

# Self-Training in Time Series Analysis

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# Acknowledgements

⇒ Beside the authors, Laurent Seinlet and Stefano Ugolini have also participated to the project

⇒ We thank them as well as

✓ Hassane Njimi and Marc Hallin - *ULB, Brussels (B)*

✓ Jan Beirlant and An Carbonez - *UCS, KULeuven (B)*

✓ André Klein - *University of Amsterdam (NL)*

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Navigation within the course

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# Table of contents

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Characteristics of the course

Navigation within the course

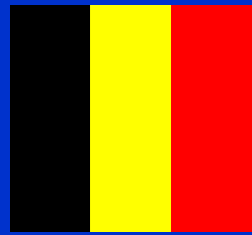
Exercises

Documents and assessment

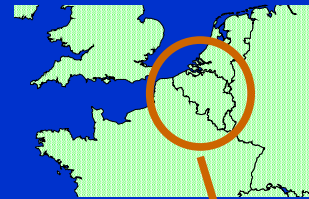
Excerpts from the advanced course

Conclusions

# Belgium



- ⇒ European country of 30000 km<sup>2</sup> and 10 millions inhabitants
- ⇒ Between France, Germany, Luxembourg and the Netherlands
- ⇒ Constitutional Kingdom
- ⇒ 3 languages : Dutch, French, German
- ⇒ 3 regions : Flanders, Wallonia, Brussels
- ⇒ Location of several European institutions including the Commission and the Parliament



# National Bank of Belgium

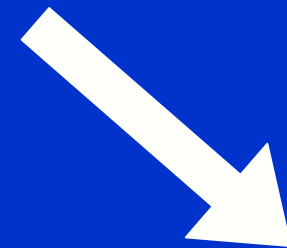


Central bank,  
but with more and more statistical activities

Financial statistics

General economic statistics

national and regional accounts,  
international commerce,  
business cycle surveys



diffusion of  
these statistics

Priority towards quality of the statistics

# General Statistical Department



- ⇒ Audience with scattered ages (20-60)
- ⇒ French speaking and Dutch speaking
- ⇒ From secondary to university education, mainly with an economic background
- ⇒ The large majority has not a strong mathematical orientation
- ⇒ staff > 250

# Training Needs



- ⇒ Provide a general statistical culture to the staff of the department
- ⇒ No development of a statistical tool but
  - ✓ understand what is used
  - ✓ take the best solution to the problem on hand
- ⇒ Two courses : basic statistics (60 h) and time series analysis (30 h)
- ⇒ Self-training with a tutor provided by the Bank rather than training cycles
- ⇒ Practical orientation without too many computations



# Constraints



⇒ Languages :

- ✓ French and Dutch (possibly English for software)

⇒ Tools :

- ✓ office suite + software packages to be delivered

⇒ Recommendations from Eurostat :

- ✓ for seasonal adjustment of time series :

**X12** (Bureau of the Census) and

**TRAMO-SEATS** ([1] V. Gómez et A. Maravall, Bank of Spain)

# Basic course in statistics



⇒ Contents : 13 chapters in 5 parts

Part I

Descriptive Statistics

Part II

Inductive Statistics

Part III

Linear Models

Part IV

Non-parametric Statistics

Part V

Index Numbers

# Time Series Analysis



Contents : 13 chapters

Chapter 0

Introduction to

- ✓ using Excel for time series analysis
- ✓ using Time Series Expert and Demetra
- ✓ using assessment tests

Chapters  
1 to 4

1. Concepts and definitions
2. Simple linear regression
3. Growth curves
4. Smoothing with moving averages

Chapter 5

5. Methods of seasonal decomposition

# Time Series Analysis

*continued*



Chapter 6

6. Exponential smoothing

Chapter 7

7. Multiple linear regression

## **Time series models**

Chapters  
8 à 11

8. Autocorrelation and forecast errors  
9. ARIMA models  
10. Box and Jenkins method  
11. Regression with autocorrelated errors

## **Advanced methods of seasonal decomposition**

Chapter

12. X-12-ARIMA method

Chapter

13. TRAMO/SEATS method

13

# References

## ⇒ Course 1

✓ [3] Moore, D. S. et McCabe, G. P. (1998).

Introduction to the Practice of Statistics ,  
3rd edition, Freeman, New York. (EN + NL)



✓ Wonnacott, Thomas. H. et Wonnacott, Ronald. J (1991).  
Statistique, Economie – Gestion – Science – Médecine,  
4e édition, Economica, Paris. (EN + FR)

## ⇒ Course 2

✓ [2] Mélard, G. (1990)

Méthodes de prévision à court terme,  
Editions de l'Université de Bruxelles, Bruxelles,  
et Editions Ellipses, Paris.



# Submission for course 2



- ⇒ Interactive and multimedia learning system
- ⇒ Integration of voice, image, computational treatment and video
- ⇒ Different pedagogical activities going from learning to self-assessment
- ⇒ Digital media : intranet and/or CD-ROM
- ⇒ Course developed starting with [2] (with 2 new chapters for X-12-ARIMA and TRAMO/SEATS)

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# Characteristics of the course (1/2)

⇒ They depend heavily on the audience and the self-learning situation :

- ✓ simple presentation of the material
- ✓ low use of mathematical formulae
- ✓ organization as an interactive multimedia slide show (100-250 slides per chapter)
- ✓ large number of questions and exercises
- ✓ detailed solutions
- ✓ ...



# Characteristics of the course (2/2)

- ✓ many simulations
- ✓ computing is avoided (software packages used : Microsoft Excel, Time Series Expert & Demetra)
- ✓ frequent recall of the structure
- ✓ frequent reminders of the material
- ✓ navigation by hyperlinks
- ✓ access to instructions and files for the exercises, as well as to the other chapters of the course
- ✓ self-assessment

⇒ We also discuss the advanced part of chapter 13 on the TRAMO/SEATS method

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# Navigation within the course

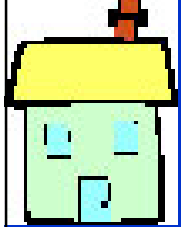
⇒ We start from the menu

⇒ Adobe Acrobat Reader is launched :

The screenshot displays the Adobe Acrobat Reader interface. The title bar reads "Adobe Acrobat - [welcome.pdf]". The menu bar includes "File", "Edit", "Document", "Tools", "View", "Window", and "Help". The toolbar contains various navigation and document manipulation icons. On the left, the "Bookmarks" pane is open, showing a tree structure:

- Main menu
  - Map of the course
    - 1 - Concepts and definitions
    - 2 - Simple Linear Regression
    - 3 - Growth Curves
    - 4 - Smoothing with moving averages
    - 5 - Seasonal Decomposition
    - 6 - Exponential Smoothing
    - 7 - Multiple Linear Regression
    - 8 - Autocorrelation and Forecasting
    - 9 - ARIMA Models
    - 10 - Box and Jenkins Method
    - 11 - Regression with Autocorrelation
    - 12 - X-12-ARIMA Method
    - 13 - TRAMO/SEATS Method

The main content area shows a colorful navigation menu for "Time series analysis, G. Mélard, ULB 2002". The menu is centered around a gear with a portrait of G. Mélard. Surrounding the gear are icons and labels for "Contents", "Basic course", "Advanced course", "Basic exercises", "Advanced exercises", "Help", "Tools", and "Exit". At the bottom of the page, logos for ULB, GIB, and UCS are visible. The status bar at the bottom indicates a zoom level of 53%, page 1 of 15, and a page size of 9.97 x 7.46 in.



# Table of contents of the basic course

⇒ Let us look at the map of the course :

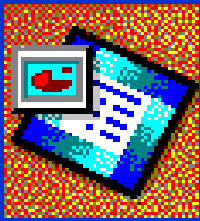
The screenshot shows the Adobe Acrobat interface. The main window displays a PDF document titled "Map of the course" which contains a table of contents for 13 chapters. The left sidebar shows a "Bookmarks" panel with a tree view of the document's structure.

Chapter 1 Concepts and Definitions	Chapter 2 Simple Linear Regression	Chapter 3 Growth Curves
Chapter 4 Smoothing with Moving Averages		Chapter 5 Seasonal Decomposition Methods
Chapter 6 Exponential Smoothing Methods	Chapter 7 Multiple Linear Regression	Chapter 8 Autocorrelation and Forecast Errors
Chapter 9 ARIMA Models		Chapter 10 Box and Jenkins Method
Chapter 11 Regression with autocorrelated errors	Chapter 12 X-12-ARIMA Method	Chapter 13 TRAMO/SEATS Method

Bookmarks sidebar:

- Main menu
- Map of the course
  - 1 - Concepts and definitions
  - 2 - Simple Linear Regression
  - 3 - Growth Curves
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  - 11 - Regression with Autocorrelated errors
  - 12 - X-12-ARIMA Method
  - 13 - TRAMO/SEATS Method

⇒ We can also reach the list of exercises



# A chapter

Adobe Acrobat - [Microsoft PowerPoint - chap01.pdf]

File Edit Document Tools View Window Help

**1. Concepts and Definitions**

*At any time you can send a message to your tutor*

**1.1 Basic concepts**

- Graphs and tables
- Types of time series data
  - Series and variable
  - Example: consumption
  - Example: Starts of holiday
  - Question: Types of time series
  - Types of time series
  - Question: Walt Disney
- Different objectives of time series analysis
  - The treatments
  - Several objectives
    - Smoothing, filtering
    - Model building
    - Forecasting
    - Control
  - Question: Objective of forecasting

**Guy Mélard**

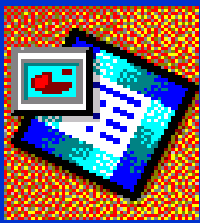
Don't forget to add comments to pages where you want to come back easily

*At any time you can exit this chapter*

51% 1 of 175 11.69 x 8.26 in

Development of a branch

Access to a page



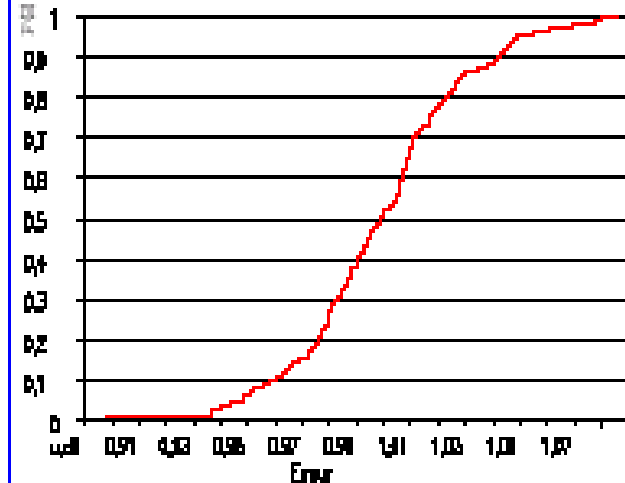
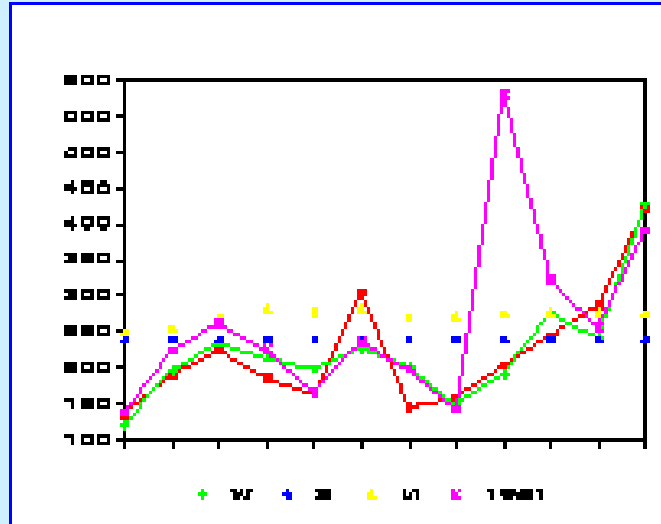
# A page of the course

Message to the tutor

## 1. Concepts and Definitions



At any time you can send a message to your tutor



Annotation of the learner

**Guy Mélard**

Don't forget to add comments to pages where you want to come back easily



At any time you can exit this chapter



Oral explanations

Fast move



# Objectives of a chapter

The  
second  
page of  
the chapter



## Objectives of the chapter

1

*Present the different aspects of time series analysis and forecasting*

*Introduce a certain number of concepts and definitions that will be used during the whole course*

*Show straightly results of an analysis and the manner to compare them with the help of criteria*

*Put some emphasis on forecasting and justify that decision*



# The contents of a chapter

The table of contents is progressively developed

<b>Types of time series data</b>	
<b>1.1 Basic concepts</b>	
⇒ <b>Graphs and tables</b>	
⇒ <b>Types of time series data</b>	
<b>1.2 Forecasting</b>	
<b>1.3 Information set and categories of methods</b>	
<b>1.4 Cost functions and criteria</b>	
<b>1.5 Forecasting intervals</b>	
<b>1.6 Conclusions</b>	



**Remember!**

# The sections

At the end  
of each  
section  
there is  
a synthesis

**Remember!**

## Synthesis

1

You have seen in this section that

- ⊗ what is a time series, in particular,
  - ✓ if the spacing between the data is regular or not
  - ✓ how to distinguish between flow and level variables
- ⊗ what should be done with the time series, i. e. the objectives of treatments : smoothing, decomposition, model building, analysis, forecasting, control

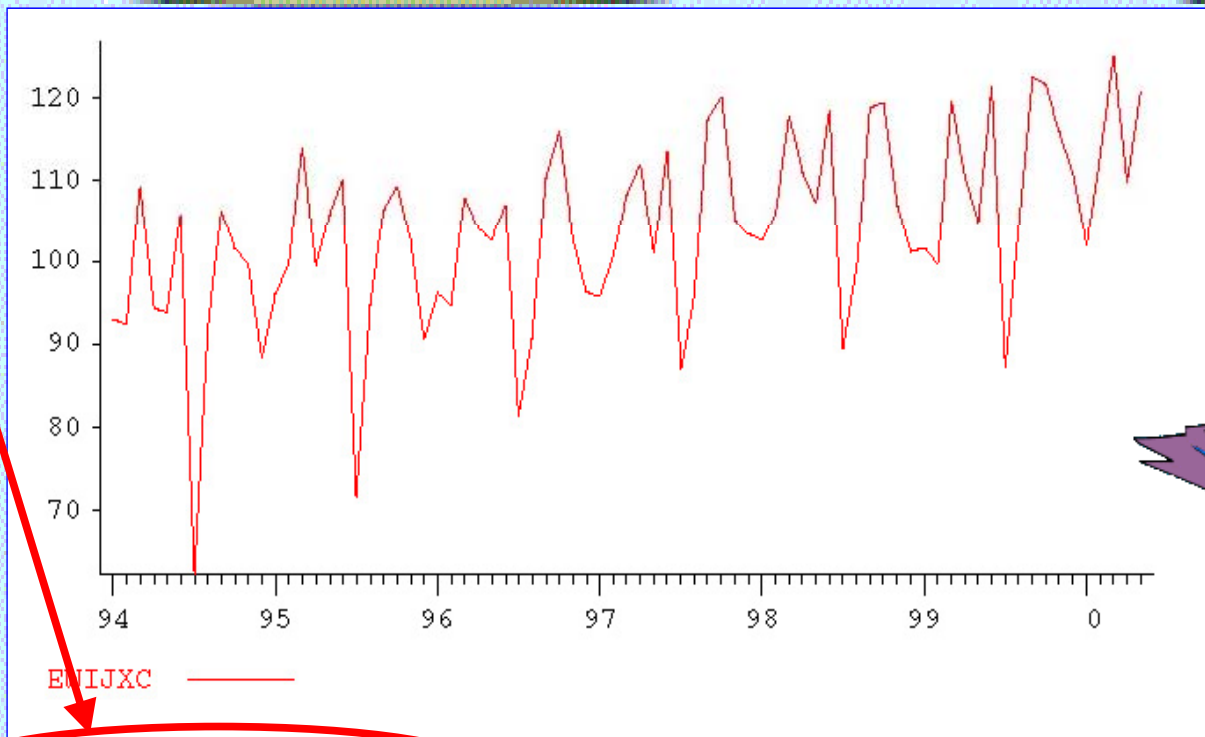
In the meanwhile, we have tackled the problem of using tables and graphs



# The questions

A space for the answer can be found on a paper document.

## Question: Belgian industrial production (1994-2000)



Write your answer on page 1. "We consider the index of the Belgian industrial production, for the whole industry (base year 1995=100). On the basis of a plot and of wise sense, do you think that the series is annual, quarterly, something else?"

**Remark.** Like all the questions, the answer will be given in the main document which corresponds to the present chapter.

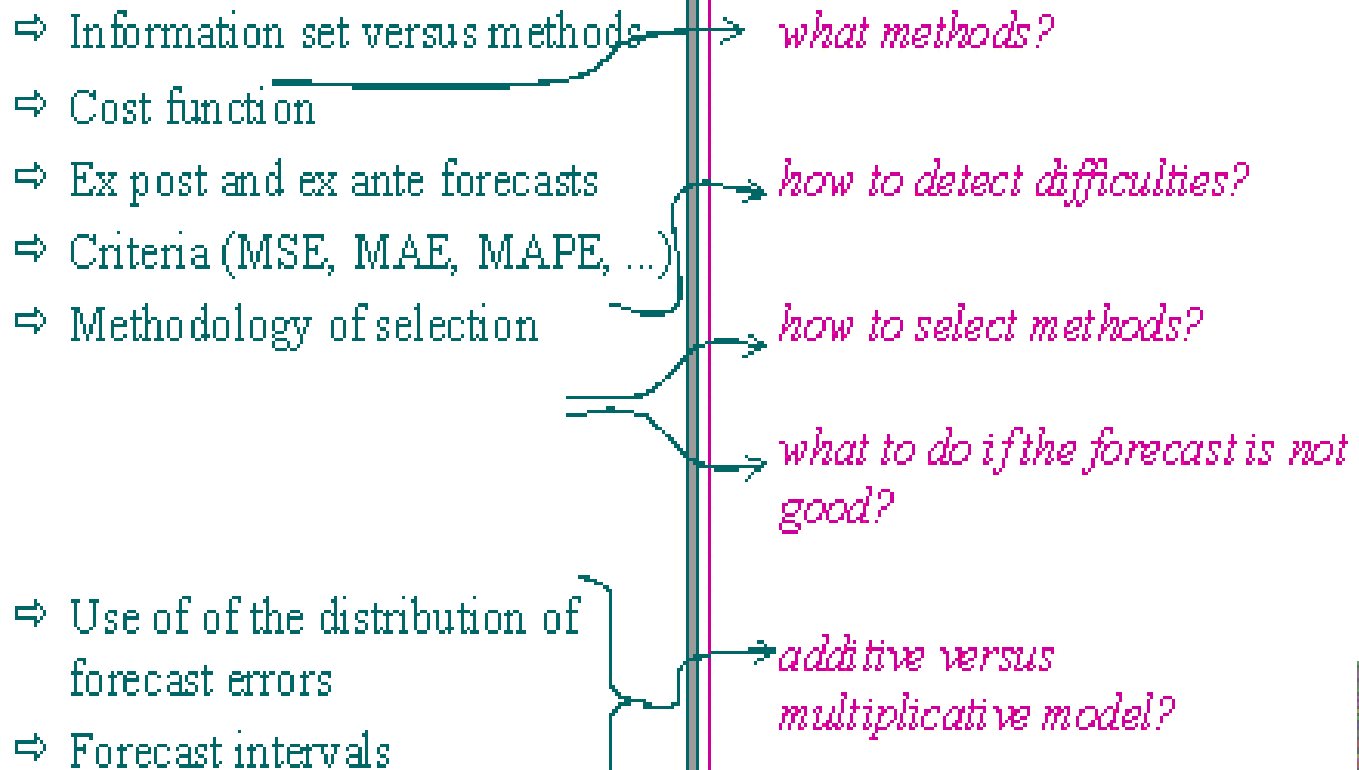




# Conclusions of the chapter

## Conclusion: concepts and definitions

1



They are always vocally commented



# The main part : the exercises

Annotation put here by the learner

Adobe Acrobat - [Microsoft PowerPoint - chap01.pdf]

File Edit Document Tools View Window Help

Bookmarks

- 1.1 Basic concepts
- 1.2 Forecasting
- 1.3 Information set and cate
- 1.4 Cost functions and crit
  - Cost function
  - Criteria in general
  - Different criteria
  - Exercise on the criteria**
  - Conclusion of the exerc
  - Remarks
  - Measure of performanc
  - Criteria applied to ex po
  - Complements : other cr
  - Exercise on the criteria
  - Methodology of selectio
  - Exercise : summary
- 1.5 Forecasting intervals

**Exercise on the criteria**

**Data:** *fictious (4 observations)*

**Purpose of the exercise :** *introduce the criteria (hence the cost functions) on a simple example where the computations are easy*

Instructions (parts 1 and 2)

Example (file CH01EX01.XLS)

Chapter 1 Time Series Analysis, G. Mèlard 123 Concepts and definitions

Access to the instructions, also delivered on paper

The exercise is directly run, here in Excel



# Instructions for the exercises

Adobe Acrobat - [CH01EX01.PDF]

File Edit Document Tools View Window Help

Bookmarks

- Chapter 1, exercise 1 Instructions
  - Basic exercise (For all the users)
    - Part 1
    - Part 2**
    - Advanced exercise (For the users)
      - Part A

Analyse de séries temporelles Guy Mélard

**Part 2** The purpose here is to study thoroughly the meaning of the MAPE criterion for each of the two methods. To do that, we will ask you several times to change the forecasts obtained by one or the other of the methods.

**2.1 EXAMINATION OF NEW DATA AND FORECASTS FOR METHOD I**

- ⇒ Come back to the initial data and forecasts. In order to do that, activate the macro CH01EX01Initial (if there is no other open workbook, the combination of keys CTRL SHIFT I will activate the macro).
- ⇒ Click on tab Second to see the new data.

For method I, they are identical to the previous ones except on the first row (line 11) : instead of 10, there is 100. Instead of the forecast 7, there is 97. The forecast error is thus equal to -3 like before.

- ⇒ Click on tab Main to see the previous results and come back quickly to worksheet Second.

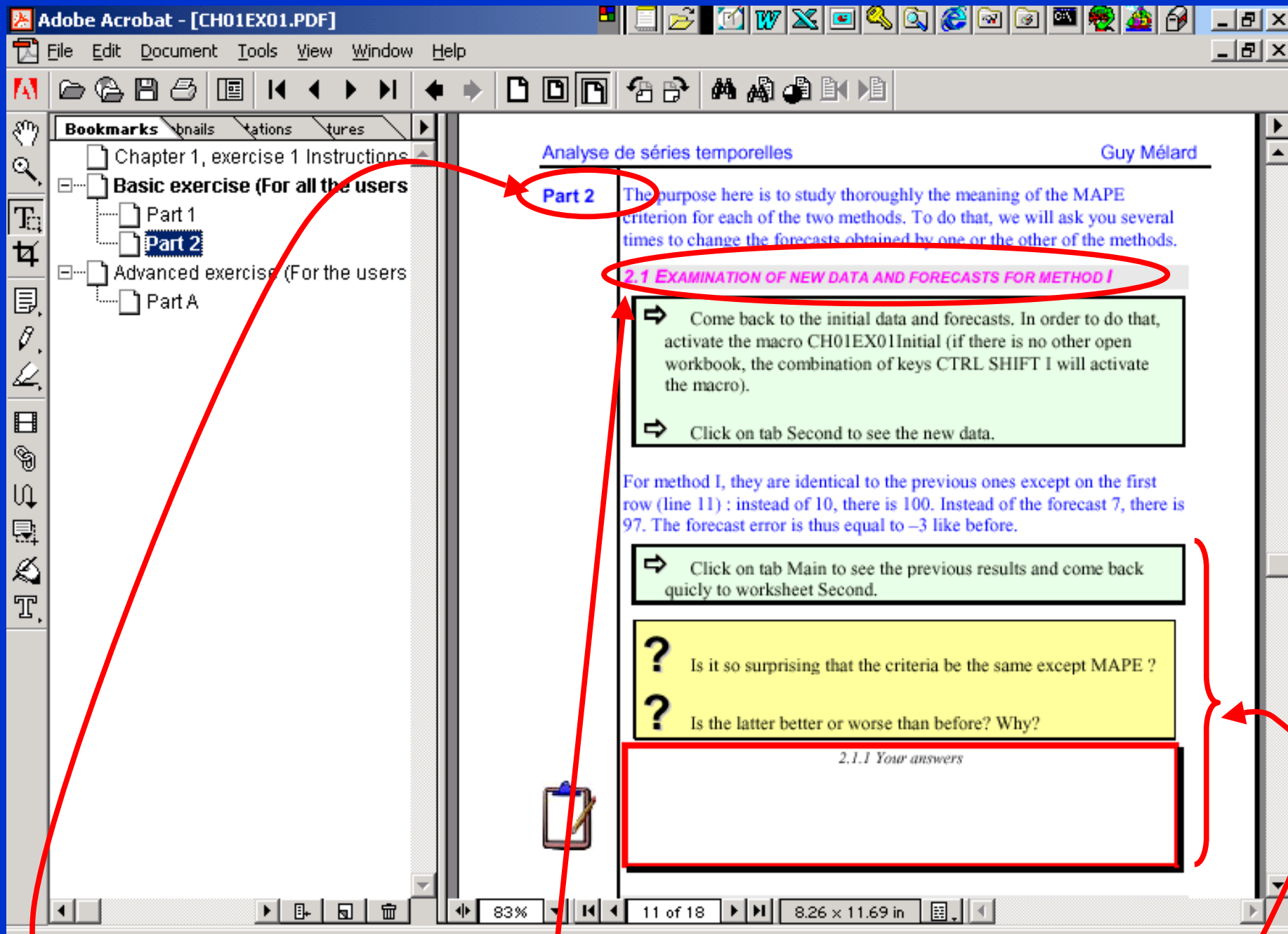
? Is it so surprising that the criteria be the same except MAPE ?

? Is the latter better or worse than before? Why?

2.1.1 Your answers

83% 11 of 18 8.26 x 11.69 in

Navigation within the instructions



part

section

instructions, questions, space for the answer



Click on tab Main to see the previous results and come back quickly to worksheet Second.



Is it so surprising that the criteria be the same except MAPE ?



Is the latter better or worse than before? Why?

*2.1.1 Your answers*

Instructions

Questions

Space for  
the answer



## EXCERPTS FROM THE MAIN DOCUMENT OF THE CHAPTER

### *Part 2*

2.1.1 The criteria have not changed because the errors have not changed. The exception is MAPE which is smaller because one of the data has been increased, hence the corresponding ratio in MAPE is smaller.





# Conclusions of the exercise

The main results of the last exercises are recalled

## Conclusion of the exercise

I hope this exercise as allowed

- ⇒ to introduce more concretely the various criteria defined in the previous pages
- ⇒ for each one, to perceive its advantages and drawbacks concerning the effect of a change of measurement unit, restrictions to positive values, sensitivity to atypical data
- ⇒ to recognize that a method A can be better than a method B for a given criterion whereas B is better than A for another criterion

This allows to a learner already at a more advanced level to have a **sketch** of the contents of the exercises





# Reminder of the material

These **reminders** allow to situate the subject and to recall the terminology and the notations

**Reminder of chapter 2** **Correlation coefficient  $r$  and determination coefficient  $R^2$**

⇒ Definition of the correlation coefficient: ratio of the covariance by the product of standard deviations:  $r = \frac{s_{xy}}{s_x s_y}$

⇒ Determination coefficient = square of the correlation coefficient:  $R^2 = r^2 = \left( \frac{s_{xy}}{s_x s_y} \right)^2$

⇒  $R^2$  is the *proportion of the variance of  $y$  explained by the linear regression*

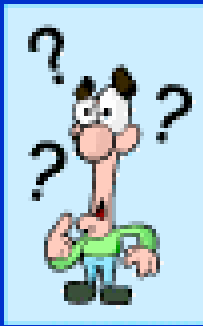
⇒ Link between  $R^2$  and MSE:

$$\text{MSE} = s_y^2 (1 - R^2)$$

Write your answer at page 14  
"What do you think will be kept and what will be suppressed?"

Chapter 7 Time Series Analysis, G. Méléard 55 Multiple regression

Each page of the course has a **number** of the chapter and its **title** (abbreviated here) 33



# The virtual learner and the virtual trainer



The class metaphor is used from time to time to lower the tension and improve the transitions

**Towards another methodology?**

*Am I really obliged to compare several methods in order to know which one is good or bad?*

*You are wright. It is not necessary to do that. I have presented things that way for reason of ease. Many people make just use of two or three forecasting methods*

*Let me know I am not in that case! My series are more complex than your example. I am not in any of the situations you have sketched. Besides, I am not only interested in forecasting*

Chapter 8 Time Series Analysis, G. Méléard 26 Autocorrelation and forecast errors


The course can be followed at two levels, basic and advanced. For two chapters (6 and 13), there are specific presentations for the advanced course



# The advanced course



Some parts of the presentation (identified by a yellow background) are reserved to those learners wishing to achieve a more advanced training in the domain of time series analysis



## Variant (see advanced course)

Sometimes it is better to use *ratios* than *differences* for measuring forecast errors

- ⇒ The assumption of *homogeneity* may be better valid that way, which means the fact that all the forecast errors come from the same statistical distribution
- ⇒ This will be illustrated in chapter 5
- ⇒ The forecast interval is then based on a multiplicative model  $\hat{y} = y * e$

**Remark:**

Of course, in that case, we could also consider a model on the logarithms of the data, see chapter 2

Chapter 1 Time Series Analysis, G. Mélard 169 Concepts and definitions

# The exercises of the advanced course



The exercises of the advanced course are identified (with a yellow background again ; parts are identified using letters instead of numbers)

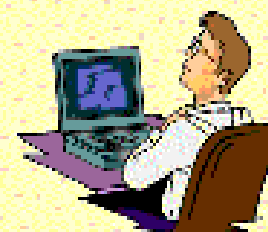
## Exercise on forecasts

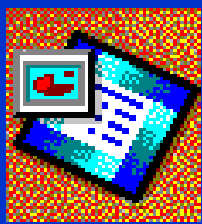
**Data** : 20 forecast errors

**Purpose of the exercise** : *introduce probabilistic forecasting and the construction of forecast intervals in the case of a multiplicative model*

⇒ Instructions (part A)

⇒ Exercise (file CH01EX03.XLS)





# Back to the basic course

## Global test of randomness (2/4)

⇒ The test statistic bears the name of Box and Pierce:

$$Q = T \sum_{k=1}^K r_k^2 \quad \chi = \text{greek letter chi}$$

⇒ If the process is white noise and if  $T$  is large enough, the distribution of  $Q$  approximately follows a  $\chi^2$  law (chi-square) with  $K$  degrees of freedom

⇒ We should therefore reject the hypothesis that the first  $K$  autocorrelations of the process are equal to 0 if the  $Q$  statistic is greater than the quantile of order 0.95 of the  $\chi_K^2$  law

⇒ Instead of Box-Pierce, we can use the Ljung-Box test

*For the basic course* →

page 180

Chapter 8 Time Series Analysis, G. Molodtsov

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Autocorrelation and forecast errors



*For the basic course* →

page 180

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# Exercises

⇒ Nearly all of them make use of a *software package*:

- ✓ **Excel** for many exercises in chapters 1 to 8, plus 13, including:
  - linear and nonlinear regression, exponential smoothing
  - seasonal decomposition on artificial series
  - details on the first steps of the Census X-11 method
  - spectral analysis and optimal filtering
- ✓ **Time Series Expert** for some exercises of chapters 2-11, mainly on real time series
- ✓ **Demetra** for chapters 12 (X-12 ARIMA) and 13 (TRAMO/SEATS)





# Excel workbooks

To access a worksheet, click on the requested tab

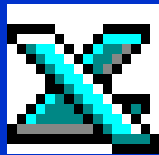
14	Index	Error	Middle	Prob.	Future va
15	0		-32.0	0.00	11
16	1	-28	-21.5	0.05	12
17	2	-15	-13.5	0.10	13
18	3	-12	-10.5	0.15	13
19	4	-9	-8.0	0.20	14
20	5	-7	-7.0	0.25	14

Navigation buttons: Main / ErrA / FutValA / ErrM / FutValM / Distribution / Second / language

Make use of the video buttons to access tabs.

Language worksheet (see below)





# Language

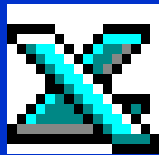
Workbooks are multilingual.  
All the texts are  
formulae which refer to a cell  
in the "languages" worksheet  
**here in French**

A4	=INDEX(trans;4;lang)			
A	B	C	D	
2	Chapitre 5, tableaux 5.29, 5.31, 5.3			
3				
4	Pour accéder au tableau désiré, pres			
5	<a href="#">Les composantes</a>			
6	<a href="#">Coefficients saisonniers (par</a>			
7	<a href="#">Extension d'un an aux deux ext</a>			
8	<a href="#">Première moyenne mobile d'ordr</a>			
9	<a href="#">Seconde moyenne mobile d'ordr</a>			
10	<a href="#">Remplacement des valeurs extré</a>			
11	<a href="#">Tendance C.F. Ex. 11.1</a>			

Navigation: Main / STAT / SAIS / RATIO / languages

	A	B	C	D
1	Language		1	
2			1	2 3
3		Français	Nederlands	English
4	1	METHODES DE PREVISION A	KORTE TERMIJN	SHORT-TERM
5	2	Chapitre 5, tableaux	Hoofdstuk 5,	Chapter 5, tables
6	3	à 5.35 et 5.37 AVEC	tot 5.35 en 5.37	to 5.35 and 5.37
7	4	Pour accéder au tableau désiré, presser la touche F5	Om toegang te hebben tot de gewenste tabel, druk op F5 en	To access the desired table, press F5 and select
8	5	Les composantes	De componenten	The components

Navigation: Main / STAT / SAIS / RATIO / languages

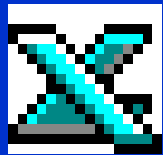


# Language

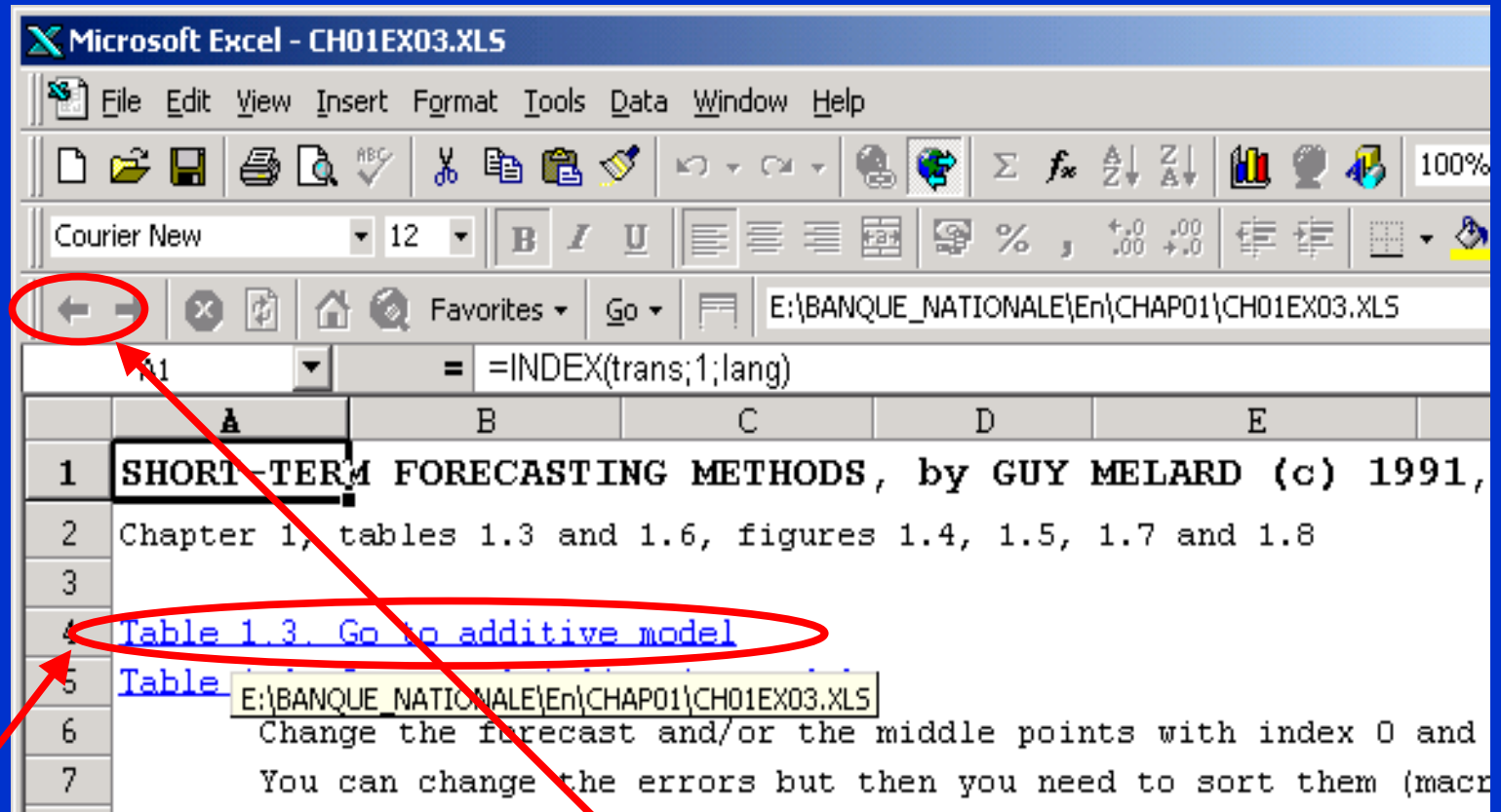
Workbooks are multilingual.  
All the texts are  
formulae which refer to a cell  
in the "languages" worksheet  
**here in English**

A4	=INDEX(trans;4;lang)
1	SHORT-TERM FORECASTING METHODS, by C
2	Chapter 5, tables 5.29, 5.31, 5.32,
3	
4	To access the desired table, press F
5	<a href="#">Tables 5.29 and 5.32: the com</a>
6	<a href="#">Table 5.31: seasonal coeffici</a>
7	<a href="#">Extension of one year at the</a>
8	<a href="#">First moving average of order</a>
9	<a href="#">Second moving average of orde</a>
10	<a href="#">Replacement of extreme values</a>
11	<a href="#">Product SxE of step B4 with e</a>

lang	= 3			
1	Language	3		
2		1	2	3
3	Français	Nederlands	English	
4	1 METHODES DE PREVISION A COURT TE	KORTE TERMIJN	SHORT-TERM FORECASTING	
5	2 Chapitre 5, tableaux 5.29,	Hoofdstuk 5, tabellen	Chapter 5, tables 5.29,	
6	3 à 5.35 et 5.37 AVEC	tot 5.35 en 5.37	to 5.35 and 5.37 WITH	
7	4 Pour accéder au tableau désiré,	Om toegang te hebben	To access the desired	
	presser la touche F5 et	tot de gewenste	table, press F5 and	
	sélectionner le nom	tabel, druk op F5 en	select the name	
		kies de naam		



# To move in a workbook



The simplest way: using predefined hypertext links.

- These fields are colored (blue or brown) and underlined
- Simply click on the link to reach the place
- Coming back can be done with the Back arrow on the Web toolbar



# Data entry

Most data and formulae are already entered. Therefore the sheets are protected except fields where parameters can be changed with a message indicating what is expected.

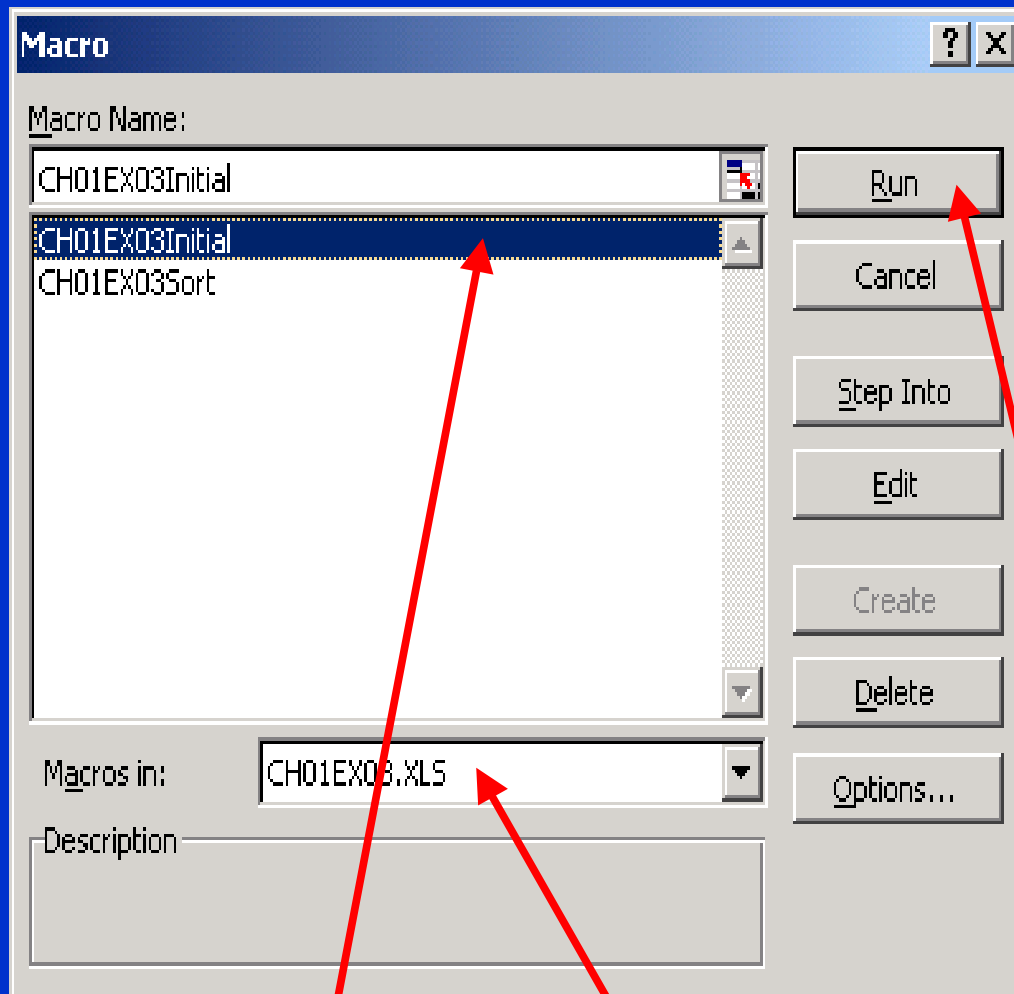
	A	B	C	D
44	Index	Error	Middle	
45	0		0.350	
46	1	0.393		
47	2	0.607		
48	3	0.670		
49	4	0.741		
50	5	0.792	0.792	

Enter a number smaller than the next number

There are sometimes constraints on the number being entered. The keyboard is also used to generate **random data** for simulation purposes (recalculation key F9)



# Call a macro



Macros are used in order to:

- restore initial data after a modification

- perform animations

Other capabilities of Excel are also used:

- scenarios

- tables of hypotheses

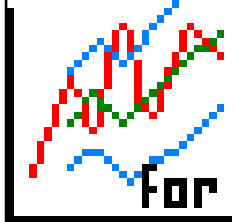
- matrix calculation

- Solver module

- complex numbers

- Check if the name of the workbook appears.

- Select the name of the macro and click on Run.



# Time Series Expert

We use an improved demonstration version of the home-made package, based on the one freely available on the Internet.

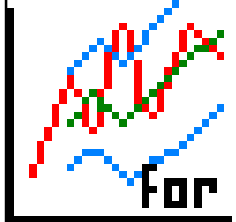
TSE

Time Series Expert. Release 2.34.

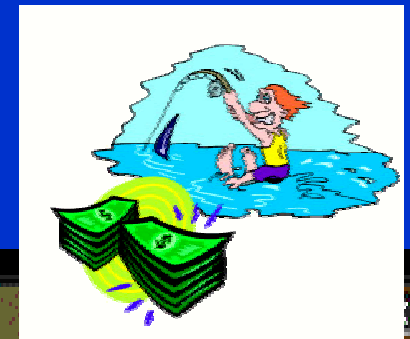
License to Soco Informatique Réseau 10 postes. Serial number : 9999

by  
Philippe BOECKX, Eric BRANCKAERT, Guy MELARD & Jean-Michel PASTEELS  
December 2000 / INFO-SOCO U.L.B.

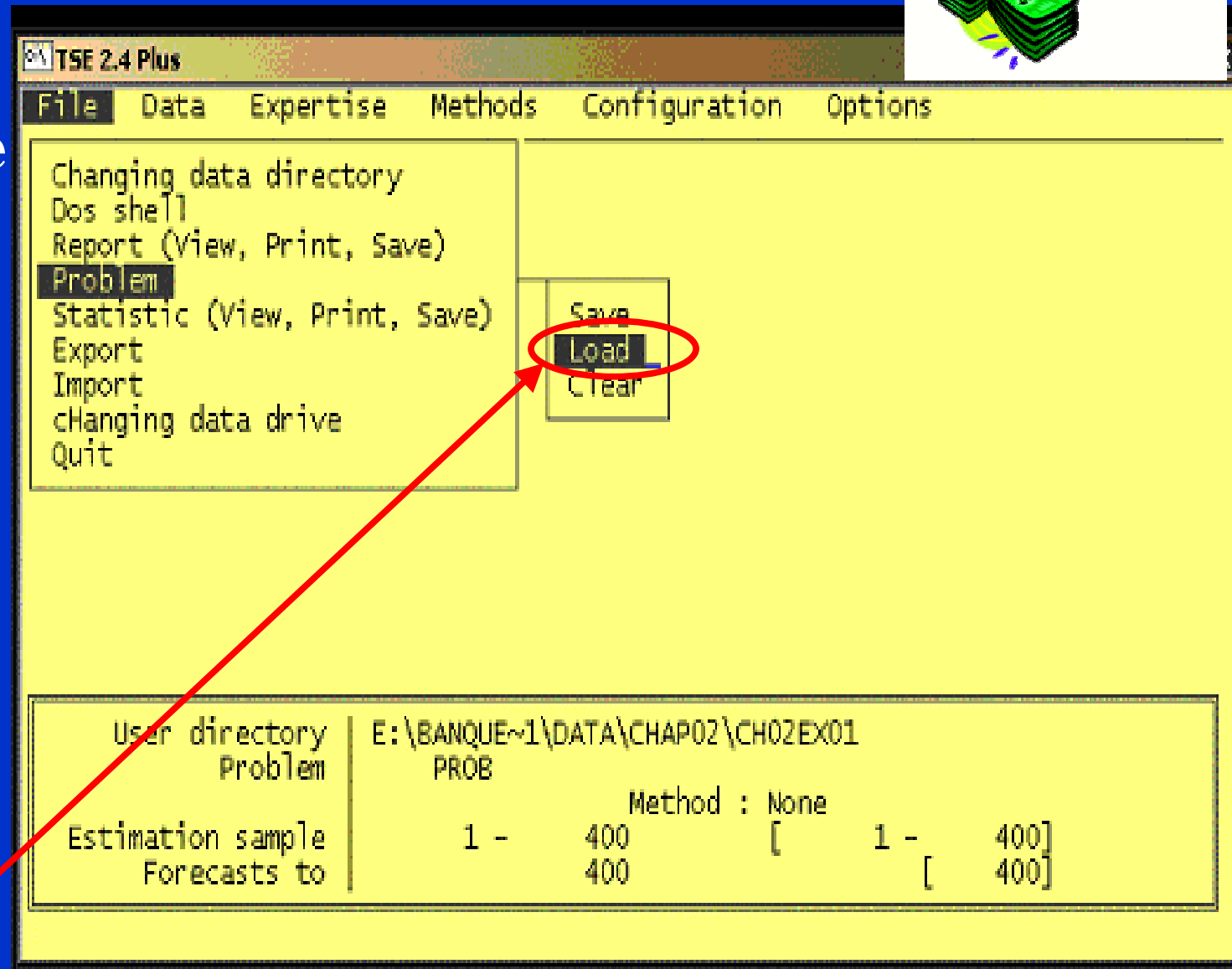
Address : Prof. G. MELARD, ISRO, Campus Plaine U.L.B. CP 210,  
Boulevard du Triomphe, B-1050 Bruxelles.  
Phone : +32-2-6505990, Fax : +32-2-6505999, E-mail : gmelard@ulb.ac.be  
Collaborators : Atika Cohen, Annie Laforet & Bertrand Hareschal.  
Supported by  
Communauté Française Wallonie-Bruxelles  
Ministère de l'Éducation, FRSSFC-IH (1988-1994), ARCC(1996- )



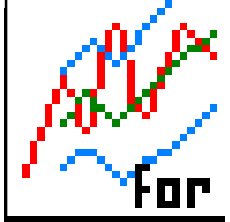
# How to use it



First select the folder  
then load a  
prepackaged  
*problem*  
entirely  
prepared  
for the  
exercise



⇒ File ⇒ Problem ⇒ Load ⇒ Holiday



# Contents of a problem



A problem includes the data series (**CHAMPC**), its dates, the method to be used, here exponential smoothing) and the options, for example under

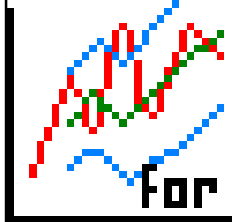
```

Exponential Smoothing
Level & Trend           : Level
Seasonality             : None (add Level & Trend)
Intervention           : Select Interventions
Power transformation (Box-Cox) : 1.0
Parameter/deterministic seasonality : Select Initial Values/Options
Save residuals          : Yes on name: RESSES
Save forecasts or predictions : Yes on Name: FORSES
Save fitted values     : Yes on Name: F2SES
Leadtime for fit       : 1
Forecast interval probability (%) : 80
{S} to save / {ENTER} to validate / {SPACE} to Change / {ESC} to Escap

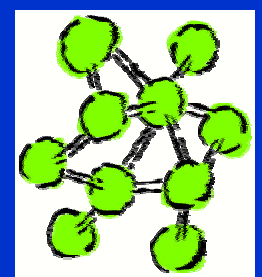
User directory | E:\BANQUE~1\DATA\CHAP06\CH06EX05
Problem        | CHSES
Dependent variable | CHAMPC      Method : Exponential smoothing
Estimation sample | 1962.01 - 1969.12 [1962.01 - 1995.04]
Forecasts to    | 1970.09          [1995.04]
  
```

which name the forecasts will be stored, in this example : **FORSES**





# Graphical aspects

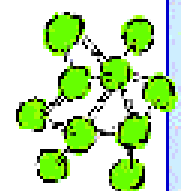
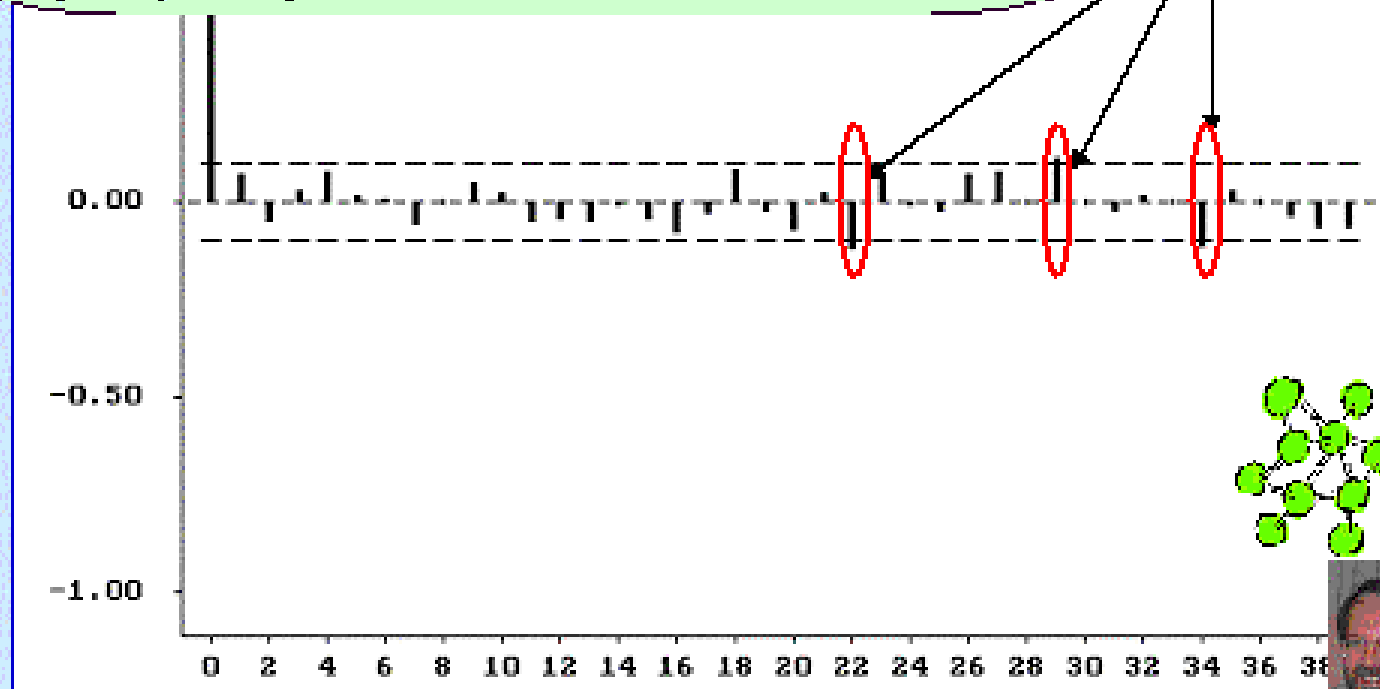


The accent is put on graphical aspects, for

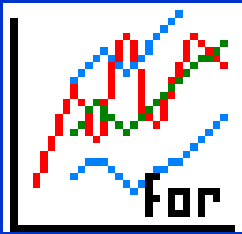
- data plots
- scatter diagrams
- autocorrelations

## The correlogram of series BLANC

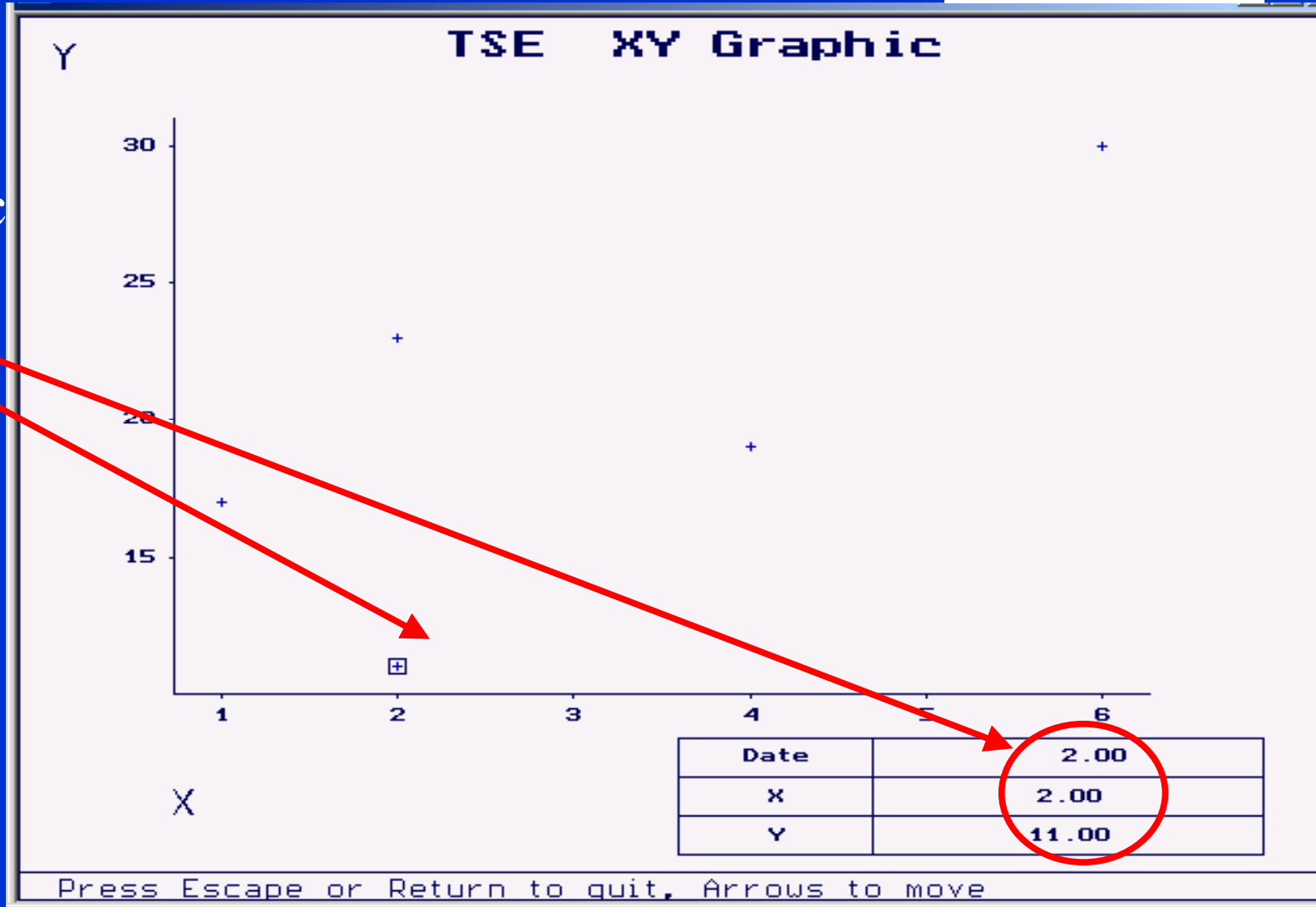
At the 5% level, we reject the hypothesis of white noise for 3 lags out of 38. If it were 2 out of 38, the frequency of rejection would be 2/38, not far from 5%



# Graphical aspects



Graphs  
are used  
in a dynamic  
and  
interactive  
way





# DEMETRA



# DEMETRA 2.0

Copyright © European Communities, 1999-2001

DEMETRA Version 2.0 (Service Pack 1) (Oct 7 2001)

developed for Eurostat mainly by:  
Jens Dossé and Servais Hoffmann

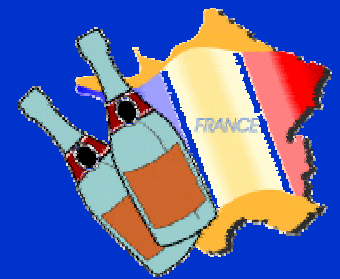
with help from:  
Raoul Depoutot, Pierre Kelsen and Christophe Planas

based on:  
TRAMO & SEATS by Víctor Gómez, Agustín Maravall  
and Gianluca Caporello  
X-12-ARIMA by the US Bureau of the Census with  
David Findley, Brian Monsell, William  
R. Bell, Marc C. Otto, Bor-Chung Chen  
and Catherine Hood

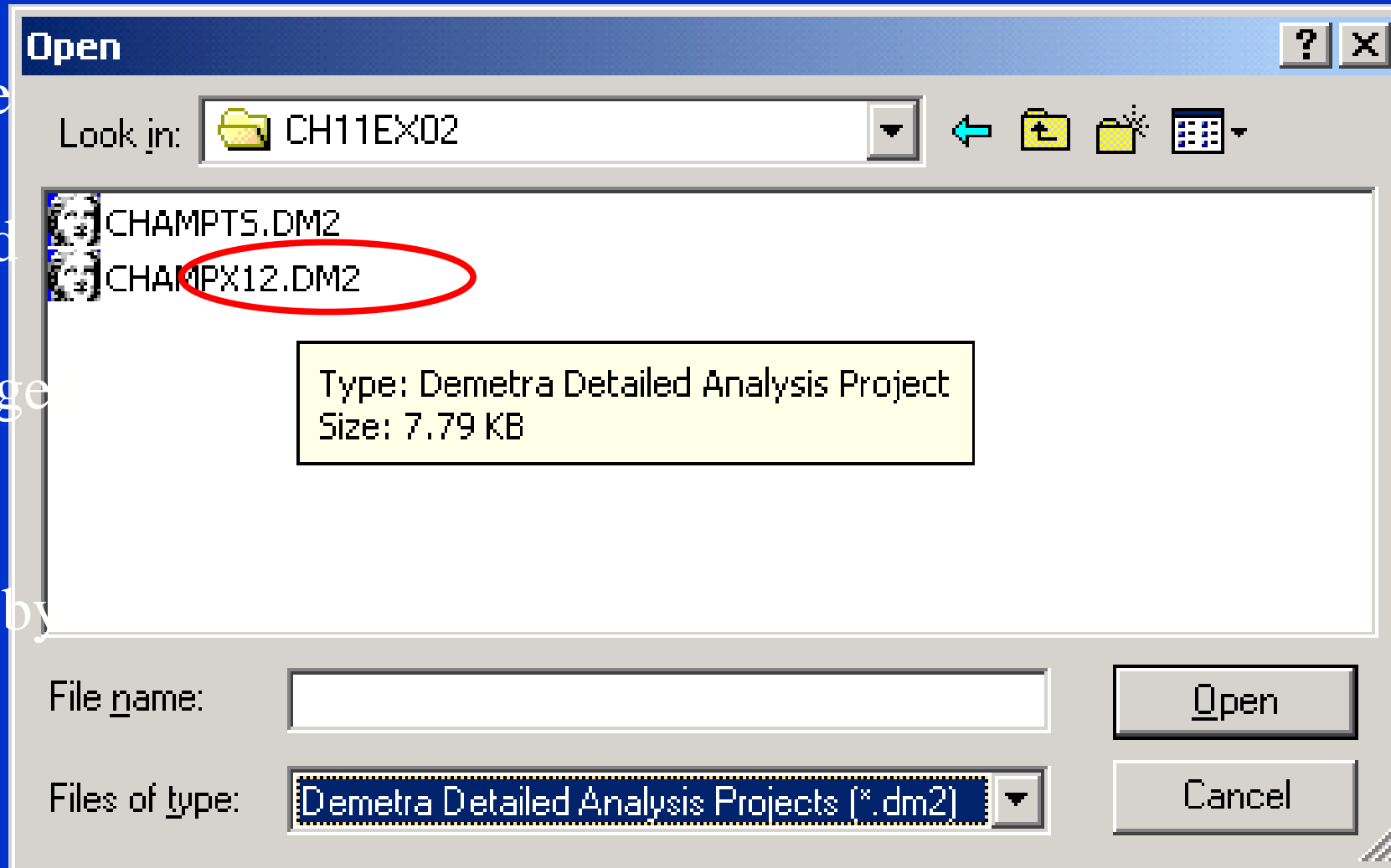
Developed by the European Communities (EuroStat), as an interface to both X-12 ARIMA (Bureau of the Census) and TRAMO/SEATS (V. Gómez et A. Maravall, Bank of Spain)



# How to use it



Select the folder  
Then load  
the  
prepackage  
*project*  
entirely  
prepared by  
advance

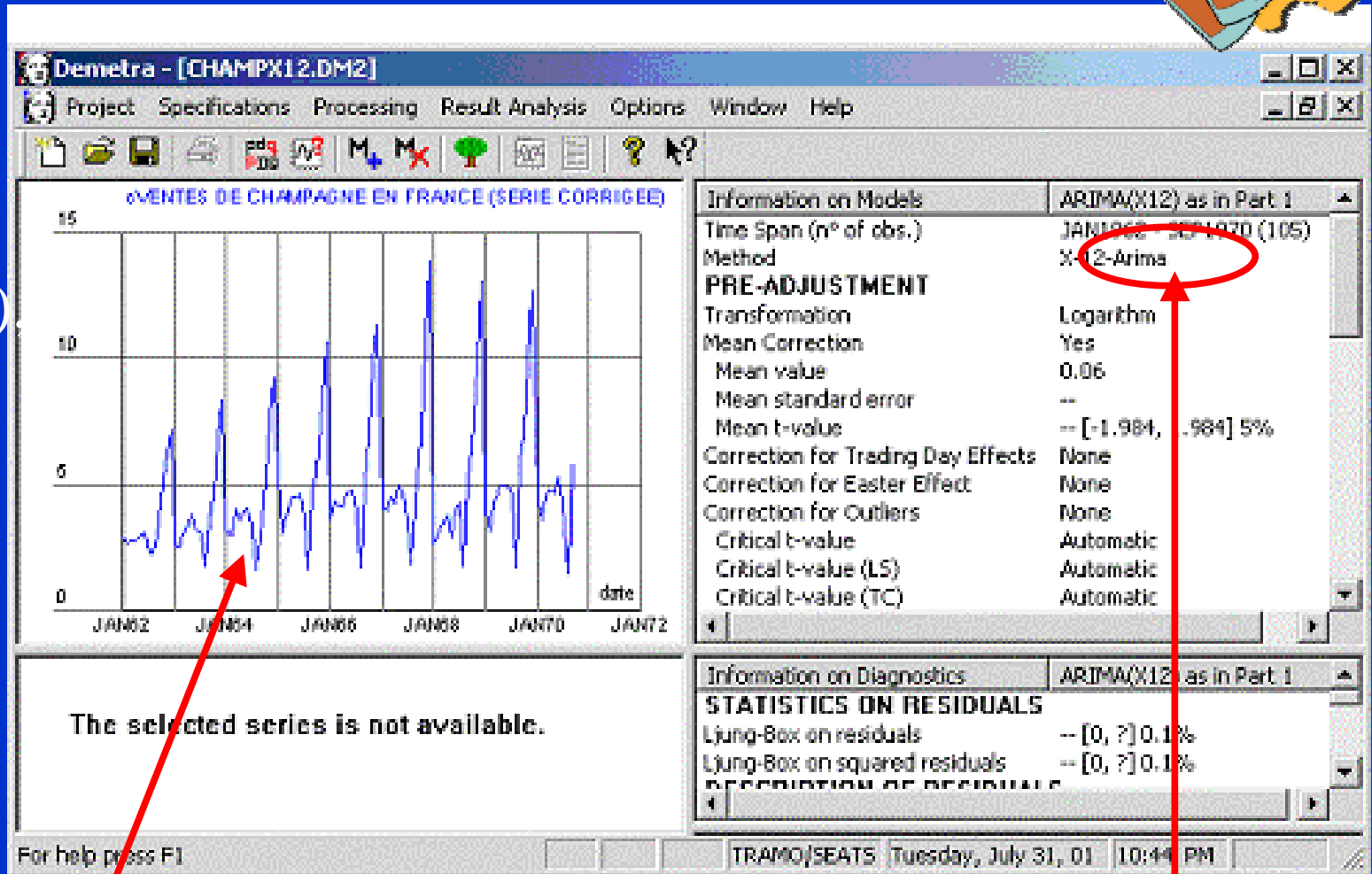




# Contents of a project



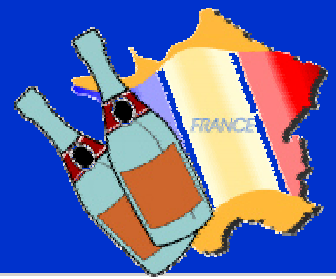
A project refers to a series (**CHAMPC**) its dates, the method to be used and options, for example the kind of parameters.



We see the data plot, the models being tried, here with name **ARIMA(X12)** and the method to be used, here **X-12-ARIMA**



# Graphical aspects



The accent is put on graphical aspects, plots w.r.t. time, autocorrelations and spectra

Select Time Series & Model

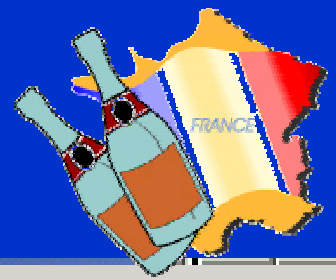
- Final Series
  - Original uncorrected series
    - 1: champ
    - 2: Intervention(X12)
  - Final trend
    - 1: champ
    - 2: Intervention(X12)
  - Final seasonally adjusted series
    - 1: champ
    - 2: Intervention(X12)
  - Robust final SA series
  - Final trend adjusted for LS outliers
  - Factors
  - Components
  - Residuals
- Preliminary Series
- Forecasts of Final Series
- Forecasts of Preliminary Series
- Autocorrelation Functions

Selected series: Add to plot Remove from plot Remove All Apply

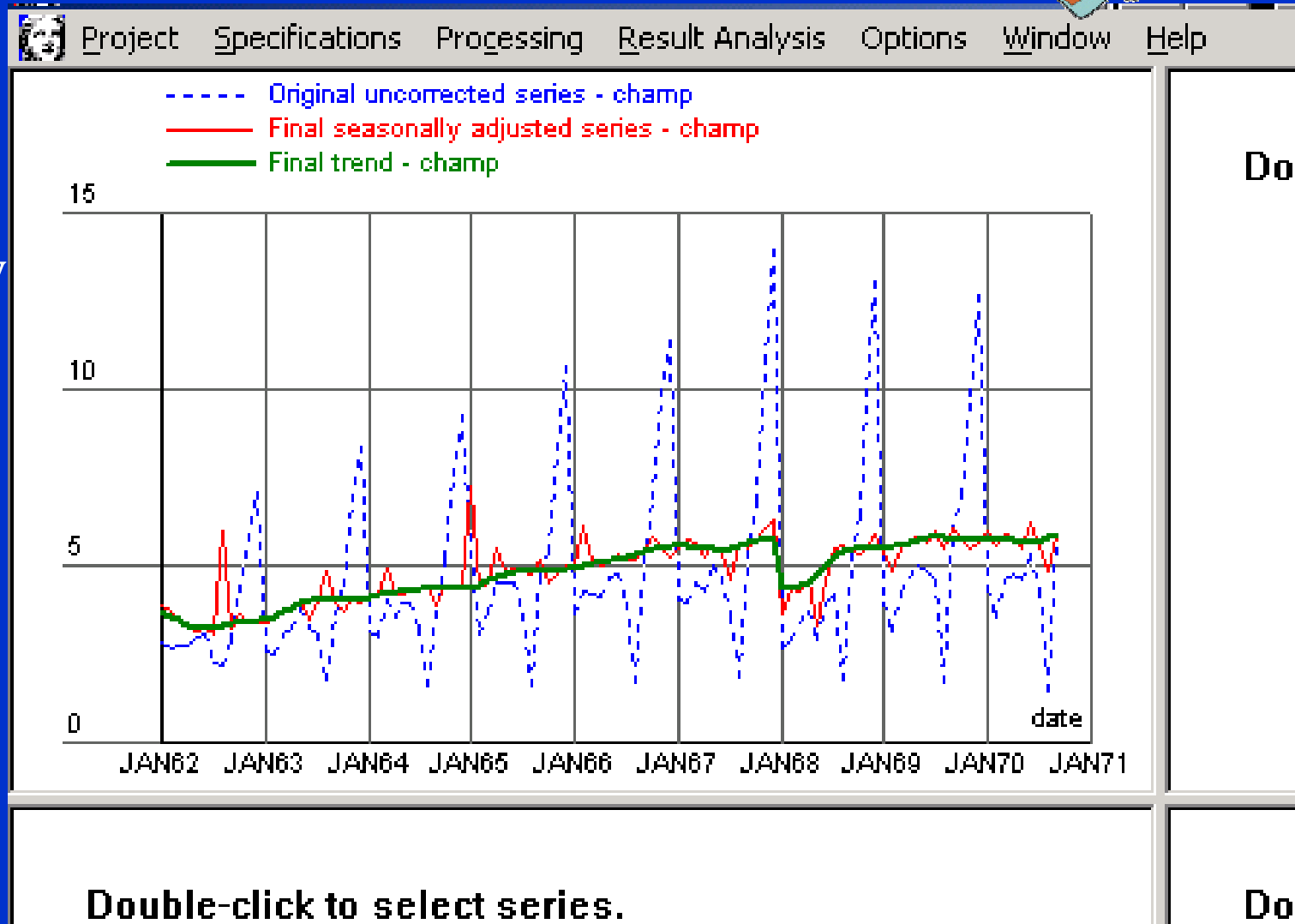
Original uncorrected series@1: champ  
Final seasonally adjusted series@1: champ



# Graphical aspects



Graphs  
are used  
in a relatively  
interactive  
way



# Table of contents

Context of the training project

Characteristics of the course

Navigation within the course

Exercises

**Documents and assessment**

Excerpts from the advanced course

Conclusions



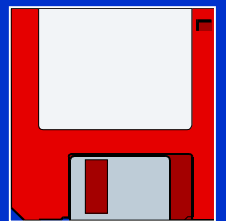
# Main paper document

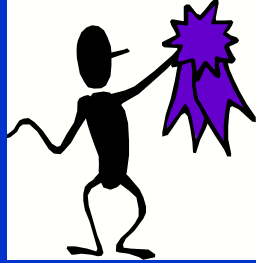
⇒ Only in paper form

⇒ Available separately for each chapter

⇒ Contents

- ✓ space for answering questions raised in the presentation
- ✓ expected answers to these questions
- ✓ corrected exercises
- ✓ instructions for additional exercises
- ✓ corrected additional exercises
- ✓ references
- ✓ in an annex: a paper copy of the presentation and of the the instructions for the exercises





# Assessment

UCS\_Test \*\*\* Student Name : Administrator

Chapter: 11 Question number: 1 out of 10

Een experiment wordt opgezet om het effect te vergelijken van twee verschillende behandelingen op de leeftijd waarop waarop een kind voor het eerst loopt. Elf kinderen werden lukraak verdeeld in twee groepen, vijf in groep 1 en zes in groep 2. Kinderen in groep 1 kregen vanaf leeftijd 1 week to leeftijd 7 weken gedurende 12 minuten per dag speciale loopoefeningen. De tweede groep kreeg dagelijks oefeningen maar niet de loopoefeningen van de eerste groep. De vooruitgang werd wekelijks gecontroleerd en de leeftijd in maanden waarop de kinderen voor het eerst liepen wordt hieronder gegeven.  
Groep 1 : 9,00 9,50 9,50 9,75 10,00  
Groep 2 : 9,50 10,00 10,50 11,00 11,75 12,75  
De Wilcoxon rang-som van de rangen voor de eerste groep is

Select the correct answer.

a 18,5  
 b 15,5  
 c 15,0

Next Submit Skip Exit

Feedback:

Select the correct answer.

a 18,5  
 b 15,5  
 c 15,0

(software package made by UCS, KULeuven)

UCS\_Test \*\*\* Student Name : Administrator

Chapter: 11 Question number: 1 out of 10

Een experiment wordt opgezet om het effect te vergelijken van twee verschillende behandelingen op de leeftijd waarop waarop een kind voor het eerst loopt. Elf kinderen werden lukraak verdeeld in twee groepen, vijf in groep 1 en zes in groep 2. Kinderen in groep 1 kregen vanaf leeftijd 1 week to leeftijd 7 weken gedurende 12 minuten per dag speciale loopoefeningen. De tweede groep kreeg dagelijks oefeningen maar niet de loopoefeningen van de eerste groep. De vooruitgang werd wekelijks gecontroleerd en de leeftijd in maanden waarop de kinderen voor het eerst liepen wordt hieronder gegeven.  
Groep 1 : 9,00 9,50 9,50 9,75 10,00  
Groep 2 : 9,50 10,00 10,50 11,00 11,75 12,75  
De Wilcoxon rang-som van de rangen voor de eerste groep is

Next Submit Skip Exit

Feedback:

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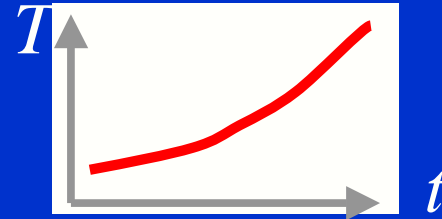
Conclusions

# Excerpts of the advanced course

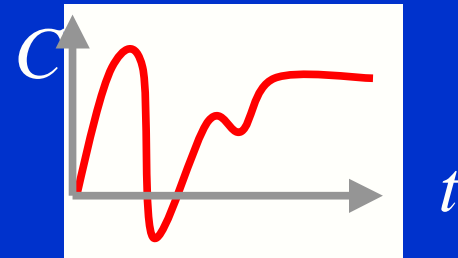
- ⇒ We show here some excerpts of the course, based mainly on the advanced course
- ⇒ Chapter 13 : TRAMO/SEATS method
- ⇒ This is a seasonal adjustment method: how to obtain the seasonally adjusted series

# General presentation

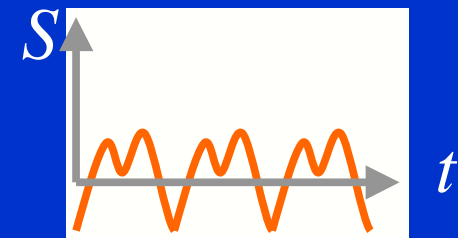
⇒ trend ( $T$ )



⇒ business cycle ( $C$ )

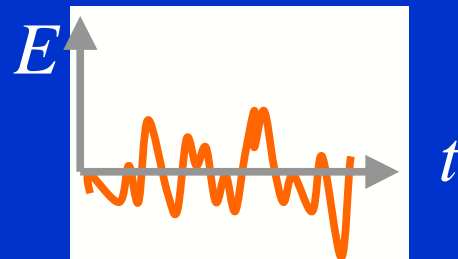


⇒ seasonal component ( $S$ )

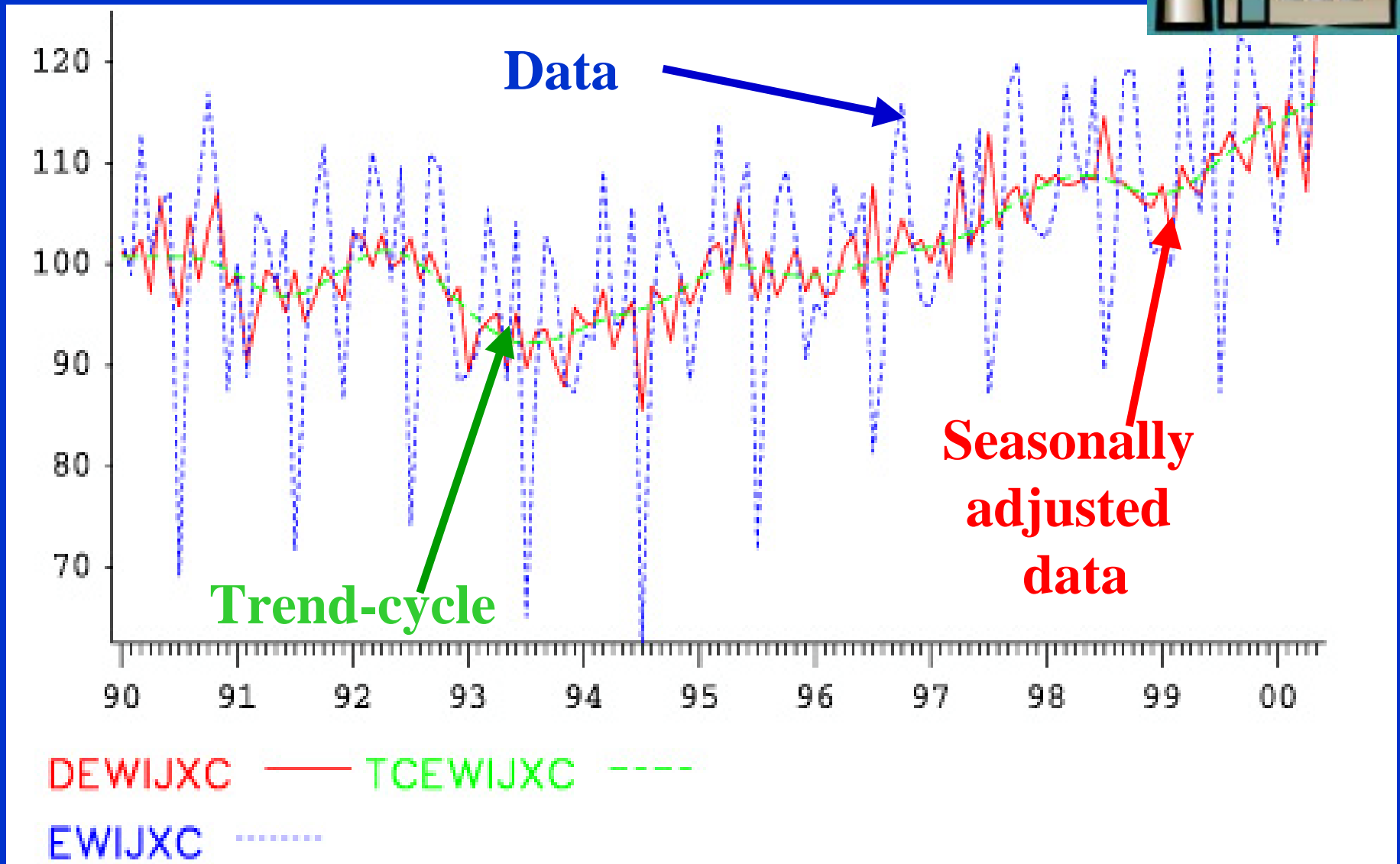


Here,  
3 years  
are shown

⇒ irregular component ( $E$ )



# Example : Industrial production of Belgi



# Advanced methods of seasonal decomposition

⇒ **Census X-11** (1957, 1967, 1988)

⇒ **X-11-ARIMA** (Statistics Canada) :

replaces artificial extensions of the moving averages by using forecasts of the data obtained by an ARIMA model (*see chapters 9 and 10*)

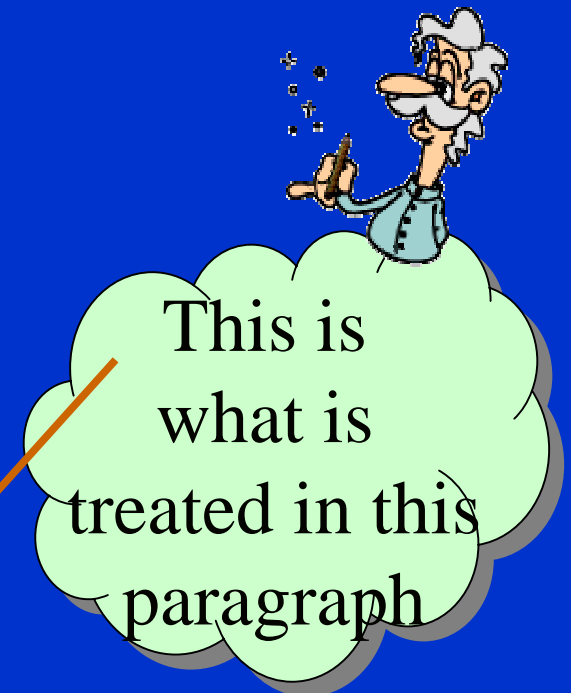
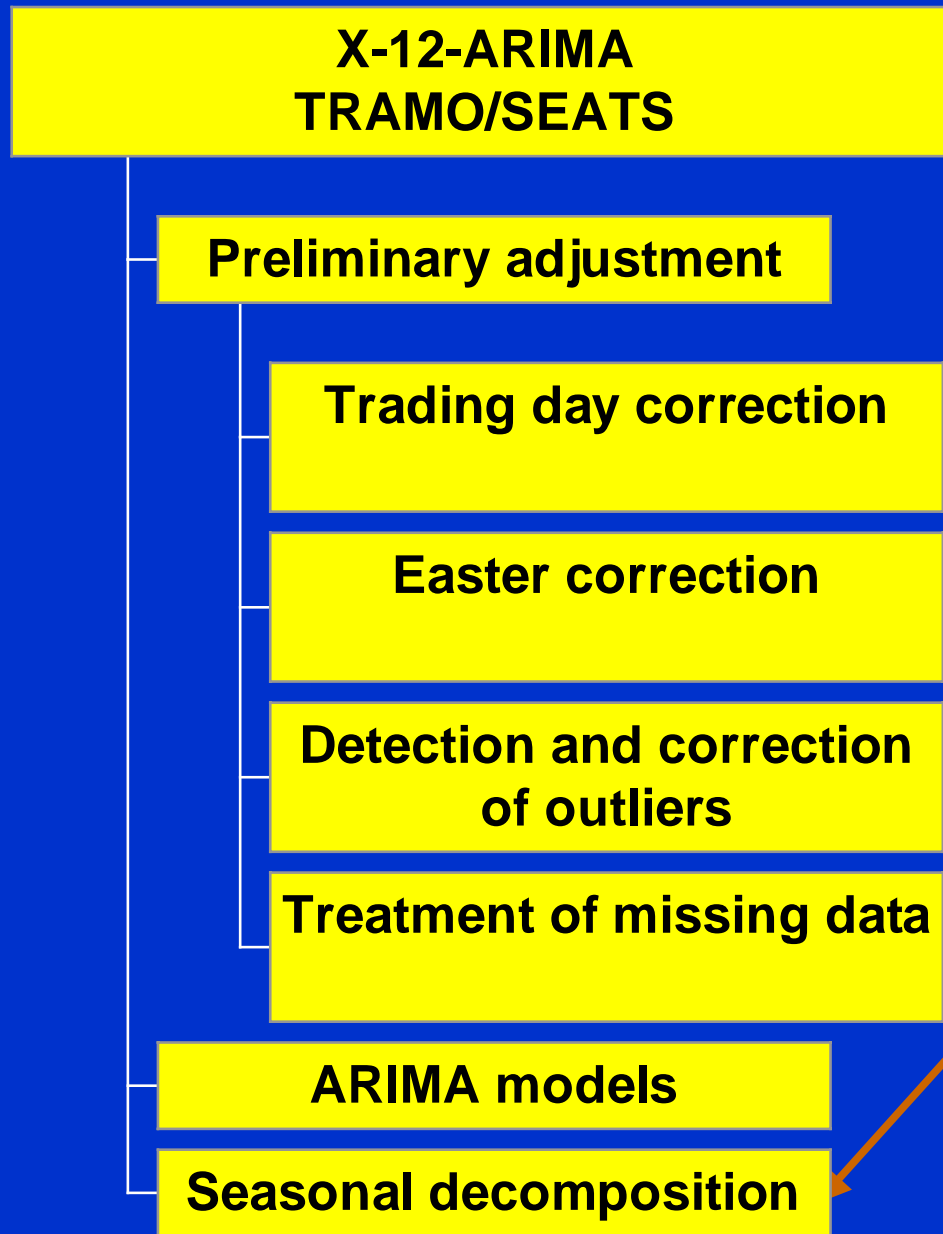
⇒ **Census X-12-ARIMA** : (Bureau of the Census)

the same + ARIMA regression for the treatment of corrections (outliers, trading day, ...)  
(*see chapter 12*)

⇒ **TRAMO/SEATS** (Bank of Spain) :

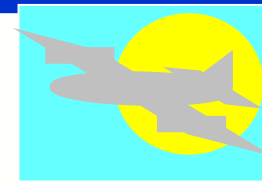
based on ARIMA models and signal extraction  
(*see chapter 13*)

# Flow chart of the 2 programs





# Motivations in favor of TRAMO/SEATS



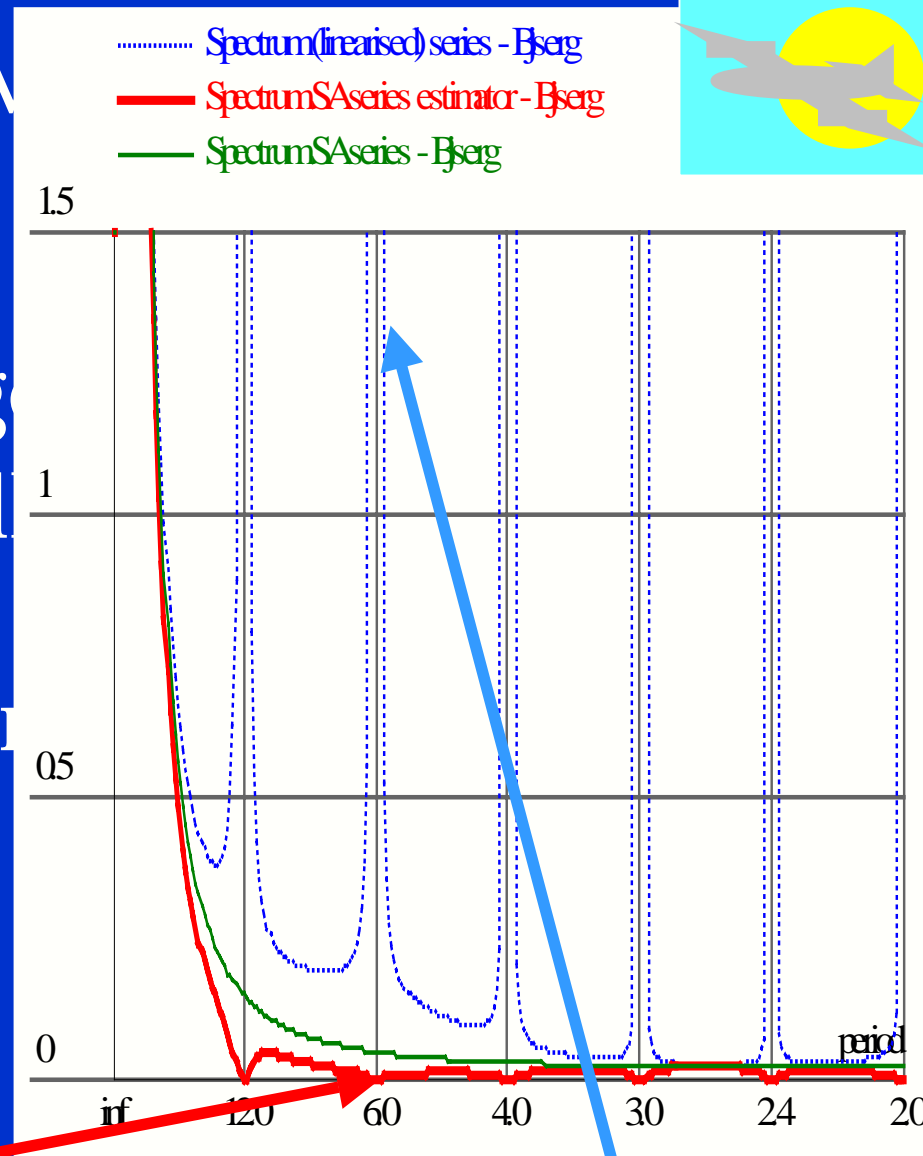
⇒ Advantage of X-12-ARIMA continuity w.r.t. X-11

⇒ In X-12-ARIMA: filters based on moving average

⇒ For Gómez and Maravall

- ✓ spectral analysis reveals some problems

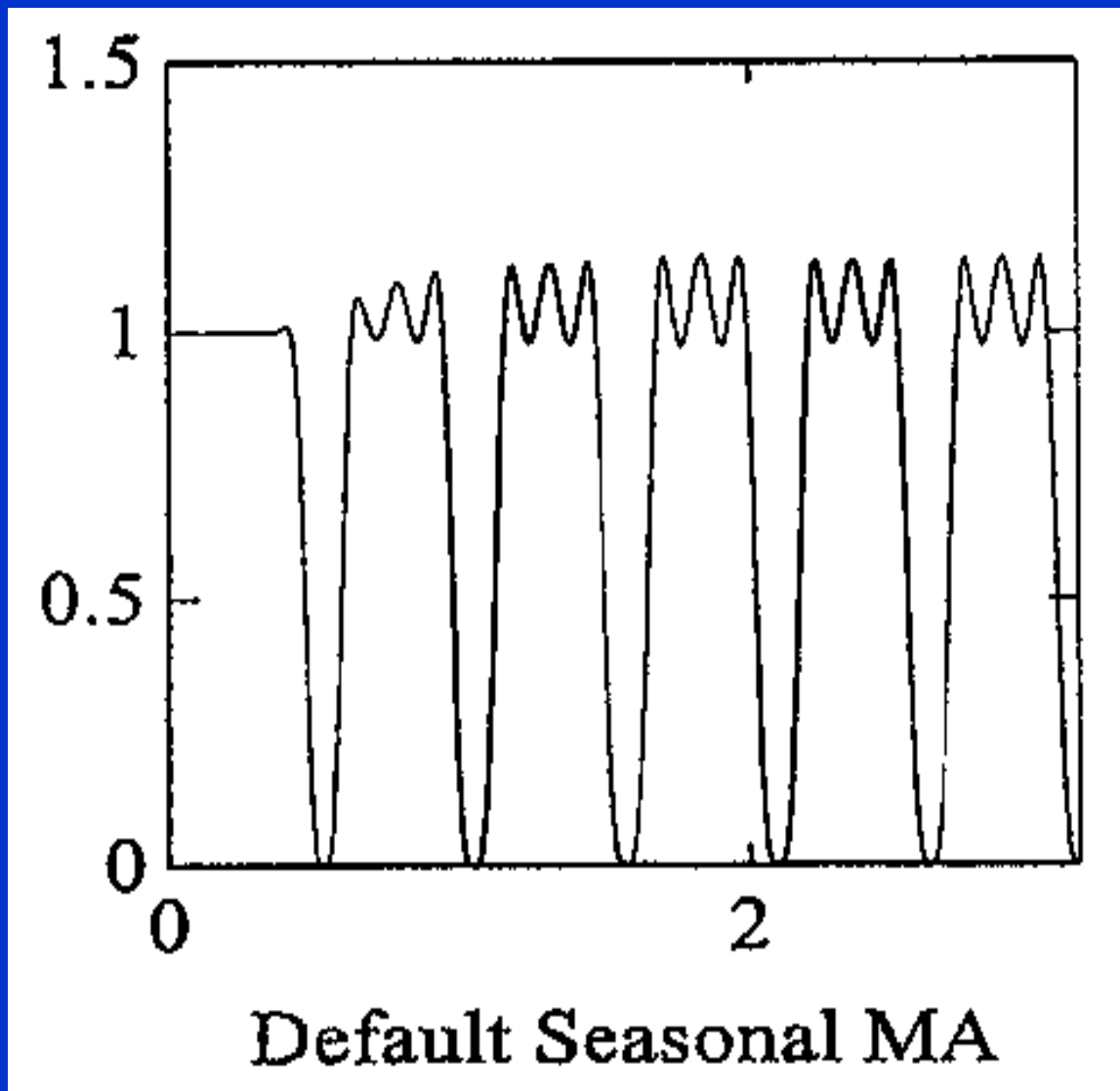
- ✓ Filters depend on the series



Seasonally adjusted series

Original pretreated series

# Gain for component S



## Monthly series

It can be seen that the default filter completely removes period 12 and the divisors of 12 (6, 4, ...), which is too strong, and that it does affect slightly the other periods in an annoying way

# Principles of TRAMO/SEATS (1/3)

⇒ First TRAMO is used, then SEATS

⇒ TRAMO is aimed for pretreatment (correct the series

for outliers, trading day effects and other effects) and build a model for the series

TRAMO = '**Time Series Regression with ARIMA Noise, Missing Observations and Outliers**'

⇒ In the sequel,  $y_t$  denotes the corrected data at  $t$

⇒ SEATS is aimed at decomposing the model obtained by TRAMO in a sum of components and extract them

SEATS = '**Signal Extraction in ARIMA Time Series**'<sup>67</sup>

# Principles of TRAMO/SEATS (2/3)

- ⇒ Here : the case of an **additive** mode of composition
- ⇒ There can be up to 4 components :
  - ✓ permanent or trend (-cycle) component
  - ✓ temporary or cycle component
  - ✓ seasonal component
  - ✓ irregular component or error
- ⇒ In the most frequent cases of a **multiplicative** mode of composition, SEATS works with an additive decomposition of the data in **logarithms**,  $\log(y_t)$

# Principles of TRAMO/SEATS (3/3)

⇒ In the simplest case :  $y_t = N_t + S_t$ , where

✓  $N_t$  is the non seasonal component

✓  $S_t$  is the seasonal component

⇒ From the ARIMA model for  $y_t$  found by TRAMO, SEATS derives ARIMA models (with independent innovations) for  $N_t$  and  $S_t$

⇒ SEATS then *builds* series  $N_t$  and  $S_t$  from the data  $y_t$  using the models for  $y_t$ ,  $N_t$  and  $S_t$

⇒ A signal extraction technique is used to that end

# The components of SEATS (1/2)

**Example (quarterly)** ARIMA model :  $\nabla\nabla_4 y_t = \theta(B) e_t$

✓  $\nabla = 1 - B$  : the **difference** is associated to the permanent component or trend ( $B =$  **lag operator**)

✓  $\nabla_4 = 1 - B^4 = (1 - B)(1 + B + B^2 + B^3) = (1 - B)U_3(B)$  , factorization of the **seasonal difference**

✓ We write **Permanent c. Seasonal c. Irregular c.**

$$y_t = \frac{\theta(B)}{(1-B)(1-B^4)} e_t = \frac{\theta_P(B)}{(1-B)^2} e_t^P + \frac{\theta_S(B)}{U_3(B)} e_t^S + e_t^I$$

✓ The variances  $V^P$ ,  $V^S$  and  $V^I$  as well as  $\theta_P(B)$  and  $\theta_S(B)$  are determined by equating the

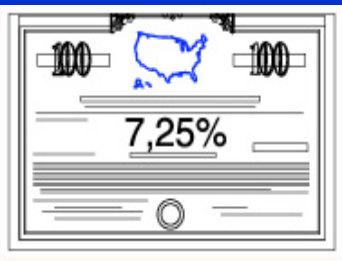
$$\nabla\nabla_4 y_t = \theta(B)e_t = U_3(B)\theta_P(B)e_t^P + \nabla^2\theta_S(B)e_t^S + \nabla\nabla_4 e_t^I$$

# The components of SEATS (2/2)

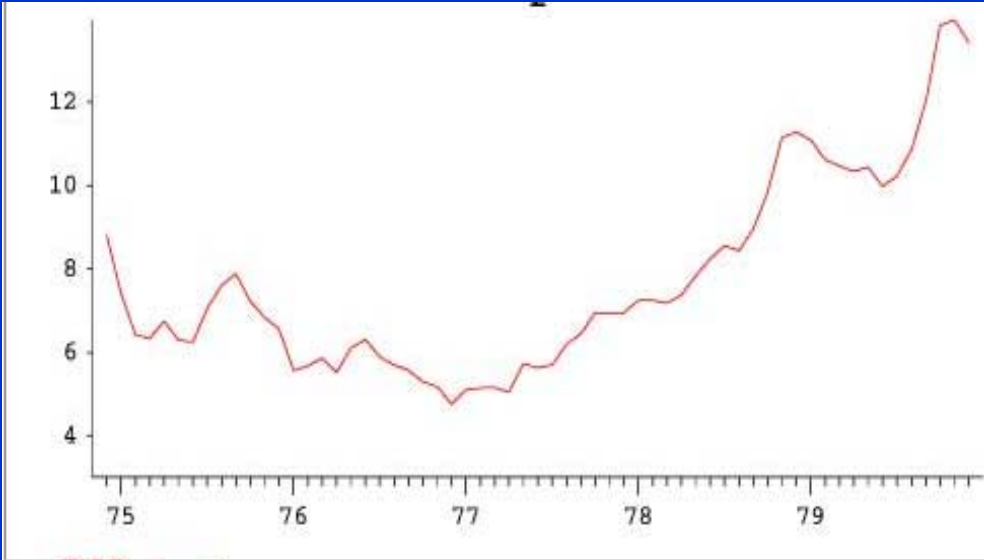
- ⇒ An *admissible decomposition*, with innovation variances  $> 0$ , doesn't always exist
- ⇒ If such decomposition does exist, others exist
- ⇒ Look then for a unique *canonical decomposition*
- ⇒ We have preferred a simple — non seasonal — example with only 2 components : permanent and irregular

$$y_t = \frac{1 - \theta B}{1 - B} e_t = \frac{\theta^P(B)}{1 - B} e_t^P + e_t^I$$

- ⇒ The consequence of various choices of the polynomial  $\theta^P(B)$  can then be studied
- ⇒ Theory is illustrated on U. S. interest rates on certificates of deposit (CD)



# Analysis of the example



The ARIMA model for the series is written :

$$\nabla \text{CDIR}_t = e_t + 0,495 e_{t-1}$$

$$y_t = \frac{1-\theta B}{1-B} e_t = \frac{1-\theta_P B}{1-B} e_t^P + e_t^I$$

where

$$\begin{aligned} \nabla y_t &= (1-\theta B)e_t \\ &= (1-\theta_P B)e_t^P + \nabla e_t^I \end{aligned}$$

**Table of variances of the components**  
in function of the parameter thetaP

$\theta_P$	$V^P$	$V^I$
-1.0	0.1313	0.0153
-0.9	0.1454	0.0149
-0.8	0.1620	0.0136
-0.7	0.1817	0.0112
-0.6	0.2051	0.0070
-0.5	0.2333	0.0007
-0.4	0.2679	-0.0089

Canonical decomposition

Admissible decompositions

Non admissible decomposition

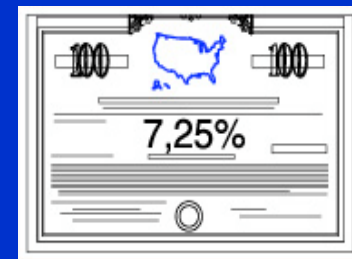


# Signal extraction in SEATS

- ⇒ Start from the canonical decomposition of the process
- ⇒ Obtain the coefficients of the optimal filters (called **Wiener-Kolmogorov**)
- ⇒ Apply the filters
- ⇒ Examine the results
- ⇒ Restore the effects and remove the corrections



# Exercise : simulation of SEATS



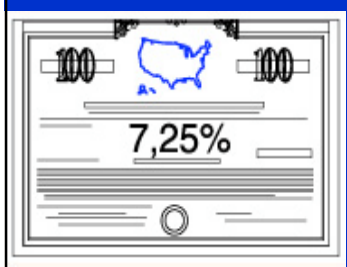
**Data:** *series of U. S. interest rates for certificates of deposits*

**Purpose of the exercise:** *illustrate how to obtain the filter for extracting the trend of the series and compare with the main results of TRAMO/SEATS*

⇒ Instructions (part E)

⇒ Exercise (file CH13EX06.XLS)





# Results (1/2)

⇒ Software output

```

WIENER-KOLMOGOROV FILTERS (ONE SIDE)
TREND COMPONENT
0.7474  0.1888  -0.0934  0.0462  ...
IRREGULAR COMPONENT
0.2526  -0.1888  0.0934  -0.0462  ...
    
```

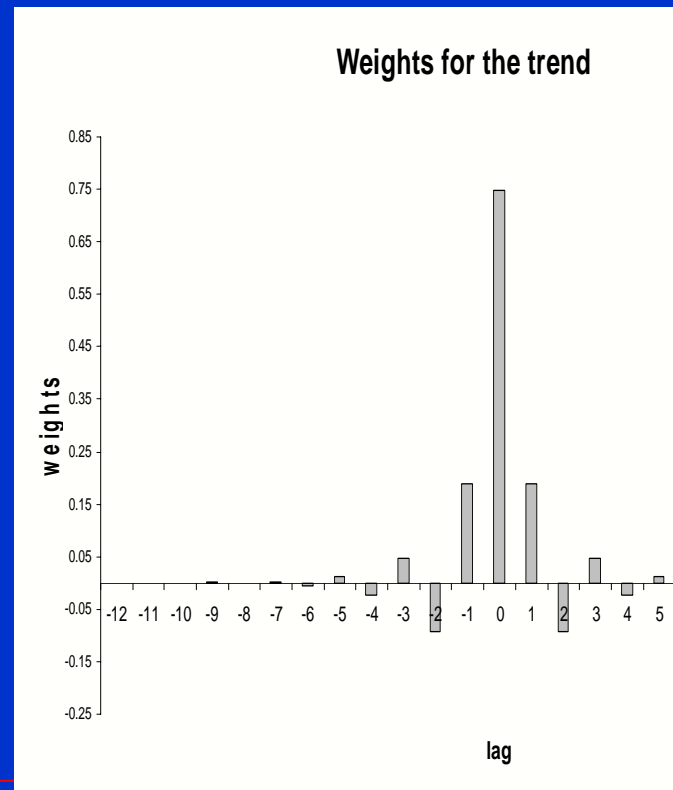
⇒ Contents of CH13EX06

Computation of autocovariances

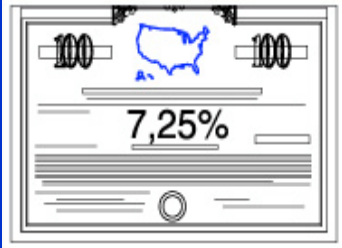
	Trend	Irregular
AR1	-0.4947	-0.4947
MA1	-1	1
Sigma <sup>2</sup>	0.55856	0.06382

Lag	Trend	Irregular
0	0.7474	0.2526
1	0.1888	-0.1888
2	-0.0934	0.0934
3	0.0462	-0.0462

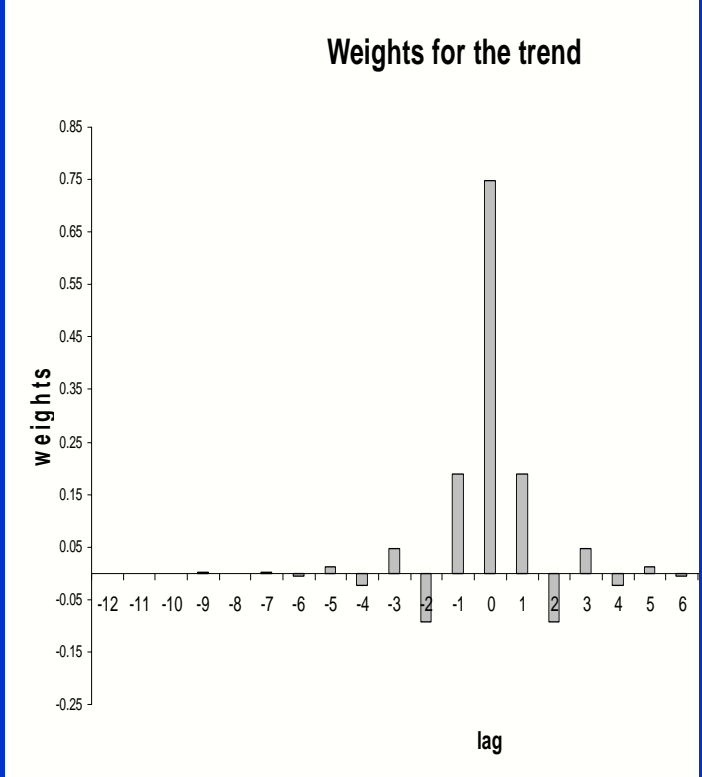


The **Wiener-Kolmogorov** filters are derived from autocovariances of some ARMA processes based on the model of the series

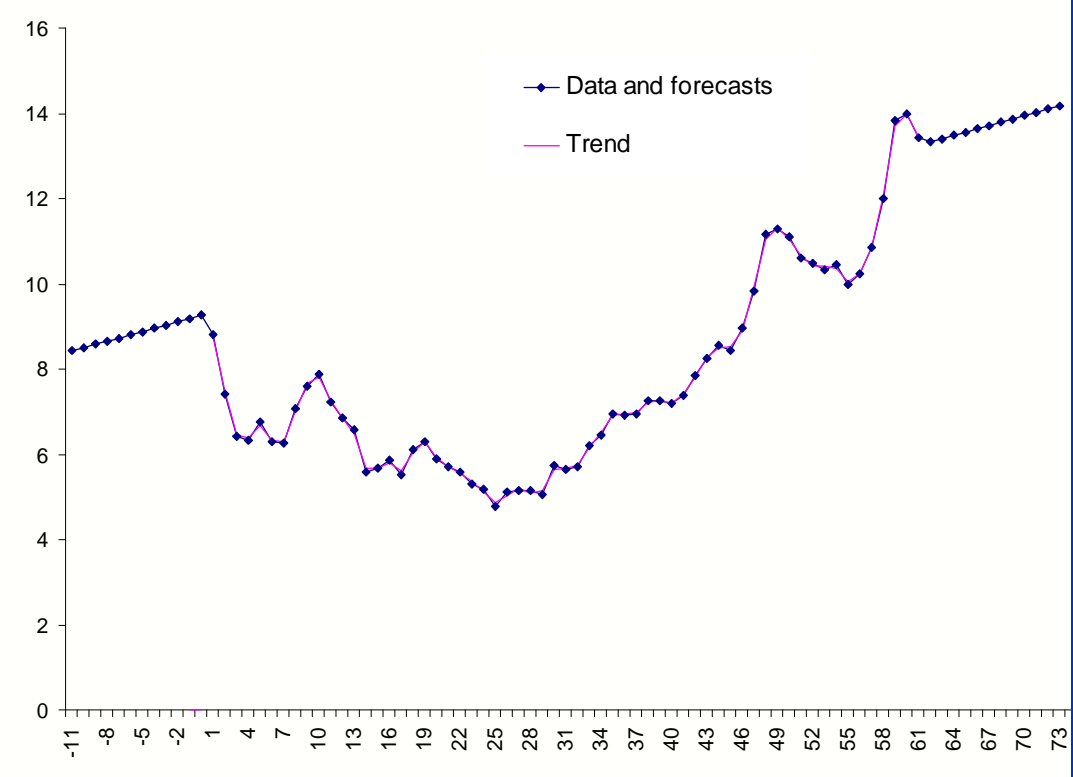


# Results (2/2)

For a given component, apply to the data a moving average weighted with these coefficients



The weights of the moving average to extract the trend



The series (extended with forecasts) and the trend component

Everything can be done in the same way for other more complex examples, just with more complex computation

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# Conclusions

- ⇒ Course on time series analysis built at the requirements of the National Bank of Belgium
- ⇒ Difficulty of self-training : keep attention by a combination of pedagogical methods
- ⇒ Additional difficulty :
  - ✓ clever use of sometimes difficult methods
  - ✓ without requiring mathematical skills
- ⇒ 2 versions : basic and advanced
- ⇒ At the advanced level :
  - ✓ autocorrelations of MA(1) or AR(1) processes
  - ✓ roots of polynomials
  - ✓ representation of trading day effects

A more detailed presentation can be organized on request

Availability outside of the framework of the National Bank of Belgium is under study

Translation in English is under way