ECON 470 – Economic and Business Forecasting

Economic Forecasts for Japan

Claude Lee (13924192)

Sebastian Borras-Ballesteros (12981189)

Matthew Brown (14161013)

Introduction

After World War II, Japanese economy started taking a different direction from fabrication of cheap textiles towards manufacturing. The change that occurred in this time period was one of the most remarkable features of Japan's economic improvement. Because of this change, Japan became one of the leaders in manufacturing of many technological products. Their economy has improved, and right now, they are in their longest postwar economic expansion. This is due to many contributing factors that Japanese economy has gone through. For example, from the 1960s to the 1980s Japan had one of the highest economic growth rates in the world, due to: high standards of education, increasingly open world trade, high rates of investment in productivity and equipment, and application of efficient industrial techniques. Japanese economic growth rate became drastically low after plummeting of stock and real estate prices in 1990s. Although Real GDP is not growing as fast as it did in the 1980s where it grew by (4%), it was growing at an average of roughly 1% yearly.

This made Japan's economy grow to be ranked as number two behind the United States from 1990 to 2010. Japan's economy overall has thrived through all the various factors and by being able to trade some of its very own natural recourses. This has allowed them to gain enough foreign exchange to help keep the economy going. The power Japan holds in the economy is in both Asian and globally. Japan has been known to keep close ties with the United States in matters of safety and protection, which benefits both the US and Japan. While doing this, they have been able to create more relationships with other countries and nations which has helped their economy form better trading ties.

Our goal for this report is to forecast future values of some variables from three main markets in Japan (labor market, goods and services market, and financial market) and to provide a dynamic evaluation on the future trend for each market. In our analyses, we selected total of 6 variables, two for each market;

- Labor Market: Unemployment Rate (for working age 15-64), Working Age Population (15-64)
- Goods and Services Market: Consumer Price Index (all items), Total Industry Production (except constructions)
- Financial Market: Total Cash, Japan/U.S. Foreign Exchange Rate

We will employ Autoregressive Integrated Moving Average (ARIMA) forecasting method by Box and Jenkins, along with utilizing statistical software 'R'.

Contents

1. Data Selection, Forecasting Method, and Our Goal

- *Data Selection*

We obtained our data from Economic Research website of Federal Reserve Bank of St. Louis and website of Bank of Japan. First, we chose adequate units for each variables, and if the data were not available in the desirable unit, we transformed them using the software JMP to get the appropriate unit. Then, to accompany the lack of length for data from Bank of Japan, we standardize our data period by 1998 quarter 3 to 2018 quarter 4, as quarterly data. Additionally, we selected them as not seasonally adjusted data, since we are only forecasting one year ahead (2019) with frequency of 4.

There are two variables we chose in the labor market of Japan. The first variable is unemployment rate (as a percent) for all persons in Japan that were ages 15 to 64. The following variable, working age population, is also consisted of the same age group, as a percentage change. By finding relationship between the two variables, we could predict the approximate employment availability changes in Japan.

For goods and services market, we chose consumer price index for all items and total industry production (excluding constructions) in Japan, both as index (2015 =100). The CPI will tell us about the change of price level of consumer goods in Japan, whereas total industry production will show the change in the actual amount of those goods. The difference between them will tell the disparity between the price and quantity in goods and services market.

For the last, we have examined percentage change of total cash in Japan and their foreign exchange rate with U.S. in their financial market. Using these two variables, we will check the overall stability and volatility in the financial market of Japan.

Market	**Variable/Data**	**Unit**	Note
Labor Market	*Unemployment Rate*	Percent	For working age (15-64)
	Working Age Population	Percentage Change	Working age: 15-64
Goods and Services Market	*Consumer Price Index*	Index: 2015 = 100	For all items
	Total Industry Production	Index: 2015 = 100	All industries except constructions
Financial Market	*Total Cash*	Percentage Change	All cash
	Japan/U.S. Foreign Exchange Rate	Japanese Yen to One U.S. Dollar	

- *Forecasting Method*

Our forecasts are generated using Autoregressive Integrated Moving Average (ARIMA) model by Box and Jenkins. ARIMA model detects non-stationarity in data and takes differencing to make the data stationary (the stationarity of data is necessary for further steps). With the stationary data, the model takes into account the values and shocks from previous years by actively utilizing autocorrelation between observations. Since time series data are strongly correlated between observations due to the nature of time, ARIMA model that regards the correlations between lags is very suitable for forecasting with time series data.

To begin fitting ARIMA model to our data, the data transformation before any process is necessary to fix issues with constant variance. Although the model detects non-stationarity of data within the process, large irregular fluctuations within variance of data is hard to fix only with differencing. This step usually involves taking log on data, which is a common practice in statistics to reduce irregular variances around the mean.

After transformation, fitting ARIMA model to data starts with differencing. Once the data become stationary, we define autoregressive (correlation between lagged values) and moving average (correlation between lagged shocks) terms by looking at their autocorrelation and partial autocorrelation functions (ACF and PACF). Importantly, the model only takes into account the lagged values and shocks that are significantly autocorrelated to reduce the number of parameters to be estimated. In addition, the model can also have seasonal components by seasonally defining stationarity, autoregressive and moving average terms.

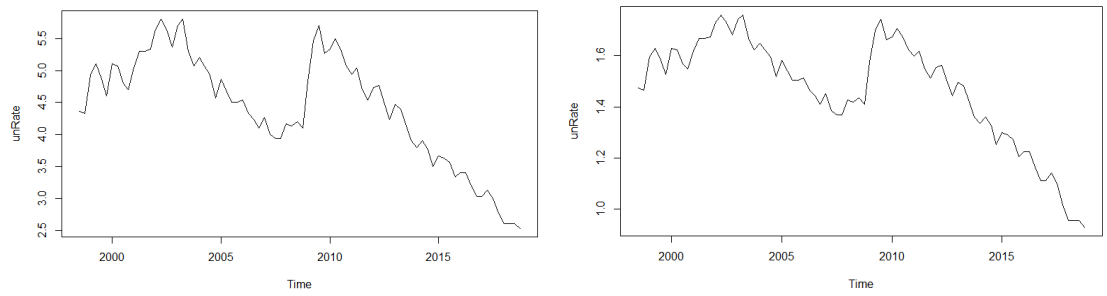
In our forecasting process, the statistical software “R” is used, along with a package of time series packages “fpp,” which includes “forecast” package. The “auto.arima” of “forecast” is a function that fits the best ARIMA model for a time series data by automatically analyzing stationarity, autocorrelation, and AIC of the time series. Since we are dealing with data with seasonality, we employ “auto.arima” function the seasonal components to generate more precise forecasting.

Part 1. Labor Market

2. Unemployment Rate in Japan

- This time series data is about unemployment rate for working age population (15-64) in Japan.
- Unit: percent
- From 1998 Q3 to 2018 Q4 (Quarterly)

a. Time Series Characteristics



Left: Original time series plot *Right: Log-transformed time series plot*

- The time series seem to have a structural break in 2009, therefore it is non-stationary.
- The time series does not seem to have a constant variance, therefore we will try both non-transformed series and log transformed series.
- It has an upward trend up to 2003, then it changes to a downward trend, not considering the structural break in 2009.
- The data also shows seasonality and cyclicality.

b. Forecasting Methods

The method we will use for forecasting in Unemployment rate in Japan is seasonal ARIMA model. Due to a structural break, seasonality, and cyclicality, the multiple regression would not work well. Additionally, since we are unsure whether the log transformation is needed, we will fit two separate ARIMA models for both original and transformed time series data.

c. Forecasting Model

- Original Time Series:

  ARIMA(2,0,0)(0,1,2)$_4$

  - Second order non seasonal autoregressive process.
  - First order seasonal differencing.
  - Second order seasonal moving average process.

  Estimates

AR1	*AR2*	*SMA1*	*SMA2*
1.2394	-0.2798	-0.5992	-0.195

  AIC = -39.01

- Log-Transformed Time Series:

  ARIMA(1,1,0)(0,1,1)$_4$

  - First order non seasonal autoregressive process.
  - First order non seasonal differencing.
  - First order seasonal differencing.
  - First order seasonal moving average process.

  Estimates

AR1	*SMA1*
0.2899	-0.7646

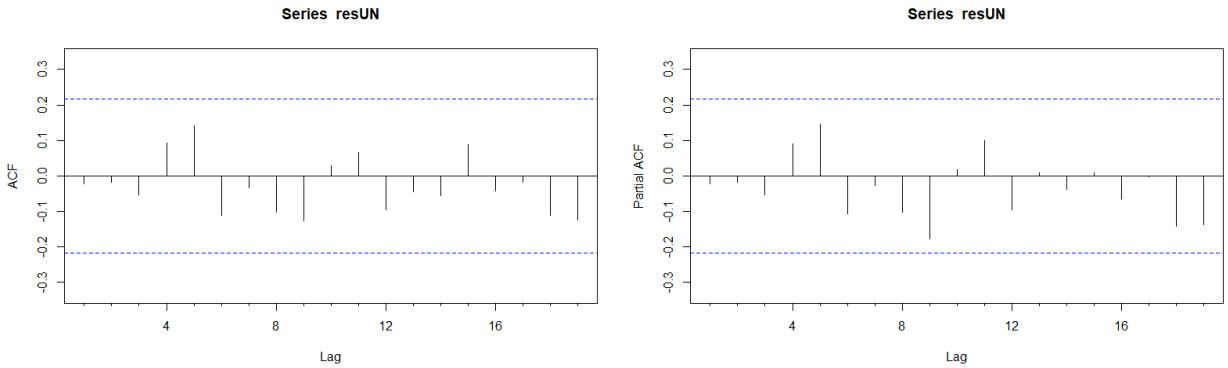
  AIC = -275.16

  ➔ Since log-transformed model has a lower AIC value, we will choose this log-transformed model.

  Equation

  $(1 - 0.2899L)(1 - L)(1 - L^4)y_t = (1 - 0.7646L^4)\epsilon_t$

- Residuals



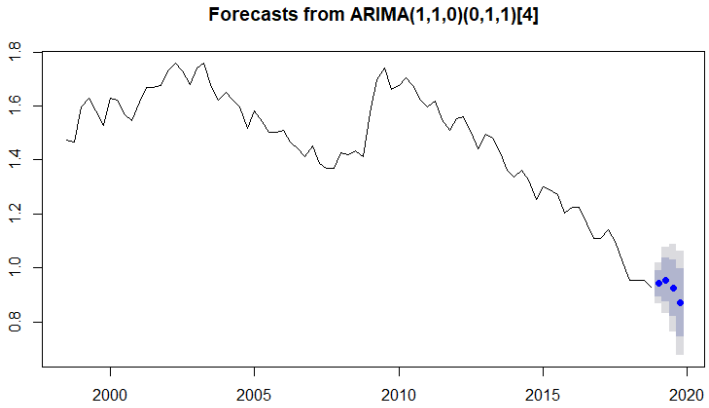
The model is a good fit for the data because there is no significant spike in the ACF and PACF plot, which means that the residuals resemble white noise.

d. Forecasting Values for 2019

- Forecasts

	Point Forecast	*Lo 80*	*Hi 80*	*Lo 95*	*Hi 95*
2019 - Q1	0.9427896	0.8933335	0.9922457	0.8671530	1.018426
2019 - Q2	0.9550151	0.8742952	1.0357349	0.8315648	1.078465
2019 - Q3	0.9250994	0.8195855	1.0306132	0.7637298	1.086469
2019 - Q4	0.8712600	0.7451018	0.9974182	0.6783176	1.064202

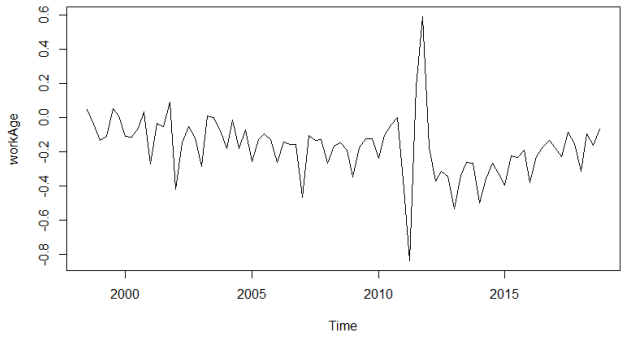
- Forecast graph



3. Working Age Population in Japan

- This time series data is about working age population (15 to 64) in Japan.
- Unit: percentage change
- From 1998 Q3 to 2018 Q4 (Quarterly)

a. Time Series Characteristics



- The time series has a large, rapid change in 2011 and 2012.
- The date seems to have constant variance overall. The mean appears to be constant over time, therefore the data is stationary.
- It has a slight downward trend until 2010, and upward trend since then.
- The data depicts seasonality and cyclicality.

b. Forecasting Methods

Same as the previous variable, the method we will use for forecasting in working age population in Japan is seasonal ARIMA model. Due to seasonality and cyclicality, the multiple regression would not work well.

c. Forecasting Model

- ARIMA(2,1,1)(0,0,2)$_4$
    - Second order non seasonal autoregressive process.
    - First order non seasonal differencing.
    - First order non seasonal moving average process
    - Second order seasonal moving average process.

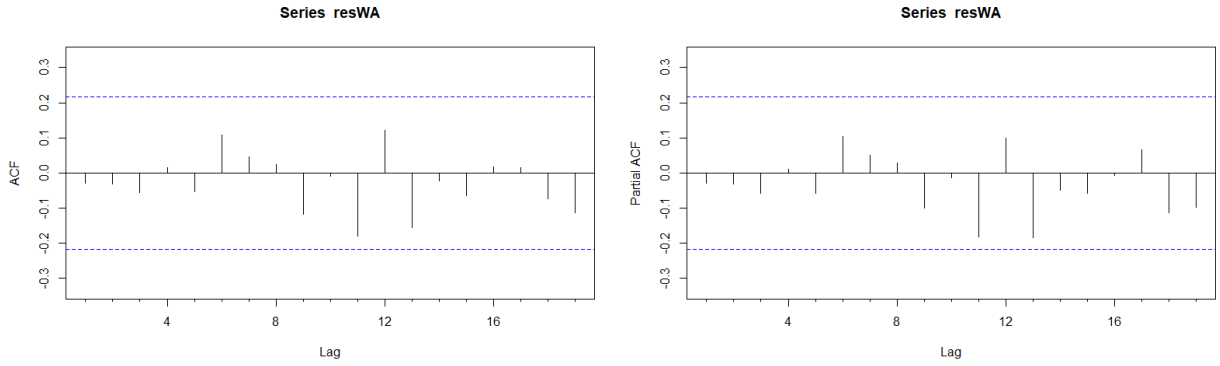
Estimates

AR1	*AR2*	*MA1*	*SMA1*	*SMA2*
0.2654	-0.3466	-0.9173	0.2260	0.2269

Equation

$$(1 - 0.2654L + 0.3466L^2)(1 - L)y_t = (1 - 0.9173L)(1 + 0.2260L^4 + 0.2269L^8)\epsilon_t$$

- Residuals



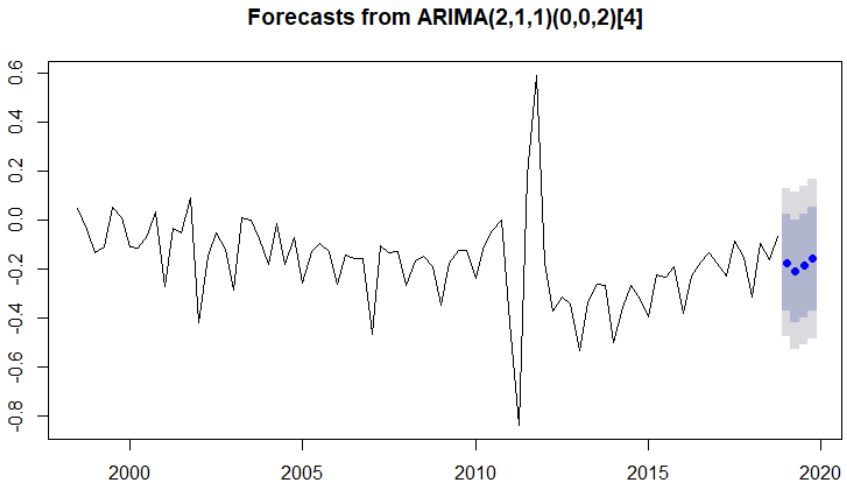
The model is a good fit for the data because there is no significant spikes in the ACF and PACF plot, which means that the residuals resemble white noise.

d. Forecasting Values for 2019

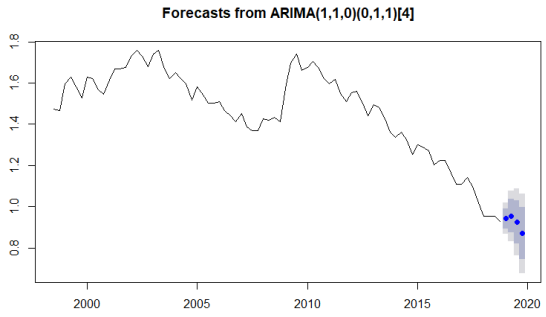
- Forecasts

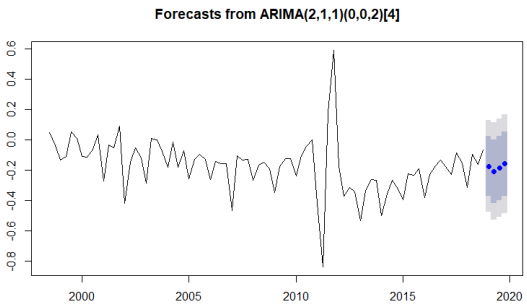
	Point Forecast	*Lo 80*	*Hi 80*	*Lo 95*	*Hi 95*
2019 - Q1	-0.1749387	-0.3733051	0.023427625	-0.4783139	0.1284364
2019 - Q2	-0.2081515	-0.4181875	0.001884407	-0.5293738	0.1130707
2019 - Q3	-0.1875145	-0.4002918	0.025262861	-0.5129293	0.1379004
2019 - Q4	-0.1583606	-0.3717818	0.055060704	-0.4847602	0.1680391

- Forecast graph



4. Dynamic Report on Labor Market in Japan





Left: Unemployment Rate Forecast Plot *Right: Working Age Population Forecast Plot*

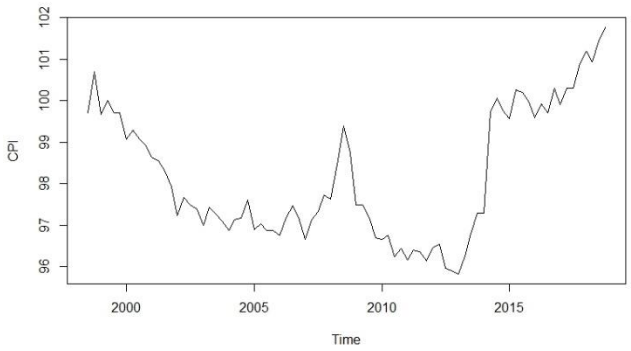
Using the Method of ARIMA forecasting, we discovered that unemployment will continue to decease in the same pattern, displayed in the downward trend of our forecasts in 2019. In Working Age Population forecast for 2019, we continue to see the cyclicality with slight upward trend. From the gathered information of the forecasts for these two variables, we can say that there will be an increasing number of employed people. This, in turn, will benefit the labor market due to an increase of people becoming employed. Since the working age population stays almost constant since the shocks from 2012, we can also say that there are more jobs available over time, which may be a positive sign for the Japanese labor market.

Part 2. Goods and Services Market

5. CPI for All Items in Japan

- This time series data is about consumer price index of all items in Japan.
- Unit: index 2015 = 100
- From 1998 Q3 to 2018 Q4 (Quarterly)

a. Time Series Characteristics



- The time series seem to have structural breaks on 2007, 2009, and 2013.
- It does not seem to have any issues with constant variance, however mean is not constant due to structural breaks. Therefore, it is non-stationary.
- It has a downward trend until 2013, and since then, it has an upward trend.
- The data shows seasonality and cyclicality.

b. Forecasting Methods

Since the data has some structural breaks, seasonality, and cyclicality, multiple regression models wouldn't work well. Therefore, we will use seasonal ARIMA model to forecast.

c. Forecasting Model

- ARIMA(0,1,0)$(1,0,0)_4$
    - First order non seasonal differencing.
    - First order seasonal autoregressive process.

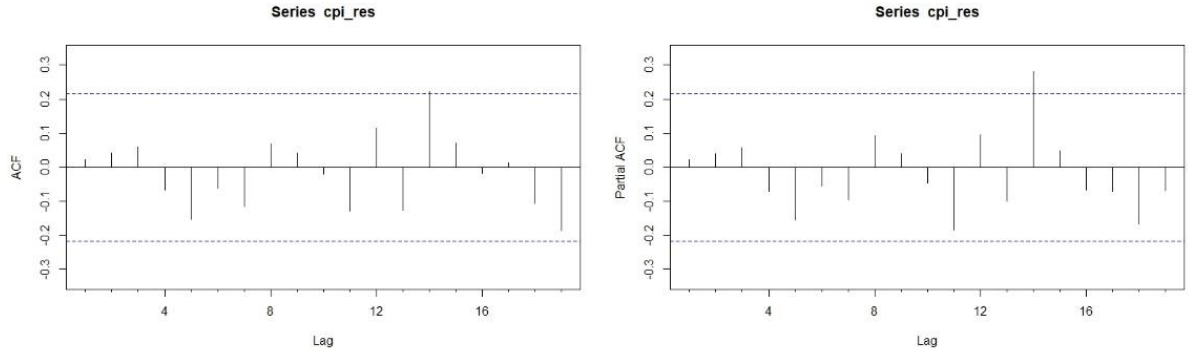
Estimates

SAR1
0.3454

Equation

$(1 - 0.3454L^4)(1 - L)y_t = \epsilon_t$

- Residuals



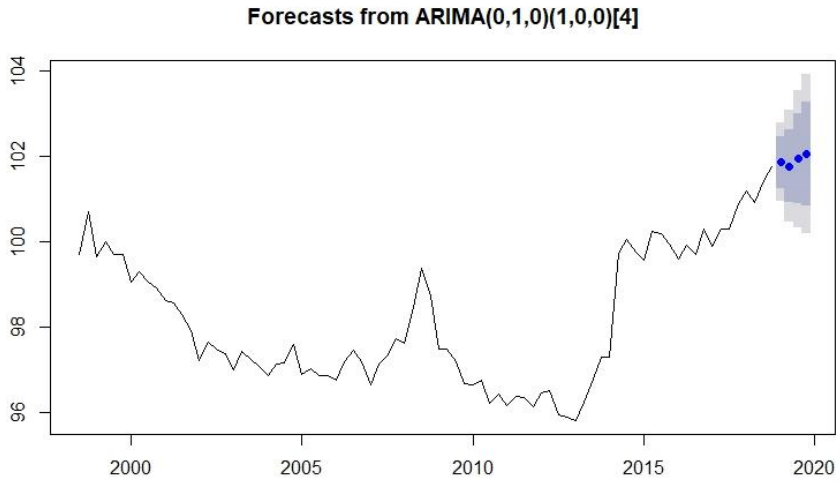
The ACF and PACF show one significant spike at lag 13. However, other than that they pretty much resemble white noise, therefore we can say that the model is a good fit for the data.

d. Forecasting Values for 2019

- Forecasts

	Point Forecast	*Lo 80*	*Hi 80*	*Lo 95*	*Hi 95*
2019 - Q1	101.8703	101.2635	102.4771	100.9423	102.7983
2019 - Q2	101.7782	100.9201	102.6363	100.4658	103.0906
2019 - Q3	101.9509	100.8999	103.0019	100.3436	103.5582
2019 - Q4	102.0660	100.8525	103.2796	100.2101	103.9220

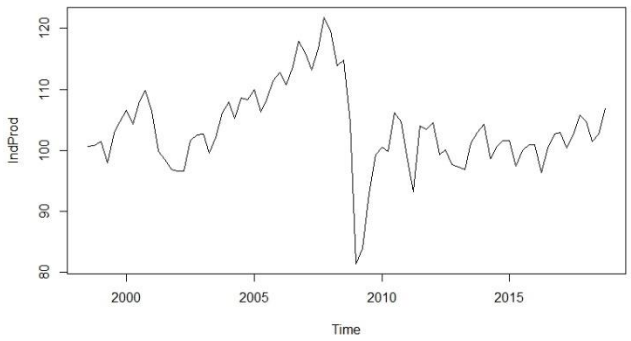
- Forecast graph



6. Total Industry Production in Japan (Excluding Construction)

- This time series data is about industry production in Japan, not including construction.
- Unit: index 2015 = 100
- From 1998 Q3 to 2018 Q4 (Quarterly)

a. Time Series Characteristics



- The time series seem to have structural breaks on 2002 and 2009.
- It does not seem to have any issues with constant variance, however there are some fluctuations in mean. Therefore, the data is non-stationary.
- It has a short upward trend from 2002 to 2009, and after 2009 structural break, it is on constant trend.
- The data shows seasonality and cyclicality.

b. Forecasting Methods

Same as CPI, the data has some structural breaks, seasonality, and cyclicality, multiple regression models wouldn't work well. Therefore, we will use seasonal ARIMA model to forecast.

c. Forecasting Model

- ARIMA(2,0,0)$(2,0,0)_4$ with mean
    - Second order non seasonal autoregressive process.
    - Second order seasonal autoregressive process.
    - Mean (constant) term included.

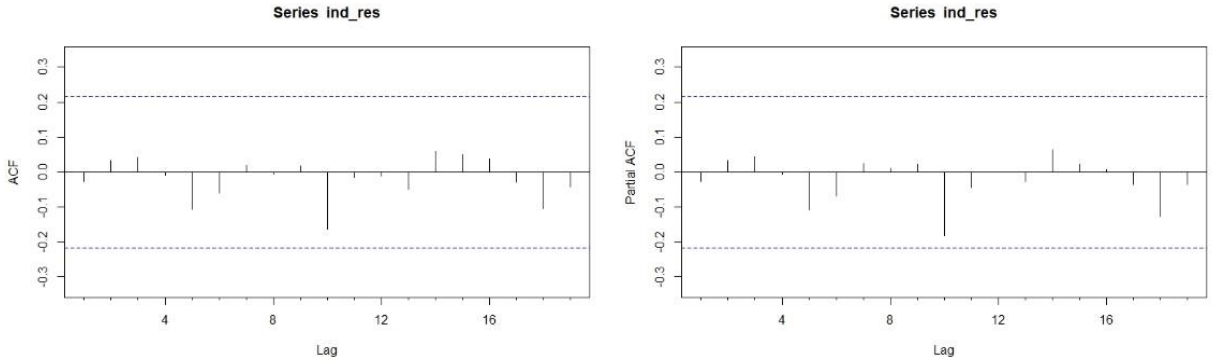
Estimates

AR1	*AR2*	*SAR1*	*SAR2*	*Mean*
1.1666	-0.4327	0.3215	0.2854	103.459

Equation

$$(1 - 1.1666L + 0.4327L^2)(1 - 0.3215L^4 - 0.2854L^8)y_t = 103.459 + \epsilon_t$$

- Residuals



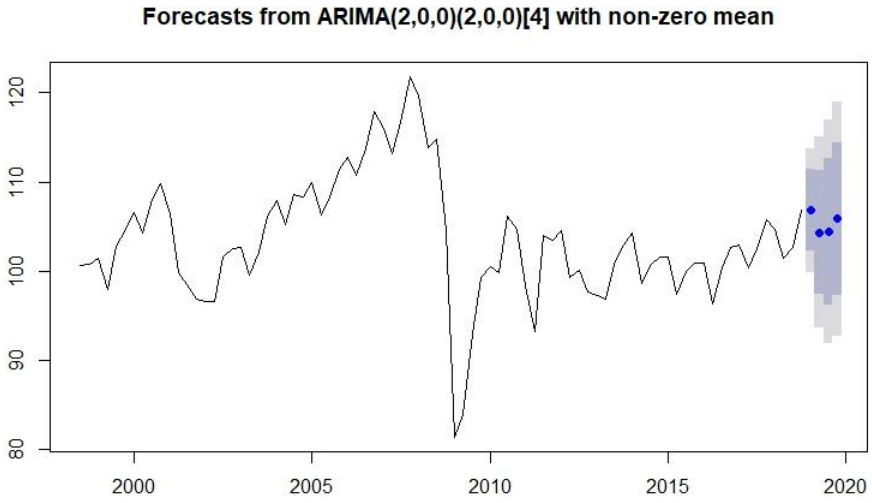
The ACF and PACF show no significant spikes in all lags nor distinctive seasonality. Therefore, the residuals resemble white noise, and we can say that the model is a good fit for the data.

d. Forecasting Values for 2019

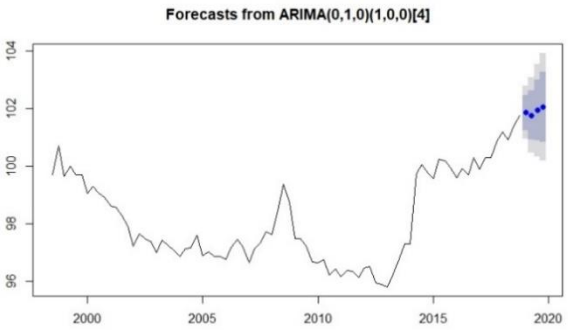
- Forecasts

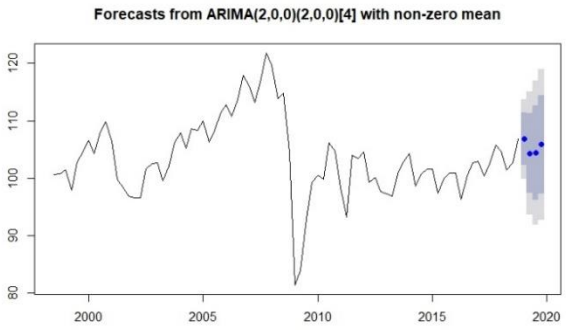
	Point Forecast	*Lo 80*	*Hi 80*	*Lo 95*	*Hi 95*
2019 - Q1	106.8166	102.27022	111.3630	99.86350	113.7697
2019 - Q2	104.3475	97.36192	111.3331	93.66396	115.0311
2019 - Q3	104.4318	96.27047	112.5932	91.95011	116.9135
2019 - Q4	105.8420	97.26784	114.4161	92.72898	118.9549

- Forecast graph



7. Dynamic Report on Goods and Services Market in Japan





Left: CPI for all items Forecast Plot *Right: Total Industry Production Forecast Plot*

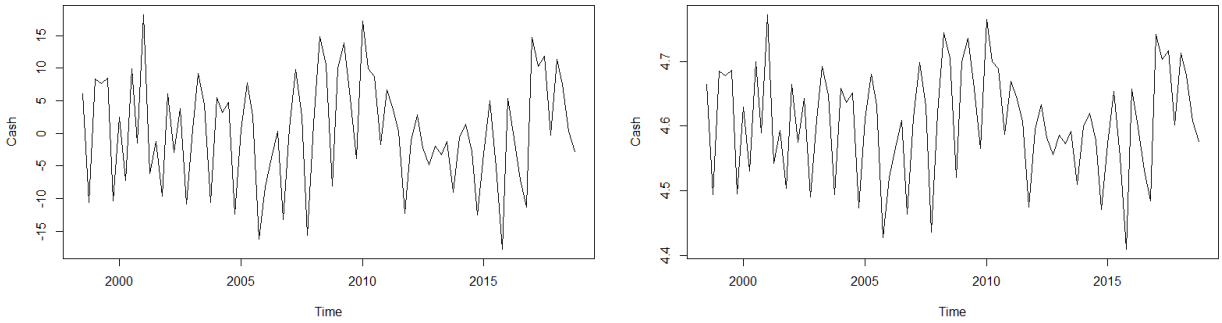
For CPI for all items, the ARIMA model forecasting shows that the index will increase as the same rate as since 2017. For total industry production excluding construction, the ARIMA model forecasting suggests that it will increase by very little, with its existing steady upward trend. We can explicitly compare the growth of these two forecasts since they have the same index of 2015 =100. From the information, we can conclude that the price of consumer goods will increase in a current rate, while the total industry itself does not grow as much as the consumer prices. This means that there is a disparity between price and quantity of goods as time goes, which implies that there will exist inflation in 2019. In order to investigate the degree of inflation, we would need to do separate analysis. However, since the trend for our forecasts are at the same degree as before, we can conclude that the inflation would not be unpredictably significant.

Part 3. Financial Market

8. Total Cash

- This time series data is about percentage change of all cash in Japan.
- Unit: percentage change
- From 1998 Q3 to 2018 Q4 (Quarterly)

a. Time Series Characteristics



Left: Original time series plot *Right: Log-transformed time series plot*

- The log transformation did not fix the non-constant variance issue. Therefore, we will use original data to reduce the redundant step, assuming taking differencing would fix the issue.
- The time series peaks around 2002, 2010, and 2017.
- It seems to have constant mean overall, however it does have non constant variance. Therefore, it is non-stationary.
- The data shows cyclicality and very strong seasonality.

b. Forecasting Methods

Since the data has very strong seasonality along with cyclicality, multiple regressions would not be able to explain those variability well. Therefore, we will use seasonal ARIMA model to forecast.

c. Forecasting Model

- ARIMA(1,0,0)(0,1,2)$_4$
    - First order non seasonal autoregressive process.
    - First order seasonal autoregressive process.
    - Second order seasonal moving average process.

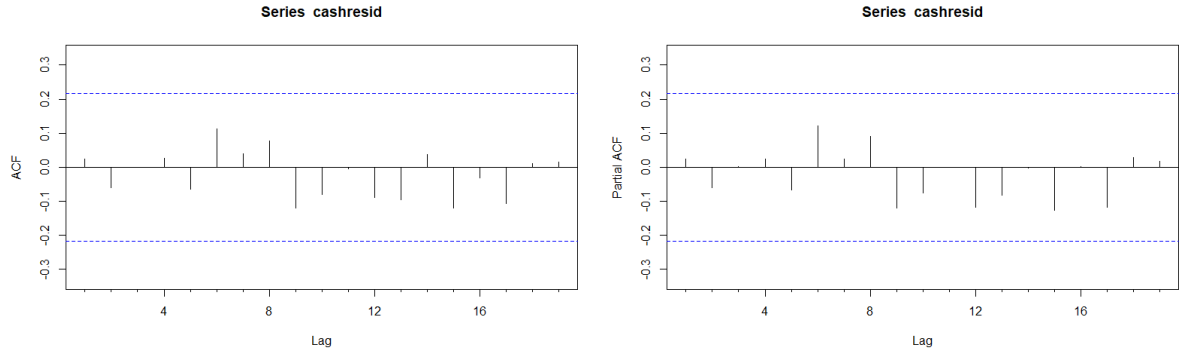
Estimates

AR1	*SMA1*	*SMA2*
0.4096	-0.5815	-0.2644

Equation

$$(1 - 0.4096L)(1 - L^4)y_t = (1 - 0.5815L^4 - 0.2644L^8)\epsilon_t$$

- Residuals



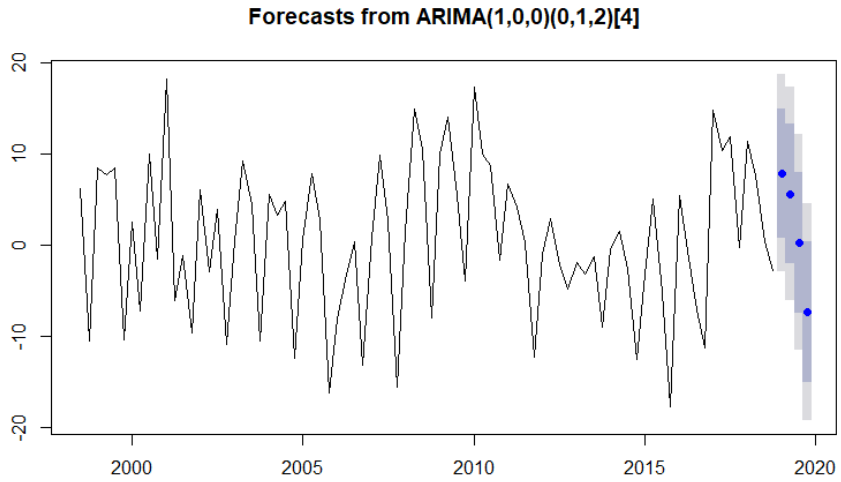
The ACF and PACF do not show any significant spikes. Because of that, the residuals resemble white noise. That means the model is a good fit for the data.

d. Forecasting Values for 2019

- Forecasts

	Point Forecast	*Lo 80*	*Hi 80*	*Lo 95*	*Hi 95*
2019 - Q1	7.8330281	0.7615938	14.904462	-2.981797	18.647854
2019 - Q2	5.5785078	-2.0629441	13.219960	-6.108084	17.265100
2019 - Q3	0.2488548	-7.4831611	7.980871	-11.576243	12.073953
2019 - Q4	-7.3782697	-15.1255264	0.368987	-19.226676	4.470137

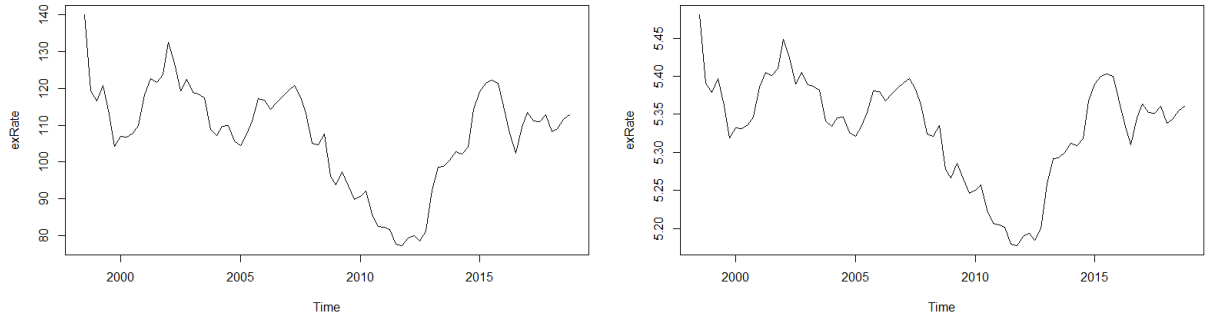
- Forecast graph



9. Japan/U.S. Foreign Exchange Rate

- This time series data is about the foreign exchange rate between U.S. dollar and Japanese yen.
- Unit: Japanese yen to one U.S. dollar
- From 1998 Q3 to 2018 Q4 (Quarterly)

a. Time Series Characteristics



Left: Original time series plot *Right: Log-transformed time series plot*

- The log transformation did not fix the non-constant variance issue. Therefore, we will use original data to reduce the redundant step, assuming taking differencing would fix the issue.
- The time series seem to have structural breaks on 2000, 2005, and 2012.
- Since the mean of the series is not constant, the time series is non-stationary.
- The trend goes downhill until 2012 then switches to upward since then.
- The data shows moderate seasonality and very strong cyclicality.

b. Forecasting Methods

The data has some structural breaks, seasonality, and very strong cyclicality. Multiple regression models would not work because of them. Therefore, we will use seasonal ARIMA model to forecast.

c. Forecasting Model

- ARIMA(0,1,2)(1,0,0)$_4$
    - First order non seasonal differencing.
    - Second order non seasonal moving average process.
    - First order seasonal autoregressive process.

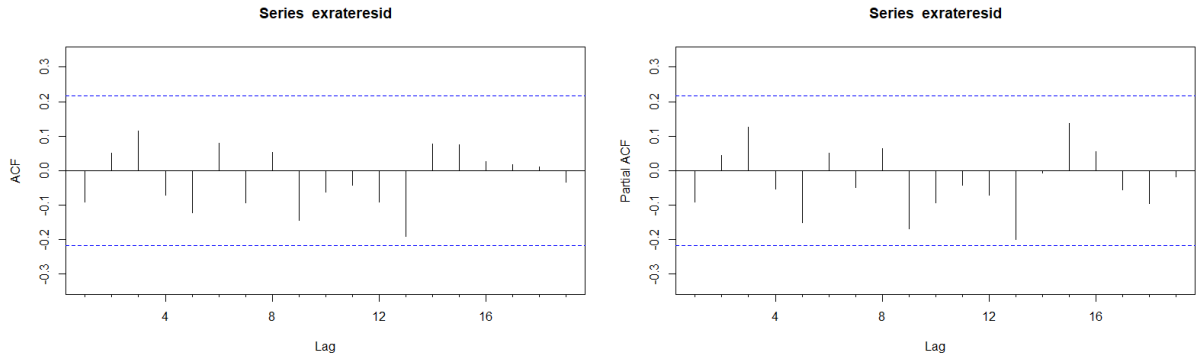
Estimates

MA1	*MA2*	*SAR2*
0.5026	-0.2127	0.2822

Equation

$$(1 - 0.2822L^4)(1 - L)y_t = (1 + 0.5026L - 0.2127L^2)\epsilon_t$$

- Residuals



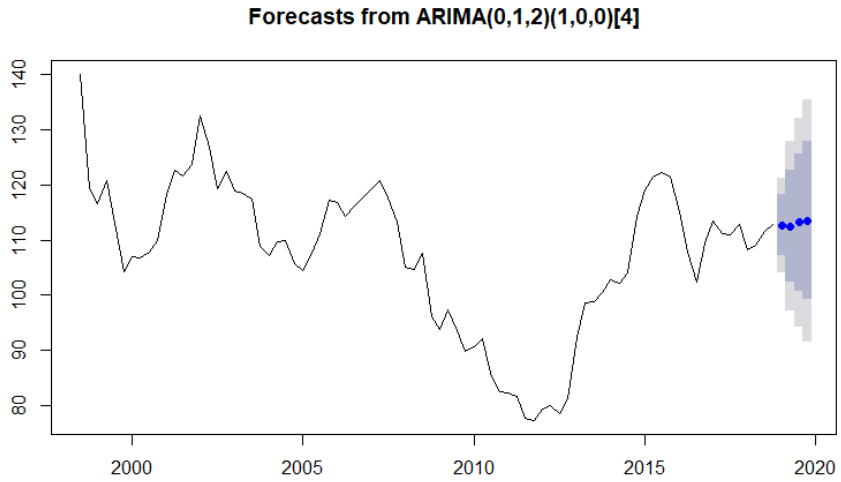
The ACF and PACF show no significant spikes in the lags. The residuals resemble white noise, and we can say that the model is a good fit for the data.

d. Forecasting Values for 2019

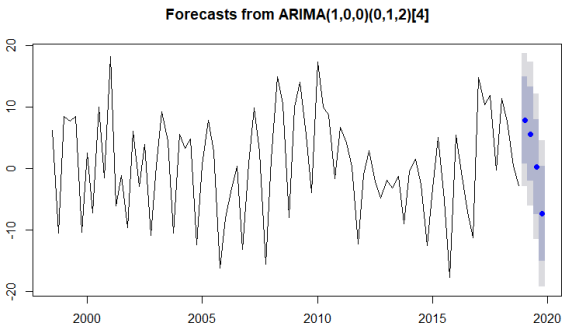
- Forecasts

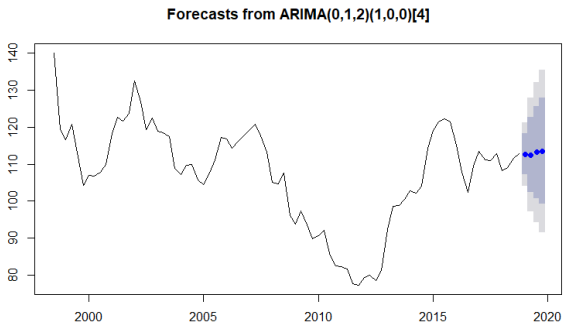
	Point Forecast	*Lo 80*	*Hi 80*	*Lo 95*	*Hi 95*
2019 - Q1	112.7057	107.10977	118.3016	104.14748	121.2639
2019 - Q2	112.5096	102.40918	122.6100	97.06234	127.9569
2019 - Q3	113.1753	100.76051	125.5901	94.18853	132.1620
2019 - Q4	113.5329	99.17205	127.8938	91.56986	135.4960

- Forecast graph



10. Dynamic Report on Financial Market in Japan





Left: Total Cash Forecast Plot *Right: Japan/U.S. Foreign Exchange Rate Forecast Plot*

For the percentage change of total cash, the ARIMA model forecast showed that the percentage will increase in the first quarter and then decrease later like in previous years. For the foreign exchange rate between Japanese yen and U.S. dollar, the ARIMA model forecasted that the rate will slowly increase. By comparing them relatively, it does seem that the exchange rate decreases when the total cash decreases, vice versa. As depicted in the graphs, they seem to have relatively the same trend at the same given time. This can be interpreted that as amount of cash increases, the value of the money appreciates. In summary, the total cash amount and Foreign exchange rate with U.S. in Japan will behave similarly as before, without any big increase or decrease. Therefore, the financial market will have relatively steady variations in their variables in 2019 as a whole.

11. Summary

We have selected unemployment rate and working age population (15-64) variables for labor market, CPI for all items and total industry production excluding construction for goods and services market, and total cash and Japan/US foreign exchange rate for financial market in our economic forecasts for Japan. Quarterly data and the period from 1998 Q3 to 2018 Q4 were employed for all of our six variables.

Almost all variable presented cyclicality, seasonality, and even some structural breaks. Due to such time series characteristics, seasonal ARIMA model is chosen, utilizing its capacity to take into account serially correlated lagged values and error terms. To articulate such process, statistical software 'R' is used, which can automatically fit the best possible seasonal ARIMA model for any time series variable under certain conditions.

For labor market, it is predicted that unemployment rate would keep falling, whereas working age population will persistently stay constant with a very little increment as it has been so far. As the dynamic report suggested, this would imply that more jobs will be open for the people.

In goods and services market, the forecasts tell us that CPI will increase in a higher rate than total industry production. Implicitly, therefore, there will be inflation. Yet, we have not been able to forecast the approximate rate of inflation with our data, but it would not cause a sudden shock in the market due to the steadiness in our variables and forecasts.

Lastly, in financial market, our goal was to see if there is any significant changes happening in the future. As our forecasts show, total cash will keep follow the current flow, and the foreign exchange rate to U.S dollar will slowly increase. Therefore, the financial market will have a steady flow in the upcoming year, with slight appreciation on their currency.

Even though we have limitations on our variables and data, all of the future trends in all three markets are depicting no negative signs, but rather steady and slight-increasing tendency. Given that no market shows no concerning predictions, we can conclude that Japan will keep their subtle growth in their economy in 2019, presuming no other external shocks would occur.

12. References

Asialink Business, *Japan's economy,* https://asialinkbusiness.com.au/japan/getting-started-in-japan/japans-economy?doNothing=1, Accessed on April 8, 2019.

U.S. Department of State Background Note, Infoplease, *Japan Department of State Background.* https://www.infoplease.com/world/countries/state-department-profiles/japan-department-of-state-background, Revised on October, 2007.

Organization for Economic Co-operation and Development, *Unemployment Rate: Aged 15-64: All Persons for Japan [LRUN64TTJPM156N]*, retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/LRUN64TTJPM156N, April 24, 2019.

Organization for Economic Co-operation and Development, *Working Age Population: Aged 15-64: All Persons for Japan [LFWA64TTJPM647N]*, retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/LFWA64TTJPM647N, April 24, 2019.

Organization for Economic Co-operation and Development, *Consumer Price Index of All Items in Japan [JPNCPIALLMINMEI]*, retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/JPNCPIALLMINMEI, April 24, 2019.

Organization for Economic Co-operation and Development, *Total Industry Production Excluding Construction for Japan [PRINTO01JPQ661N]*, retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/PRINTO01JPQ661N, April 24, 2019.

Bank of Japan Time-Series Data Search, http://www.stat-search.boj.or.jp/index_en.html, Accessed on April 8, 2019.

Board of Governors of the Federal Reserve System (US), *Japan / U.S. Foreign Exchange Rate [DEXJPUS]*, retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/DEXJPUS, April 24, 2019.