METHODOLOGY FOR CHOOSING THE SEASONAL ADJUSTMENT MODELS OF ECONOMIC SERIES:
A STUDY OF MONTHLY SALES, INDUSTRY AND SERVICES SERIES IN BRAZIL.
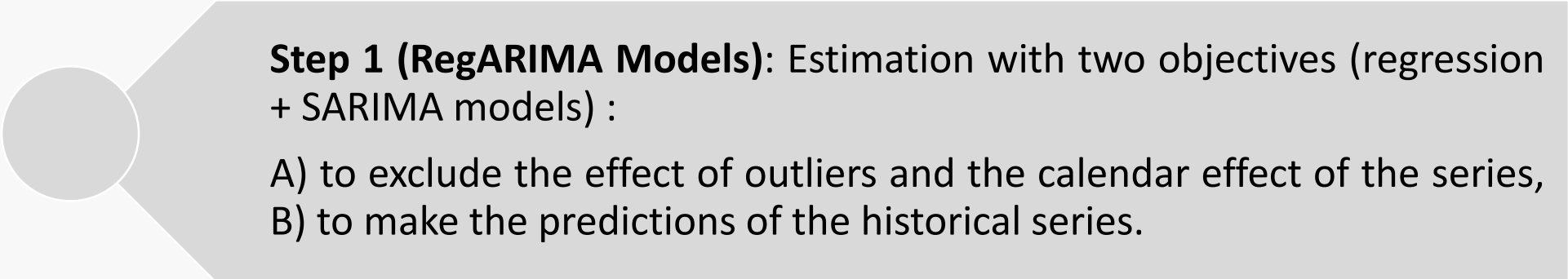
Manoela Cabo , Carla Mello, Marcelo Barboza and Felipe Figueiredo

Abstract

Seasonal adjustment of economic time series provides basis for data comparison. The Brazilian SALES, Industry and Services monthly series are adjusted using the X13-ARIMA methodology, divided into two steps: Reg-ARIMA modeling and deseasonalization. To define the best model selection algorithm and calendar effect variable to be used in Reg-ARIMA models for each of the economic survey, this work uses a decision support method based on the error metrics of prediction and residual autocorrelation. As a result, 6 models were found for each survey resulting from the combinations of 3 possible variables of calendar effect and 2 selection algorithms.
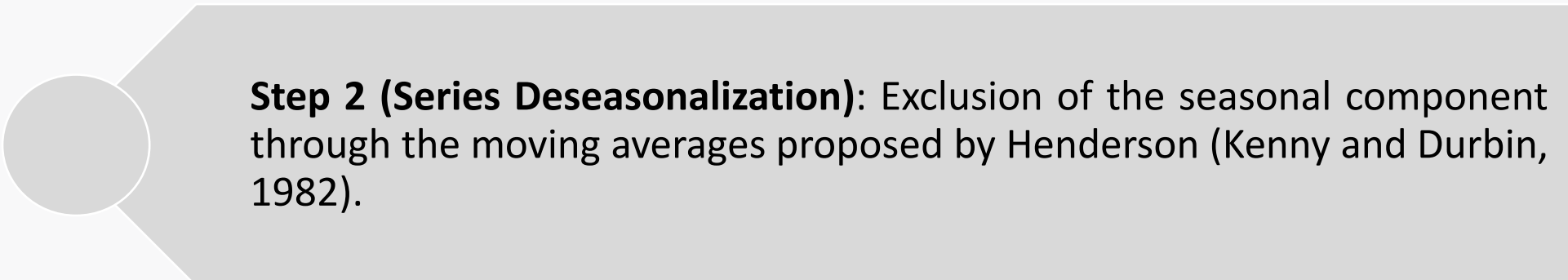
Seasonal adjustment in the IBGE economic series (SALES, INDUSTRY AND SERVICES) - X13-ARIMA

- These series are adjusted in the X13-ARIMA software, a tool formulated by the U.S. Census Bureau (U.S. Census Bureau, 2015), with the objective of extracting from the originally calculated indices, the seasonal influences of each month of the year, in order to compare the series of indices of the month with the previous month;

- The X13-ARIMA software is divided in two steps:

Step 1 (RegARIMA Models): Estimation with two objectives (regression + SARIMA models) :

A) to exclude the effect of outliers and the calendar effect of the series,
B) to make the predictions of the historical series.

Step 2 (Series Deseasonalization): Exclusion of the seasonal component through the moving averages proposed by Henderson (Kenny and Durbin, 1982).

Step 1 - X13-ARIMA (before adjustment)
A) *RegARIMA Model: Model Selection Algorithm*

- To find the best REG-ARIMA models, that is, those with the best and most parsimonious diagnoses, two algorithms available in X13 can be used: PICKMODEL or AUTOMODEL:

PICKMODEL: Specifies that the ARIMA part of RegARIMA will be selected based on X11-ARIMA.

AUTOMODEL: Specifies that RegARIMA will be selected based on TRAMO (Gomez and Maravall (2001,a)).

Diretoria de Pesquisas DPE

IBGE

Step 1 - X13-ARIMA (before adjustment)
B) *RegARIMA Model: Calendar Variable*

- In Reg-Arima modeling, the regression variables referring to the calendar effect can be chosen before starting the modeling update.

Trading Day (TD):

$$T_{1,t} = (\text{number of Mondays}) - (\text{number of Sundays})$$
$$T_{2,t} = (\text{number of Tuesday}) - (\text{number of Sundays})....$$
$$T_{6,t} = (\text{number of Saturdays}) - (\text{number of Sundays})$$

Working Days:

Working days of each month - 21

X-13 Variable:

number of Mondays to Fridays of each month – 5/2 number of Saturdays to Sundays of each month

Choice of Selection Algorithm and Calendar Variable

To define the model selection algorithm and the calendar effect variable that will be used in the next update of the seasonal adjustment models of the industry series (PIM), retail sales (PMC) and service (PMS), 6 models were estimated, resulting of the possible combinations between algorithm and variable. These models were estimated for each of the historical series of the fixed base indices (IBF) of the 3 surveys:

Selection algorithms for RegARIMA models

- AUTOMODEL
- PICKMODEL

×

Calendar Variable

- Trading Day (TD)
- Working Days
- X-13 Variable

=

Combinations

- AUTOMODEL - TD
- AUTOMODEL - working days
- AUTOMODEL - X-13 Variable
- PICKMODEL - TD
- PICKMODEL - working days
- PICKMODEL - X-13 Variable

IBGE
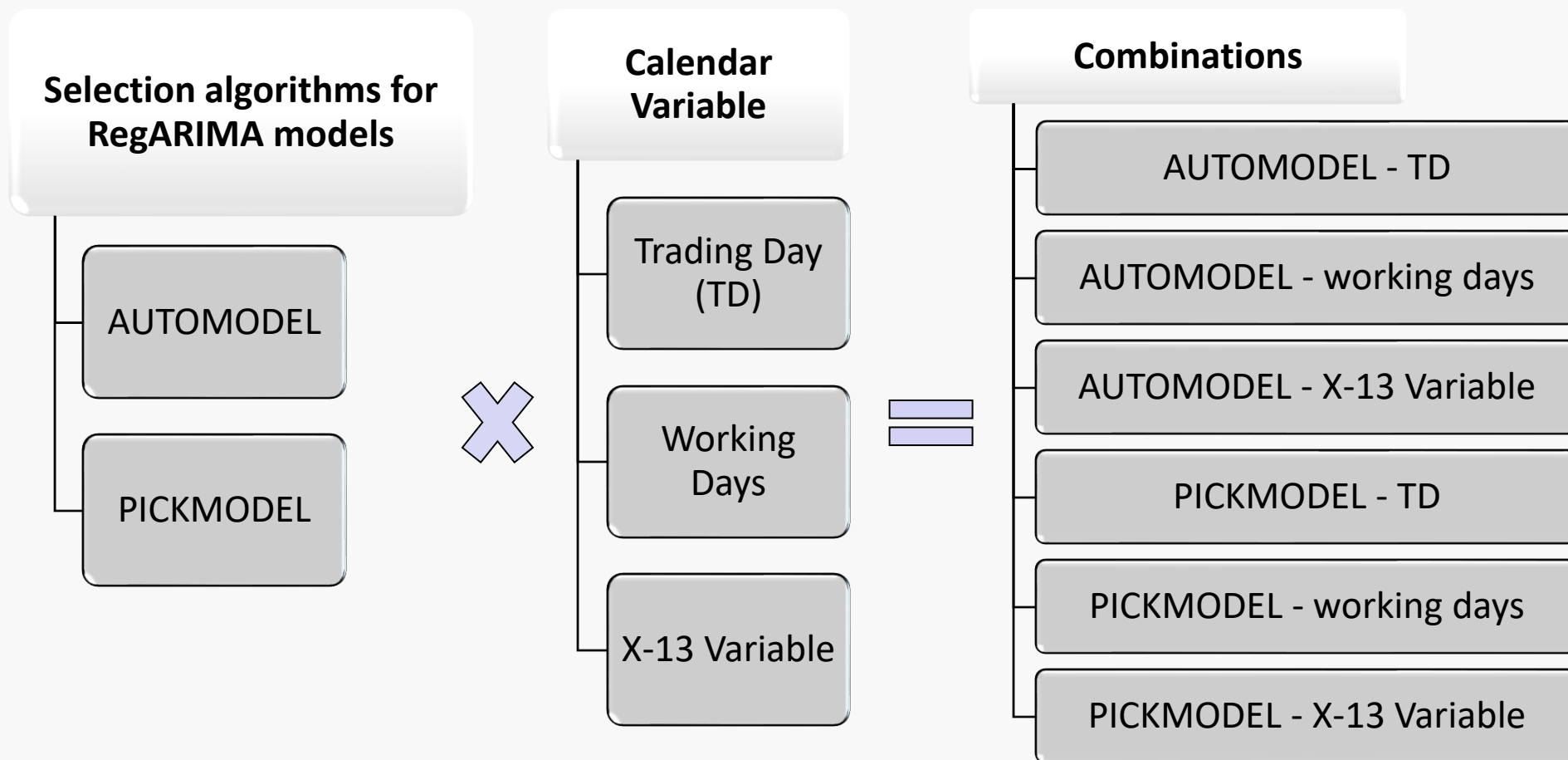
Choice of Selection Algorithm and Calendar Variable

For each of the models, the following metrics and the following test were calculated:

✓ **Metrics based on the prediction error of the RegARIMA model:**

MAPE (Mean Absolute Percentage Error) :
$$\frac{1}{n}\sum_{i=1}^{n}\frac{|y_i - \hat{y}_i|}{y_i}x100$$

MAE (Mean Absolute Error) :
$$\frac{1}{n}\sum_{i=1}^{n}|y_i - \hat{y}_i|$$

RMSE (Root Mean Squared Error):
$$\sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}$$

where

y_i: data observed ; $\hat{y}_i$: estimated data ; n: Number of observations

✓ **Ljung-Box test for the autocorrelation of model residuals (**MORETTIN & TOLOI, 2004**)**

Steps for Choosing the Selection Algorithm and Calendar Variable

1. Metric median calculation for each of the 6 model combinations (calendar variable X selection algorithm) of each historical series, considering forecasts within the sample and outside the sample;

2. Exclusion of models that showed residual correlation, according to the Ljung-Box Test;

3. Verification of the lowest median of the metrics, to identify the best combination of calendar effect variable and model selection algorithm in each series, since the lowest median represents the model with the lowest forecast error and, therefore, the best combination of variable and calendar effect;

4. Verification of the best combination of calendar effect variable and model selection algorithm in survey from two perspectives:

    4.1) Considering that each seasonally adjusted series has the same importance within each survey: in this way, the number of survey series in which each of the 6 possible combinations was considered the best was calculated;

    4.2) Considering the relative importance of each activity or regional series in relation to Brazilian total serie, within each survey: in this way, weights were assigned to each of the series, reflecting its contribution in relation to Brazil, and then the weights of the series of the survey in which each of the 6 possible combinations was considered the best.

Results: Choice of Selection Algorithm and Calendar Variable
Choice methods

surveyes

Frequency of Combinations

Combinations	Number of simulations	%
TD X AUTOMODEL	109	40,7%
TD X PICKMODEL	71	26,5%
Dias úteis X PICKMODEL	29	10,8%
Dias úteis X AUTOMODEL	23	8,6%
Variável X-13 X AUTOMODEL	20	7,5%
Variável X-13 X PICKMODEL	16	6,0%
Total	**268**	**100,0%**

Sum of Series Weights by Combination

Combinations	Total weight	%
TD X AUTOMODEL	9,38	44,4%
TD X PICKMODEL	5,83	27,6%
Dias Úteis X AUTOMODEL	3,46	16,4%
Dias Úteis X PICKMODEL	1,96	9,3%
Variável X-13 X PICKMODEL	0,29	1,4%
Variável X-13 X AUTOMODEL	0,21	1,0%
Total	**21,14**	**100,0%**

PMC

Combinations	Number of simulations	%
Variável X-13 X PICKMODEL	66	27,5%
TD X PICKMODEL	52	21,7%
Dias úteis X PICKMODEL	47	19,6%
Dias úteis X AUTOMODEL	29	12,1%
TD X AUTOMODEL	28	11,7%
Variável X-13 X AUTOMODEL	18	7,5%
Total	**240**	**100,0%**

Combinations	Total weight	%
Variável X-13 X PICKMODEL	3,83	20,6%
Dias Úteis X AUTOMODEL	3,47	18,7%
TD X PICKMODEL	3,46	18,6%
Dias Úteis X PICKMODEL	3,05	16,4%
Variável X-13 X AUTOMODEL	3,00	16,2%
TD X AUTOMODEL	1,75	9,4%
Total	**18,57**	**100,0%**

PMS

Combinations	Number of simulations	%
Dias úteis X PICKMODEL	24	26,1%
TD X PICKMODEL	23	25,0%
TD X AUTOMODEL	20	21,7%
Dias úteis X AUTOMODEL	12	13,0%
Variável X-13 X AUTOMODEL	7	7,6%
Variável X-13 X PICKMODEL	6	6,5%
Total	**92**	**100,0%**

Combinations	Total weight	%
TD X AUTOMODEL	3,57	35,3%
TD X PICKMODEL	2,12	21,0%
Dias Úteis X PICKMODEL	2,03	20,1%
Variável X-13 X AUTOMODEL	1,51	15,0%
Variável X-13 X PICKMODEL	0,45	4,5%
Dias Úteis X AUTOMODEL	0,41	4,0%
Total	**10,10**	**100,0%**

PIM-PF

IBGE

Next Steps:

 1- Study other possibilities of algorithms for Model Selection;

2- Study other regression variables referring to the calendar effect can be chosen.

....

References

GÓMEZ, V. and A. MARAVALL (2001a). Automatic modeling methods for univariate series. In D. Pena, G.C.Tiao, and R.S.Tsay (Eds.), A Course in Time Series Analysis. New York, NY: J. Wiley and Sons.

MORETTIN, Pedro Alberto; TOLOI, Clélia Maria de Castro. Análise de séries temporais. [S.l: s.n.], 2004.

Notas metodológicas da Pesquisas:

PIM - https://www.ibge.gov.br/estatisticas-novoportal/economicas/industria/9294-pesquisa-industrial-mensal-producao-fisica-brasil.html?=&t=downloads

PMC - https://www.ibge.gov.br/estatisticas-novoportal/economicas/comercio/9227-pesquisa-mensal-de-comercio.html?=&t=downloads

PMS - https://www.ibge.gov.br/estatisticas-novoportal/economicas/servicos/9229-pesquisa-mensal-de-servicos.html?=&t=downloads

SHISKIN, J.; YOUNG, A. H.; MUSGRAVE; J. C. *The X-11 variant of the census method II seasonal adjustment program*. [Washington, DC]: Bureau of the Census, 1967. 66 p. (Technical paper, 15). Disponivel em: <http://www.census.gov/ts/papers/>

U.S. Census Bureau, *X-13 - ARIMA Reference Manual, Version 1.1* (2015).

https://www.census.gov/ts/x13as/pc/docsX13.zip

Diretoria de Pesquisas DPE

IBGE

Diretoria de Pesquisas DPE

IBGE