A SAS® Macro Application for Efficient Interrupted Time Series (ITS) analysis Using Segmented Regression

Sreedevi Thiyagarajan[1,2]

[1]Stanford Prevention Research Center, Stanford University, Palo Alto, CA 95014

[2]Department of Statistics, Pennsylvania State University, PA.

Abstract

A comparison between a SAS macro application and an existing software tool (Joinpoint software) was conducted to identify the most efficient software application to do a segmented regression for doing an interrupted time series (ITS) analysis for the asthma related death trends over time. The SAS macro developed using the SAS (v.9.3) procedures NLIN and REG, when compared with the Joinpoint software for an interrupted time series(ITS) analysis has given the same results as the latter and showed better efficiency as well as lesser time to prepare the data sets, and total analysis time.

Introduction

Interrupted time series is the best quasi-experimental design to evaluate longitudinal effects of time de-limited interventions. The time series analysis could be used to analyze a constant trend over time. When the trend of the outcome measures change between two periods, the best way to analyze change in trends over time is by doing a segmented regression.

This type of analysis is useful to determine the change points in trends of outcomes such as, the sale of therapeutics after a policy change, or medical expenses after the introduction of new drugs, or some experimental interventions. A SAS macro was developed to do this type of analysis which helps to draw a formal conclusion about the impact of a policy change or an intervention on the outcome measure of interest.

Method

The first step in interrupted time series was the visual inspection of the series over time. The series was divided into segments, and a graphical comparison of patterns in trends during different segments of time was done, to analyze the impact of an event, and compare the pattern before and after the event. We assumed for each segment, there is a level(intercept), and a trend (rate of change).

The next step after visual inspection was to see whether the change in trend and level was significant, and whether it could be attributed to the intervention, which was analyzed by a segmented regression.

The following interrupted time series model was used to estimate the trend and level during each of the segments in time.

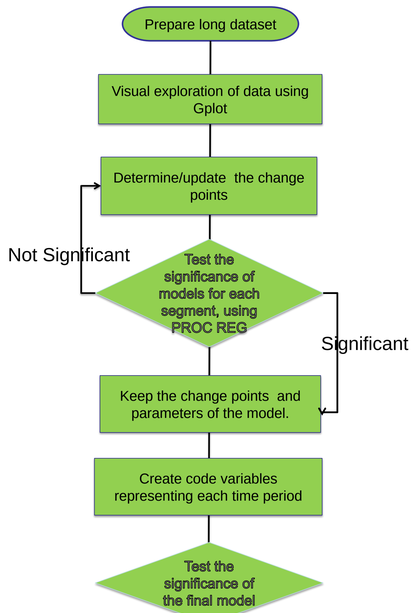
$$Y_t = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \varepsilon_1 ;$$

where β_1 was the intervention or policy change, x_1 time before the first intervention, x_2 was the time after the first intervention, and x_3 was the time after the second intervention if any.

The code variables to indicate the segment before and after an event were created, and the last step was to run a regression model with the code variables, along with the time variable, on the whole data set.

Work Flow Diagram

Figure 1. Work Flow Diagram showing steps for doing segmented regression analysis.



Use Case and Data

The number of asthma related deaths per 1 million children, 0 – 17 years of age in the United States in 1980 -2004 were published in CDC. The trend in asthma related deaths were on the rise until 1996 and then started declining. The publication from CDC used joinpoint software to check whether the change in trend was significant or not. This change is trend could be attributed to some event happened in the health care system, or some policy change, or change in asthma care routine implemented by health professionals.

A SAS macro was designed to estimate the change in trends in asthma related deaths and identify any association to health policy change, by doing an interrupted time series using segmented regression.

Figure2. Trend in Asthma related deaths ,1980 - 2004

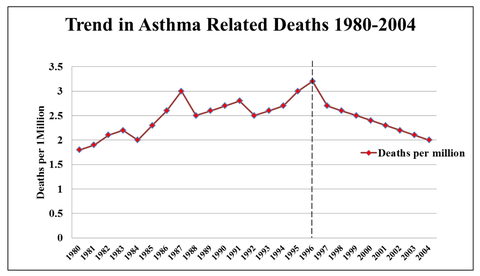


Figure3. Trends at Two Time Segments

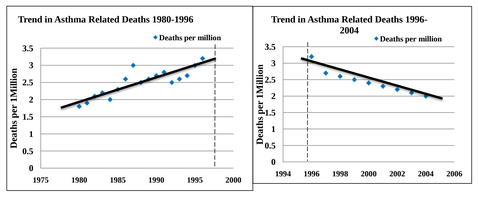


Figure 4. Observed Vs Predicted Trends in Asthma Related Deaths (per 1 Million)

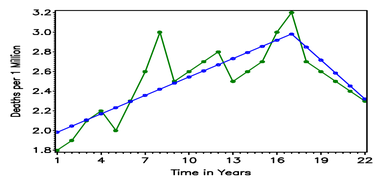
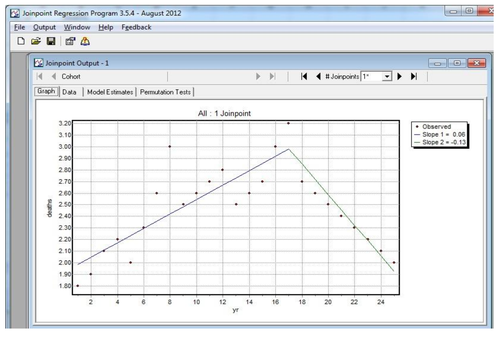


Table1. Parameter Estimates from the Segmented Regression Model

Parameter Estimates for the Final Model		
Parameter	Estimate	95% CI
a1	1.33	(1.16, 1.50)
b1	0.068	.
c	17	.
b2	0.013	(-0.01, 0.03)

Figure 5. Trends in Observed Vs Predicted Asthma Related Deaths As Output from JoinPoint Software



Conclusions

The macro developed using SAS® (version.9.3) procedures NLIN and REG, when compared with the Joinpoint software for an interrupted time series (ITS) analysis gave results similar to the latter and ran more efficiently with less time spent preparing the data sets.

This macro could be used for analyzing interrupted time series, commonly used in studies assessing the effect of educational, administrative and policy interventions carried out to improve the quality of medication use, reduce costs, and improve quality of care. Interrupted time series analysis visually display the differential response of a population to an intervention showing whether an effect was immediate or delayed, abrupt or gradual, and segmented regression analysis estimate the effect size at different time points.

References

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Contact Information

Sreedevi Thiyagarajan, MS(Statistics),
Data Analyst, Stanford University, Palo Alto, CA.
Email: sreedevithyagu@gmail.com

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