

Research on the Time Series Analysis of Core CPI Index during the COVID-19 Pandemic

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Abstract. People's lives have altered in recent years as a result of the COVID-19 outbreak. People have modified their habits to adapt to the world after the pandemic. The inflation rate is a crucial index that represents the stage of lifestyles high-quality of people, as well as a critical index that indicates the developments and changes of economy. Global incidents continually play an necessary position in altering the inflation rate. The COVID-19 pandemic is one of the most influential incidents in people's each day lifestyles in the previous decades. This paper tries to figure out how the COVID-19 pandemic influences the inflation rate in the United States or people's expectation on the change of inflation rate. Apart from that, this paper discusses the several indexes that represent the inflation rate as well. This paper also covers the research of the Core CPI, by using time series analysis with the help of R language and R-studio, and tries to draw conclusion from the analysis and related literature.

Keywords: COVID-19 Pandemic; Core CPI; Inflation; United States.

1. Introduction

The COVID-19 epidemic has recently had a considerable impact on people's lives. After the epidemic, people modified their routines to fit in with the new environment. More significantly, the virus has an impact on both people's economic health and "physical life" (such as social distance and other related regulations). Money may not be as "worthy" to people as it once was. People end up having to spend more money to maintain their standard of living as a result. In other words, over the years, there have been significant changes in people's living expenses. People must pay more for the same services or goods as the inflation rate rises. It also reduces people's capacity to purchase. Inflation for core items has been higher than it has been in the previous 30 years. Since 2000, core goods inflation has been negated approximately 50% of the time, which means that average product prices have decreased. Consumer Price Index (CPI) measures the average change in market prices over time, and it represents the economic situation of a country and the citizens' living quality.

According to the recent report from the Bureau of Labor Statistics (BLS), the annual inflation rate, defined as consumer price index (CPI), was 8.6% in May, reaching its highest number in the recent 40 years. This unforeseeable high rate of inflation led to numerous major negative social issues and events. However, there are several indexes which are related with the inflation. For example, CPI (which mentioned before), Core-CPI, Chained-CPI, CPI-U, and etc. This paper mainly discusses the Core-CPI and CPI and uses these two indexes to analyze and forecast the future inflation tendency. What's more, this article tries to find how did the Covid-19 pandemic influence the CPI/Core-CPI, or the forecast of CPI/Core-CPI.

2. Literature Review

This paper mainly focuses on investigating if there is any relation between the occurrence of the COVID-19 Pandemic and tries to explain the "how" and "why" of it. The subject, which related with the forecast of CPI, Core CPI, or inflation, has been explored deeply in many papers by multitudes of authors, such as Fisher et al., Meyer and Mehmet, Atkeson and Lee. This section goes through and analyzes the works that they have done in the past and explains what this paper works on the base of their work.

Fisher et al. believed that inflation, or any CPI index, was almost impossible to forecast because of the complexity of inflation and the factors which may influence it [1]. Fisher et al. tried several indexes and a number of ways to predict the tendency of inflation. They found out that the correctness of the predict result was too unstable to be valuable for any analysis and stated that much more theoretical and empirical works were required to prove that inflation or CPI is predictable.

Atkeson and Lee held the similar thoughts with Fisher et al. The inflation is too inconsistent to be predicted, Atkeson and Lee said [2]. They tried using other index (Phillips curve) to forecast the inflation, and they figured out that there was no strong correlation between the forecast result and what would happen in real life. However, they insisted on that the forecast of inflation was still meaningful for people to analyze the tendency of inflation and did not deny that inflation might be a predictable thing in the future with the development of forecast method and the social economy system.

Although the forecast of inflation seems to be hard due to the papers that mentioned before, Meyer and Mehmet tried to find if there is a relatively better forecast method for it [3]. Especially for time series analysis, they wanted to find out if there is a optimal model or solution. They concluded that they did not find the “best” model for this case and they did not think that the complexity of the model indicates the correctness of the forecast result. Meyer and Mehmet mentioned that, in some cases, the “naive” model and method may even get a better result than the complicated one.

3. Methodology

3.1 Hypothesis Development

According to the articles, mentioned in the previous section, merely predict the inflation or CPI may not give people more valuable information, since the result may even be incorrect. Because of that, this paper is going to focus on analyze the relation between the COVID-19 pandemic and the CPI index, instead of the predication of the CPI index. Apart from that, in the Data section, this paper discusses the differences between several CPI-related indexes and try to explain which index would be the best choice to analyze in the context of the COVID-19 pandemic.

3.2 Research Framework

This essay begins by examining the ways in which the COVID-19 pandemic has disrupted people's lives and how those changes have an impact on their economic health, which could cause inflation rate (or Consumer Price Index as a proxy of inflation) to increase. This paper goes through several indexes, which are all related with the inflation, and discusses which might be the suitable one to dig into and find out more valuable information from it. Then this paper analyzes the time series analysis results of Core-CPI/CPI, by using R-studio and R language, and drives conclusions based on the analysis results. The methodology of time series analysis are also introduced and discussed in this paper.

3.3 Data

The Consumer Price Index for All Urban Consumers (CPI) is a way of measuring inflation, based on monthly change in prices paid by U.S. consumers. The CPI is calculated by the Bureau of Labor Statistics (BLS) as a weighted average of prices for a basket of certain goods and services since 1980.

This section introduces and discusses the time series data, which used for the time series analysis. All the time series data is obtained from the U.S. BLS portal. Examples of CPI-related index are Sticky Price Consumer Price Index Less Food and Energy, Consumer Price Index: Total All Items for the United States, Sticky Price Consumer Price Index, and etc.

The most common CPI index is the Consumer Price Index for All Urban Consumers: All Items in U.S. City Average. The formal abbreviation for it is CPIAUCSL. For reader's convenience, this paper uses CPI to refer it. The CPI is a price index that represents a basket of services and goods paid by urban consumers. The “basket” usually includes accommodation, clothing, transportation, schooling,

communication, food and drink, health care, and recreation, and few other goods and services. In other words, CPI is a monthly time series data which could represent the purchasing habits of urban consumers, which includes more than around 88 percent of the total population in the U.S.

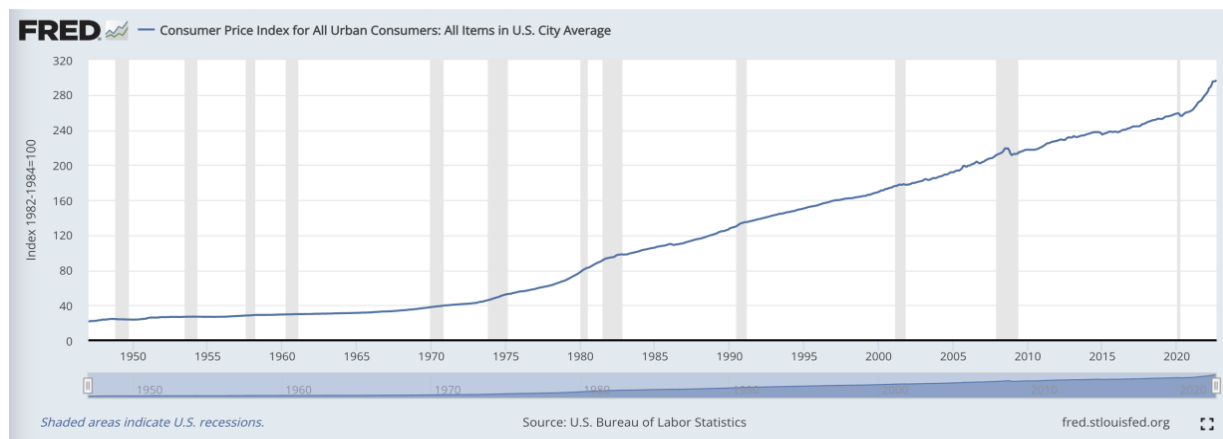


Fig 1. U.S. CPI from BLS [4].

However, some researchers found that the CPI might not be the most suitable index to reflect people's buying habits and life quality. Clark argued that the CPI index covered too much "trivial and unstable" component which could not represent the real purchasing power and habits of citizen consumers [5]. He insisted that the "energy and food price" components, which are also included in the "CPI basket", were not effective in capturing the trend of inflation. Those components were influenced by too much uncertain factors and should not be considered for the "CPI basket". The Core CPI, Clark said, was a more reliable index to reflect urban consumers' buying power and habits, which means that the Core CPI was also a better index for analyze the inflation.

The full name of Core CPI is Consumer Price Index for All Urban Consumers: All Items Less Food & Energy. This time series data is also provided by the BLS. The Core CPI excludes the volatile components, like food and energy, to better reflect the real purchasing power and habits of the citizens. Although some researchers argue that the Core CPI is still a defective index, they also admit that this index is good enough for people and economists to learn the trend of inflation. Peach and Alvarez believed that BLS was supposed to exclude more component in the Core CPI to make it a better and more useful index [6]. They stated that the "used car" component was a much more volatile stuff that should not be considered for the Core CPI. Few other researchers also had the similar idea with them. However, BLS only provided the Consumer Price Index for All Urban Consumers: All Items Less Food & Energy as the only Core CPI index. In this paper, that index is also the only Core CPI used for the time series analysis.

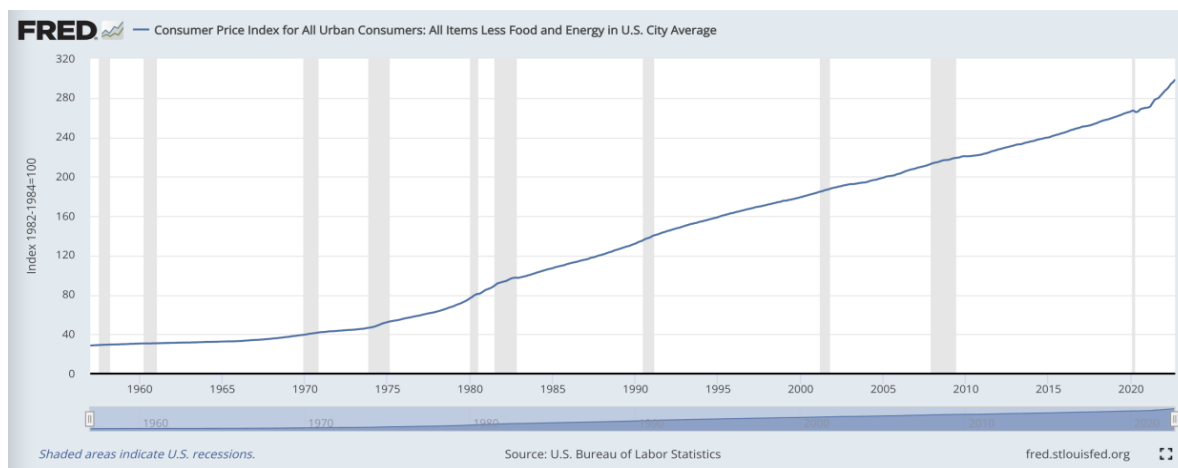


Fig 2. U.S. Core CPI from BLS [4].

3.4 Modelling

The primary research methods used in this paper are case study, content analysis, literature search, and time series analysis. It examines academic articles, theses, business reports, and website data. The inquiry and research approach entails directly gathering pertinent materials through examination, comprehension, and analysis of the objective situation.

In order to draw critical conclusions about the subject, this report utilizes other trustworthy and pertinent literature as references. The literature discusses issues affecting living costs at the macroeconomic, microeconomic, and other levels. Apart from only listing the mentioned literature as references, this article also quotes other papers to support the time series analysis of the Core CPI. More specifically, this paper uses Simple Exponential Smoothing and Auto-Regressive Integrated Moving Average, as known as ARIMA, as the two models for the time series analysis and its forecasting.

Simple Exponential Smoothing, as known as SES, is a time series forecasting way for uni-variate data without any trend or seasonality. SES is always used to predict the short-term forecast, instead of the long-term one. The aim behind Simple Exponential Smoothing is to forecast future values of the target variable using the smoothed data. However, the recent data points in the series data have more influence on the forecast of the series, compared with the more distant data points. Ostertagová and Ostertag mentioned in their paper that SES is a decent choice for time series analysis and relatively short-term forecast [7]. Simple Exponential Smoothing, which constructs the forecast from an exponentially weighted average of the historical observations, is a reasonably simple and useful approach of forecasting.

Auto-Regressive Integrated Moving Average, as known as ARIMA, is the generalization of the Auto-Regressive Moving Average (ARIMA) model. ARIMA models utilize differencing to convert a non-stationary time series into a stationary one, and they then extrapolate present values into the future. These models apply "auto" correlations and moving averages over residual errors in the data to forecast future values. Nelson stated that ARIMA modeling is a relatively complex methodology for the forecasting in time series analysis [8]. He also mentioned that although the methodology for ARIMA is much more complicated than some other forecast modeling, it does not mean that ARIMA always get a better prediction result than other methods.

Although there are also other decent and reliable time series analysis models, such as Random Forest and XGBoost, like Meyer and Mehmet analyzed before, there is no such a "best model" for any case. In this experiment, only Simple Exponential Smoothing and ARIMA will be deployed and analyzed.

In the time series analysis of this paper, it pays more attention to the influence of the Covid-19 Pandemic on Core-CPI, instead of purely predicting the future value of the Core CPI. This article uses R and R-studio to analyze the time series. Thanks to the "SES" and "ARIMA" packages in R-studio, there procedure of modeling was finished by the packages and R language. Ahmar et al. also explained in his paper that how did the ARIMA package work to forecast the time series data [9]. The analysis deploys SES and ARIMA modeling on monthly Core CPI data from two time periods. The COVID-19 Pandemic started in the US in roughly the start of 2020. So, one called "Including the Pandemic" data, which is Core CPI data from Jan 2012 to Jan 2022; the other called "Excluding the Pandemic", which is Core CPI data from Jan 2010 to Jan 2020. After deploying the mentioned two forecasting models on the two data series (from two time periods), this paper summarizes the results in the next section.

4. Results

Figure 3 and Figure 4 below are the results of the forecasting of the Core CPI, by using Simple Exponential Smoothing and ARIMA. The left graphs show the prediction result by using the "Including the Pandemic" data, and the right ones show the prediction result by using the "Excluding the Pandemic" data. The blue part is the predicted data range for Core CPI time series data.

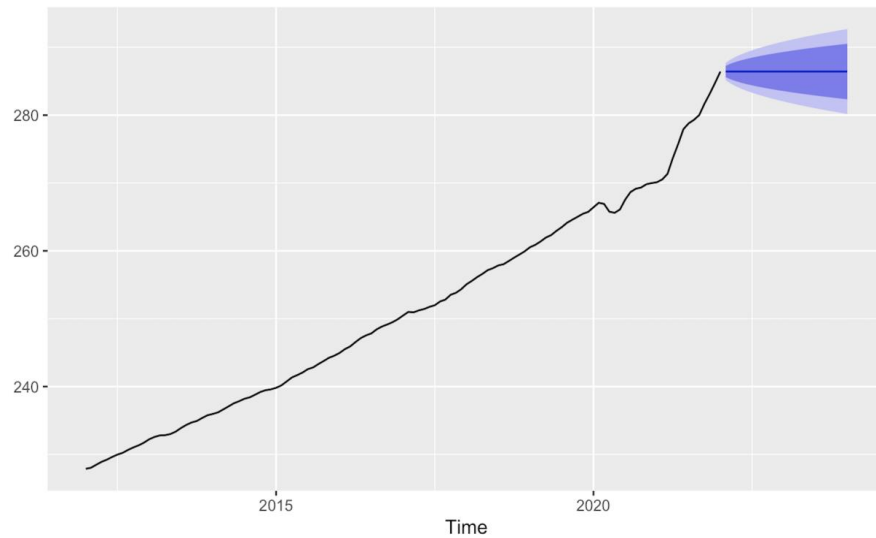


Fig. 3 Simple Exponential Smoothing Forecast on Core CPI on “Including the Pandemic” time period (Photo credit: Original).

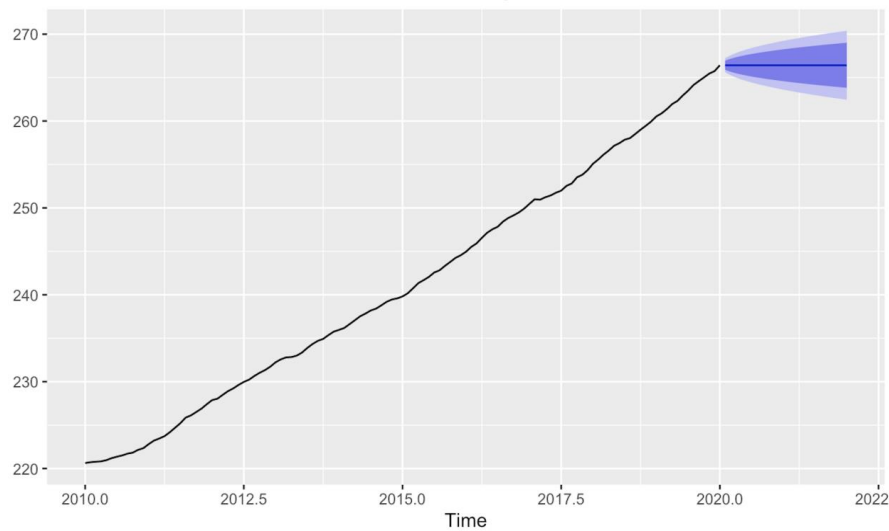


Fig 4. Simple Exponential Smoothing Forecast on Core CPI on “Excluding the Pandemic” time period (Photo credit: Original).

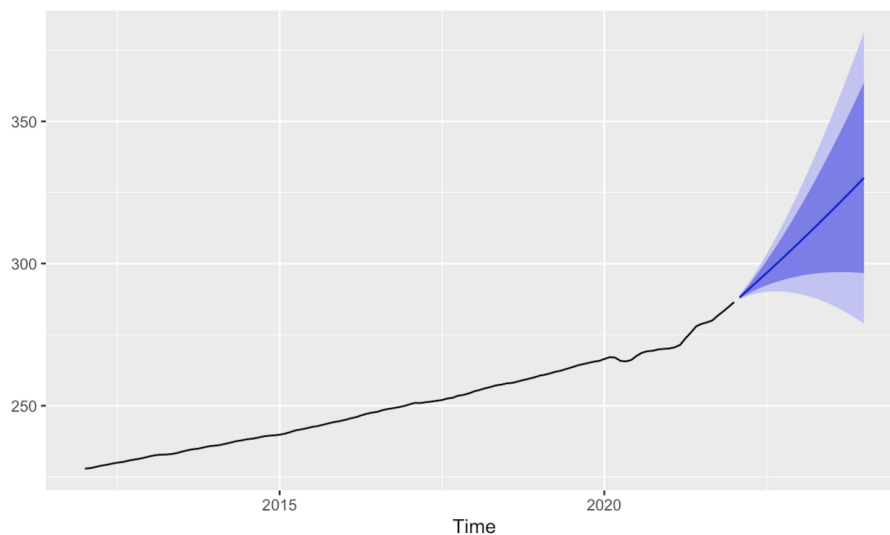


Fig 5. ARIMA Forecast on Core CPI on “Including the Pandemic” time period (Photo credit: Original).

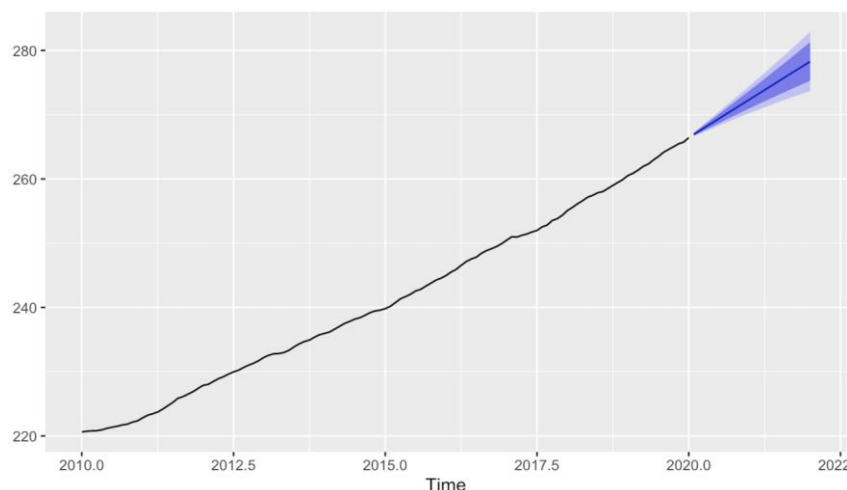


Fig 6. ARIMA Forecast on Core CPI on
“Excluding the Pandemic” time period (Photo credit: Original).

As shown in Figure 3 and Figure 4, the predicted range (for 2 years) for “Including the Pandemic” and “Excluding the Pandemic” by using Simple Exponential Smoothing model is approximately (282.9, 291.8) and (264.6, 268.3). This model shows that the occurrence of the Covid-19 Pandemic widened the Core CPI predication range from 3.7 to 8.9. In order to get more objective information about the prediction range, the percentage of the range is calculated as 1.39% for “Excluding the Pandemic” and 3.10% for “Including the Pandemic”.

As shown in Figure 5 and Figure 6, the predicted range (for 2 years) for “Including the Pandemic” and “Excluding the Pandemic” by using ARIMA model is approximately (297.2, 362.5) and (274.7, 282.1). This model shows that the occurrence of the Covid-19 Pandemic widened the Core CPI predication range from 7.4 to 65.3. In order to get more objective information about the prediction range, the percentage of the range is calculated as 2.78% for “Excluding the Pandemic” and 22.75% for “Including the Pandemic”.

As the above four figures shown, although there is not any precise predicted Core CPI value, the tendency and range of the prediction still illustrate some crucial things about the future Core CPI. It is fair to say that the predicted range of the Core CPI of “Including the Pandemic” data is much wider than the range of the Core CPI of “Excluding the Pandemic” data, which are respectively 7.4/65.3 and 3.7/8.9 for the two models’ prediction. This means that it is much harder for people to predict the Core CPI after the pandemic happened and influenced the Core CPI. In other words, this may indicate that the COVID-19 Pandemic unstablized the Core CPI value, which complies with people’s first impression of the pandemic.

As Akbulaev, Mammadov, and Aliyev stated that the COVID-19 Pandemic, as a public emergent incident, confused not only individuals’ minds but also groups and organizations’ minds on making economic decision, which may result in the chaos of the economy [10]. Moreover, Meyer, Prescott, and Sheng also believed that the pandemic changed the business expectations on both individuals and companies, which led to the unexpected economic behaviors from citizens and groups [11]. This also made the Core CPI more difficult to predict because of the economic unexpected behavior.

5. Conclusions

Although draw some important and valuable conclusion, this paper still has a few limitations in itself. The time series analysis could only give roughly tendency of the future Core CPI value, which might be improved in any future studies by using more comprehensive analysis methods. In the two-time series analysis experiment, the Simple Exponential Smoothing model shows that occurrence of the COVID-19 pandemic unstablized the expectation of Core CPI index a little bit. More specifically, the range of it enlarged from 3.7 (1.39%) to 8.9 (3.10%). The ARIMA model shows a more

considerable change while the range of Core CPI enlarged from 7.4 (2.78%) to 65.3 (22.75%). Both models show that the occurrence of the Covid-19 Pandemic unstablized the expectation of the Core CPI index. Further researches could be conducted based on other time series analysis models, which may lead to a more comprehensive and accurate result on the change of expectation of the Core CPI index. Apart from this, as mentioned and discussed in the previous section, there might be “better” Core CPI time series data in the future, which may give more valuable information on the analysis results. For any future studies, based on this paper, interviews and questionnaire surveys may also be decent measures to get some primary data, which could give a more comprehensive understanding of this topic to the readers.

Last but not least, the experiments show that the COVID-19 Pandemic disturbed and unstablized people’s life by badly influencing the cost used to maintain and improve people’s life quality. Public need to realized that inflation is also a normal economic phenomenon happens in people’s daily life. With the help of decent economic policy, as mentioned in previous sections, the inflation could always be solved in a relatively smooth way in the following years.

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