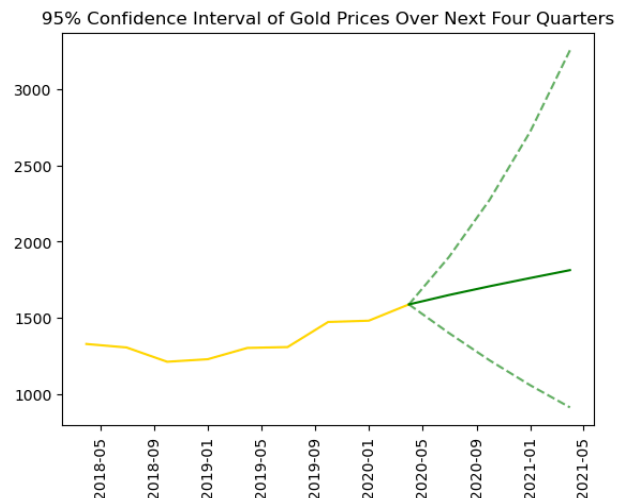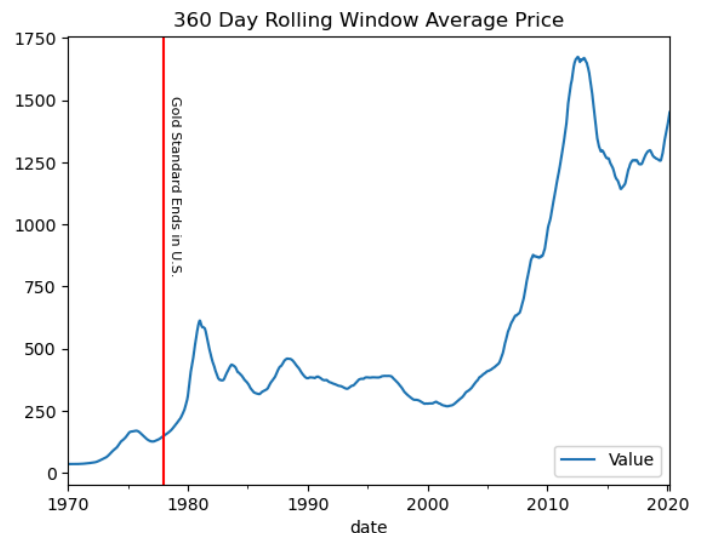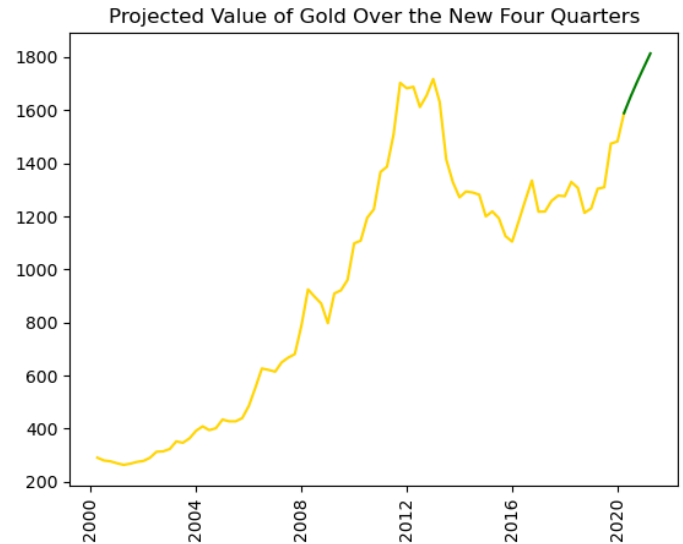# Projecting the Price of Gold Over the Next Year

Problem Statement
What is the projected price of gold over the next year using the quarterly historical data of the price of gold? Using historical trend data, I will determine if the upcoming year is a good time to buy gold and, extrapolating the data further, determine the next great time to buy gold.

Overall Findings
After studying the data of gold prices over the past 50 years and using that information to model. It would appear that gold prices are set to rise over the next four quarters, as shown in the green prediction line on the figure to the right. It is a good time to buy gold for these reasons, with one caveat at the end:

1. gold prices have traditionally gone up quickly right before, during and for some time after major global events that negatively affect the GDP in the United States. We are in one of those moments with the COVID Pandemic. More information on this in Appendix A.

2. gold prices have been mostly up for the duration of the 2000s after a stagnant period through the economic boom times of the 1990s, showing in the 360 Day Rolling Window Average Price graph to the right.

3. however, the confidence interval of the model will show some risk in making this purchase along with some major opportunities for growth. The upper end of the 95% confidence interval shows prices north of $3000 per ounce, almost doubling current prices. The lower end shows losses of over 20%, so your risk preferences will play into how much gold investing you'll do.

Projected Value of Gold Over the New Four Quarters

360 Day Rolling Window Average Price

95% Confidence Interval of Gold Prices Over Next Four Quarters

Process

Exploratory Data Analysis

The data in the set is the prices of gold at levels ranging from quarterly to daily. To get a feel for the data set, I graphed the data as a time series to see what the prices have looked like over time. Seeing that chart immediately led to me to see that we were not looking at a stationary data set, which would be required for modeling. Knowing that, I converted to analyzing the percent change for each data point from the last data point. There were outliers in the early years, which I discovered were because there were fewer data points for those years, particularly in the 1970s. To address this, the data set was upsampled linearly to ensure that all dates since 1970 were encompassed in the prices data set. I analyzed daily, weekly and quarterly price changes to ensure that the data stayed stationary. Because of the size of the data set, I decided that I would use the quarterly data, which required a downsample, but also allowed for future models to work on the data. It was during the exploratory process where I realized that economic events had an impact on price changes, which is when I decided to bring in the GDP information as part of my modeling and story telling for this set of data.

Pre-Processing

The pre-processing for this data set required work to ensure that all of my index values were datetime objects so that time series modeling would work. The percent change for the quarterly data set was used to ensure the data was stationary and this was checked using KPSS to ensure that the data was stationary. Having a quarterly price and a stationary percent change, I was ready to start the modeling process for predicting future gold prices.

Modeling

Three prediction models were built and tested using mean squared error as the test of the best model with regard to the error in the model versus the actual percent. Several ARIMA p, d and q values were tested and the model that performed the best was ARIMA(1,0,1), so those values made it to the modeling stage. Appendix B has the ARIMA Model graphed with the actual values.

Polynomials of degree 1, 2, 3 and 4 were tested, but all performed significantly worse than the other two models and were thrown out before modeling.

Simple Exponential Smoothing was also used to develop and model and test for mean squared error. Appendix C has the SES Model graphed with the actual values.

Final Model Comparisons & Choosing ARIMA (1,0,1)

To look at performance, the mean squared error of models was examined. The ARIMA (1,0,1) performed the best and was the model chosen to move into predictions and applications.

Figure: Performance Statistics on the Models

Model	Mean Squared Error
ARIMA (1,0,1)	0.00307
Simple Exponential Smoothing	0.00699
4th Degree Polynomial	68591670

Applying the Model & Confidence Interval

The ARIMA model was applied to the time series of gold prices. Once the model was fit, the forecast was used to determine the forecasted percent increase in price over the next quarter. From there, those predicted growth numbers were used to build out prices that could be added to the graph to visually show the graph (page 1). The values are in the figure below.

Figure: Projected Prices from ARIMA Model

Model	Predicted % Growth in Price	New Price Prediction
2020-03-31 (Last Data Point)	–	$1588.25
2020-06-30	3.89%	$1650.00
2020-09-30	3.47%	$1707.26
2020-12-31	3.16%	$1761.21
2021-03-31	2.93%	$1812.84

As these prices are predicted, I also applied the confidence interval to the prices to determine the range of values that would encompass 95% of the possible outcomes. This story isn't as definitive as the single model, but does show there is some risk in this purchase. On the flip side of this coin, there is also potential for a large payout from this purchase. From the figure below, you can see the bottom end of the 95% confidence interval and the top end of the 95% confidence interval shown as percentages and the prices that would come from that growth or decline.

Figure: Projected Prices from ARIMA Model (95% Confidence Interval of Predictions)

| Model	Predicted Percent (Lower End)	Predicted Percent (Higher End)	Lower End Price Predicted	Higher End Price Predicted
2020-03-31 (Last Data Point)	–	–	$1588.25	$1588.25
2020-06-30	-11.84%	19.61%	$1400.25	$1899.76
2020-09-30	-12.75%	19.69%	$1221.65	$2273.90
2020-12-31	-13.33%	19.65%	$1058.79	$2720.76
2021-03-31	-13.70%	19.57%	$913.70	$3253.12

Conclusion

After reviewing, processing and modeling the data, it is clear that it is a good time to buy gold. The economic conditions are consistent with gold booms of the past, gold has been a strong investment over the past 20 years and the top end possibilities right now are major returns in a year's time. There is always the possibility of a loss, but, in the end, gold is a good buy right now.

Appendix A: Gold Prices vs. GDP

Gold prices have increased dramatically after dips in GDP, as shown by the slight dip in 2001 and then the larger dip in 2008. The current dip, fueled by the COVID-19 Pandemic, has already sent gold prices up as shown, but the increases last several quarters beyond the dip in the GDP.

Gold Prices Rise Right Before Dips in GDP
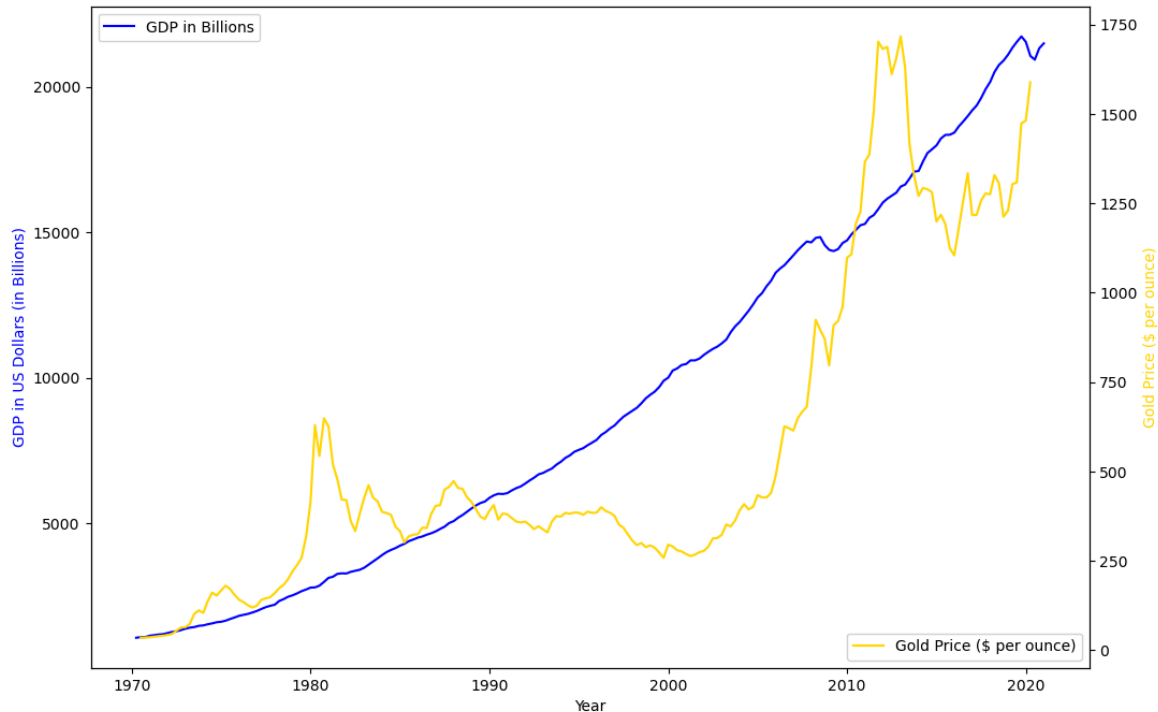
Appendix B: Percent Change Actual vs. Percent Change Model for ARIMA
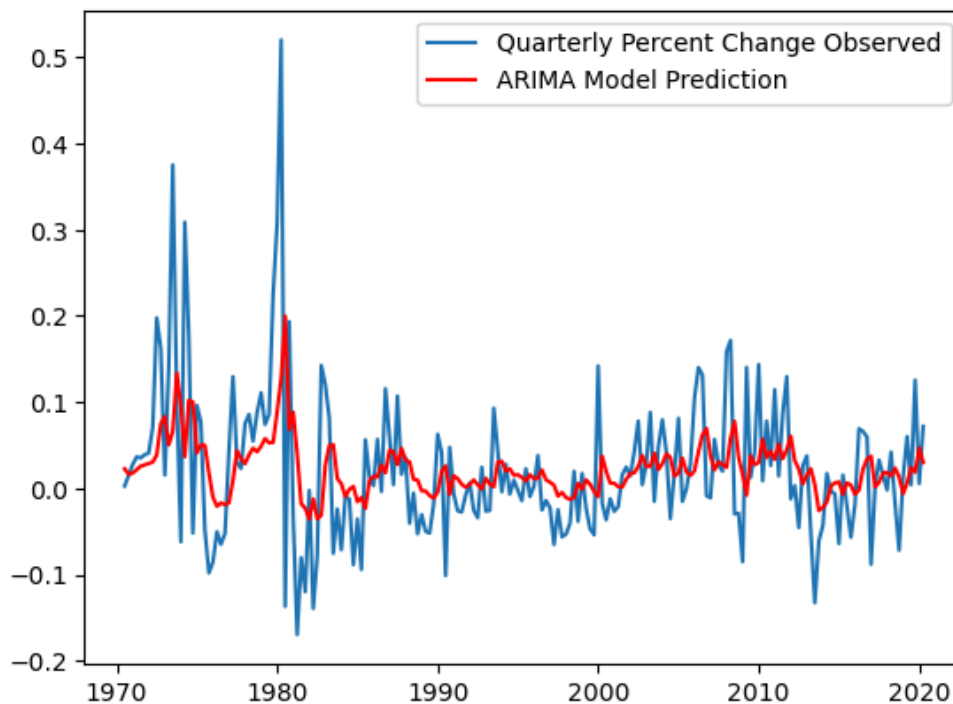
Appendix C: Percent Change Actual vs. Percent Change SES