Proposal: Uncovering the X-13-ARMIS-SEATS model for Seasonal Adjustment

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1 Introduction

Amongst the many responsibilities of the The Ministry of Statistics and Program Implementation (MoSPI) is the assembling and sharing of critical country indexes like Gross Domestic Product (GDP) and Consumer Price Index (CPI). GDP and CPI are two key economic indicators that provide insights into the overall economic performance and inflation of a country.

GDP is a comprehensive measure of a country's economic activity and is often used to ascertain the health of an economy. An increasing GDP indicates economic growth, while a declining GDP may signal a recession. Similarly, CPI measures the average change in prices paid by consumers for a basket of goods and services over time. It reflects the cost of living and is commonly used to gauge inflation. This information is not only critical for the general public of our country, but also for banks and policymakers to make decisions about interest rates and other economic policies.

It is a common understanding that there are possible seasonal trends in many economic factors as a consequence of holidays, seasons, agricultural trends, tourism etc. Many of these are systematic across years, and thus adjusting for such seasonal trends often ensures that the indexes shared are robust and accurate. Seasonal adjustment is a statistical technique used to remove the effects of

seasonal variations from time series data. These seasonal effects are regular, predictable patterns that occur at specific times of the year. Their removal provides a clearer view of the underlying trends and cycles in the data, allowing analysts and policymakers to make more informed decisions. The X-13-ARIMA-SEATS model is a sophisticated statistical tool used for seasonal adjustment by many countries all over world.

As of now, MoSPI does not carry out any seasonal adjustments in the indices. This is primarily because of the lack of clarity behind the technical details of the model. In this project, we aim to provide clarity on the technical details of this popular model and equip MoSPI with the tools required for its correct implementation.

2 Objectives

The X-13-ARIMA-SEATS model builds on the X-11 model (Shiskin et al., 1967), and the X-12 ARIMA model (Findley et al., 1998) of the U.S. Census Bureau, along with the SEATS (Signal Extraction in ARIMA Time Series) model of Maravall and Gómez (1996). Here, ARIMA stands for the popular AutoRegressive Integrated Moving Average model. This model is widely employed by statisticians and economists to analyze economic indicators, remove seasonal effects, and produce more accurate forecasts. Developed and maintained by the U.S. Census Bureau, the X-13-ARIMA-SEATS software integrates the robustness of ARIMA modeling with the advanced seasonal adjustment capabilities of SEATS, making it a powerful resource for time series analysis.

However, the X-13-ARIMA-SEATS model only exists as a software, with a manual available at U.S. Census Bureau (2017). There is little comprehensive resource available for the technical details of the model and the exact statistical methodologies of every step of the model. Despite this, the model has been adopted and used by various countries including USA, Canada, European Union, Japan, Australia, UK, Brazil, South Korea, Mexico, New Zealand etc.

Despite its widespread use, the X-13-ARIMA-SEATS model exists mainly in software and the detailed steps of implementation do not seem to be documented anywhere. The lack of rigorous understanding of the models prohibits its use for India, where many of seasonal patterns might differ from the west. During the course of the next year, we propose to do the following:

- create a technical document that explicitly lays down the theory and methodology of the X-13-ARIMA-SEATS model
- test the appropriateness of the model as it pertains to Indian data, with consultation with the experts at MoSPI
- make an `R` software package independently available to MoSPI for specific use of the X-13-ARIMA-SEATS model for application to Indian data, according to the needs of MoSPI.

3 Data Elements and Sources

The main sources available to study the model and learn about the methodology seem to be the following:

1. Findley et al. (1998) describe the X-12 ARIMA model (without SEATS) in a statistical way and would be the first source for understanding the mathematical details of the model
2. Maravall and Gómez (1996) develop SEATS methodology and share their mathematical construction of the same
3. To understand the main differences going from X-12 ARIMA to X-13-ARIMA-SEATS there are not many resources. However, we will pivot to backtracking the details of the model from the open-source code available at the following sources:
    - The U.S. Census Bureau software
    - The `R` package `seasonal` along with manual Sax and Eddelbuettel (2018)
    - The Python `statsmodels` package Seabold and Perktold (2010)

4 Proposed analytical framework and methodology

Given the lack of information on the X-13-ARIMA-SEATS model, our main task would be understand theory from the code available in the open-source software `seasonal` and `statsmodel`. This is

certainly a challenging task, however, given my research group's experience with programming in `R` and developing software, we are confident that we will be able to handle this task.

After writing the explicit steps of the model, we will create our independent software implementation and compare outcomes from our software and U.S. Census Bureau software, to validate our understanding of the model. When both results match exactly over a wide variety of test data, we will conclude that we have perfectly understood the model. At this point, we will contact MoSPI office for a summary and presentation of our findings, and discussion over next step of their preferred deliverables.

5 Specific outputs

There are two specific outcomes of this project:

1. A technical document that carefully explains every step of the X-13-ARIMA-SEATS model. We envision this document to be the go-to source for MoSPI officials when using seasonal adjustments in the future and for training new statistics officers.

2. Either an `R` package or an `R` workflow that allows MoSPI officials to use seasonal adjustment with confidence and complete understanding.

6 Potential and value addition

There is an opportunity for tremendous value addition in the reporting and understanding of economic indicators like GDP and CPI. Since currently there are no seasonal adjustments done in the sharing of these indicators, it is unclear if the underlying trend is significantly different from reality. Seasonal adjustments have the potential for bringing not only improved clarity on the trends in Indian economy, but also correctly informing policymakers. Further, MoSPI will have the option of sharing adjusted and unadjusted data so that policymakers, banks, and citizens may employ whichever is more appropriate for their use.

7 Budget

Budget Head	Explanation	Amount

References

Findley, D. F., Monsell, B. C., Bell, W. R., Otto, M. C., and Chen, B.-C. (1998). New capabilities and methods of the x-12-arima seasonal adjustment program. *Journal of Business & Economic Statistics*, 16(2):127–152.

Maravall, A. and Gómez, V. (1996). Programs tramo and seats: Instructions for the user (beta version: June 1996). Working Paper 9628, Banco de España.

Sax, C. and Eddelbuettel, D. (2018). Seasonal adjustment by x-13arima-seats in r. *Journal of Statistical Software*, 87:1–17.

Seabold, S. and Perktold, J. (2010). statsmodels: Econometric and statistical modeling with python. In *9th Python in Science Conference*.

Shiskin, J., Young, A. H., and Musgrave, J. C. (1967). Seasonal adjustment of time series with the x-11 method. *US Department of Commerce, Bureau of the Census*.

U.S. Census Bureau (2017). *X-13ARIMA-SEATS Reference Manual, Version 1.1*. U.S. Census Bureau, U.S. Department of Commerce.