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Analysis of the National Consumer Price Index Using Temporary Series

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Abstract: *In Brazil the first studies referring to price indexes are from 1936. One of the price indexes used is the National Consumer Price Index (INPC). In July 1994 the Real Plan came into being and since its creation the minimum wage has experienced several periods of real losses and gains in relation to its nominal value [1]. This work aims to adjust a model of Time Series to the INPC series in order to verify the existence of trends, seasonality and interventions. Compare a model with and without intervention. The INPC time series was collected monthly by the IBGE from January 1980 to September 2017. The model that fit the best was the one with intervention. Intervention number 76 (04/1986) coincided with the period of governmental intervention in the creation of the crossed plan which began in March 1986. Intervention number 175 (07/1994) also had a significant result, since it was the period that was introduced the real plan. The policy did not interfere with the INPC, the changes occurred in the series were caused only by the change in the currency.*

Keywords: *Interventions, seasonality, time series and trend.*

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I. Introduction

In Brazil the first studies referring to price indices are from 1936 and had as objective to provide elements to fix the minimum wage. One of the price indices used is the National Consumer Price Index (INPC) conducted by the Brazilian Institute of Geography and Statistics (IBGE) [5]. Inflation was a chronic problem, especially in the 1980s and early 1990s, with several failed attempts at control. In July 1994, the Real Plan came into being, and since its inception the minimum wage has experienced several periods of real losses and gains in relation to its nominal value, yet the economy has lived with inflation rates that are immensely lower than those previously experienced [1]. In view of the above, this work aims to adjust a Time Series model to the INPC series with the purpose of verifying the existence of trends, seasonality and interventions to analyze the influence of the economic plans and the oscillation of the economy in the INPC.

II. Material And Methods

The INPC time series under study was collected monthly by IBGE [5] from January 1980 to September 2017, generating 453 observations. Initially, the amplitude versus mean test was used to ascertain the need to apply a logarithmic transformation to stabilize the variance. To verify the existence of trend, a visual study was performed on the chart of the original series and the increased Dickey-Fuller test[7] was applied. Looking for evidence of seasonality in the series, the graph of the autocorrelation function (FAC) was observed and Fisher's test [6] was applied. For the stationary series, a model with and without interventions was adjusted to the data, following the methodology of Box & Jenkins [2]. After adjusting the model, the Box Pierce test [7] was used to verify if the residues represented white noise.Finally, it was verified which the model was more efficient taking into account the information criterion of Akaike (AIC).

III. Results And Discussions

Figure 1 shows the INPC series chart for the period from January 1980 to September 2017, however, all calculations for model adjustment were based on the period from January 1980 to May 2017. The last four months will be used for forecasting. From the visual inspection it can be said that the series is not stationary, since it assumes an increasing behavior and level change in some periods, thus indicating the existence of a trend.

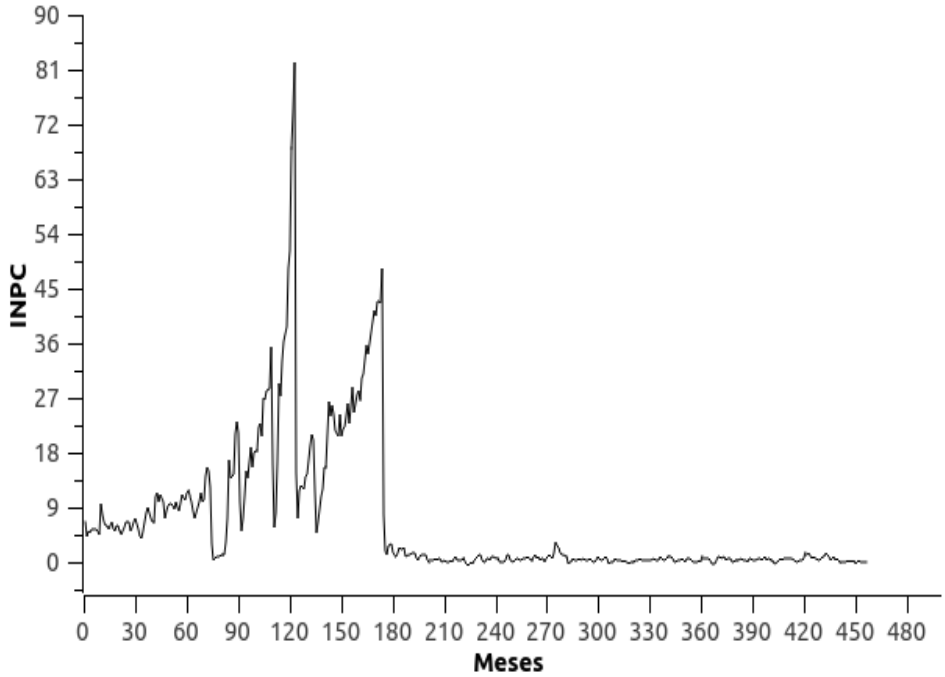
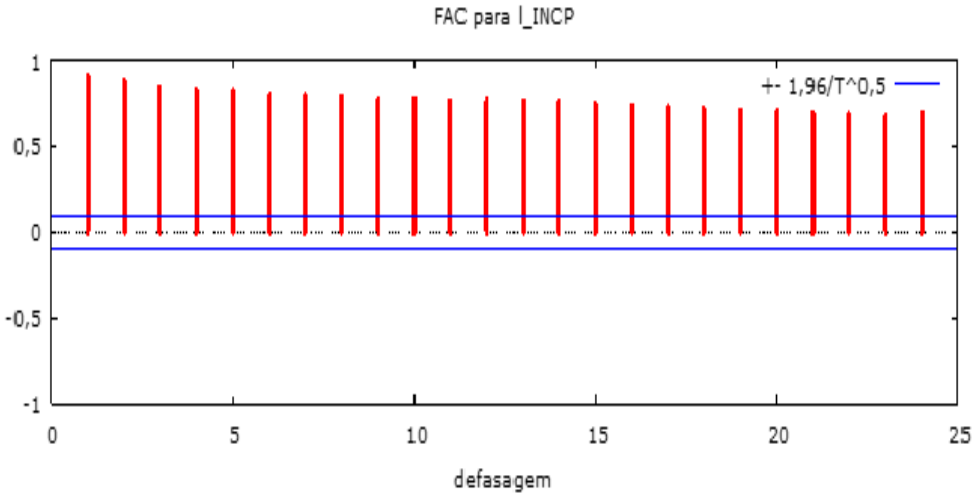


Figure 1. Graph of the time series of the National Consumer Price Index (INPC) from January 1980 to September 2017.

The amplitude versus mean test [7] was significant (P = 1.477x10-6), indicating the need to make a logarithmic transformation in the original data to stabilize the variance. In Figure 2, it can be seen from the FAC graph that the INPC series is not stationary, since the correlation decays slowly. Thus, the increased Dickey-Fuller test [7] was applied to confirm the existence of the trend component (P = 0.1879, H_0: there is at least one root within the unit circle). The series without trend is shown in Figure 3.

Figure 2. Graph of the autocorrelation function (FAC) of the INPC series for the period from Jan/1980 to May/2017 with the stabilized variance.



To evaluate evidence of seasonality in the differentiated series, since the visual inspection is not corroborating, Fisher's test [6] was applied by performing the ANOVA calculation. The test was not significant (P = 0.9609, H0: no seasonality) for the seasonal component. Figure 4 shows the autocorrelation (FAC) and partial autocorrelation (FACP) functions. An iterative cycle was performed to find out which model was most efficient, considering the Akaike information criterion (AIC). The estimates of the parameters of the suggested model are presented in Table I.

Table I. Estimation of the parameters of the model suggestedINPC for the series without intervention.

Model	Parameter	Estimate	Standard error
ARIMA (1,1,1)	φ_1	0,36298	0,07626
	θ_1	- 0,80726	0,05088

The adjusted model was an ARIMA (1,1,1) given by equation 1:

$$(1-B)Z_t = \frac{(1+0{,}80726)a_t}{(1-0{,}36298B)} \qquad (1)$$

After adjusting the model, the Box Pierce test [7] was performed, resulting in non-significance (P = 0.083, Q (24) $<\lambda^2_{22;0.05}$ = 33.92, H_0: residues are i.i.d.) the graph of the residuals in Figure 5 is white noise.

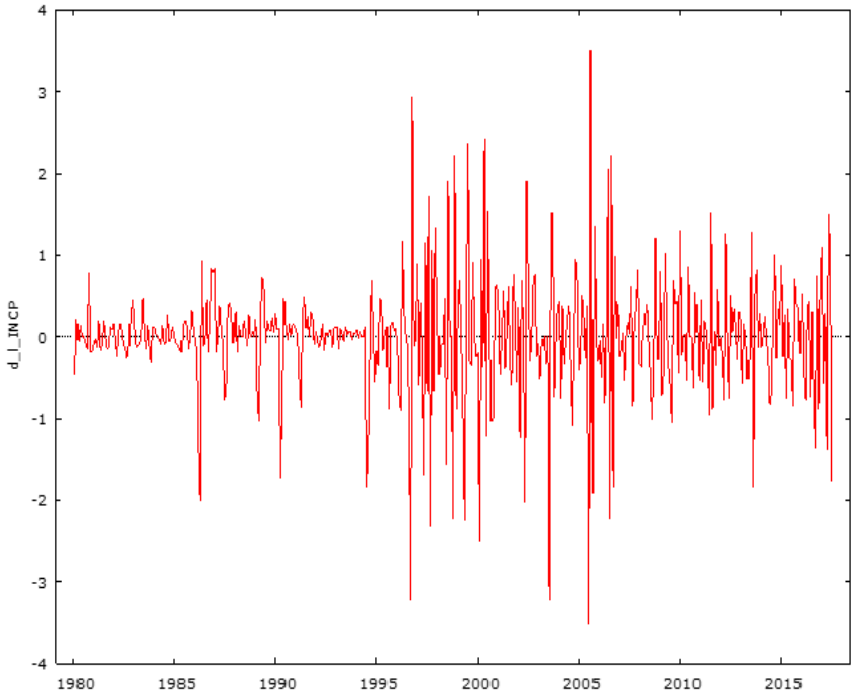


Figure 3. Graphic of the temporary series of INPC regarding the period Jan/1980 to May/2017.

Inspection of the INPC series of Figure 1 shows the presence of possible interventions: gradual gradual in month 76 (04/1986), temporary gradual in months 123 (03/1990) and 285 (11/2002), and finally abrupt permanent in the month 175 (07/1994). By adjusting the ARIMA model (1,1,1) - CI and including the four interventions mentioned above we have the estimates of the parameters of the suggested model presented in Table II. The significant interventions were those of numbers 76 and 175, periods in which the government created the plans, cruzado and real, respectively. After adjusting the ARIMA model (1,1,1) with the interventions (76 and 175) and applying the Box Pierce test(P = 0,146) [7], it can be stated that the graph of the residuals in Figure 6 is white noise.

Table II. Estimates of the parameters of the model suggested INPC for the series with intervention.

Model	Parameter	Estimate	Standard error
ARIMA (1,1,1) - CI	φ_1	0,36298	0,07626
	θ_1	-0,80726	0,05088
	δ_1	-2,17802	0,35768
	δ_2	-2,80388	0,41046

The adjusted model is an ARIMA (1,1,1) - CI given by equation 2:

$$(1-B)Z_t = \frac{1}{1+2{,}17802B}X_{1,t} + \frac{1}{1+2{,}80388B}X_{2,t} + \frac{(1+0{,}88365)a_t}{(1-0{,}30158B)} \qquad (2)$$

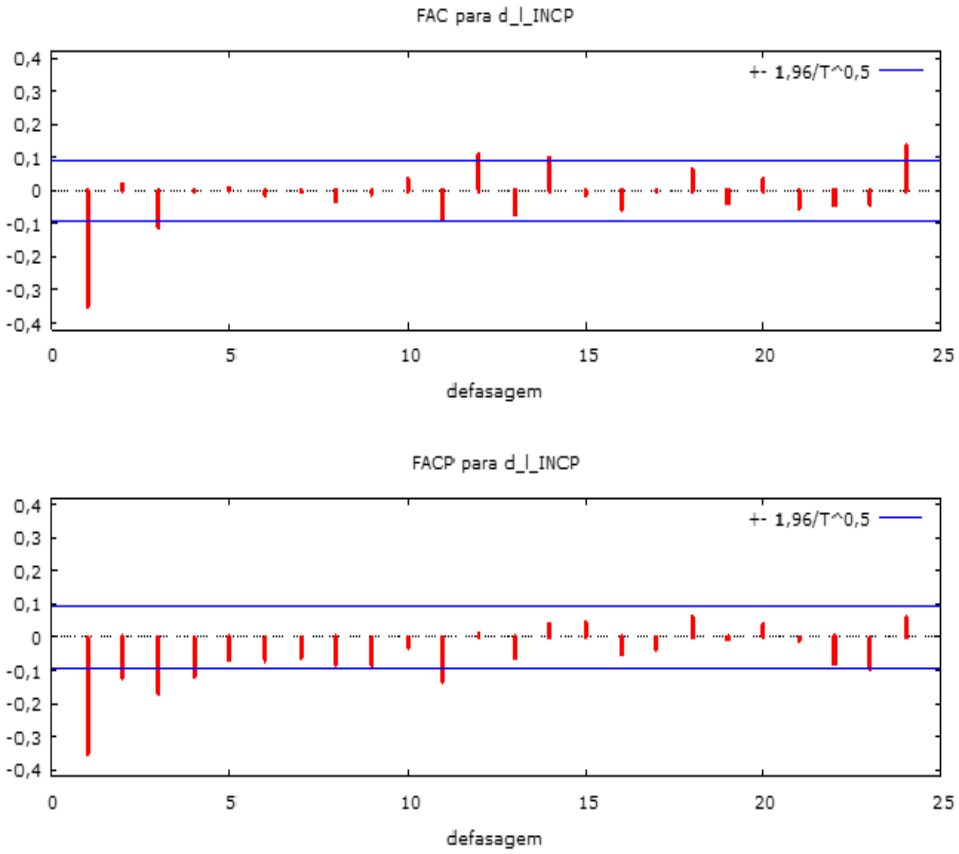


figure 4. Graph of the autocorrelation function (FAC) and partial autocorrelation (FACP) of the INPC series for the period from January 1980 to May 2017.

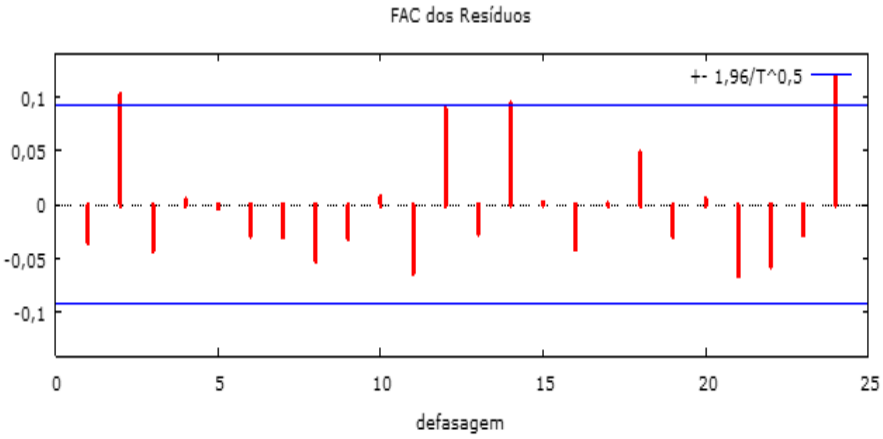


Figure 5. Graphic of the residues of the INPC time series for the period from Jan/1980 to May/2017.

Being $X_{1,76} = \begin{cases} 0 & \text{se} \quad t < 76 \text{ and } t > 82 \\ 1 & \text{se} \quad 76 \leq t \leq 82 \end{cases}$ and $X_{2,175} = \begin{cases} 0 & \text{se} \quad t < 175 \\ 1 & \text{se} \quad t \geq 175 \end{cases}$.

The AIC for the models with and without intervention it was of 904.37 and 883.75, respectively. The model adjusted with intervention is more appropriate.

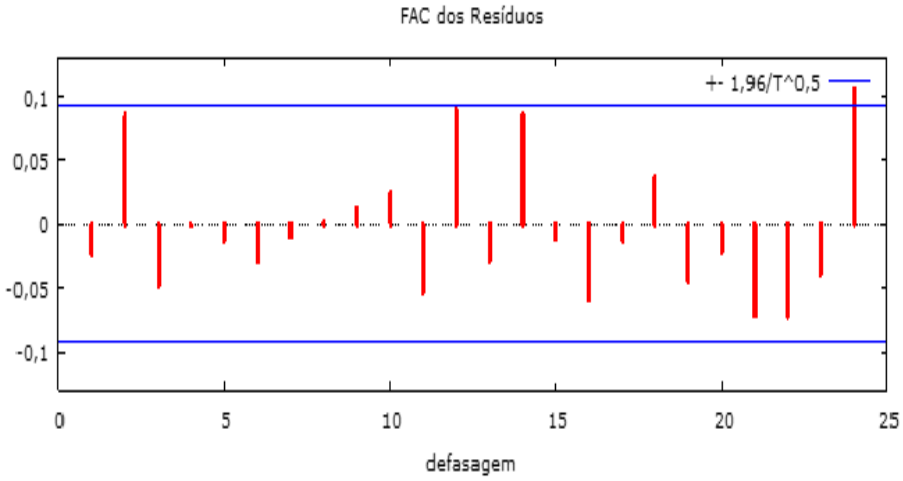


Figure 6. Graphic of the residues of the INPC time series referring to the period from Jan/1980 to May/2017.

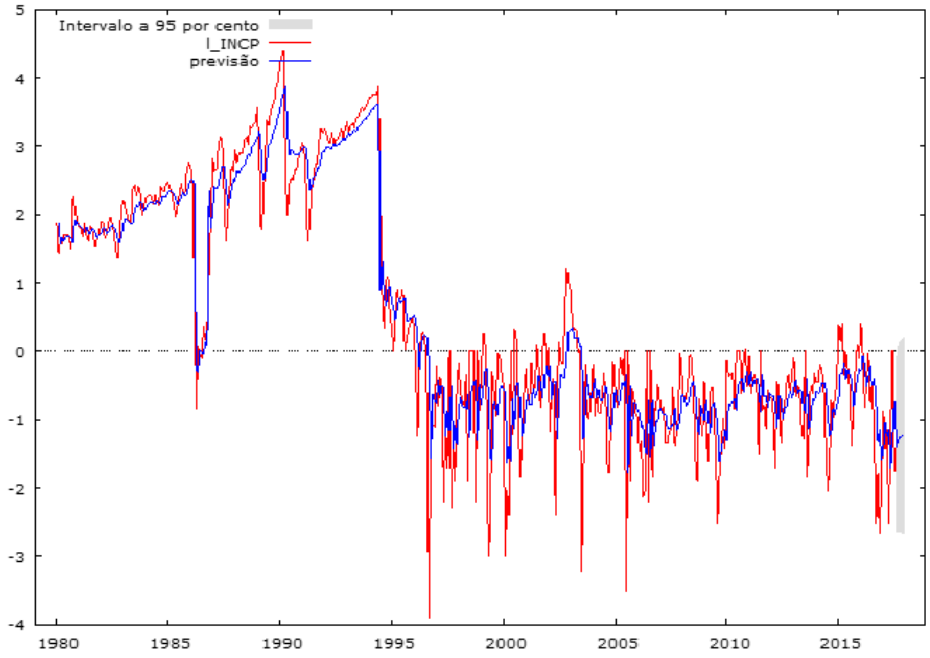


Figure 7 shows the original INPC series chart (red) compared to the series chart after adjusting the ARIMA model (1,1,1) with the interventions $X_{1,76}$ and $X_{2,175}$ (blue) in the period from Jan/1980 to Sep/2017. Table III shows the actual and estimated values for the INPC series from June 2017 to September 2017 adjusted with the ARIMA model (1,1,1) with intervention.

Table III Actual and estimated values for the INPC series.

Months	Actual INPC	Estimated INPC
06/17	- 0,30	- 0,24
07/17	0,17	- 0,08
08/17	- 0,03	- 0,03
09/17	- 0,02	- 0,01

Verifying the predictions of the ARIMA model (1,1,1) and comparing with the actual values an average absolute percentage error of forecast (MAPE) of 19.26% is observed. All tests applied in this article were performed in the GRETL [7] software, with the exception of the Fisher test, which was performed in software R [6].

Figure 7. Graph of the time series of the original INPC (red) and the time series of the INPC adjusted to the model with the interventions $X_{1,76}$ and $X_{2,175}$ (blue) in the period from January 1980 to September 2017.

IV. Conclusion

The Box & Jenkins methodology was efficient to represent the national consumer price index series (INPC). Between the two models the one that adjusted best was the second one, because it presented a smaller AIC. Intervention number 76 (04/1986) coincided with the period of governmental intervention in the creation of the crossed plan, which began in March 1986. Intervention number 175 also had a significant result, since it was precisely when the real plan was introduced in July 1994. The policy did not interfere with the INPC, the changes occurred in the series were caused only by the change in the currency.

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