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Intervention Model of Sinabung Eruption to Occupancy of the Hotel in Brastagi, Indonesia

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ABSTRACT

This paper presents an analysis of intervention of Sinabung eruption to the rate of hotel reservation in Brastagi, North Sumatera, Indonesia. The weekly data of this study was collected from four hotels in Brastagi for the period of January 2012 – May 2015. The method that be used is an analysis of the intervention with ARIMA (Autoregressive Integrated Moving Average) process by Box – Jenkins. To see the stationary of data is used the plot of ACF (Autocorrelation Function). For identification of model is used the plot of PACF (Partial Autocorrelation Function), and to choose the best of model is used AIC (Akaike Information Criterion). Meanwhile to see the suitability of data to model is used Q-Statistics Ljung-Box. The result shows that decline the rate of hotel reservation only until the 30th period after the intervention. After that, the rate of hotel reservation will be as normal as before the eruption. The results of this study are limited, valid only on the subject of research, not generally applicable, to be generalizable needed further research.

Keywords: ARIMA Process, Box-Jenkins Model, Hotel Reservation, Intervention, Sinabung Eruption.

INTRODUCTION:

The eruption of Mount Sinabung in Karo district, province of North Sumatera, Indonesia on September 15, 2013 had a negative impact on the tourism sector in Brastagi city which is approximately 11 km from Mount Sinabung, especially in term of hotel reservation in the surrounding areas impacting the city's income. Intervention in time series is an event or events that may affect the data pattern of the time series. Intervention model in time series analysis was introduced by Box and Tiao in 1975 that discussed the effect of the enactment of legislation engine design to the level of pollution oxidant in Los Angles (Box & Tiao, 1975). Others the paper related to this research are (Montgomery & Weatherby, 1980) investigated the influence of the Arab oil embargo against the level of electricity consumption in the United State. (Suhartono & Huriroh, 2003) investigated the influence of New York WTC bombing against fluctuations in the price of the world. (Chung, Ip, & Chan, 2009) using ARIMA intervention model in research, investigated the effects of the financial crisis on manufacturing industry in China, while (Jarrett & Kyper, 2011) also uses the ARIMA intervention model to predict and analyze the Chinese stock prices. This paper focuses on the determination of the intervention model of Sinabung eruption to the rate of hotel reservation in Brastagi city.

MATERIAL AND METHODS:

The data used in this study is the rate of hotel reservation in Brastagi based on the number of rooms booked by visitors. Data collected weekly from four hotels in Brastagi, two hotels located alongside Sumatera highway, namely Grand Mutiara hotel and The Hill Sibolangit, while two more hotels are located alongside the road to Gundaling, namely Sibayak International Hotel, and Brastagi Cottage. All four hotels are seen to represent all hotels in Brastagi. This study does not consider the peak time, because the data is weekly and the peak time occurs on weekens. Sampling strategy using cluster sampling for determining the location, then the selection of hotels is done randomly. The number of time series data the hotel reservation rate there are 178 of data, starting on the first week in January 2012 as the 1st data until the fourth week of May 2015 as the 178th data. Based on the data used, the first Sinabung eruption at second week of September 2013 viewed as the intervention on the 89th data. The method used is the analysis of intervention with ARIMA process.

RESULTS:

The data ploting when eruption ocucured at t = 89, as Figure 1 below:

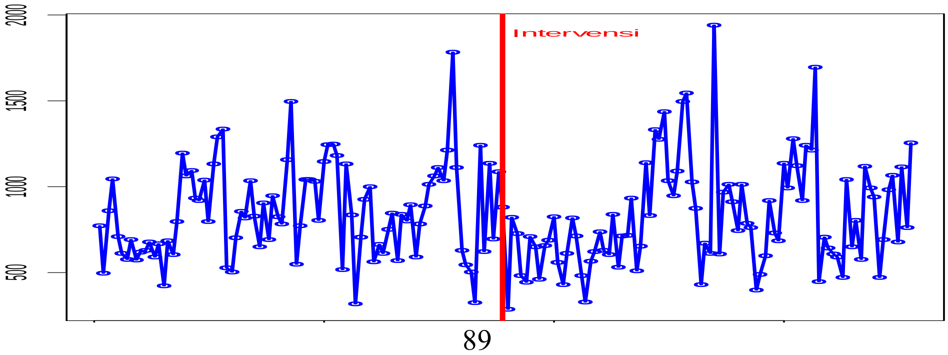

Figure 1: Plot of time series data and Intervention

Analisys before Intervention:

Based on the Sinabung eruption on the second week of September 2013 viewed as the intervention on the 89th data, therefore there are 88 datas before the intervention on the 1st data through to 88th data and are denoted as x1. The data plotong, ACF, and PACF consecutive for x1 presented in Figure 2, 3, and 4 below:

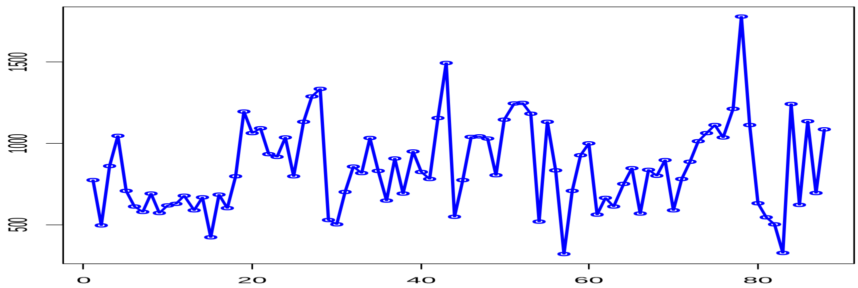

Figure 2: Plot of x1

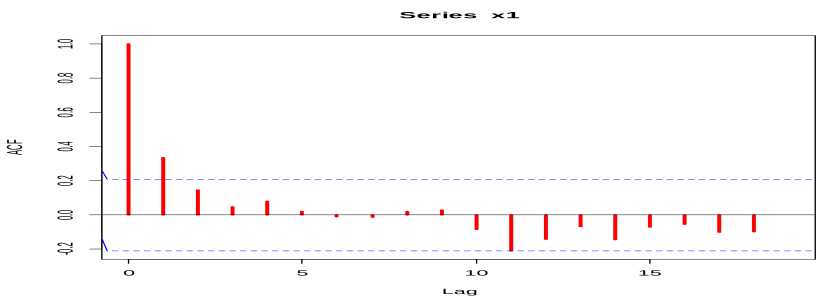

Figure 3: ACF of x1

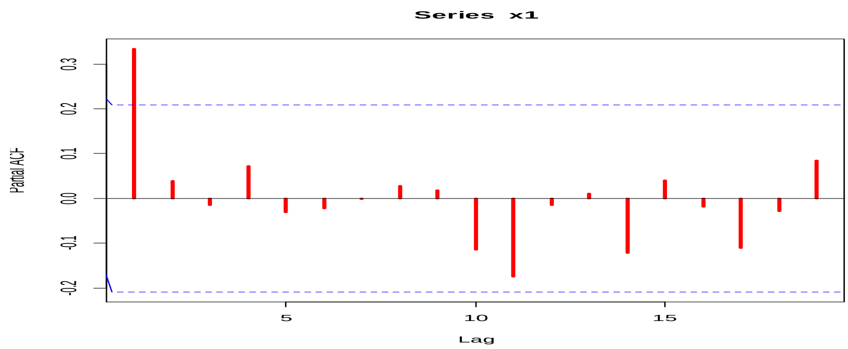

Figure 4: PACF of x1

ACF plot in Figure 3 in the form damped sine wave, this indicates that the time series data for x1 is stationary. ACF plot in Figure 3 is disconnected after first lag and PACF plot in Figure 4 is also disconnected after first lag, this indicates that the model is appropriate for x1 series is ARIMA (1,0,0), ARIMA (0,0,1) and ARIMA (1,0,1). Furthermore, the calculation with the software "R", obtained the value of parameters and the value of AIC as Table 1 below:

Tabel 1: The Estimate value of parameters and AIC

Model	Parameters and AIC			
	$\hat{\phi}$	$\hat{\theta}$	$\hat{\mu}$	AIC
ARIMA(1,0,0)	0.3335	-	853.0606	1229.07
ARIMA(0,0,1)	-	0. 2856	853.2511	1230.71
ARIMA(1,0,1)	0.4323	− 0.1116	852.8317	1230.95

The smallest AIC value is 1229.07 on ARMA (1,0) model, means the suitable model for x1 is the ARMA(1.1) model. In Yt, its model is written:

$$Y_t = 853.0606 + 0.3335\,Y_{t-1} + a_t \qquad (1)$$

To conclude whether the model of equation (1) fits to the data, the author used diagnostic checking of residuals, by examining the autocorrelation for residuals by Q-Statistic Ljung-Box, to test whether the residuals $\{a_t\}$ is a sequence of random variables with mean zero and constant variance, as Figure 5 below:

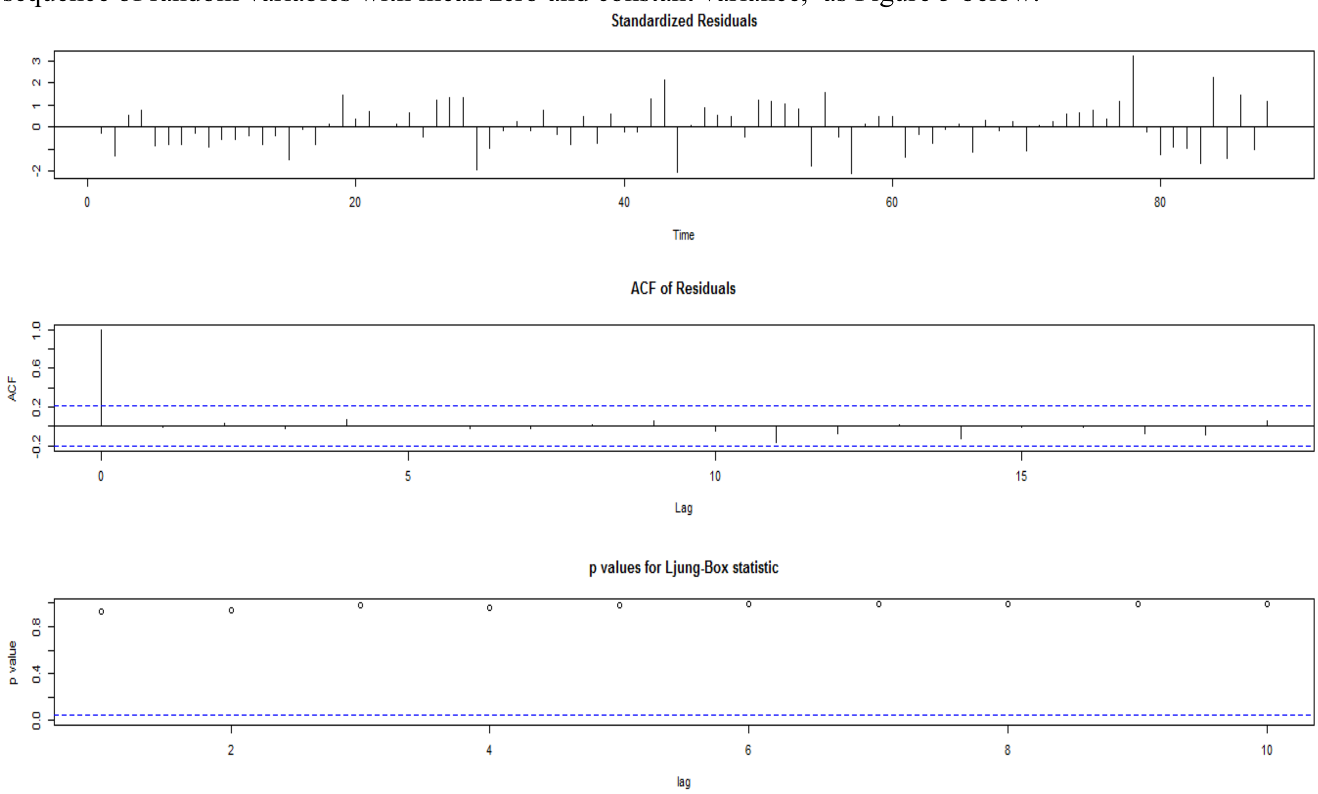

Figure 5: Check diagnostic of residual x1

Testing with Q-statistic Ljung-Box: Chi-squared = 0.0069, df = 1, p-value = 0.9337. Value statistics count < value of Statistics Tables, so it can be concluded that the model is fit data.

Analisys of Intervention:

Identification of intervention response which has been done by observing the data pattern before, during, and after the intervention. Observations were made on the data pattern around the 89th data, ie from the 70th data until the 108th data, presented in Figure 6 below:

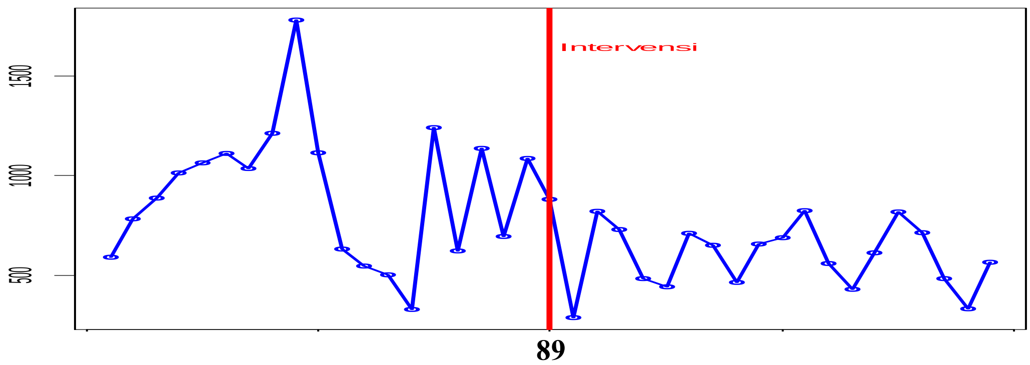

Figure 6: Plot the data around the intervention

In Figure 6 can be seen that the effect of interventions at the 2nd week of September 2013 (89th data). Although not decline dramatically, however, after the eruption seen a decline until some lag time in the future, so that the function of intervention for this case is:

$$f(I_t) = wo\ S_t^{(89)} \tag{2}$$

As it was explained earlier that the number of hotel reservation used there are 178, starting at the first week of January 2012 as the 1st data until the fourth week of May 2015 as the 178th data, while the Sinabung eruptions at the second week of September 2013 or on the 89th data, so that the data be used after intervention is the 90th data until to the 178th data, denoted by x2. The data ploting, ACF and PACF consecutive for x2 are presented in Figures 7, 8 and 9:

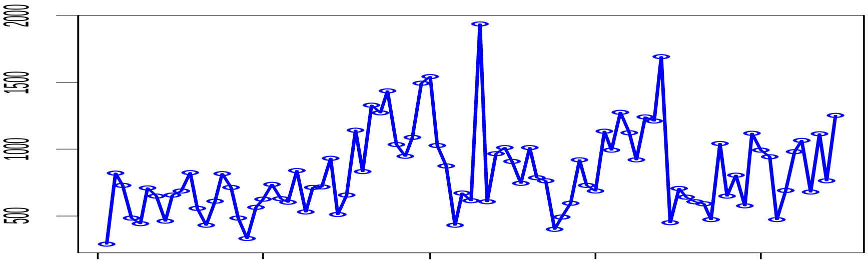

Figure 7: Plot of x2

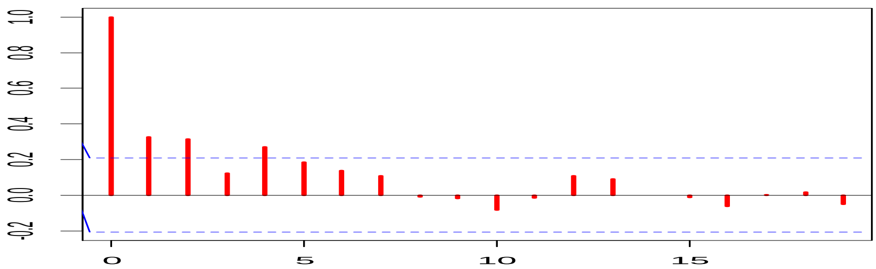

Figure 8: ACF of x2

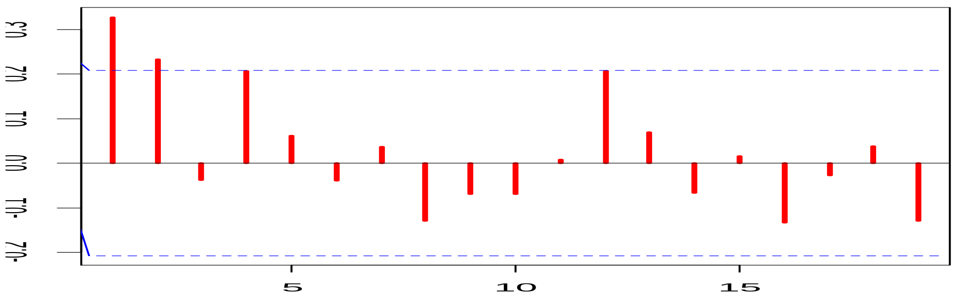

Figure 9: PACF of x2

ACF plot in Figure 8 in the form damped sine wave, this indicates that the time series data of x1 is stationary. ACF plot in Figure 8 and PACF plot in Figure 9 are disconnected after second lag, this indicates that the model is appropriate for series x2 is ARIMA (1,0,0), ARIMA (0,0,1), ARIMA (1,0,1), ARIMA (0,0,2), ARIMA (2,0,0), ARMA (1,0,2), ARMA (2,0,1) and ARMA (2.0, 2). Furthermore, the calculation with the software "R", obtained the value of parameters and the value of AIC as Table 2 below:

Table 2: The Estimate value of parameters and AIC

Model	Parameters and AIC					
	$\hat{\phi}_1$	$\hat{\phi}_2$	$\hat{\theta}_1$	$\hat{\theta}_2$	$\hat{\mu}$	AIC
ARIMA(1,0,0)	0.3419	-	-	-	822.8134	1270.38
ARIMA(0,0,1)		-	0.2226	-	823.2296	1274.26
ARIMA(1,0,1)	0.8273	-	-0.5756	-	820.3793	1267.38
ARIMA(0,0,2)	-	-	0.3159	0.2726	821.9489	1268.55
ARIMA(2,0,0)	0.2586	0.2361	-	-	821.9871	1267.49
ARIMA(1,0,2)	-0.5182	-	0.8311	0.4161	821.5352	1269.24
ARIMA(2,0,1)	-0.1758	0.3810	0.4659	-	821.6267	1268.45
ARIMA(2,0,2)	-0.0027	0.5910	0.2325	-0.2916	820.7830	1270.05

The smallest AIC value is 1267.38 on ARMA (1,0,1) model, means the suitable model for x2 is the ARMA (1.01) model. In Zt, its model is written:

$$Z_t = 820{,}3793 + 0{,}8273 Z_{t-1} - 0{,}5756 a_{t-1} + a_t \qquad (3)$$

To conclude whether the model of equation (3) fits to the data, used the autocorrelation test for residuals by Q-Statistic Ljung-Box, to test whether the residuals $\{a_t\}$ is a sequence of random variables with mean is zero and constant variance, as Figure 10 below:

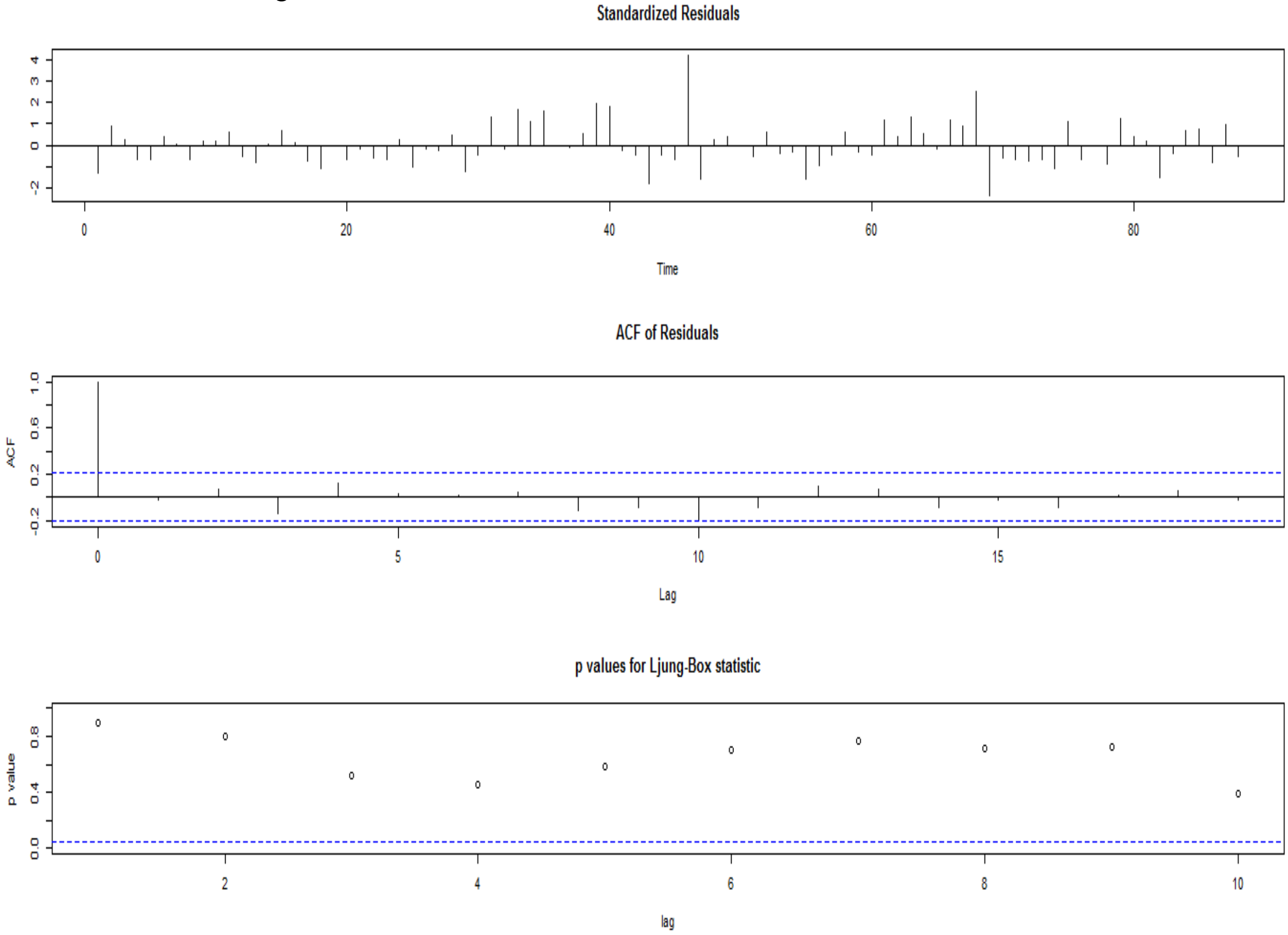

Figure 10: Check diagnostic of residual x2

Testing with Q-statistic Ljung-Box: chi-squared = 0.0283, df = 1, p-value = 0.8665. Value of statistics count < value of Statistics Table, so it can be concluded that the model fits for data.
Based on the values of the parameters, obtained the intervention model:

$$Z_t = ((-1.4373)B)\, S_t^{(89)} + Y_t \tag{4}$$

where Z_t= model intervention when t, B is operator backshif $B^k Y_t = Y_{t-k}$ with the response of intervention.

$$S_t = \begin{cases} 1, & t = 89 \\ 0, & t \neq 89 \end{cases} \tag{5}$$

CONCLUSION:

Plot of the time series data in figure 11 shows that after the Sinabung eruption on 15 September or the 3rd week of September 2013 as the 89th data, the data pattern changes that inflict decrease of hotel reservation until the 119th data. After the 119th data, the pattern back into its previous form before the intervention, this indicates that the imfact of intervention on the hotel reservation only until the 119th data or for 30 weeks after the eruption, after that, the rate of hotel reservation will be as normal as before the eruption.

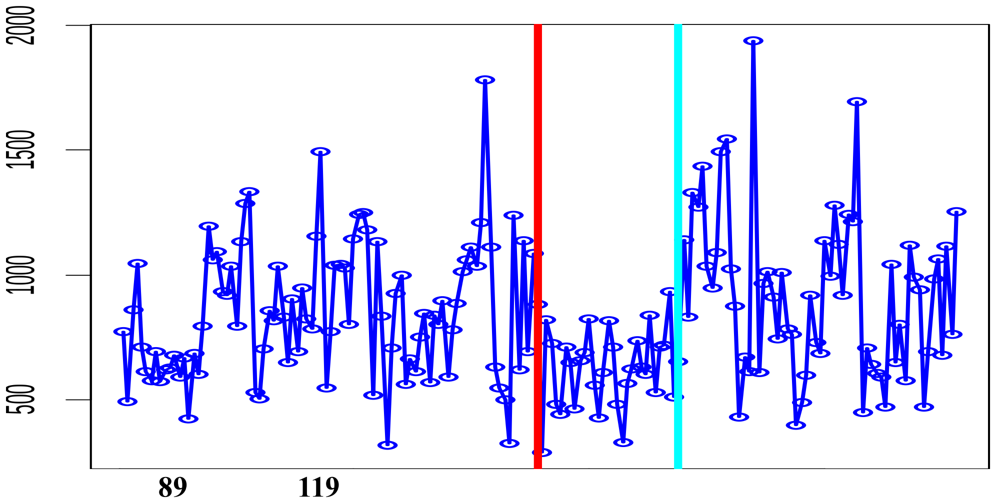

Figure 11: Limit the impact of intervention

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