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Assignment 2

Predictive Analytics

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Executive Summary

Australian inflation, as measured by the consumer price index (CPI), has recently been at its highest level for more than 30 years. The reasons include supply-side disruptions caused by the pandemic, Russia's invasion of Ukraine, and the large fiscal and monetary policy responses that supported economies during the pandemic. In the context of heightened inflation and fears of a potential recession, Australia faces a challenging economic environment. Analysis of key macroeconomic aggregates – the CPI inflation, GDP growth, and Unemployment rate – reveals significant risk factors. Forecasting indicate CPI inflation may decrease to 5.4% in 2023Q2 and potentially decrease to 2.8% in 2024Q1 due to the Reserve Bank of Australia (RBA) increased the average cash rate target to 3.3% in 2023Q1. This approach has the potential to reduce the inflation in the future. However, there is also a risk of recession as the trade-off, which came from increasing heavily of cash rate in short time period (4% cumulative rate increase since 6 April 2022). This effect will potentially slowdown the economic growth from rising borrowing interest between the banks. High cash rate will make loans more expensive for both businesses and consumers. This could lead to a reduction in capital expenditure and consumer spending. The short-term forecast for GDP Growth in 2023Q2 is 5.4% and may decrease to 4.6% in 2024Q1. The unemployment rate may rise to 4.2% in 2023Q1 and potential increase to 4.3% within 2024Q1. Businesses may face lower revenue due to consumers prefer to save their spending and more likely to put money in the bank. If the businesses have lower revenue, they might be forced to cut back on labour costs, potentially leading to increased unemployment rate. Given these challenging circumstances, it is recommended that RBA maintain the current cash rate until 2023Q4 to reduce the inflation rate to 3% (according to medium-term forecast). After the inflation has fall into the good economical range around 2-3% (Australia's Inflation Target, n.d), then RBA will need to slowly decrease cash rate until the point that it will balance the good range of inflation, Growth, and low unemployment rate. This approach could help strike a delicate balance between mitigating inflation and supporting economic growth. Keeping the cash rate steady until 2023Q4 can prevent exacerbating inflation. Simultaneously, it can help to support economic growth by ensuring that borrowing costs do not rise too steeply, which could otherwise stifle investment and consumer spending. In conclusion, Australia's economic environment is fraught with significant challenges, and careful management of monetary policy will be crucial in navigating this difficult period. The RBA will need to keep a careful eye on these key macroeconomic indicators and be ready to adjust its policy stance as necessary to ensure the stability and health of the Australian economy.

Exploratory Data Analytics (EDA)

Analysing the Australian inflation rate, GDP growth rate, and unemployment rate involves understanding these indicators in depth, their interrelationships, and the factors influencing them. The aim of such analysis is to uncover patterns, outliers and trends, predict future occurrences, test hypotheses, check assumptions or explain particular phenomena. The analysis will be conducted from 1992Q1 to 2023Q1 because the Reserve Bank adopted an inflation target in the early 1990s (Australia's Inflation Target, n.d). **CPI Inflation:** This measures the average change in prices over time that consumers pay for a basket of goods and services and is the most widely used indicator of inflation. **Issues:** Abrupt changes in the economy, due to events like natural disasters, or global issues like the Global Financial Crisis and COVID-19 pandemic, can cause volatility in the CPI. Also, changes in consumer behaviour or technological progress can make the basket of goods outdated, leading to inaccurate CPI measurements. Besides, a significant part of the Australian economy relies on imports, exchange rates can impact CPI inflation. **EDA** here can involve analysing trends over time, identifying periods of high inflation, and comparing inflation rates with those of other countries. Moreover, the relationship between CPI and other variables such as GDP Growth, Unemployment rate, and cash rate could be investigated. **GDP Growth:** This indicates the speed at which an Australians economy is growing or shrinking. Issues: As a single measure, GDP can't accurately capture all economic activity, especially in the informal sector. It also doesn't account for income inequality or environmental impact. GDP's quality as a measure also depends on the accuracy and timeliness of the data used to calculate it. **EDA** can involve visualizing GDP growth over time, correlating it with other economic variables, and identifying periods of growth or recession. Additionally, sectoral contributions to GDP could be explored. **Unemployment Rate:** This measures the number of people actively looking for a job as a percentage of the labour force. **Issues:** This metric may not account for underemployment (people who are working but would prefer to work more) or those who have become discouraged and stopped seeking work. The rise of gig economy and contractual work might also distort the traditional understanding of employment.

EDA might explore trends in unemployment, relationship between unemployment and other economic indicators such as the impact from Inflation, GDP Growth, and Cash rate, as well as other demographic factors influencing unemployment. Sectoral and geographical variations could be another area of interest. **Cash Rate:** This is the policy interest rate set by the Reserve Bank of Australia. **Issues:** The effectiveness of cash rate changes in influencing the economy could be impacted by a range of factors including global economic

conditions, bank lending practices, and the overall confidence of consumers and businesses. In a low-interest-rate environment, there's also the risk of limited room to maneuverer in case of an economic downturn. **EDA** could involve analysing how changes in the cash rate have corresponded with changes in other economic indicators. Additionally, the influence of international interest rates could be considered. **In conclusion,** EDA is an essential process that can help uncover the underlying structures in these economic indicators, identify important variables, detect outliers and anomalies, and test underlying assumptions. However, the interpretation of the findings will require economic expertise, as the relationships between these variables can be influenced by a wide range of factors.

Technical Analysis

We do both multivariate and univariate model and make the comparison in term of the prediction performance using interpretability, forecast interval, RMSPE for one-step-ahead forecast (short-term horizon) and one-year-ahead forecast (medium-term horizon) using "for" loop and extend the window size base on the number of steps ahead forecast. The data set has been separated into two parts, which are training set: 1992Q1 to 2011Q4 (2/3) and the testing set 2012Q1 to 2023Q1 (1/3). The first part of technical analysis includes **univariate time series** of the key macroeconomic indicators. We use the Random walk model without drift as the benchmark, compare with ETS and ARIMA models to predict for future economy movement. The **Random walk (RW)** model is constructed by taking the last observed value of the variable as the forecast for the next period. Assumption for the random walk is that the future value of a variable is equal to the current value plus some random noise. For model selection and forecast assessment, we compared the predicted data with actual value we have (testing data), calculate the RMSPE and make future prediction by out-of-sample validation techniques. **ETS (Exponential Smoothing State Space)** will be used as the function for auto-selected the suitable model. As the results, we have **Simple Exponential Smoothing (SES)** as there are no obvious trend/seasonal components on CPI inflation and GDP Growth. The forecast assessment is similar by comparing and selecting lowest RMSPE. The **ARIMA (Autoregressive Integrated Moving Average)** model is constructed by specifying three components: the autoregressive (AR) component, the differencing (I) component, and the moving average (MA) component. The assumptions for the ARIMA model are that the variable is stationary, meaning its statistical properties do not change over time and the relationship between the variables is assumed to be linear. The ARIMA model selection involves determining the appropriate orders (p, d, q) for the AR, I, and MA components. We use ADF and KPSS tests to test the stationary of the data. As the

results, ADF and KPSS provide the conflict results of non-stationary and stationary, respectively. The reason why they don't have stationary is because there is the heteroscedasticity due to changing of variance as the suppose of changing the mean, thus we should account this by the changing of the volatilities, which we will leave them for the future research. Since we have taken annual differenced to calculate CPI inflation and GDP Growth, therefore we should not do another differenced because our goal is to forecast inflation and GDP growth not the first differenced of the inflation or Growth. We use the PACF to select the number of lags used in an AR model. We observed that there are autocorrelations (Appendix B), hence, we have ARIMA(9,0,0) for CPI Inflation, ARIMA(6,0,0) for GDP Growth, and ARIMA(14,1,0) for Unemployment rate. The auto arima function is also used for selecting the model. The forecast assessment involves comparing the forecasted values to the actual values for both one-step and four-step ahead predictions by comparing and selecting lowest RMSPE.

The second part include **multivariate time series** analysis of the key macroeconomic indicators. We first conduct the correlation matrix to check multicollinearity issue. After that, a **Vector Autoregressive (VAR)** model was chosen for its ability to account for dynamic interactions between multiple time-series variables. Assumptions include stationarity and homoscedasticity of the residuals. Model selection was conducted by using information criteria and determine the appropriate lag order by the VARselect () function in RStudio. Granger Causality testing has been introduced for proposed a simple statistical test for whether one variable is useful in forecasting another (with 10% significant level). As the results, we found that cash rate is useful in forecasting inflation and GDP Growth. Unemployment rate granger causality by inflation, growth, and unemployment rate. Therefore, we use these relationships for constructing VAR to minimise overparameterization problems when specifying too many lags and we only want to include variables that are good predictors. We select the lag length of the VAR model using information criteria such as AIC, HQ, SC, and FBE. To determine whether the model is mis-specified we can look at the residuals using Portmanteau test for serial correlation. Checking eigenvalues is also require validating the model stability. We aim to have the eigenvalues less than 1 for stability. However, VAR that has eigenvalues greater than 1 will not be suitable for future prediction because the forecasting will be explode in the long-term. Forecast assessment was performed via out-of-sample validation techniques using RMSPE. **In conclusion,** we will find the best model for short-term and medium-term forecast horizon in both univariate and multivariate for the different variables including inflation, growth, and

unemployment rate. Then we compare the best model from previously best of univariate and multivariate models and select one model to forecast each of key economic indicators for short-term and long-term horizon. We use the one-sided DM test to test whether model 2 is more accurate than model 1. This includes testing between RW with the best model and test the best model of univariate against the multivariate to find the best model for the key indicators. Lastly, we will check on normality using plotting to visualise on histogram and q-q plot and we will use LJjung-Box test to test the white noise, where H0 is white noiseand H1 is not white noise.

Discussion of Key Results

We first perform the plotting to check the stationary of the data (see Figure C1 to C3 in Appendix C). Then we conduct the ADF and KPSS test. There are the conflict results on Inflation and GDP Growth, which ADF report non-stationary (insignificant) but KPSS report stationary (insignificant). The reason why they don't have stationary is because there is the heteroscedasticity due to changing of variance as the suppose of changing the mean, thus we should account this by the changing of the volatilities, which we will leave them for the future research. For unemployment rate, the results are conformed, which is non-stationary in ADF (insignificant) and KPSS (significant). Therefore, the first differenced is required (see Table C1 in the Appendix). As the result from the first-differenced, we have ADF and KPSS test conform each other in Unemployment. Taken together the evidence suggests that the resulting both series are stationary after the first-differenced. **Univariate analysis** conduct using RW as a benchmark, ETS, AR model, auto ARIMA model as we discussed in the technical analysis section. The models initially fit with the training set to compare the in-sample fit and re-fit again with the testing set. As the results of training set, most of models here perform better than the RW. For in-sample fit, **CPI Inflation**, ARIMA(9,0,0) perform the best according to RMSPE. **GDP Growth**, ARIMA(6,0,0) perform the best. **Unemployment Rate**, ARIMA(14,1,0) perform the best. The summary of results is show in Table D1 in the Appendix D. After that, we perform short-term and medium-term forecast using the testing set to find best model for each key indicator. As the results, both short-term and medium-term forecast have the same best model for out-sample fit. **CPI Inflation**, ARIMA(9,0,0) perform the best. **GDP Growth**, ARIMA(6,0,0) perform the best. **Unemployment Rate**, ARIMA(14,1,0) perform the best. The summary of results is show in Table 1.

Table 1: Summary results of out-sample fits across the different models (Univariate)

One-step-ahead forecast			One-year-ahead forecast		
Key indicator	Model	RMSPE	Key indicator	Model	RMSPE
Inflation	RW without drift	0.782	Inflation	RW without drift	0.773
	ETS (A,N,N)	0.782		ETS (A,N,N)	0.773
	ARIMA (9,0,0)	**0.714**		ARIMA (9,0,0)	**0.663**
	ARIMA (2,0,2)	0.762		ARIMA (2,0,2)	0.704
GDP Growth	RW without drift	2.949	GDP Growth	RW without drift	2.934
	ETS (A,N,N)	2.949		ETS (A,N,N)	2.934
	ARIMA (6,0,0)	**2.923**		ARIMA (6,0,0)	**2.537**
	ARIMA (0,0,3)	3.401		ARIMA (0,0,3)	3.287
Unemployment Rate	RW without drift	0.536	Unemployment Rate	RW without drift	0.533
	ETS (A,A,A)	0.544		ETS (A,A,A)	0.531
	ARIMA (14,1,0)	**0.429**		ARIMA (14,1,0)	**0.434**
	ARIMA (0,1,1)	0.571		ARIMA (0,1,1)	0.564

Note: We rounded up/down the number to three digits. The actual results of ETS are slightly different from RW model. Please refer to the R code. **One-step-ahead, CPI Inflation:** DM test did not confirm that ARIMA(9,0,0) perform better than RW statistically significant. This suggests that two models statistically equivalent accuracy. However, ARIMA(9,0,0) has improved prediction performance by 9.6% (economic significant). **GDP Growth:** DM test did not confirm that ARIMA(6,0,0) perform better than RW statistically significant. However, ARIMA(6,0,0) is improve prediction performance (comparing from RMSE) by 0.9% (economic significant). **Unemployment rate:** DM test confirm that ARIMA(14,1,0) perform better than RW statistically significant and It is improve prediction performance (comparing from RMSE) by 24.8% (economic significant) From the three plotting, it also confirm that with one step ahead forecast has the plotting line close to the testing set (see Figure 2 below). The summary of DM result is provided in Table D2 in the Appendix D.

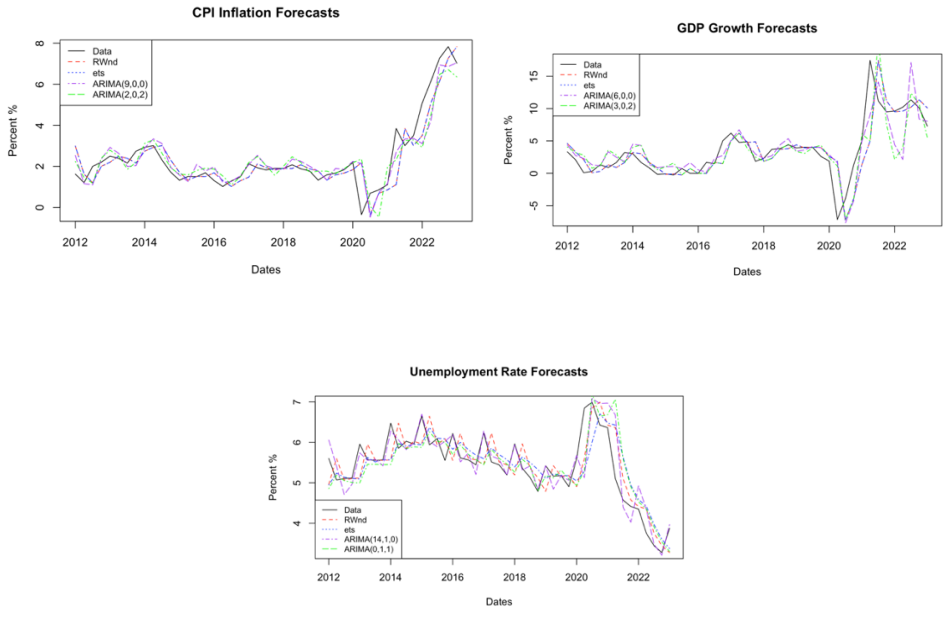

Figure 2: CPI Inflation, GDP Growth, Unemployment rate for short-term

One-year-ahead, CPI Inflation: DM test did not confirm that ARIMA(9,0,0) perform better than RW statistically significant. This suggests that two models statistically equivalent accuracy. However, ARIMA(9,0,0) has improved prediction performance by 16.5% (economic significant). **GDP Growth:** DM test did not confirm that ARIMA(6,0,0) perform better than RW statistically significant. However, ARIMA(6,0,0) is improve prediction performance (comparing from RMSE) by 15.7% (economic significant). **Unemployment rate:** DM test confirm that ARIMA(14,1,0) perform better than RW statistically significant and it is improve prediction performance by 23% (economic significant) From the three plotting, it also confirms that with one step ahead forecast has the plotting line close to the testing set (see Figure 2 below). The summary of DM result is provided in Table D2.

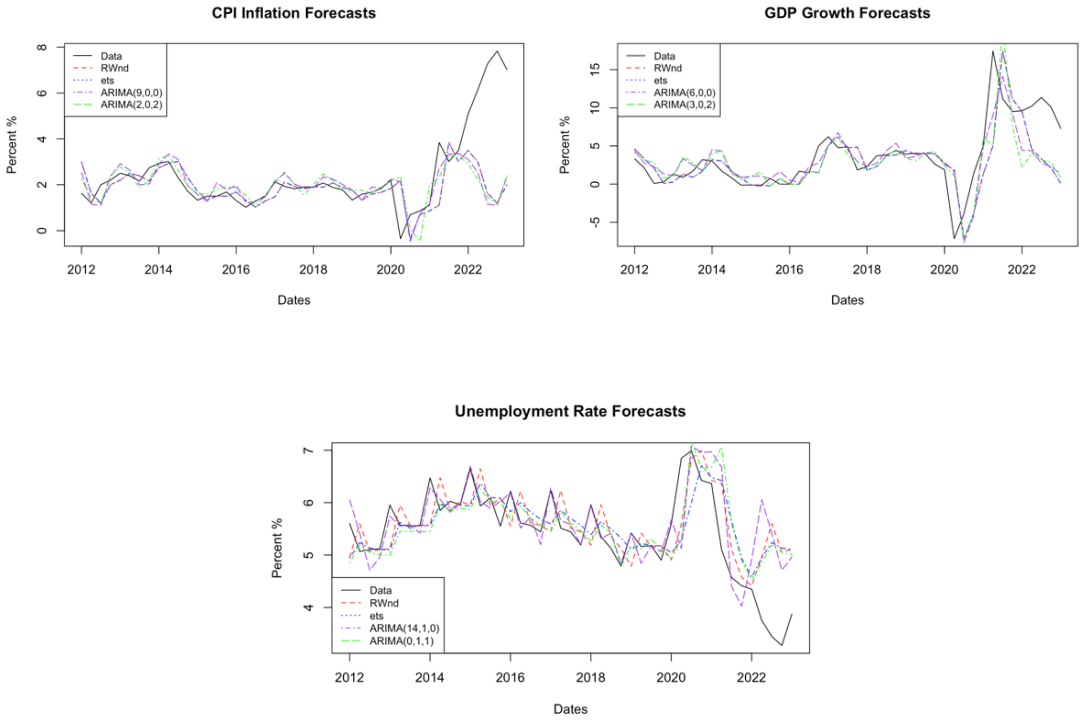

Figure 3: CPI Inflation, GDP Growth, Unemployment rate for medium-term

Multivariate analysis, according to the correlation matrix (see Figure D3 in Appendix D), there is no multicollinearity issue. We can see that CPI inflation has the positive correlation to GDP growth. This suggests that increase GDP Growth has the potential to increase the inflation rate. However, CPI inflation has the negative correlation to unemployment rate. This make sense because if GDP growth increase, it suggests that there is the increase of economic performance. Therefore, there will be a decreasing of unemployment rate. Cash Rate has the positive correlation on CPI Inflation, GDP Growth Rate, and Unemployment Rate (lager positive correlation). Granger Causality testing has been introduced for

proposed a simple statistical test for whether one variable is useful in forecasting another. As the results, we found that cash rate is useful in forecasting inflation and GDP Growth. Inflation, GDP Growth, and Cash rate are useful in forecasting Unemployment rate. The granger causality results are shown in Table D5. As we discussed in the previous section, we selected the lag numbers of the VAR model using information criteria. For forecasting **Inflation**, we used a cash rate as a predictor, the majority results above suggest that the VAR(2) is the best model according to all the selection criteria. For **GDP Growth**, we used cash rate as a predictor, the majority results above suggest that the VAR(5) is the best model according to the AIC and FPE. For **Unemployment rate**, we used all available predictors, the results suggest that the VAR(13) is the best model according to the AIC,HQ and FBE. The summary statistic can be see in Table D4. In addition, the results from the **Portmanteau test** for serial correlation show that for inflation, the VAR(2) model has no serial correlation. For GDP Growth, the VAR(5) has no serial correlation. However, Unemployment rate, the VAR(13) models have serial correlation for both one-step-ahead and one-year-ahead (Table D5). The eigenvalues of VAR(2) and Var(5) are less than 1 suggests the stability. However, Var(13) has eigenvalues greater than 1 suggests instability and will not be suitable for future prediction because the forecasting will be explode in the long-term (Table D6).

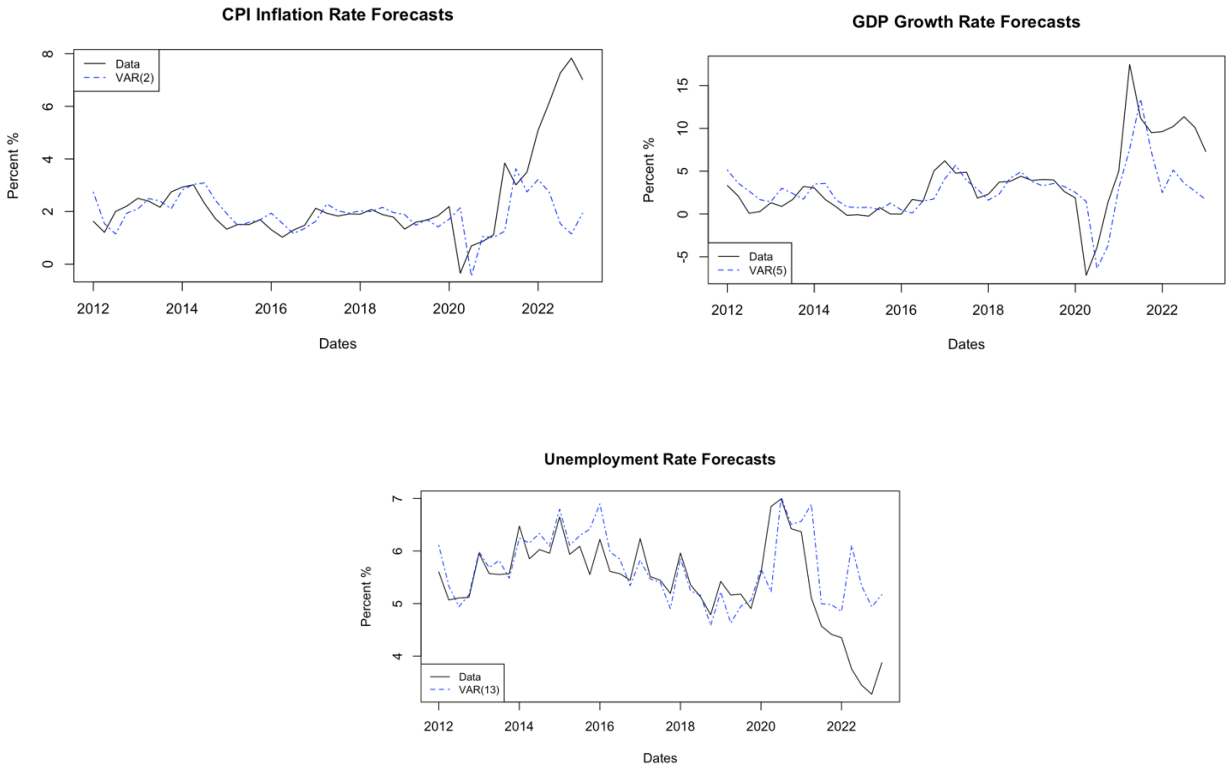

Figure 4: CPI Inflation, GDP Growth, Unemployment rate for short-term

After we know the best model for univariate and multivariate, then we use the DM test to compare in order to selected one model that outperform for each key indicators. According to the results, for both short-term and medium-term AR(9) perform the best to forecast inflation compare to VAR(2) and AR(6) is perform the best for GDP Growth compare to VAR(5). In addition, ARIMA(14,1,0) is perform the best for unemployment rate according to RMSPE (see Table 2 below). The DM test results are shown in Table D7 in the Appendix D. Even though the DM test are not statistically significant but AR models have improved the prediction performance by 15.1% of Inflation, 7.5% of GDP Growth, and 16.6% of Unemployment rate (economic significant).

Table 2: Comparing of RMSPE between best model from univariate and multivariate

		One-step-ahead forecast	One-year-ahead forecast
Key indicator	Model	RMSPE	RMSPE
Inflation	ARIMA(9,0,0)	**0.714**	**0.663**
	VAR(2)	0.822	0.776
GDP Growth	ARIMA(6,0,0)	**2.923**	**2.537**
	VAR(5)	3.142	2.738
Unemployment Rate	ARIMA(14,1,0)	**0.429**	**0.434**
	VAR(13)	0.505	0.469

Then, we will use the best model from the above to forecast Inflation, GDP Growth, Unemployment rate with one-step-ahead forecast and one-year-ahead forecast. **In conclusion,** with all the information we have, we predict that the inflation may decrease from 7% in 2023Q1 to 5.4% in 2023Q2 and it may further decrease to 2.8% in 2024Q1. For GDP Growth, we predict that it may decrease from 7.3% in 2023Q1 to 5.4% in 2023Q2 and may further reduce to 4.6% in 2024Q1. For Unemployment rate, we predict that it may increase from 3.9% in 2023Q1 to 4.2% in 2023Q2 and may further reduce to 4.3% in 2024Q1. This is the effect of RBA increased the cash rate cummulative to 4%, with the cash rate target at 3.3% in 2023Q1 and 4.1% in 2023Q2. The results are shown in Table 3, Figure 5&D2.

Table 3: Forecasting of Australia Economic Indicators

	One-step-ahead	One-year-ahead	One-step-ahead	One-year-ahead	One-step-ahead	One-year-ahead
	Piont Forecast	Piont Forecast	Piont Forecast	Piont Forecast	Piont Forecast	Piont Forecast
Date	Inflation		GDP Growth		Unemployment Rate	
2023Q2	5.420	5.420	5.371	5.371	4.175	4.175
2023Q3	-	4.459	-	3.919	-	4.360
2023Q4	-	3.471	-	4.119	-	4.151
2024Q1	-	2.790	-	4.577	-	4.335

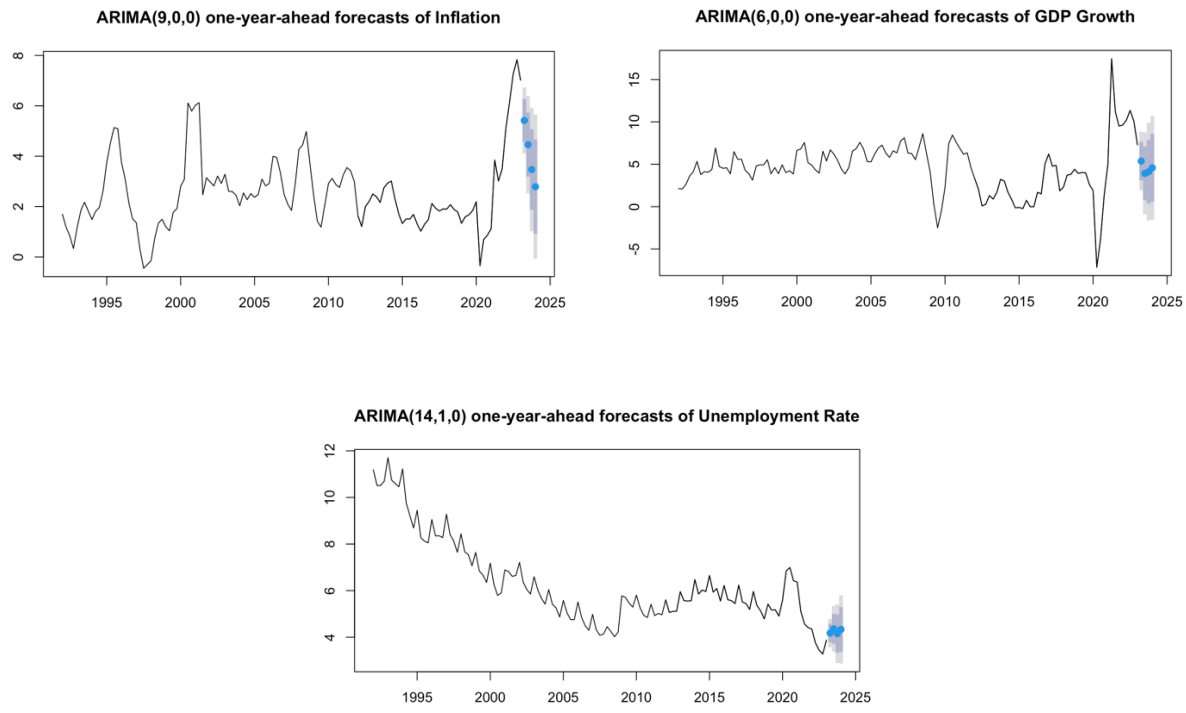

Figure 5: One-year-ahead forecast of Australia Economic Indicators

We then check on the normality of the best models using the q-q plot, histogram, and Ljung-Box test. From the results, it suggests that the models have white noise. So we can confidence that our best model using for forecasting has no autocorrelation (see in Table D8 and Figure D4 to D12 in the appendix D).

Limitations of the Analysis

The analysis does not account for potential future shocks to the economy, such as changes in international trade policies, further geopolitical events, or pandemic-related developments. With more time, a more comprehensive analysis including sensitivity analysis and simulations for potential future shocks would be desirable. In addition, accounting for heterscedasticity and capturing volatility also important for the future research.

There is one more important issue, which is the stability of forecast performance over time. In the context of macroeconomic data, even when a useful predictor or method is found for a certain subsample of data, its performance may deteriorate in the future due to a structural break. Although the factors and models that we discussed and selected above is valid through this period, they may still become useless due to future economy change like the influence of Covid-19 these days (Anastasios Panagiotelis, George Athanasopoulos, Rob J

Hyndman, Bin Jiang, Farshid Vahid, 2018). The accuracy of this analysis could be limited by a variety of factors. From the research that we did above, all the predictions of future economy movements are based on the variables that we selected, which are only CPI inflation, GDP growth and Unemployment rate which may influence from the cash rate. But more variables may also have influence on economy movement. For example, exchange rate can be an important feature which significantly influence economic conditions. A weaker currency makes exports cheaper and imports more expensive, which can influence trade balances, inflation, and economic growth. Furthermore, Stock Market Performance (The S&P/ASX200 index) may have an impact on decisions regarding the cash rate. The health of the stock market can influence consumer and business confidence and affect spending and investment decisions. With better index, people are more likely to consume, and the economy movement would be stable.

There are still more factors to consider like Wage Growth or Global Economic Conditions, but due to the time limitation, we are unable to discover all these factors. On the other hand, too many variables in the model can lead to overfitting and complexity in the process. There is always a trade-off between simple model or best fitting model. For example, the VAR(13) model included in the research above may be useful in the short run, but it can lead to explosion in the long run, which is not suitable for future prediction. In addition, when doing research by multivariate models, we only try for VAR model but not the combination models. Although we tried the combination models, they are too complex and time-consuming, also the result does not make sense, so we just remove them for further research in the future. The in-sample fit and out-sample fit may be different, which some variable may give the small RMSPE but it may have no impact on out-sample fit, which can lead to the different analysis. However, the best we can by using any available testing tools to find the best model that will give the best out-sample fit. By adding more analysis or predictors will come with cost as it may lead to computationally expensive.

Policy Recommendation

The Australian economy is market-based those productions or consume goods and services determined by demand and supply in the market, which is different to other countries that the government has a prominent role in deciding what goods and services will be produced. To investigate the economy, the key indicators of economic activity are GDP growth rate, Inflation rate and unemployment rate.

The economy has an optimal range over which it can grow – we can call this range its ‘speed limit’. We are aiming to have a steady GDP growth, as if it grows too fast, demand for goods and services may exceed what businesses can supply and businesses may increase wages if it is difficult to find workers, both factors will lead to higher prices, people may be worse off through high inflation; It is also harmful if the economy grows too slowly, as people may lose their jobs and businesses struggle to make profits which lead to less spending on goods and services, damaging business profits, economic growth and increasing in the unemployment rate. There are many different tools to influence the economy performance (Inflation) through Macro and Micro aspects, such as monetary policy, fiscal policy, government spending on public services.

The main way the RBA conducts monetary policy is by setting a target for the ‘cash rate’. The cash rate influences interest rates that households, businesses and governments pay to borrow money and receive for saving money. This can affect their decisions about consumptions. The goal of monetary policy is aiming to have a constant economic growth, lower unemployment rate and low inflation rate. If the economy is expanding too quickly and inflation is too high. The Reserve Bank is likely to raise the cash rate target which will lead interest rates to rise. Borrowing money becomes more expensive and saving more attractive. Households and businesses will spend less. Economic growth decreases. Inflation decreases. Unemployment may rise.

By inspecting from the graph that the cash rate has increased since 2022, as the effect of increasing in the cash rate, the corresponding reaction from the GDP growth, Inflation and unemployment rate are expected. The GDP growth has been decreased immediately, the Inflation rate has been decreased and the unemployment rate has been increased after a while due to the lag effect. While there will always be a lag in its effects, fiscal policy seems to have a greater effect over long periods of time and monetary policy has proven to have some short-term success. Government spending is a part of the GDP component.

Given the potential economic slowdown and the high inflation, it is recommended that the RBA maintains the current cash rate. While this may not fully mitigate inflation, it prevents further contraction of the economy and enables a moderate adjustment to the new economic conditions. The RBA should closely monitor economic indicators and be prepared to adjust rates if necessary.

Reference

Anastasios Panagiotelis, George Athanasopoulos, Rob J Hyndman, Bin Jiang, Farshid Vahid. (2018, September). *Macroeconomic forecasting for Australia using a large number of predictors.* Retrieved from Monash Business School: https://robjhyndman.com/papers/ausmacrofcastR2.pdf

Australia's Inflation Target. (n.d, n.d). Retrieved from Reserve Bank of Australia: https://www.rba.gov.au/education/resources/explainers/australias-inflation-target.html#:~:text=What%20Is%20the%20Inflation%20Target,Consumer%20Price%20Index%20(CPI).

Goods and services tax (Australia). (2023, May). Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Goods_and_services_tax_(Australia)

Nyoni, T. (2019, February). *Forecasting Australian CPI using ARIMA models.* Retrieved from Munich Personal RePEc Archive: https://mpra.ub.uni-muenchen.de/92412/

Performance of the Australian Economy. (n.d, n.d). Retrieved from Reseve Bank of Australia: https://www.rba.gov.au/education/resources/presentations/pdf/performance-of-the-australian-economy.pdf

The Global Financial Crisis. (n.d, n.d). Retrieved from Reserve Bank of Australia: https://www.rba.gov.au/education/resources/explainers/the-global-financial-crisis.html

Appendix A

<u>CPI Inflation, GDP Growth, Unemployment and Cash Rate plots</u>

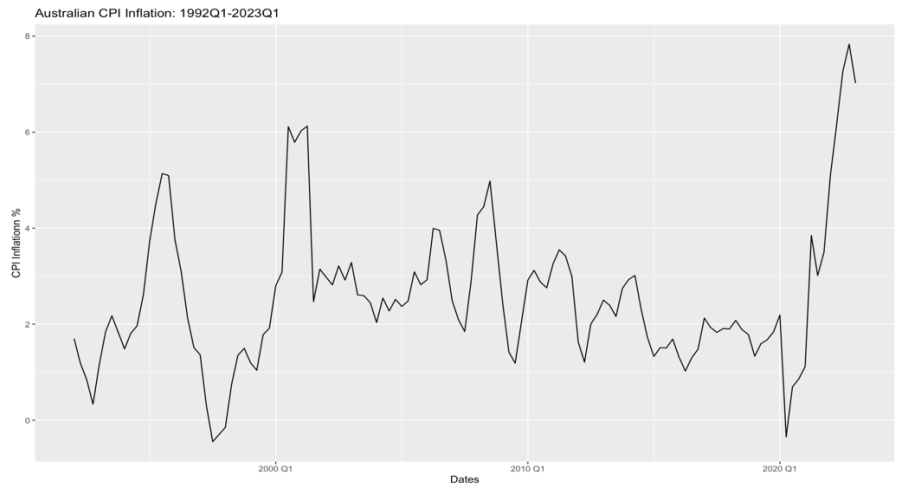

Figure A1: Australian CPI Inflation: 19920Q1-2023Q1

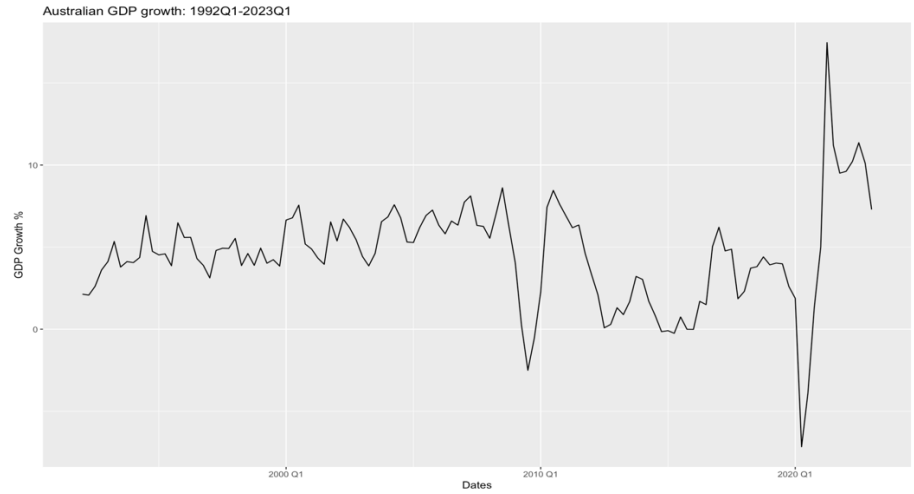

Figure A2: Australian GDP growth: 1992Q1-2023Q1

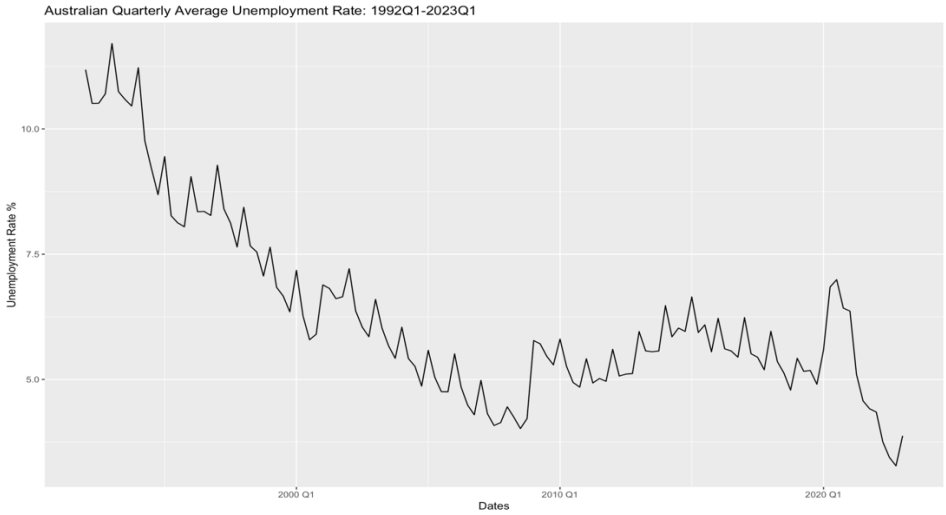

Figure A3: Australian Quarterly Average Unemployment Rate: 1992Q1-2023Q1

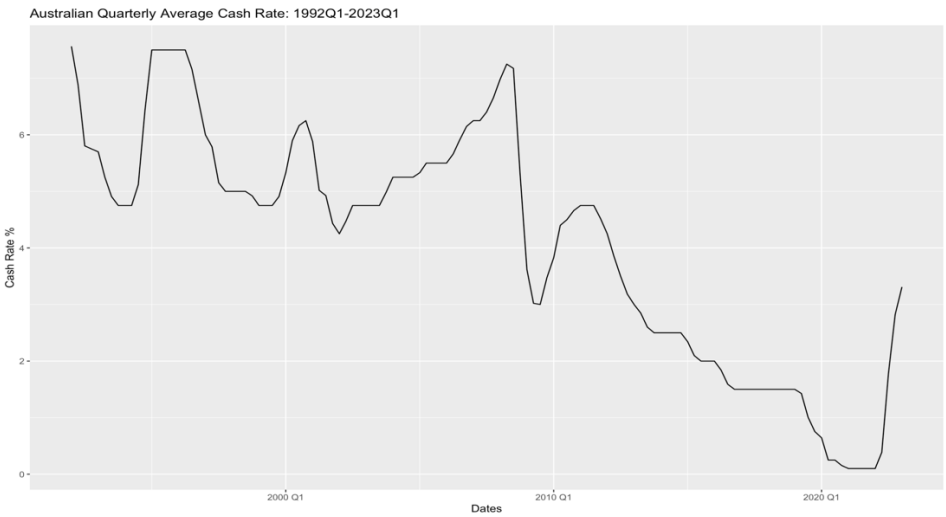

Figure C4: Australian Quarterly Average Cash Rate: 1992Q1-2023Q1

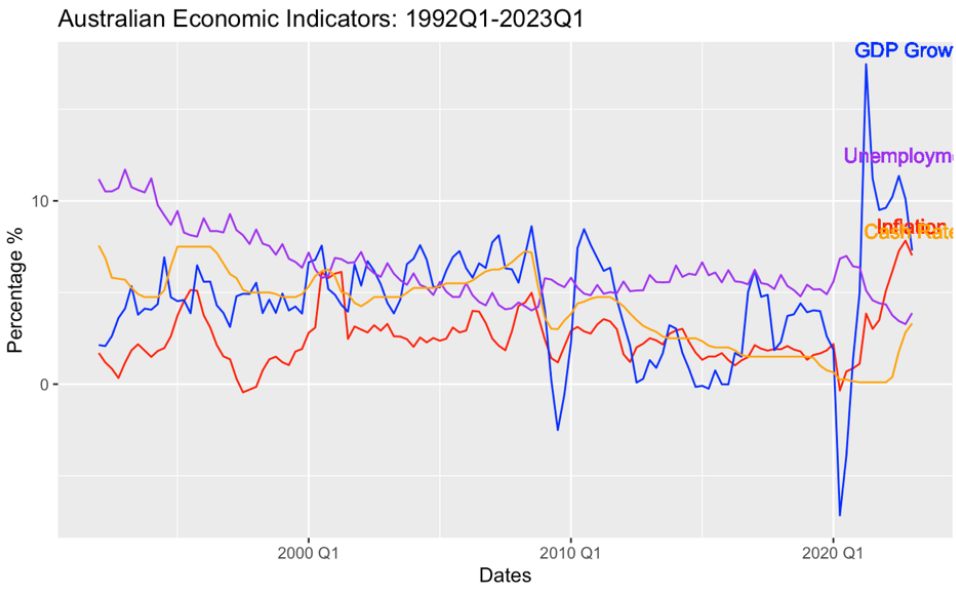

Figure C5: Australian Economic Indicators: 1992Q1-2023Q1

Appendix B

ACF plot

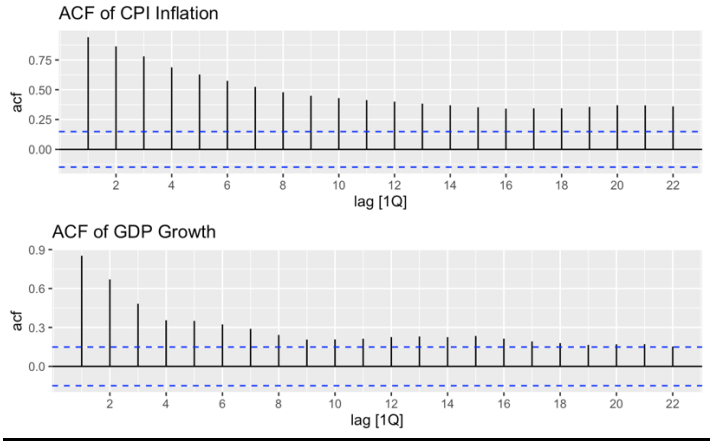

Figure B1: ACF of CPI Inflation and GDP Growth

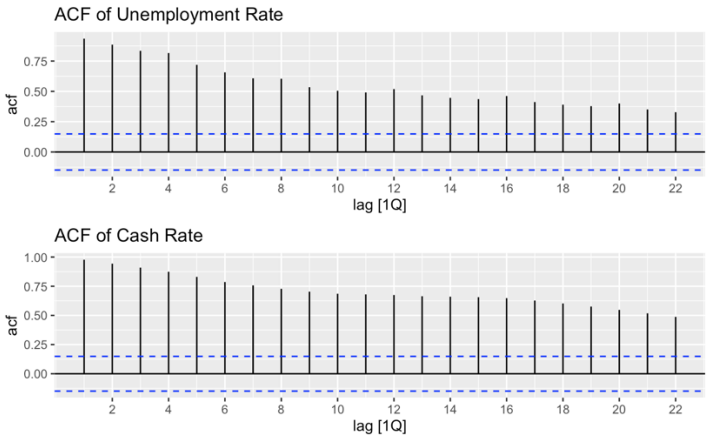

Figure B2: ACF of Unemployment and Cash Rate

PACF plot

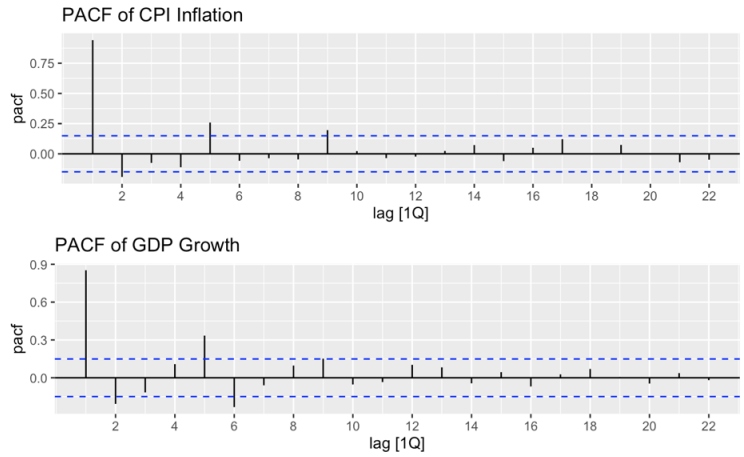

Figure B3: PACF of CPI Inflation and GDP Growth

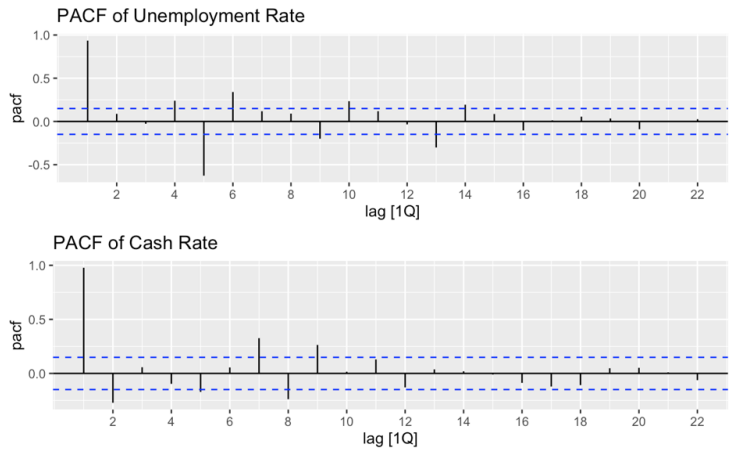

Figure B4: PACF of Unemployment and Cash Rate

Appendix C

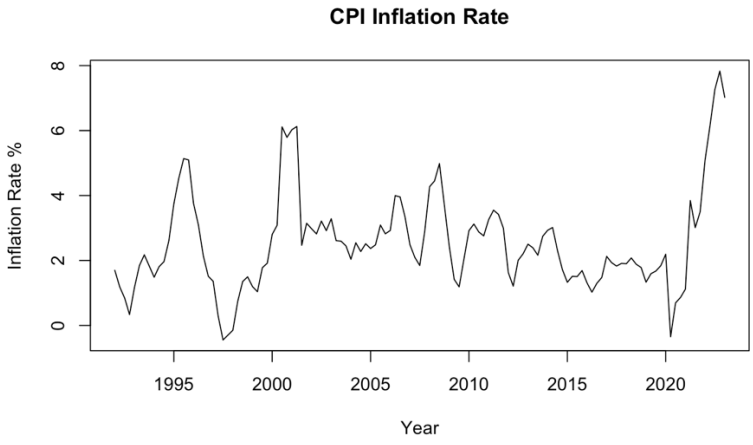

Figure C1: CPI Inflation

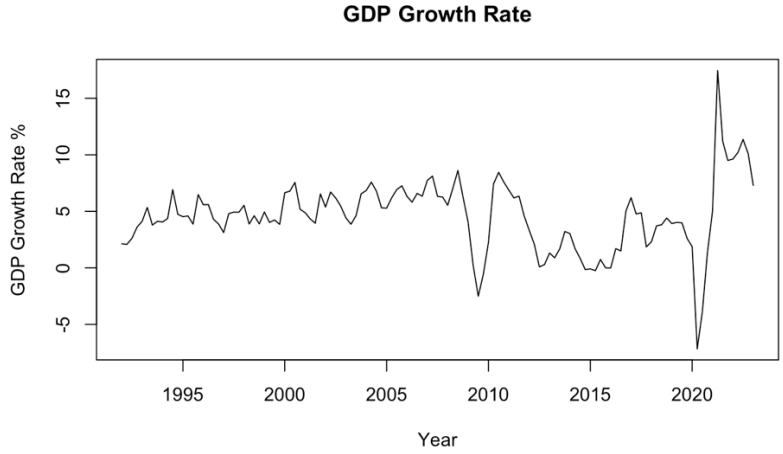

Figure C2: GDP Growth

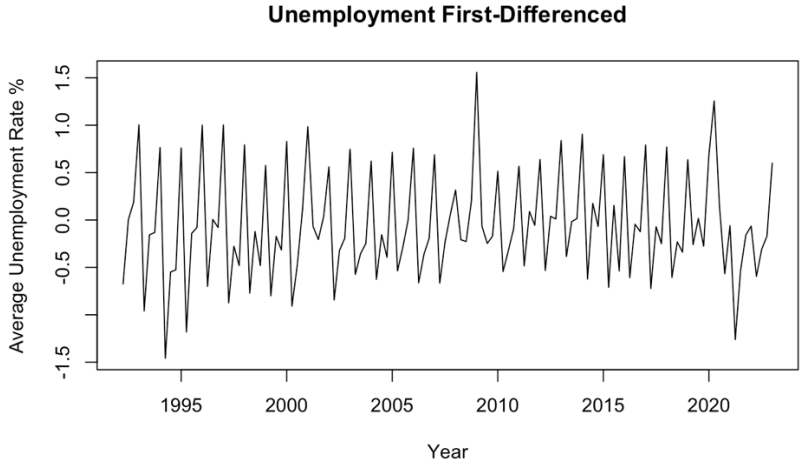

Figure C3: Unemployment Rate

Table C1: ADF and KPSS test p-value of key indicators

Variable	ADF test p-value	KPSS test p-value
Inflation	0.4837	0.1
GDP Growth	0.3408	0.1
Unemployment Rate	0.03218	0.1
Unemployment Rate (First-Differenced)	0.01	0.1

Appendix D

Table D1: Summary results of in-sample fits across the different models (univariate)

Key indicator	Model	RMSPE
Inflation	RW without drift	0.798
	ETS (A,N,N)	0.794
	ARIMA (9,0,0)	**0.624**
	ARIMA (2,0,2)	0.669
GDP Growth	RW without drift	1.431
	ETS (A,N,N)	1.422
	ARIMA (6,0,0)	**1.055**
	ARIMA (0,0,3)	1.061
Unemployment Rate	RW without drift	0.583
	ETS (A,A,A)	0.247
	ARIMA (14,1,0)	**0.215**
	ARIMA (0,1,1)	0.529

Table D2: Summary DM test results across the different models (univariate)

		One-step-ahead	One-year-ahead
Key Indicators	Model	one-tailed test p-value	one-tailed test p-value
Inflation	ETS (A,N,N)	0.507	0.312
	ARIMA(9,0,0)	0.263	0.143
	ARIMA(2,0,2)	0.417	0.24
GDP Growth	ETS (A,N,N)	0.513	0.525
	ARIMA(9,0,0)	0.477	0.156
	ARIMA(2,0,2)	0.927	0.891
Unemployment Rate	ETS (A,N,N)	0.578	0.479
	ARIMA(9,0,0)	0.037	0.048
	ARIMA(2,0,2)	0.733	0.703

Table D3: Summary Granger Causality (multivariate)

	p-value (including Inflation)	p-value (including GDP)	p-value (including UM)	p-value (including CR)
Inflation	-	0.400	0.639	0.001
GDP Growth	0.786	-	0.925	0.096
Unemployment Rate	0.000	0.000	-	0.000
Cash Rate	0.089	0.265	0.452	-

Table D4: Summary of Selection Criteria

	AIC	HQ	SC	FPE
Inflation	2	2	2	2
GDP Growth	5	3	2	5
Unemployment Rate	13	13	4	13

Table D5: Portmanteau test for serial correlation

	One-step-ahead	One-year-ahead
Model	p-value	p-value
VAR(2)	0.088	0.1863
VAR(5)	0.715	0.5769
VAR(13)	2.20E-16	2.44E-15

Table D6: Summary of Eigenvalues

	One-step-ahead	One-year-ahead
Model	Eigenvalues	Eigenvalues
VAR(2)	0.944	0.976
VAR(5)	0.938	0.981
VAR(13)	0.997	1.015

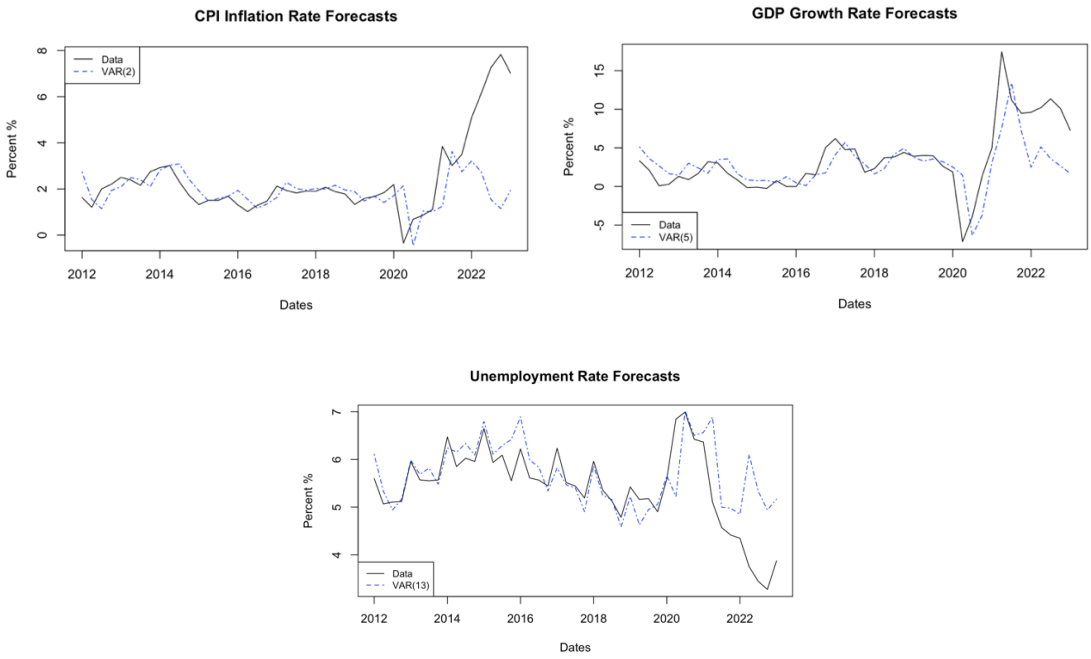

Figure D1: CPI Inflation, GDP Growth, Unemployment rate for medium-term

Table D7: Summary DM test results across the different models (univarte vs multivariate)

			One-step-ahead	One-year-ahead
Key Indicators	Model 1	Model 2	one-tailed test p-value (Greater)	one-tailed test p-value (Greater)
Inflation	VAR(2)	ARIMA(9,0,0)	0.449	0.551
GDP Growth	VAR(5)	ARIMA(6,0,0)	0.092	0.908
Unemployment Rate	VAR(13)	ARIMA(14,1,0)	0.229	0.771

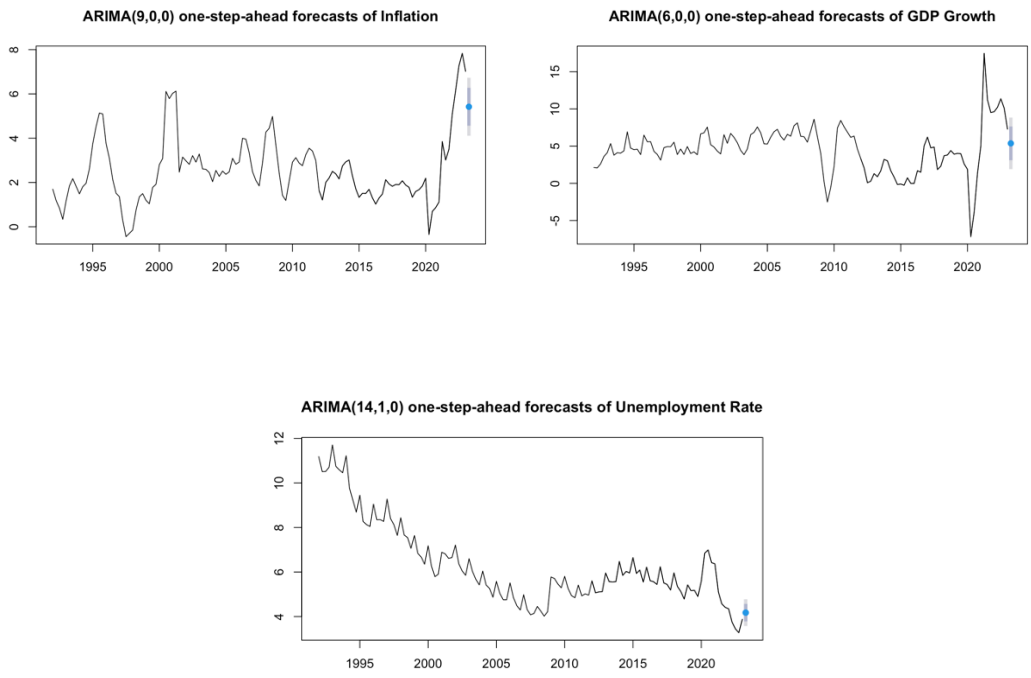

Figure D2: One-step-ahead forecast of Australia Economic Indicators

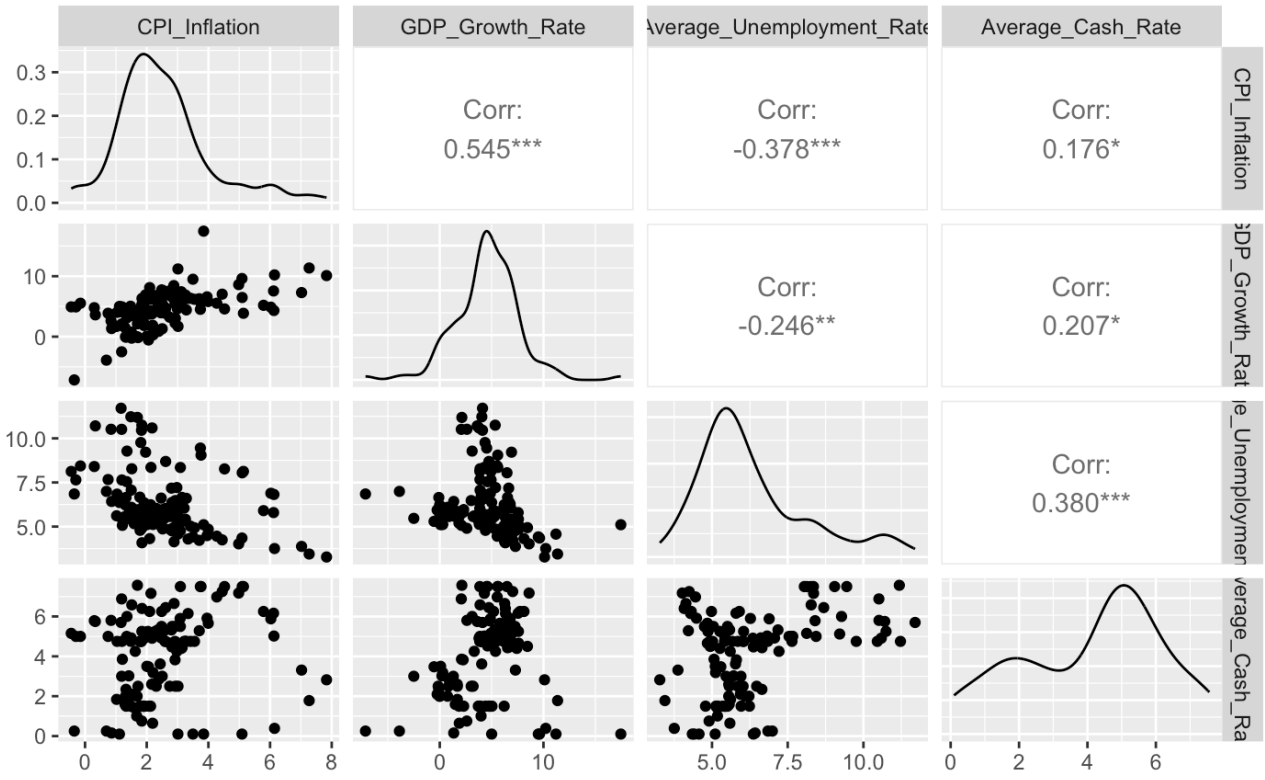

Figure D3: Correlation Matrix

Table D8: Ljung-Box test

Model	p-value
ARIMA(9,0,0)	0.82
ARIMA(6,0,0)	0.37
ARIMA(14,1,0)	0.88

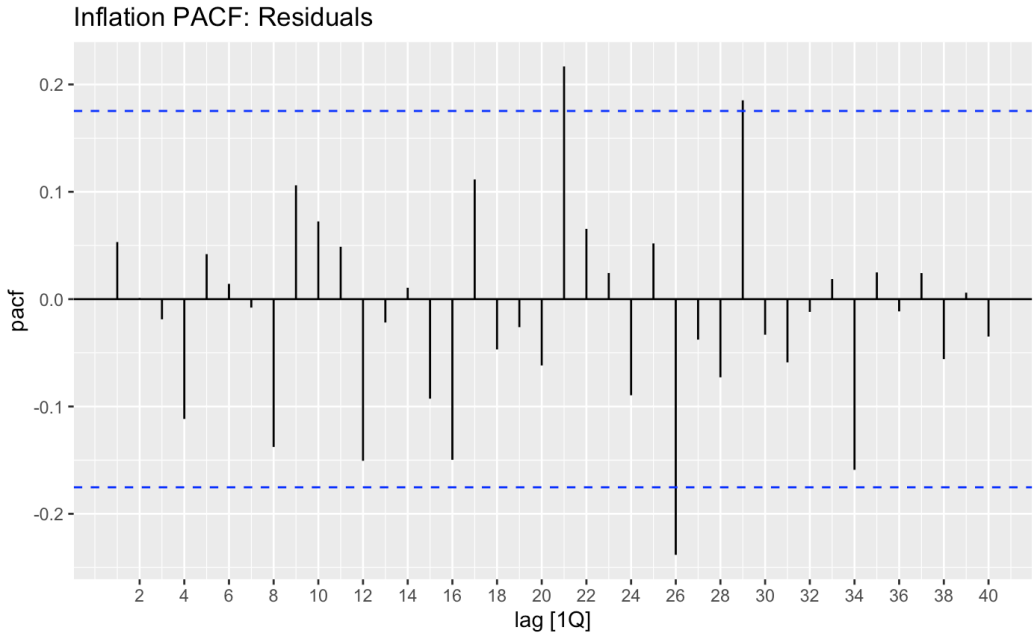

Figure D4: Inflation PACF: Residuals

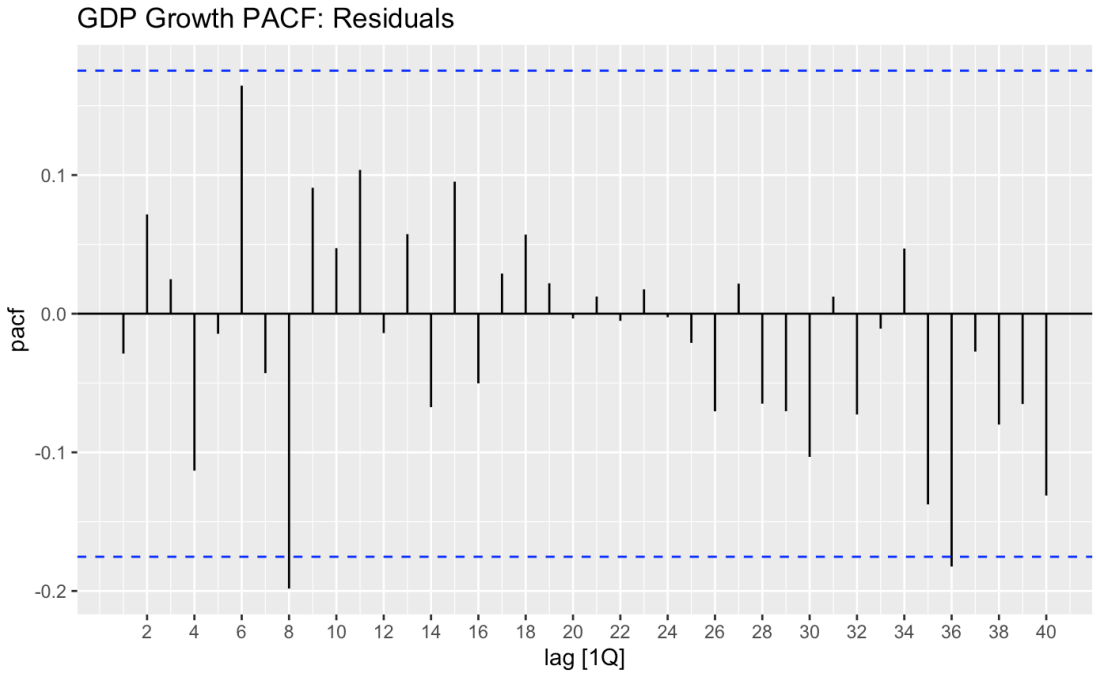

Figure D5: GDP Growth PACF: Residuals

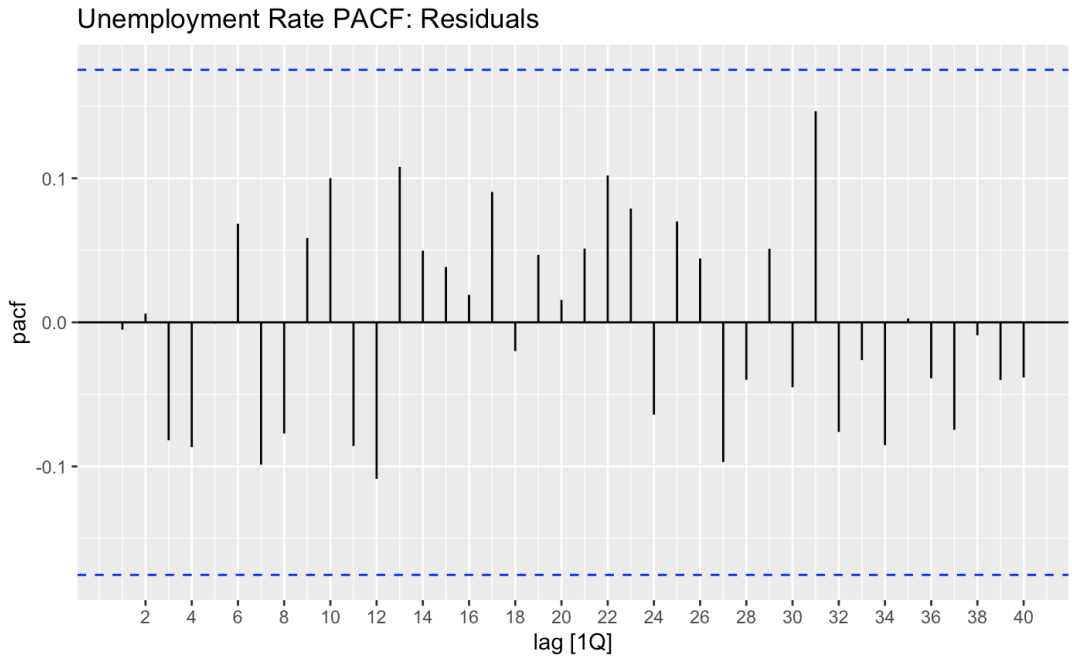

Figure D6: Unemployment Rate PACF: Residuals

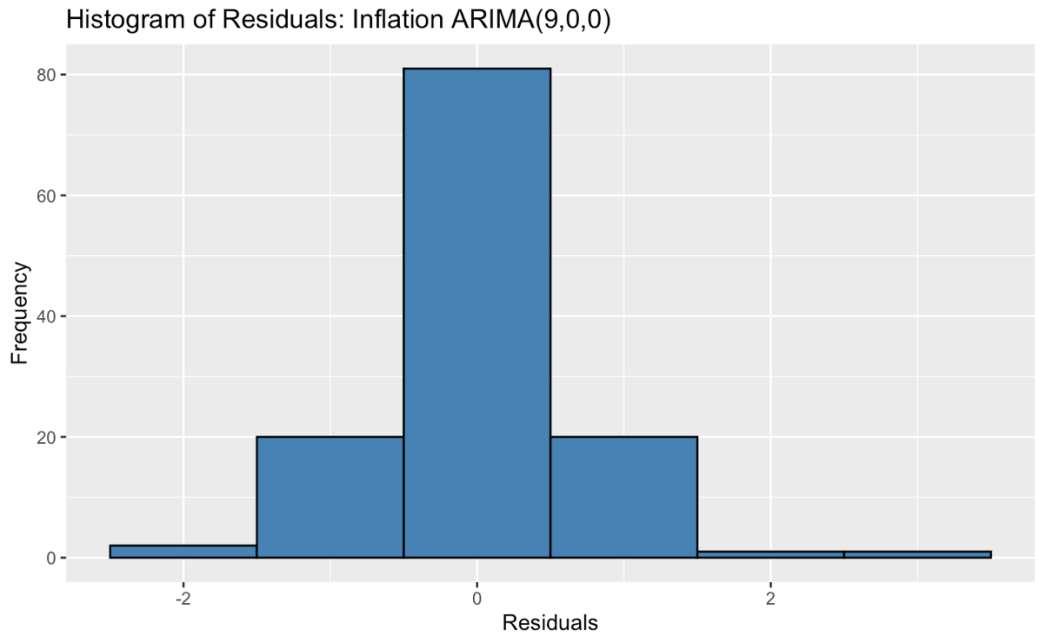

Figure D7: Histogram of Residuals: Inflation ARIMA(9,0,0)

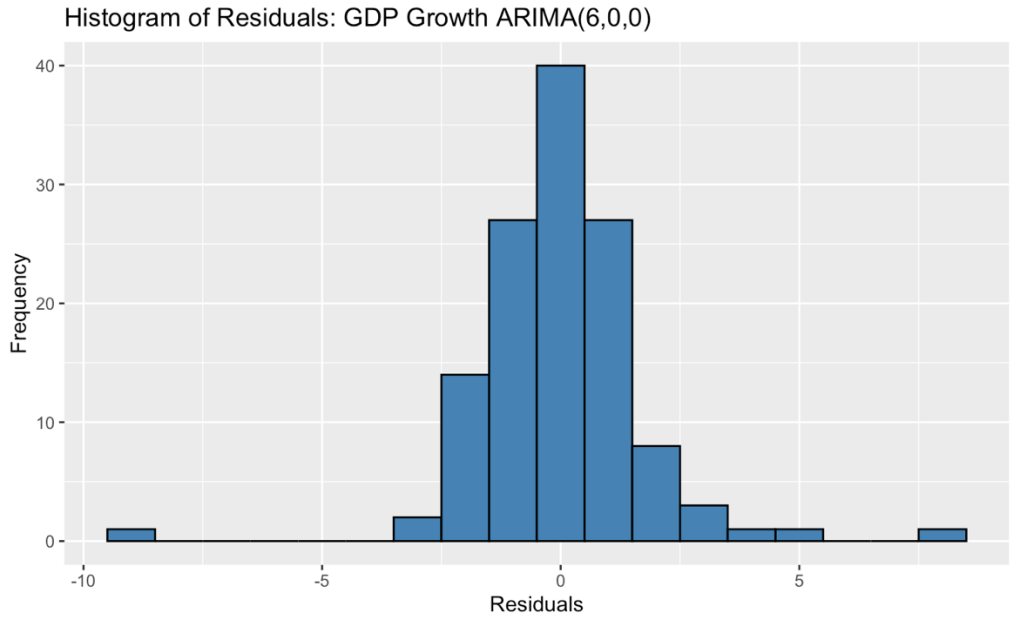

Figure D8: Histogram of Residuals: GDP Growth ARIMA(6,0,0)

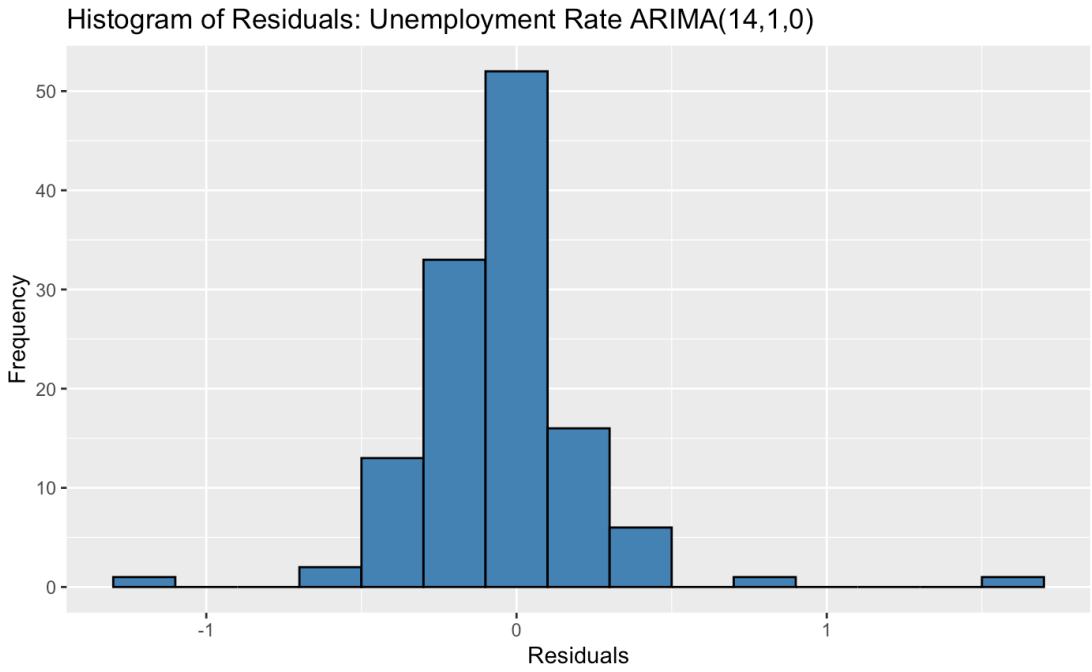

Figure D9: Histogram of Residuals: Unemployment Rate ARIMA(14,1,0)

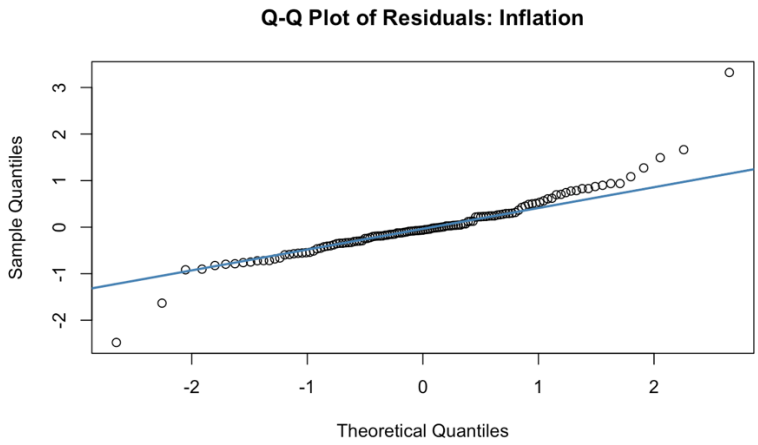

Figure D10: Q-Q Plot of Residuals: Inflation

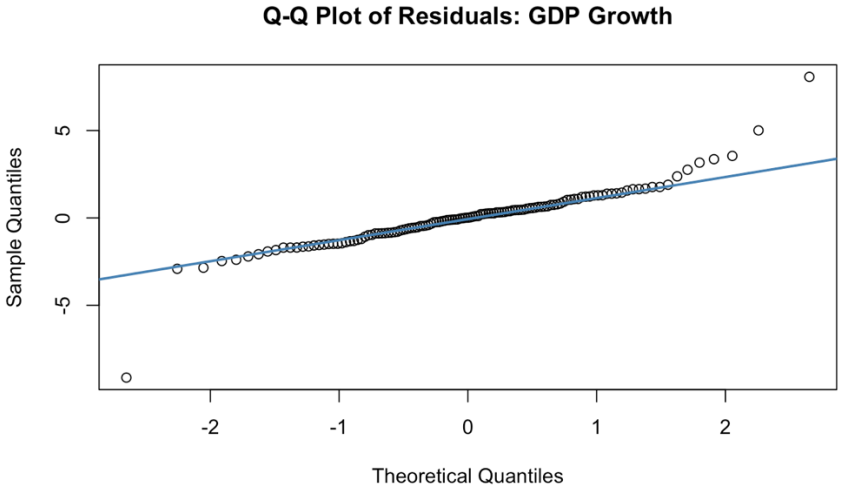

Figure D11: Q-Q Plot of Residuals: GDP Growth

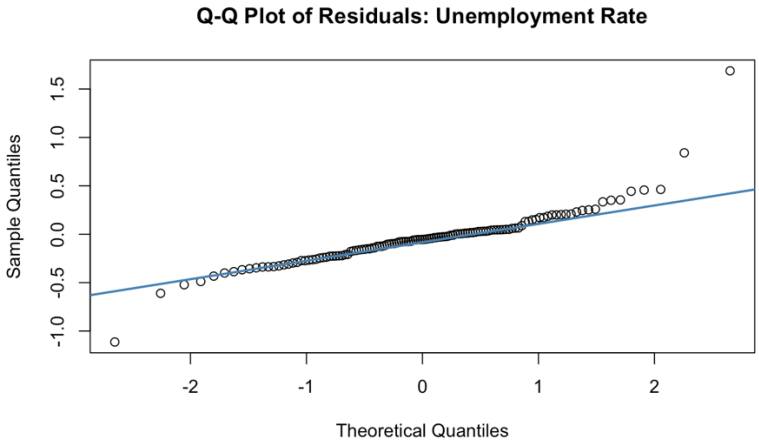

Figure D12: Q-Q Plot of Residuals: Unemployement Rate

	Point Forecast <dbl>	Lo 80 <dbl>	Hi 80 <dbl>	Lo 95 <dbl>	Hi 95 <dbl>
2023 Q2	5.420119	4.564964	6.275274	4.112273	6.727966

	Point Forecast <dbl>	Lo 80 <dbl>	Hi 80 <dbl>	Lo 95 <dbl>	Hi 95 <dbl>
2023 Q2	5.371194	3.110128	7.632259	1.913192	8.829195

	Point Forecast <dbl>	Lo 80 <dbl>	Hi 80 <dbl>	Lo 95 <dbl>	Hi 95 <dbl>
2023 Q2	4.17541	3.783109	4.567711	3.575438	4.775383

Figure D13: Summary of One-step-ahead Forecast

	Point Forecast <dbl>	Lo 80 <dbl>	Hi 80 <dbl>	Lo 95 <dbl>	Hi 95 <dbl>
2023 Q2	5.420119	4.5649644	6.275274	4.11227268	6.727966
2023 Q3	4.459726	3.1893152	5.730136	2.51680050	6.402651
2023 Q4	3.471343	1.8729169	5.069769	1.02676126	5.915925
2024 Q1	2.790359	0.9206856	4.660033	-0.06905985	5.649779

	Point Forecast <dbl>	Lo 80 <dbl>	Hi 80 <dbl>	Lo 95 <dbl>	Hi 95 <dbl>
2023 Q2	5.371194	3.1101282	7.632259	1.913192	8.829195
2023 Q3	3.919727	0.7623366	7.077118	-0.909085	8.748540
2023 Q4	4.118560	0.3520778	7.885043	-1.641778	9.878898
2024 Q1	4.576694	0.5715765	8.581811	-1.548605	10.701993

	Point Forecast <dbl>	Lo 80 <dbl>	Hi 80 <dbl>	Lo 95 <dbl>	Hi 95 <dbl>
2023 Q2	4.175410	3.783109	4.567711	3.575438	4.775383
2023 Q3	4.360019	3.721074	4.998965	3.382837	5.337202
2023 Q4	4.151248	3.328923	4.973573	2.893610	5.408885
2024 Q1	4.335499	3.377498	5.293500	2.870362	5.800636

Figure D14: Summary of One-year-ahead Forecast

Appendix E

Coding

Refer to R code in the attachment file