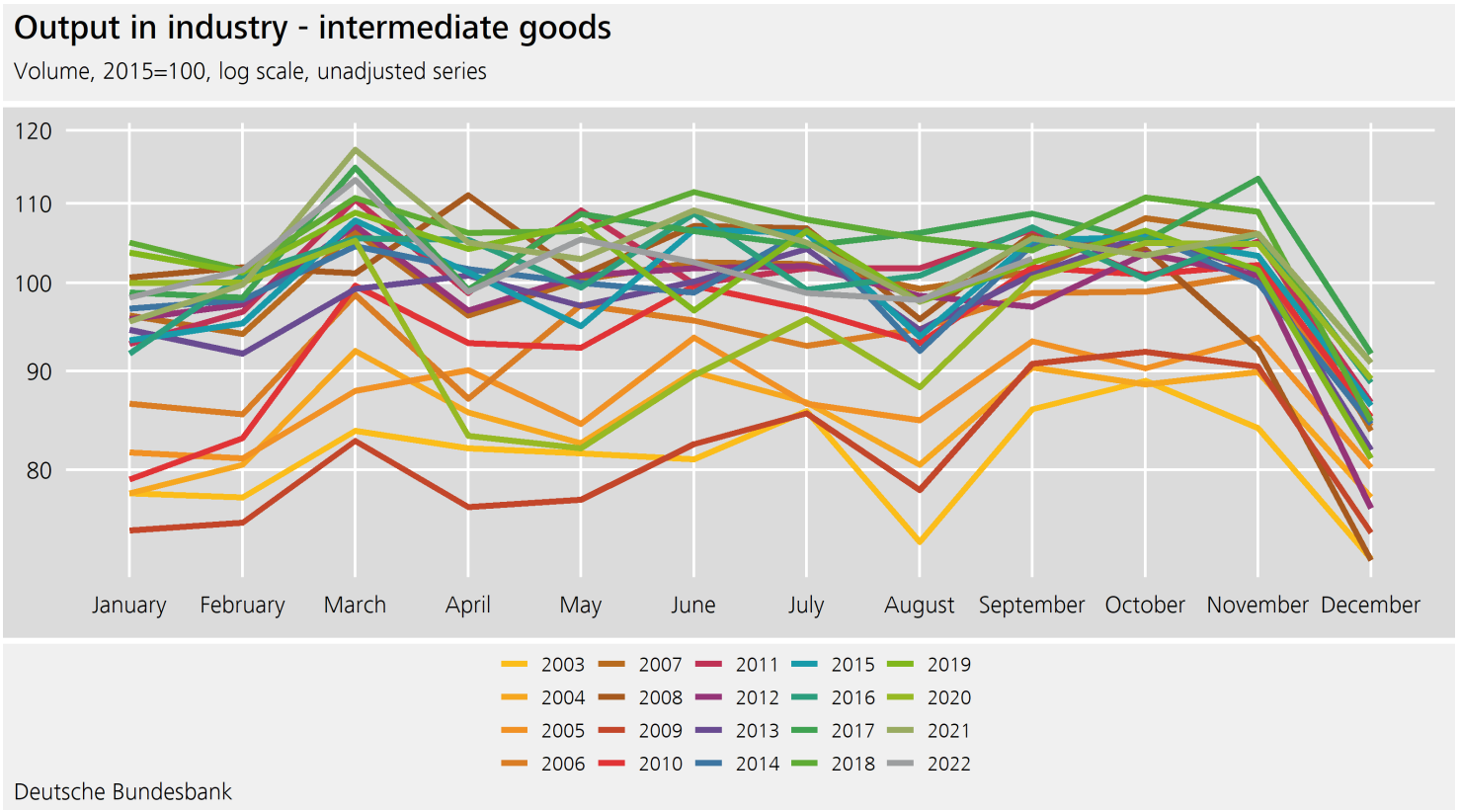
Step 1: Basic exploration (graph the data)

Time-series plot



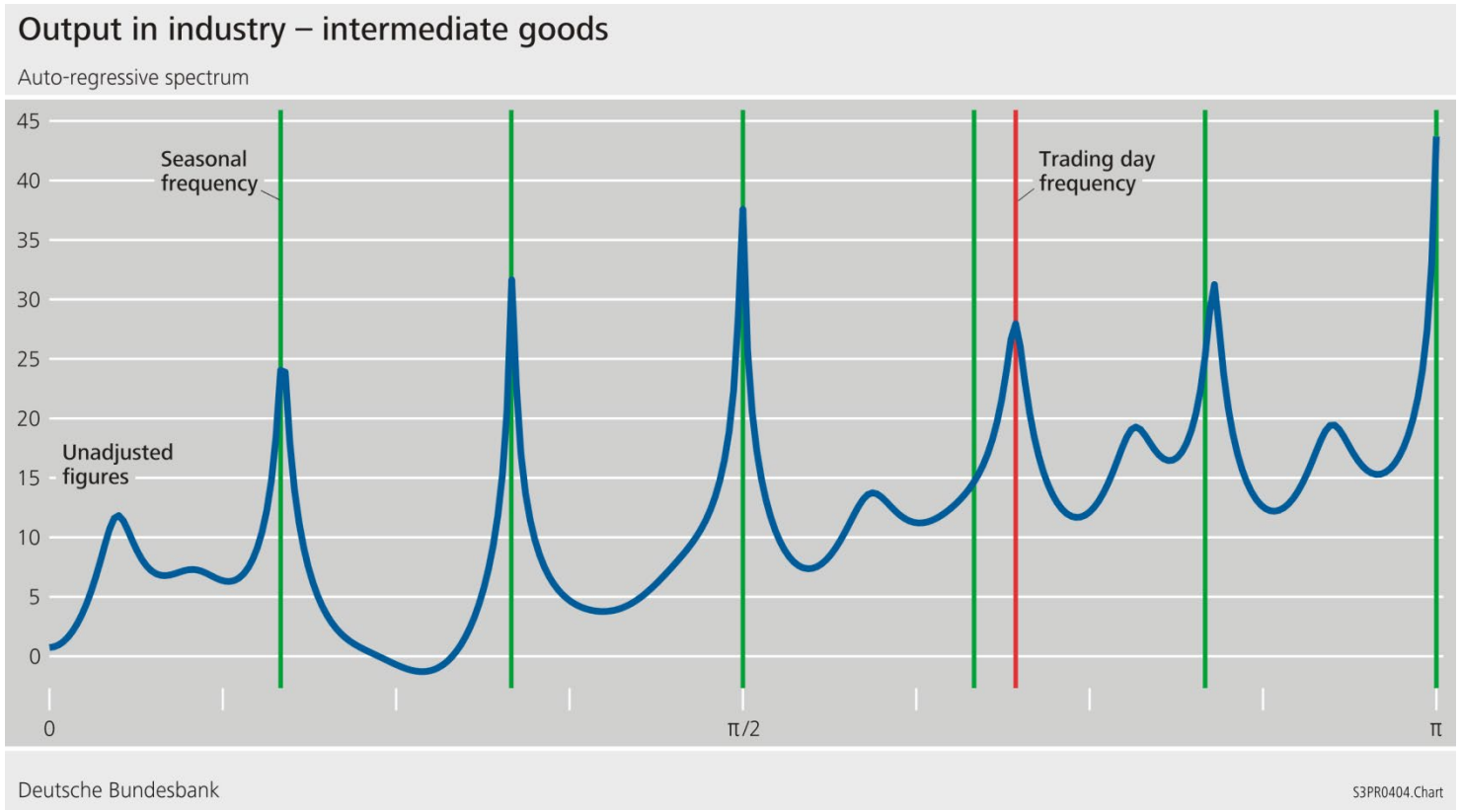
Step 1: Basic exploration (graph the data)

Yearly components plot



Step 1: Basic exploration (graph the data)

Spectrum plot



Step 2: Constant in variance

Transformation and decomposition

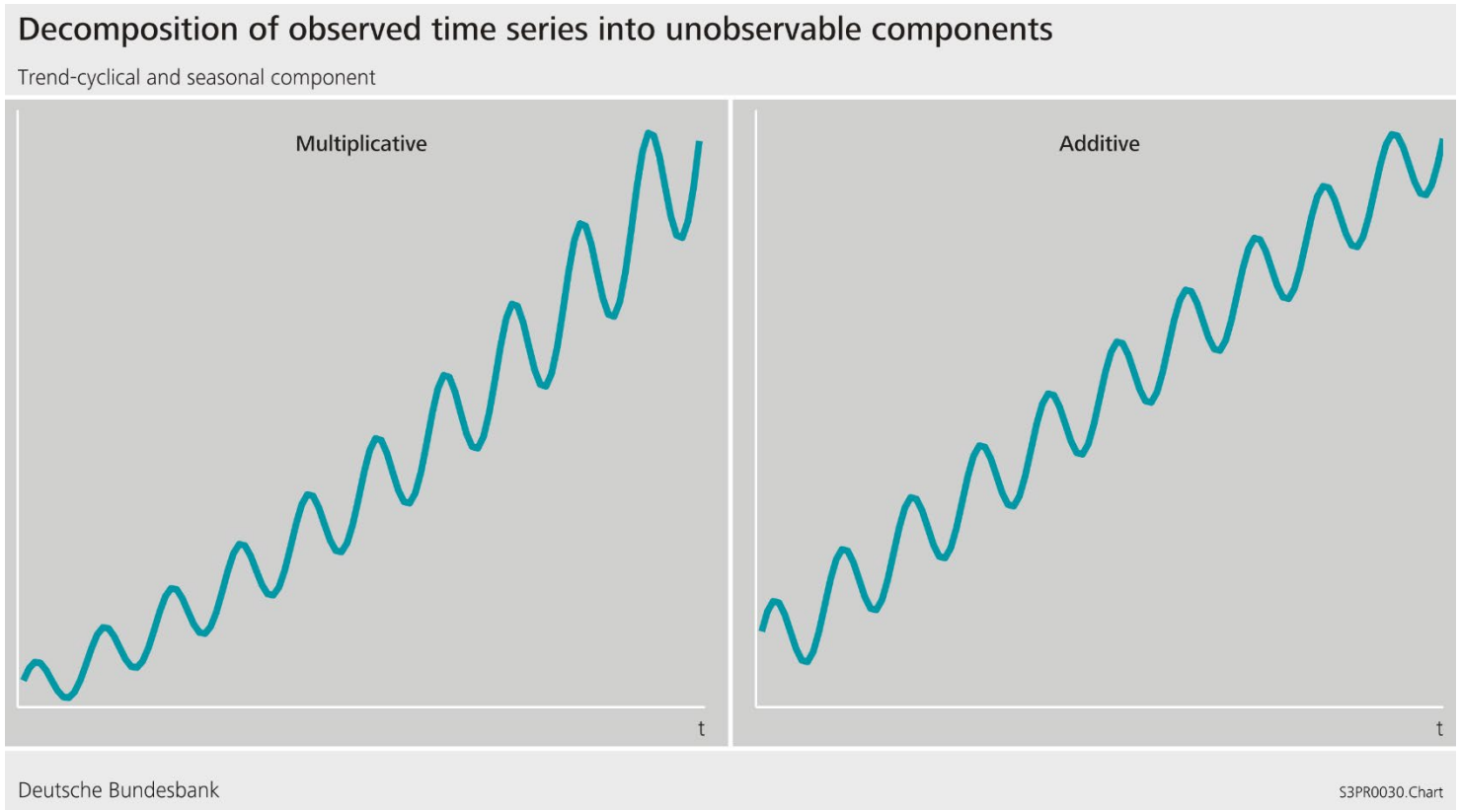
- Graphical inspection
- Compare different options with the aid of
  - information criteria
  - automatic decomposition scheme selection
- Special investigations for series with zeros or negative values
  - e.g. adding a constant before testing the decomposition scheme
- Use of non-automatic selection for more problematic series
  - e.g. if the series has a decreasing level with positive values close to zero

→ If the diagnostics for choosing between additive and multiplicative decomposition models are inconclusive, you can chose to continue with the type of transformation used in the past to allow for consistency between years

(ESS guidelines, item 2.10)

Step 2: Constant in variance

Transformation and decomposition



Step 2: Constant in variance

Transformation and decomposition

- Box-Cox transformation

$$Y_t \rightarrow y_t = \begin{cases} \log(Y_t) & \lambda = 0; \\ \lambda^2 + (Y_t{}^{\lambda} - 1)/\lambda & \lambda \neq 0. \end{cases}$$

- Special cases:
  - $\lambda = 0$ log
    → multiplicative model
  - $\lambda = 1$ level
    → additive model

- JDemetra+ offers a log-level test based on information criteria

Example:
Output in industry – intermediate consumption

- No transformation (Level):
  - AIC: 1114.36
  - AICC: 1115.73
- Log transformation:
  - AIC: 1085.77
  - AICC: 1087.35
- Auto:
  - Log transformation is chosen

Step 3: Calendar effects

- Which regression effects are plausible?
  - trading day/working day
  - leap year
  - moving holidays (e.g. Easter, End of Ramadan, Thanksgiving)
  - national holidays
- If the effects …
  - …are not plausible for the series → do not model calendar effect
  - …are not statistically significant → do not model calendar effect
  - …are marginally statistically significant → model calendar effect if there is an economic reason to keep them in the model

(ESS guidelines, item 2.3)

→ In more detail on day 2

Step 4: Outliers

- Check for different types of outliers
  - with exogenous knowledge
  - with the aid of graphical inspection
  - with the automatic outlier detection
- Outliers due to data errors should be corrected in the unadjusted data before pre-treatment
- Outliers with clear interpretation possibility are included as regressors in the model, even if their effects are somewhat below the general significance level

(ESS guidelines, item 2.7)

→ **In more detail on day 2**

Step 5: ARIMA modelling

- Find an appropriate model via
  - the Box-Jenkins approach
  - check for model adequacy using standard statistical tests (normality, heteroscedasticity, serial correlation, etc.)

    (automatic model identification can be used in a first step)

(ESS guidelines, item 2.9)

- Fix the model and re-estimate the coefficients only with each new observation until the next annual campaign

(ESS guidelines, item 4.2)

- Focus:
  - filter-based approach: best forecast
  - AMB approach: best decomposable model

Step 6: Check the filters (X-11 only)

- Set the trend filter length
  - according to the I/C ratio
- Set the seasonal filter length
  - according to the amount of moving seasonality (moving seasonality ratio) and/or heuristics and additional expert knowledge
  - possibly different for different months/quarters (ESS guidelines, item 3.6)
- Check extreme value procedure settings
  - sigma limits
  - calculation of the standard deviation

→ **In more detail on Day 2**

Step 7: Residuals/Irregular component

- Check for absence of seasonal and calendar effects
  - in the seasonally adjusted
  - in the irregular component
  - model residuals
- Tools
  - spectral graph: in case of residual seasonality or residual calendar effects check the model and regressors
  - Normality statistics
  - Ljung-Box Q-statistics
- Check indirectly seasonally adjusted series

→ **In more detail on Day 2**

Step 8: Stability diagnostics

- Sliding spans
- Revisions history
- Model stability

→ Large revisions and instability indicated by the revisions history and sliding spans diagnostics indicate severe problems with the identification of a seasonal pattern

→ **In more detail on Day 3**

Step 9: Publication policy

- Issue a reference paper as a separate publication together with the quality report (if it is available) once a year, including the following information:
  - seasonal adjustment method in use
  - decision rules for the choice of different options in the program
  - aggregation policy
  - outlier detection and correction methods
  - decision rules for transformation
  - revision policy
  - description of the Working/Trading Day adjustment
  - contact address

European Commission

References

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Hylleberg, S (ed.) (1992), Modelling Seasonality, Oxford University Press, Oxford.

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The end of part I

JDemetra+ in R

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Technical requirements

- Base R (≥3.6.0)
  - R: The R Project for Statistical Computing (r-project.org)
  - cheatsheets/base-r.pdf at main · rstudio/cheatsheets · GitHub
- Package {RJDemetra} (0.1.19)
  - CRAN - Package RJDemetra (r-project.org)
  - GitHub - jdemetra/rjdemetra: R interface to JDemetra+
- Java SE Runtime Environment (JRE) (≥8)
- Package {rJava} (≥0.9)
  - CRAN - Package rJava (r-project.org)

Recommended

- Rstudio
  - Download the RStudio IDE - RStudio
  - cheatsheets/rstudio-ide.pdf at main · rstudio/cheatsheets · GitHub
- Rtools
  - Using Rtools4 on Windows (r-project.org)

RJDemetra

- R interface to JDemetra+
  - Specifications
  - Multidocuments
  - Workspaces

⇒ Script based specification of seasonal adjustment

⇒ Direct access to...

  - Results of prior computations for seasonal adjustment
  - Seasonally adjusted series for further computations

R code

- Part 1: Introduction to R & Rstudio
  - Variables
  - Dataframes
  - Lists
  - Time series
  - Help
- Part 2: Introduction to RJDemetra
  - Installation
  - Predefined specifications
  - Customisation
  - Results
  - Workspaces