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Consumer Sentiment:University of Michigan Consumer Sentiment is the predicted value for the forecasting model. The initial consumer sentiment data is provided as a monthly score, the relative sentiment score using the first quarter end measurement of 1966 as a baseline value of one hundred, covering the dates Dec, 2001 to Jan, 2022. The raw score data (Exhibit 1) displays a significant trend and appears to follow a random walk pattern. Because the analysis and forecasting model will forecast the monthly percent change in consumer sentiment, the score is transformed into a monthly % change by subtracting the prior period score from the current score, subtracting 1, and multiplying by 100. The resulting monthly % change in consumer sentiment is plotted (Exhibit 2.) The decomposition of the % change in consumer sentiment (Exhibit 3) suggests limited trend in the data but some seasonality. The ACF analysis of the % change in consumer sentiment (Exhibit 4) shows a significant negative autocorrelation at lag(2) but otherwise suggests that the data has no significant autocorrelation. While the ACF does not show significant seasonality, note the alternating pattern over time; some seasonality appears in the data and will be considered when fitting a model. The result is aligned to the plot in Exhibit 2. The consumer sentiment monthly percent change data likely has seasonality, and this feature will be considered when selecting the forecasting model.

Exhibit 4: ACF of Consumer Sentiment Monthly % Change

Exhibit 1: Consumer Sentiment Score Data

Exhibit 3: Decomposition - Consumer Sentiment Monthly % Change

Exhibit 2: Consumer Sentiment Monthly Percent Change

**U.S. Consumer Sentiment:**

**Team:** Team 7 - Andrew Sommers **Date:** April 2, 2022

**Data Visualization, Decomposition, and Discussion:**

**Title:** Forecasting U.S. Consumer Sentiment; Can a Sufficiently Robust Forecasting Model Be Developed?

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Consumer Price Index :This index provides a representation of changes in the prices of consumer goods, and therefore, represents changes in consumer purchasing power from January 1, 2002 to January 1, 2022. The data is provided as the monthly percentage change, so no transformation was necessary to arrive at monthly percentage change data. The CPI data is plotted (Exhibit 5.) The CPI decomposition is provided (Exhibit 6) and displays both a trend and seasonality. The trend and annual seasonality are also suggested by the ACF plot (Exhibit 7.) These features of the CPI data will be considered in model selection and forecasting % change in consumer sentiment.

Exhibit 7: ACF of Consumer Price Index Monthly % Change

Exhibit 6: Decomposition of Consumer Price Index Monthly % Change

Exhibit 5: Consumer Price Index Monthly % Change

**Consumer Price Index (‘CPI’):**

Chart

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**Gross Domestic Product (‘GDP’):**

Timeline

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Exhibit 11: ACF of U.S Monthly GDP % Change

U.S. Gross Domestic Product: The GDP data is available quarterly, seasonally adjusted, and contains no missing values. The dataset provides the quarter end gross domestic product in relative terms using 2012 dollars as a basis for the measurement (Exhibit 8.) Because the data is quarterly, a straight-line interpolation was applied using a linear forecasting model to generate missing monthly observations. The monthly observations were converted to the percentage change in GDP for the date range of January 1, 2002 to January 1, 2022 (Exhibit 9.) From Exhibit 9 and the decomposition (Exhibit 10), the data does not appear to display seasonality (the data was seasonally adjusted) and displays a limited trend towards the end of the time series. However, the ACF of the GDP monthly percentage change does show significant alternating and decaying autocorrelation. The trend will be considered in the final model selection for forecasting % change in consumer sentiment.

Exhibit 10: Decomposition of U.S Monthly GDP % Change

Exhibit 9: U.S. Monthly GDP % Change

Exhibit 8: U.S Quarterly Gross Domestic Product

Timeline

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U.S. Consumer Disposable Income: The Income dataset provides the month end consumer disposable income in relative terms using 2012 dollars as a basis for the measurement (Exhibit 12.) Monthly Income data was converted to monthly percentage change in Income (Exhibit 13.) Income percent change shows minor change over time until the last two years which is likely attributable to the Covid pandemic causing volatility in labor markets. The decomposition of the Income monthly percentage change (Exhibit 14) suggests seasonality in the data with a strong downward trend at the end of the time series range. The ACF (Exhibit 15) suggests negative short term autocorrelation with some positive seasonality. These features of the income data will be considered when selecting the final model for forecasting % change in consumer sentiment.

Exhibit 14: Decomposition of Consumer Disposal Income Monthly % Change

Exhibit 15: ACF of Consumer Disposal Income Monthly % Change

Exhibit 13: Consumer Disposal Income Monthly % Change

Exhibit 12: Consumer Disposal Income Monthly Data

**Consumer Disposable Income (‘Income’):**

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Exhibit 17: U.S. Unemployment Rate Monthly % Change

Exhibit 16: U.S. Monthly Unemployment Rate

**Unemployment Rate (‘Unemployment’):**

Chart

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U.S. Unemployment Rate: The Unemployment dataset provides the month end unemployment rate (Exhibit 16.) Monthly Unemployment data was converted to monthly percentage change in Unemployment (Exhibit 13.) Unemployment percent change data shows minor change over time until the last two years which is likely attributable to the Covid pandemic which caused volatility in labor markets. The decomposition of the Income monthly percentage change (Exhibit 14) suggests seasonality in the data with a strong downward trend at the end of the time series range. The ACF (Exhibit 15) suggests no significant autocorrelation in the data. The trend and seasonality are not long-term patterns in this data.

Exhibit 19: ACF of U.S. Unemployment Rate Monthly % Change

Exhibit 18: Decomposition of U.S. Unemployment Rate Monthly % Change

**Initial Project Objective:** The initial objective of the project is prediction of the monthly % change in U.S. consumer sentiment given changes in underlying economic variables. The underlying economic variables, predictors, to be explored are CPI, GDP, consumer disposable income, and the unemployment rate with all predictors converted to monthly percentage change. If a sufficiently robust regression model using the provided predictors is not found, the best model to forecast % change in consumer sentiment will be selected and allow for interactive inputs by the project user (‘Researcher’.)

To achieve the objective of the project, different models were considered. Various models were fitted to determine the appropriate model to fit and forecast the data. A discussion of the models and outcomes follows.

Naïve Models:

These models were fit to the monthly % change sentiment dataset to determine if a model on the sentiment data alone allows for a good predictive model. However, the Naïve models do not provide a good fit to the consumer sentiment data.

ARIMA Model:

An ARIMA model providing a good fit for the % change consumer sentiment data was found. Given the results of the other models, the optimal ARIMA model provides the best fit for the data and will be used for forecasting. See the final model selection and updated project objective at the end of this report.

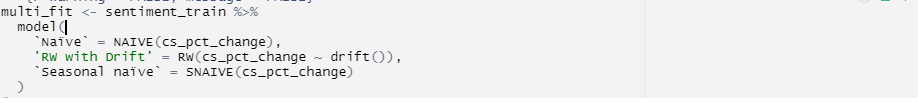
VAR Model:

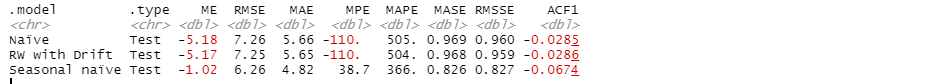
Vector autoregression models are typically good for fitting a model to multivariate economic data. For this project, a VAR model is not applied because the model does not allow for researcher specified scenarios for predictors, and the consumer sentiment data is not stationary (see Exhibit 4.)

Multivariate Regression with Dummy Variables:

Regression models, including dummy variables to address trend and seasonality, are fit to determine if a viable multivariate regression model can be found. Based on the results from applying various models, no model was found that provides a sufficiently good fit to the data. While the approach of converting all data to monthly % change differ from past research on this topic, the results align with the past research that failed to find good predictive regression model for U.S. consumer sentiment using economic factors as predictors.

**Fitting Models**





**Naïve Models:** Naïve models are fit to the monthly consumer sentiment data and evaluated.

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While the Seasonal Naïve model provided the best fit for the Naïve models, analysis shows that seasonality exists within the residuals. Additionally, some autocorrelation exists at a lag of 9 months. The distribution of the residuals demonstrates a material skew to the right. The selected Naïve model does not provide a sufficiently acceptable fit to the data and is rejected.

Based on the evaluation of the models, the Seasonal Naïve Model appears to provide the best fit.

Residuals from SNAIVE model applied to % change in consumer sentiment.

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**ARIMA Models:** ARIMA models are fit to the monthly consumer sentiment data and evaluated.

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The ARIMA(1,0,3) model provides a good fit for the monthly % change consumer sentiment data. The residuals appear to be white noise with no significant autocorrelation. The distribution of the residuals is slightly skewed right but is relatively near a normal distribution. The model was the best fit based relative to other models that were tested. This model is selected for forecasting % change in consumer sentiment. The project will allow the Researcher to forecast % change in consumer sentiment for 3 months forward. Additionally, the project will allow the Researcher to input forward values, up to 3 months of estimated % change in consumer sentiment, and provide an additional 3 month forecast. See the updated project objective stated below.

Based on the evaluation of the models, the ARIMA p=1, d =0, q =3 model appears to provide the best fit.

Residuals from ARIMA(1,0,3) model applied to % change in consumer sentiment.

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Exhibit 21: U.S. CPI monthly percentage change adjusted for trend and seasonality

Exhibit 20: U.S. GDP monthly percentage change adjusted for trend

Adjustments to the datasets: The monthly % change U.S consumer sentiment data includes seasonality and a lagged autocorrelation (see Exhibits 3 and 4), so the regression model will consider these features in fitting a model. The % change GDP dataset includes autocorrelation, and this trend is removed prior to using this dataset as a predictor to avoid this noise in the model The % change CPI dataset includes a trend and seasonality (see Exhibit 7), and these features are removed prior to using this dataset as a predictor. The adjusted datasets are plotted.

**Regression Models:** Multivariate linear regression models are fit to the monthly data and evaluated.

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The selected multivariate regression model:

Adding the trend dummy variable results in a higher adjusted AIC and AIC versus only including seasonal dummy variables. Therefore, the Trend dummy variable will be excluded from the model.

After adjusting the data, various multivariate linear regression models, with seasonal dummy variables, are fitted to the data. Based on the adjusted AIC, a model using lagged % change GPD, lagged % change CPI, ,and % change unemployment to predict % change consumer sentiment is best. However, a model using the same predictors plus % change consumer disposable income provides nearly the same adjusted AIC, a better AIC, and allows all predictors to be included in the model. This model is selected for the next step: Determine if a trend dummy variable will improve the multivariate regression model.



Graphical user interface

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Residuals from selected multivariate regression model applied to % change in consumer sentiment.

Table

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Report from selected multivariate regression model applied to % change in consumer sentiment.

The selected multivariate regression model with seasonal dummy variables does not provide a good fit to the data. (Note that this report does not display the many regression models attempted on the data including models with and without trend and seasonal dummy variables.) The model residuals are mostly white noise, no significant autocorrelation exists, and the distribution of the residuals appears to be relatively normal. However, the model has a low Adjusted R-Squared and does not provide a sufficiently meaningful prediction of % change in consumer sentiment. Therefore, the best regression model for forecasting % change in consumer sentiment is rejected.

**Summary of Model Selection:** The ARIMA(1,0,3) model provided the best model to fit the % change in consumer sentiment data and will be selected for the project.

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**Project Objective Updated:** Given a viable regression model was not found, and the best model found was an ARIMA(1,0,3) model, the project will forecast % change in consumer sentiment using the ARIMA model. Note the ARIMA model tends to provide relatively low mean values. The important outcome is the direction of the mean and the confidence level ranges. By understanding the direction of the change and confidence levels, the Research can obtain a good idea of expected % change in consumer sentiment. Because economic factors can be quite volatile in the short-term, a 3 month forecast for % change in consumer sentiment is viable. To allow for interaction by the Researcher with the project, the Researcher will be allowed to provide her/his own forward estimates of % chance in consumer sentiment and forecast another three months forward. The interaction allows for a 6 month forward estimate of % change in consumer sentiment. By studying the % change value, the Research can consider expected changes in consumer sentiment relative to other economic valuables stated in monthly percentage change terms and use these values for forecasting securities markets (as stated in the project proposal, forecasting of securities markets is beyond the scope of this project.)

The 3 month forecast plot and mean projection are provided. The plot provides the 80 and 90 percent confidence levels.

**Forecast:** Based on the selected model, a 3 month forecast of % change in U.S. consumer sentiment is generated

Graphical user interface

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Following is an example of the forecast of % change in consumer sentiment with the Researcher providing values for the next 3 months. Given the inputs by the Researcher, a 3 month forecast of % change in consumer sentiment is generated. Note that this forecast provides predicted values for May through July of calendar year 2022.

Researcher Provided Values:

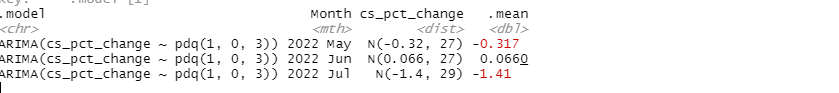
Month % change in consumer sentiment

February, 2022 5.2

March, 2022 -3.1

April, 2022 4.5

**Forecast with Researcher Input:** Based on the selected model and Researcher input, a 3 month forecast of % change in U.S. consumer sentiment is generated.



**Summary:** The project object is updated to apply an ARIMA(1,0,3) model to % change in U.S. consumer sentiment data, allow a Researcher to input up to 3 forward estimates for the data, and generate a 3 month forecast. An important outcome from this analysis is Naïve and regression models using economic factors do not provide good fits to the data for predictive purposes.