Forecasting Financial Sector Variables

ECON 373: Forecasting and Time-Series Analysis

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1. Introduction

The financial sector is one of the main pillars of the modern economy. At the end of the year 2019, the sector was doing well overall, even though there were some warning signs. The effective federal funds rate had been decreasing since the end of the year 2018. This meant that the Federal Reserve had been increasing money supply to encourage economic activity, or that there was less demand on federal reserve surpluses among financial institutions. These were other warning signs for the economy and the financial sector. However, the Fed responding to a possible economic slowdown was another good sign. Forecasts for the federal funds rate that drives the Effective Federal Funds Rate according to the FOMC were 1.6% for 2020 and 1.9% for 2021, so the economic activity was expected to increase, another good news for the health of the financial markets and the economy. The 3-Month Treasury Constant Maturity Rate was seeing an increase up to 2019 and then a decrease in 2019. This means investors had started to be unsure of the economic stability in 2018 in the short term, so more of them started looking into different investment options. This could have been due to the tax cut in 2018. Since 2019 started this trend changed, however, with demand increasing for the 3-month treasury bills, a good sign for financial stability. However, this change could also be explained by the fact that the interest rates mainly influenced by the Federal Funds Rate were increasing during this period, so there was more demand on non-fixed rate investment at that time, decreasing the demand on treasury bills and thus increasing their rate in 2018. Since the start of 2019 FOMC lowered the interest rates, therefore there was more demand for fixed-rate investment options. Since interest rates were expected to be low, the 3-month treasury bill rates were also expected to be lower, but slowly increase as interest rates went up again. Livingston Survey estimated the rates to be 1.60% in 2020 and increase to 1.72% in 2021. On the other end, the 10-year and 30-year Treasury Constant Maturity Rates had been decreasing (from 3.04% and 3.27% to 1.79% and 2.25% respectively) since the end of 2018, which means investors had been competing for the 10-year Treasury bonds, lowering the average yield. This means they had relatively less confidence in the future financial and economic conditions and chose to invest in low-risk bonds, which was a warning sign for the financial sector in the short term. At the same time, the fact that the average yield was not high meant the inflation was not high, which was a good sign but might hint to an economic slowdown. Finally, the real S&P 500 saw an increase at the end of 2019 as the real S&P percentage changed from a year ago shot up from 2.4% to 12.6% in the last quarter, which was a good sign for the stock market and the financial sector.

With a lot of uncertainty about what direction the financial sector will go in 2020 and 2021 as more economists fear a recession, it is important to develop different forecasting models and see were the economy might head in the future. For this reason, this study examines five financial variables and develops forecasts for them using three different time-series forecasting methods.

2. Sector Description

Studying the financial sector is crucially important in evaluating the health of the modern U.S. economy. The variables in this sector measure various types of economic activity, incorporating stock markets, currency exchange variables, commodities, access to credit housing and interest rate markets, and investor confidence. Some of the most important financial sector variables are Standard and Poor 500 (S&P 500) index and the Dow Jones Industrial Average for the stock market; Effective federal funds rate, the 3-month, 10-year and 30-year Treasury constant maturity rates for interest rate market; 30-year mortgage rate for the housing market; Investor confidence index; Consumer loans at commercial banks for credit access and trade-weighted exchange rate for exchange rate market. The main driving forces of the financial sector are also spread widely, with monetary policy, exchange rates, the fiscal policy of leading economies, and global, as well as U.S., business confidence affecting each of the variables. Expected inflation, uncertainty, and oil price volatility are also some of the biggest factors driving the sector variables.

To study and forecast the state of the financial sector in 2020 and 2021, this paper focuses on data from five financial variables: the effective federal funds rate, 3-month, 10-year, and 30-year Treasury constant maturity rates, and the S&P 500 index to get a good scope of the overall state of the sector in both short and long run. Below is the table for descriptive statistics of the data used in this study. All data is secondary and was obtained from FRED[1] database.

Table 1: Descriptive Statistics of Data

Variable	Mean	Median	Standard Deviation
Effective Federal Funds Rate, Percent	5.08	4.91	3.68
3-Month Treasury Constant Maturity Rate, Percent	3.91	3.96	3.12
10-Year Treasury Constant Maturity Rate, Percent	6.12	5.89	2.90
30-Year Treasury Constant Maturity Rate, Percent	3.47	3.14	0.77
S & P 500 Index, Real Percent Change	2.49	3.09	3.85

The effective federal funds rate is a variable based on quarterly time-series data from 1962Q2-2019Q4 measured in percentage points. The effective federal funds rate is the average rate with which financial institutions have traded their federal reserve surpluses. From the descriptive statistics table above we can see that mean and median values of the federal funds rate have been approximately 5% in 1962-2019. There has been a fair amount of variation in the variable with 3.7% as the standard deviation, which is very close to the mean value. It is also worth noting that the minimum value of federal funds rate data is very close to 0, but not below it. Changes in effective federal funds rate are generally caused by the monetary policy of the Federal Reserve. Increasing the money supply usually decreases the effective federal funds rate to meet the target. To explain the variation of federal funds rate we will want to look at expected inflation, monetary base, bank reserve balances, GDP growth rate, target federal funds rate, and unemployment rate.

[1] "Federal Reserve Economic Data | FRED | St. Louis Fed."

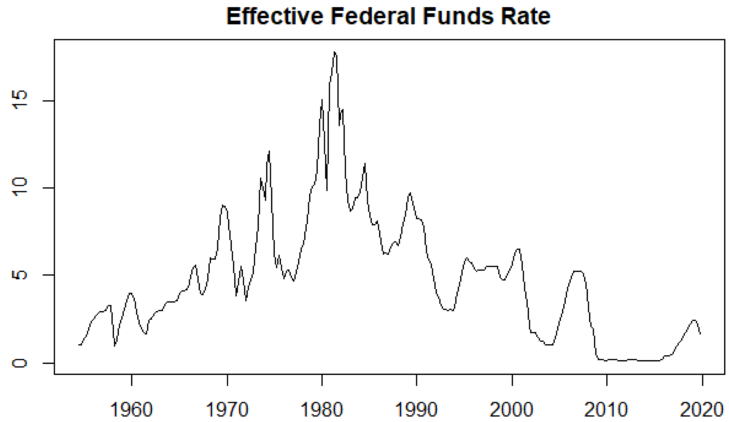


Figure 1: Effective Federal Funds Rate, 1962Q2 – 2019Q4

Forecasting effective federal funds rate will be useful for banks who have surplus reserves in the Federal Reserve, or the Fed itself to help set its target rate in the future.

Another variable of interest in the financial sector is the 3-month Treasury constant maturity rate, a quarterly time-series variable measured in percentage points in years 1982Q1-2019Q4. This variable is based on the average yield of Treasury securities adjusted to the equivalent of a 3-month maturity. From the descriptive statistics table, we can see that the mean value of the 3-month Treasury constant maturity rates have been around 3.9% and the standard deviation of 3.1% shows there has been a significant variation in the variable over time.

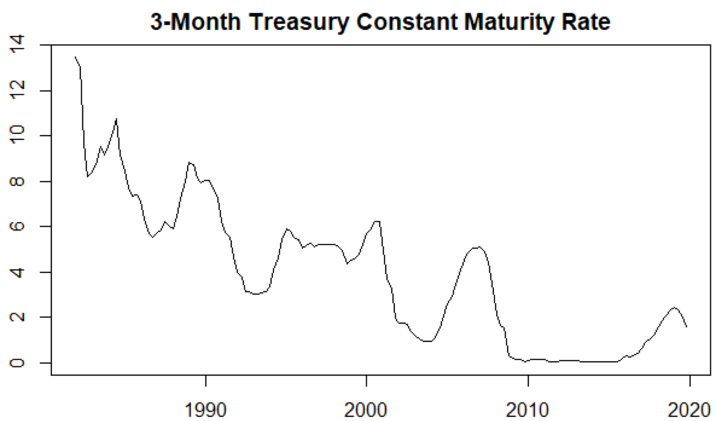


Figure 2: 3-Month Treasury Constant Maturity Rate, 1982Q1 – 2019Q4

Forecasting the 3-month Treasury bill rate will be useful in determining the state of the economy in the short run. To forecast the 3-month Treasury bill rate, looking at quarterly expected inflation, GDP growth rate, federal funds rate, and unemployment rate data will be useful.

A similar variable, the 10-year Treasury constant maturity rate is a quarterly time-series variable measured in percentage points in the years 1962Q1-2019Q4. This variable is based on the average yield of Treasury securities adjusted to the equivalent of a 10-year maturity. From the descriptive statistics table, we can see that the mean and median values of the 10-year Treasury constant maturity rates have been approximately 6% and there has been a fair amount of variation in the variable as standard deviation is 2.9%.

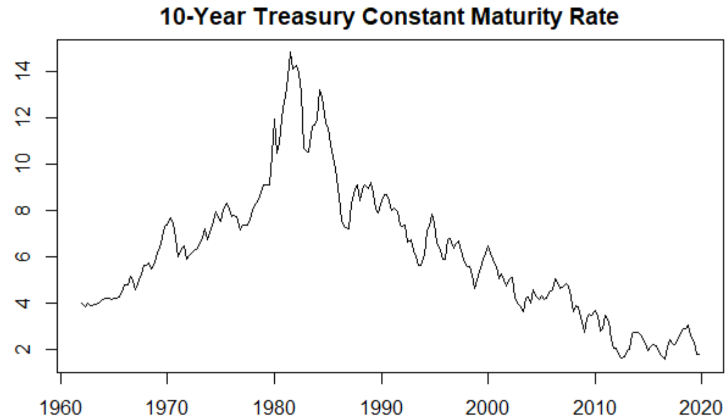


Figure 3: 10-Year Treasury Constant Maturity Rate, 1962Q1 – 2019Q4

During contraction phases of the business cycle bidders are more likely to compete for low-risk 10-year bonds, thus lowering the average yield. During periods of high inflation fewer investors are willing to purchase fixed-rate bonds, which should increase the Treasury bond rates. Further, when the federal funds rate is lower than the 10-year T-bill rate there is more demand for 10-year bonds. Therefore, an equation explaining the variation of 10-year Treasury Constant Maturity Rate will be expected inflation, GDP growth rate, federal funds rate, and unemployment rate. Forecasting 10-year Treasury Constant Maturity Rate will be useful for individuals and firms looking into investing in steadier bonds or are planning to sell their Treasury bonds.

The 30-year Treasury constant maturity rate is a quarterly time-series variable measured in percentage points in the years 2007Q1-2019Q4. This variable is based on the average yield of Treasury securities adjusted to the equivalent of a 30-year maturity. From the descriptive statistics table, we can see that the mean values of the 30-year Treasury constant maturity rates have been around 3.4% and there has not been too much variation in the variable as standard deviation is 0.77.

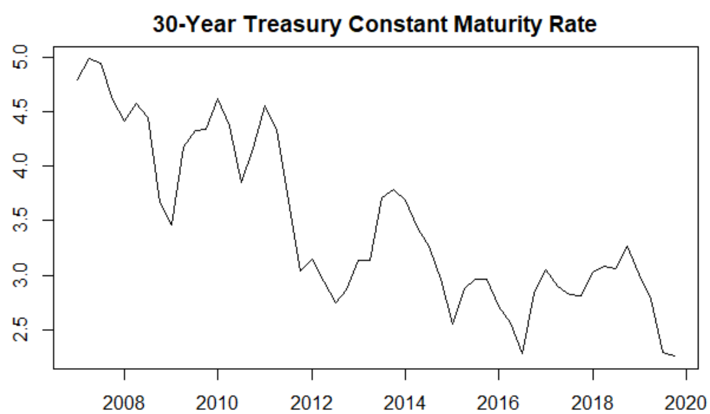


Figure 4: 30-Year Treasury Constant Maturity Rate, 2007Q1-2019Q4

Forecasting the 10-year and 30-year Treasury bill rates will be useful in determining the stability of the economy. The main driving forces of these variables are quarterly expected inflation, GDP growth rate, federal funds rate, and unemployment rate data. These variables are important when looking to evaluate the bond market, state of the economy, or when looking into investing in steadier bonds, or planning to sell Treasury bonds.

The final variable studied in this paper is the real S&P 500 index variable, which is calculated using the PCE chain-type price index excluding food and energy. This variable is based on quarterly time-series data from 2010Q4-2019Q4 and is measured as a percentage change. S&P 500 is a stock market index measuring the stock performance of the largest 500 companies on stock exchanges in the United

States. From the descriptive statistics table, we notice that the mean and median values of the S&P 500 have been 2.5% and 3.1% respectively. The difference between these values hints to a higher degree of variation. This is supported by the value of standard deviation, which is 3.8%, more than the mean itself. The minimum value of percent change is around -7.5%, while the maximum value is around 10%, again showing a high degree of variation.

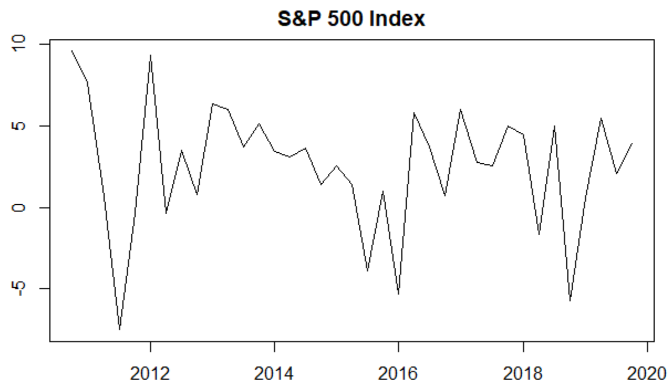


Figure 5: S&P 500 Index, Real Percent Change, 2010Q4 – 2019Q4

Forecasting real S&P 500 will be useful to determine the state of the financial markets, investor confidence, and therefore the state of the economy. S&P 500 is affected by investor confidence, business cycle state, and GDP growth rate. Thus, these variables need to be considered if we wanted to explain the variation in the index.

These five variables were chosen because they represent health and the perception of the economy in different sectors and different times. The loss functions for forecasting quarterly values of all variables except the real S&P 500 index is $L = e^2$ as larger errors would cause a larger financial impact on the economy due to interdependence. The loss function I would use for forecasting quarterly and yearly values of the real S&P 500 would be $L = |e|$ as betting decisions are not based directly on the S&P 500. The forecast object of this paper is a time series, estimating all five variables in 2020Q1-2021Q4. The forecast statement is a point forecast. The forecast horizon is an 8-step-ahead forecast.

3. Autoregressive Integrated Moving Average Models and Forecasts

To obtain quarterly forecasts for years 2020 and 2021 for the chosen variables based on their inertia, autoregressive integrated moving average (ARIMA) modeling was conducted using the 'forecast' package in the R statistical software. This technique was used to see if the variables depend on their past values and if we will get good forecasts using that fact. Before the ARIMA modeling was conducted, the data was manipulated to make it more stationary as preferred for the ARIMA forecasting method. The percentage changes of all variables except for the effective federal funds rate were calculated. As for the federal funds rate, the natural logarithm was calculated.

To choose the best ARIMA model, first, the mean model was constructed and after running the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) and the Augmented Dickey-Fuller (ADF) tests, unit roots were removed when necessary. After no unit roots remained, a linear trend was modeled on the best model so far. The model whose Bayesian information criterion (BIC) proved to be the lowest was chosen for further use in the ARIMA modeling. For this, the residual autocorrelations (ACs) and partial autocorrelations (PACs) of the best model were investigated. Depending on the number of significant

ACs and PACs, the first guess for the autoregressive or moving average term was modeled and after examining the neighboring ARMA models, the appropriate number of lags was selected using the BIC. After checking the residuals for white noise, the best model 8-quarter-ahead forecasts were made. On average, 8 different models were checked with the lowest BIC for each variable.

Table 2: ARIMA Modeling Results

Effective Federal Funds Rate, Natural Log		3-Month Treasury Constant Maturity Rate, Percent Change		10-Year Treasury Constant Maturity Rate, Percent Change		30-Year Treasury Constant Maturity Rate, Percent Change		S&P 500 Index, Percent Change	
Model (p,d,q)	BIC	Model (p,d,q)	BIC	Model (p,d,q)	BIC	Model (p,d,q)	BIC	Model (p,d,q)	BIC
(0,0,0)	892.092	(0,0,0)	243.986	(0,0,0)	317.97	(0,0,0)	34.235	(0,0,0)	210.94
(0,1,0)	-92.25	(0,0,0) With Trend	245.099	(0,0,0) With Trend	320.95	(0,0,0) With Trend	38.214	(0,0,0) With Trend	213.98
(0,1,0) With Trend	-83.25	(1,0,0)	201.770	(1,0,0)	309.65	(1,0,0)	36.59	(1,0,0)	214.50
(1,1,0)	-140.74	(1,0,1)	205.610	(1,0,1)	310.41	(2,0,0)	32.32	(1,0,1)	218.16
(1,1,1)	-138.66	(2,0,0)	205.840	(2,0,0)	312.75	(1,0,1)	36.67	(0,0,1)	214.49
(0,1,1)	-142.87	(0,0,2)	206.570	(0,0,1)	306.22	(2,0,1)	36.22	(2,0,0)	217.72
(3,1,0)	-138.05			(0,0,2)	310.45	(0,0,1)	33.79	(0,0,2)	217.6
(0,1,2)	-138.21					(0,0,2)	34.28	(2,0,2)	219.72
						(3,0,0)	36.23		

*Gray areas denote lowest BIC.

Our analysis showed that the best ARIMA models were ARIMA(0,1,1) for the effective federal funds rate variable, ARIMA(1,0,0) for the 3-month Treasury constant maturity rate, ARIMA(0,0,1) for the 10-year Treasury constant maturity rate, ARIMA(2,0,0) for the 30-year Treasury constant maturity rate and ARIMA(0,0,0) for the S&P 500 index. The residuals from the best ARIMA models of all variables showed to be white noise when tested using the Ljung-Box test. The results of this test are in the table below.

Table 3: Ljung-Box Test Results

Variable	Q^*	p-value
Effective Federal Funds Rate, Natural Log	8.6972	0.1913
3-Month Treasury Constant Maturity Rate, Percent Change	11.515	0.1742
10-Year Treasury Constant Maturity Rate, Percent Change	14.857	0.0620
30-Year Treasury Constant Maturity Rate, Percent Change	8.6332	0.2801
S&P 500 Index, Percent Change	4.9972	0.5442

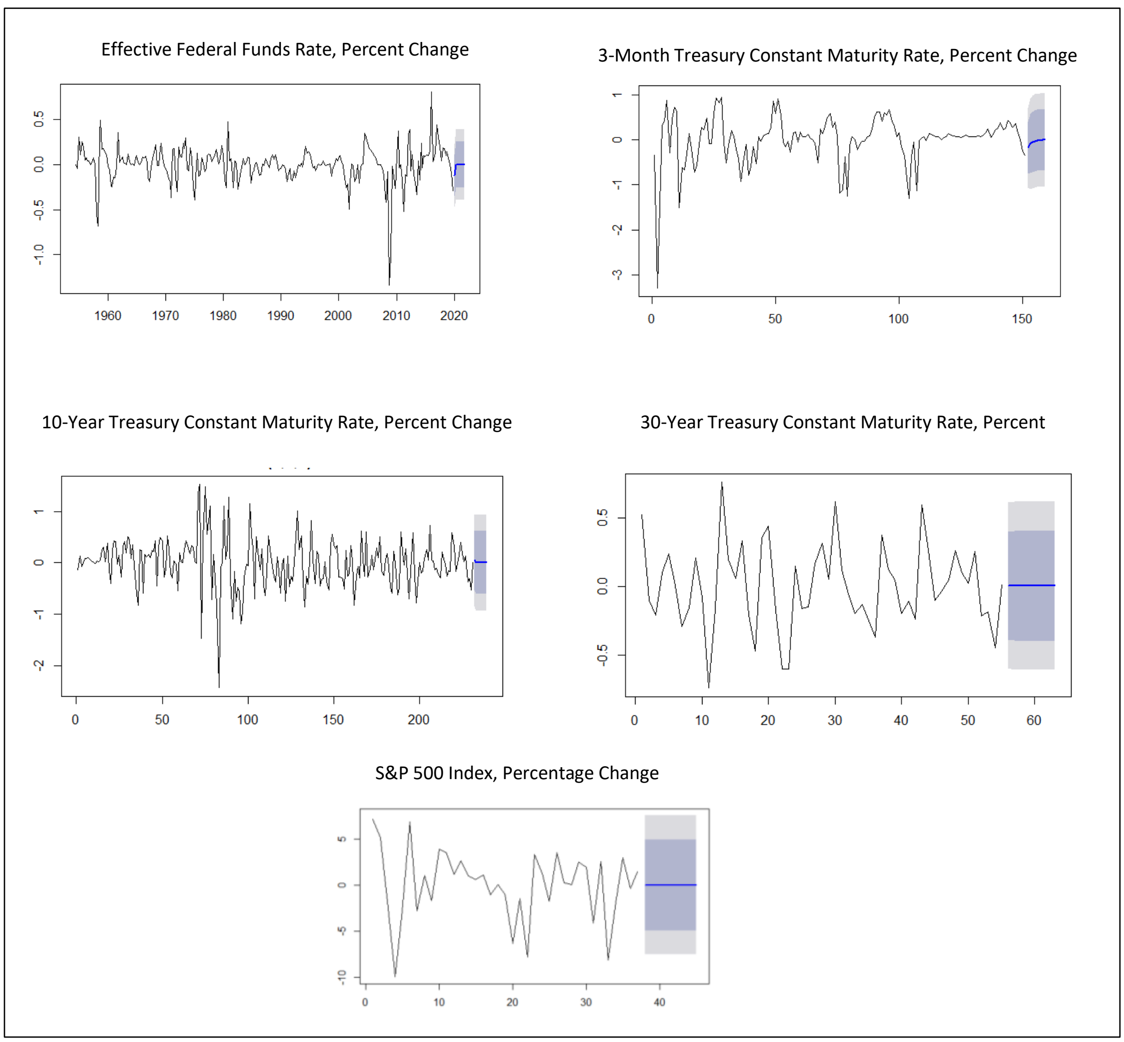
All p-values exceeded $\alpha=0.05$, therefore the null hypothesis of residuals being white noise was not rejected in any of the cases.

The forecasts obtained using this method were S&P 500 index, 3-month, 10-year, and 30-year Treasury constant maturity rates as percentage change and the effective federal funds rate as a natural log in the period 2020Q1-2021Q4. The forecasts for each of the variables using the best ARIMA models, as well as lower and upper bounds of the variables are in tables 4 and 5.

Table 4: ARIMA Forecasts

	Effective Federal Funds Rate, Natural Log		3-Month Treasury Constant Maturity Rate, Percent Change		10-Year Treasury Constant Maturity Rate, Percent Change		30-Year Treasury Constant Maturity Rate, Percent Change		S&P 500 Index, Percent Change	
Quarter	Best Model	Best Model Forecast	Best Model	Best Model Forecast	Best Model	Best Model Forecast	Best Model	Best Model Forecast	Best Model	Best Model Forecast
2020Q1	(0,1,1)	-0.117	(1,0,0)	-0.178	(0,0,1)	0.045	(2,0,0)	0.003	(0,0,0)	-1.460156e-16
2020Q2		0.001		-0.095		-0.00007		0.002		-1.460156e-16
2020Q3		0.001		-0.051		-0.00007		0.002		-1.460156e-16
2020Q4		0.001		-0.029		-0.00007		0.002		-1.460156e-16
2021Q1		0.001		-0.017		-0.00007		0.002		-1.460156e-16
2021Q2		0.001		-0.011		-0.00007		0.002		-1.460156e-16
2021Q3		0.001		-0.008		-0.00007		0.002		-1.460156e-16
2021Q4		0.001		-0.006		-0.00007		0.002		-1.460156e-16

Table 5: ARIMA Forecasts with Confidence Intervals



4. Vector Autoregressive Models and Forecasts

To obtain additional forecasts for the financial variables, vector autoregressive (VAR) modeling was conducted. We use this forecasting technique to see if the variables are linearly interdependent and give better forecasts if this interdependence is included in the forecasts. Two VAR models were created. For the first VAR model (VAR1) it was hypothesized that a relationship existed between the total monetary base (MON), S&P 500 index (SP500), and the total real estate loans owned and securitized by finance companies in real terms (REALEST) in the order specified above. For the second VAR (VAR2) model it was theorized that the real personal consumption expenditure, federal funds rate (FedFunds), and the 30-year (DGS30), 10-year (DGS10), and 3-month (DGS3MO) Treasury constant maturity rates were related in that order. The order of the VAR1 was determined because it was hypothesized that total monetary base was not impacted by S&P 500 index or total real estate loans in the short term, while the S&P 500 index, as a very responsive financial variable, was impacted by the monetary base in the short term. Accordingly, the total real estate loans owned and securitized by finance companies were affected by both S&P and the monetary base in the short run as inflation and the overall financial stability would urge financial companies to hold more or sell more real estate loans. The order of VAR2 was determined because it was believed that the real personal consumption expenditure was not impacted by the other five variables in the short run. The 30-year Treasury constant maturity rate was affected by the effective federal funds rate and the personal consumption expenditure as the inflation measure, the 10-year Treasury constant maturity rate was impacted by the previous three variables and the 3-month Treasury constant maturity rate was impacted by all other variables. The relationships in both models were theorized because of economic theory and intuition but because the relationships between financial variables are not very well determined and sometimes go both ways the orthogonal impulse responses should not be accepted as fundamentally true.

The impulse response functions for both models can be found in tables 6 and 7 below.

Table 6: Orthogonal Impulse Responses on S&P 500, Model VAR1

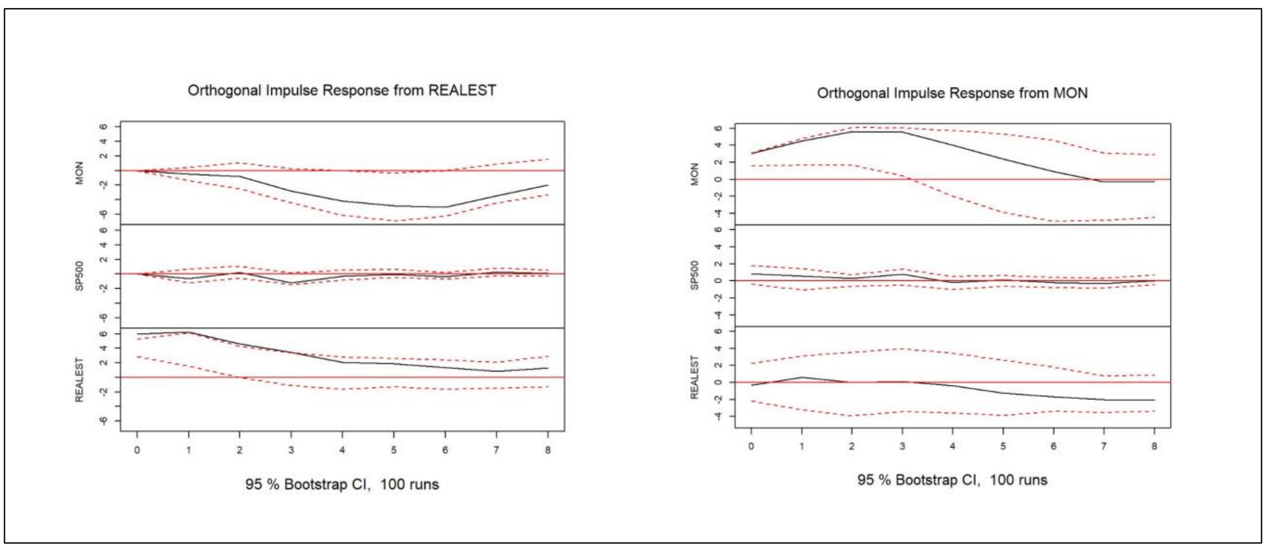
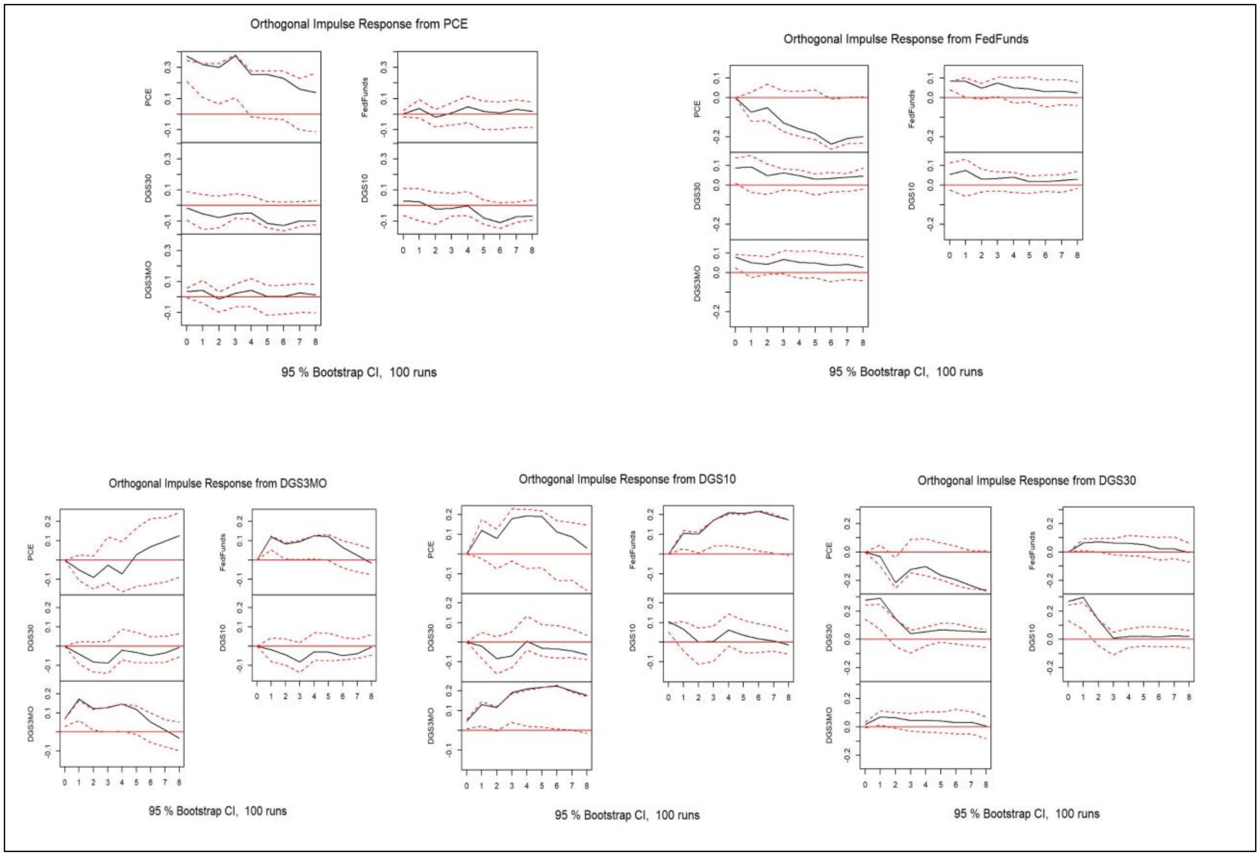


Table 7: Orthogonal Impulse Responses on DGS3MO, DGS10, DGS30, Model VAR2



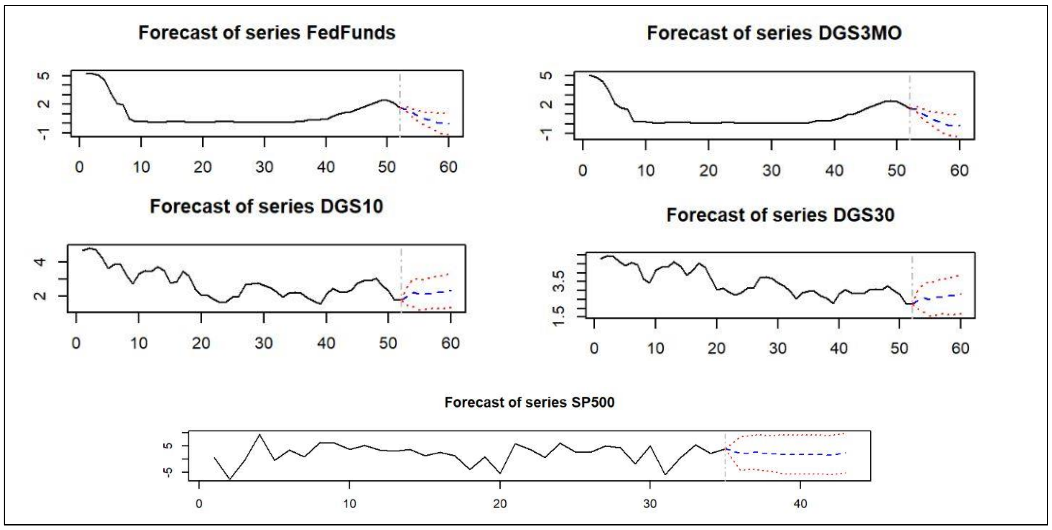
The impulse response functions showed that for VAR1 as the total monetary base and the real estate variable increased, the S&P 500 declined. For VAR2 model, the impulse responses indicated that with the personal consumption expenditure index and the 10-year Treasury constant maturity rate decreasing, we would see the effective federal funds rate going up, whereas when the 3-month and the 30-year Treasury constant maturity rates went up, the effective federal funds rate went up as well. The 3-month Treasury constant maturity rate declined as PCE and the effective federal funds rate declined, whereas it increased when the 30-year Treasury constant maturity rate increased, or the 10-year Treasury constant maturity rate decreased. The 10-year Treasury constant maturity rate declined when the PCE and the effective federal funds rate declined, or when the 3-month Treasury constant maturity rate increased. It went up when the 30-year rate increased. The 30-year rate went down when PCE, the effective federal funds rate and the 10-year rate decreased, or when the 3-month rate increased. These patterns generally align with the economic theory and general intuition about how the state of the economy affects investment choices. However, the impulse response functions change when the order of the variables in any of the two models change, therefore it might be that these responses are not what we see in real life. However, the main goal of this section is to construct forecasts for the financial variables using the vector autoregressions model and even though the ordering of this model might not be accurate, the forecasts will still be dependable as models with any other order, but the same variables would produce.

The forecasts obtained were effective federal funds rate, the 3-month, 10-year, and 30-year Treasury constant maturity rates in percentage points and the S&P 500 index as percentage change, all for the period 2020Q1-2021Q4. The VAR forecasts, as well as lower and upper bounds of the variables, are in tables 8 and 9 below.

Table 8: VAR Forecasts

Quarter	Effective Federal Funds Rate, Percent	3-Month Treasury Constant Maturity Rate, Percent	10-Year Treasury Constant Maturity Rate, Percent	30-Year Treasury Constant Maturity Rate, Percent	S&P 500 Index, Percent Change
2020Q1	1.496	1.479	2.051	2.507	2.223
2020Q2	1.100	1.045	2.216	2.600	2.652
2020Q3	0.737	0.661	2.079	2.493	2.135
2020Q4	0.496	0.373	2.160	2.622	1.761
2021Q1	0.310	0.126	2.217	2.665	1.670
2021Q2	0.095	-0.108	2.219	2.694	1.664
2021Q3	-0.023	-0.197	2.263	2.739	1.556
2021Q4	-0.033	-0.171	2.363	2.809	2.324

Table 9: VAR Modeling Forecasts with Confidence Intervals



5. Exponential smoothing models and forecasts

The third and final model used for forecasting the five financial variables is the exponential smoothing method for time-series analysis. We use exponential smoothing to see if the recent values of the variables should receive more weight while forecasting because of seasonality or trend in the variables. In order to forecast effective federal funds rate, the 3-month, 10-year, 30-year Treasury constant maturity rates, and the S&P 500 index, we used three types of exponential smoothing models: the simple exponential smoothing, Holt exponential smoothing, and the Holt-Winters' double exponential smoothing methods. The alpha, beta and gamma coefficients were optimized to reduce the sum of squared estimate of errors. The best model for each variable was determined using the Bayesian information criterion. After determining the best exponential smoothing models for the variables, the best models were used to produce 8-step-ahead forecasts. It is worth noting that here the real values of the S&P 500 index were used instead of the percentage change values. This is because the exponential smoothing method does not require the data to be stationary.

The analysis showed that the best exponential smoothing model was the simple smoothing model in all cases apart from when modeling the 3-month Treasury constant maturity rate and the S&P 500 index. For these variables, the best model was Holt's exponential smoothing. The table with all exponential smoothing models examined, their respective BIC's and coefficients is below.

Table 10: Exponential Smoothing Models

Variable/Model	Simple		Holt's			Holt-Winters			
	BIC	Alpha	BIC	Alpha	Beta	BIC	Alpha	Beta	Gamma
Effective Federal Funds Rate	1394.75	0.9999	1405.81	0.9999	0.0001	1459.70	0.9718	0.0059	0.0282
3-Month Treasury Constant Maturity Rate	585.22	0.9999	569.06	0.9999	0.5435	602.52	0.9801	0.2999	0.0199
10-Year Treasury Constant Maturity Rate	929.12	0.9999	940.99	0.9999	0.005	962.38	0.9999	0.0296	0.0001
30-Year Treasury Constant Maturity Rate	95.27	0.9999	102.69	0.9999	0.0098	115.87	0.9999	0.0001	0.0001
S&P 500 Index	467.084	0.9999	462.158	0.9179	0.0001	475.068	0.9318	0.0001	0.0001

*Gray areas denote lowest BIC

The forecasts obtained were effective federal funds rate, 3-month, 10-year, and 30-year Treasury constant maturity rates in percentage points and the S&P 500 index as an inflation-adjusted index. The forecasts, as well as lower and upper bounds of the variables, are in tables 11 and 12 below.

Table 11: Exponential Smoothing Model Forecasts

	Effective Federal Funds Rate, Percent		3-Month Treasury Constant Maturity Rate, Percent		10-Year Treasury Constant Maturity Rate, Percent		30-Year Treasury Constant Maturity Rate, Percent		S&P 500, Real Index	
Quarter	Best Model	Best Model Forecast	Best Model	Best Model Forecast	Best Model	Best Model Forecast	Best Model	Best Model Forecast	Best Model	Best Model Forecast
2020Q1	Simple	1.643	Holt's	1.305	Simple	1.791	Simple	2.254	Holt's	2780.24
2020Q2		1.643		1.002		1.791		2.254		2821.87
2020Q3		1.643		0.699		1.791		2.254		2863.49
2020Q4		1.643		0.396		1.791		2.254		2905.12
2021Q1		1.643		0.093		1.791		2.254		2946.75
2021Q2		1.643		-0.210		1.791		2.254		2988.38
2021Q3		1.643		-0.519		1.791		2.254		3030.00
2021Q4		1.643		-0.816		1.791		2.254		3071.63

Table 12: Exponential Smoothing Model Forecasts with Confidence Intervals

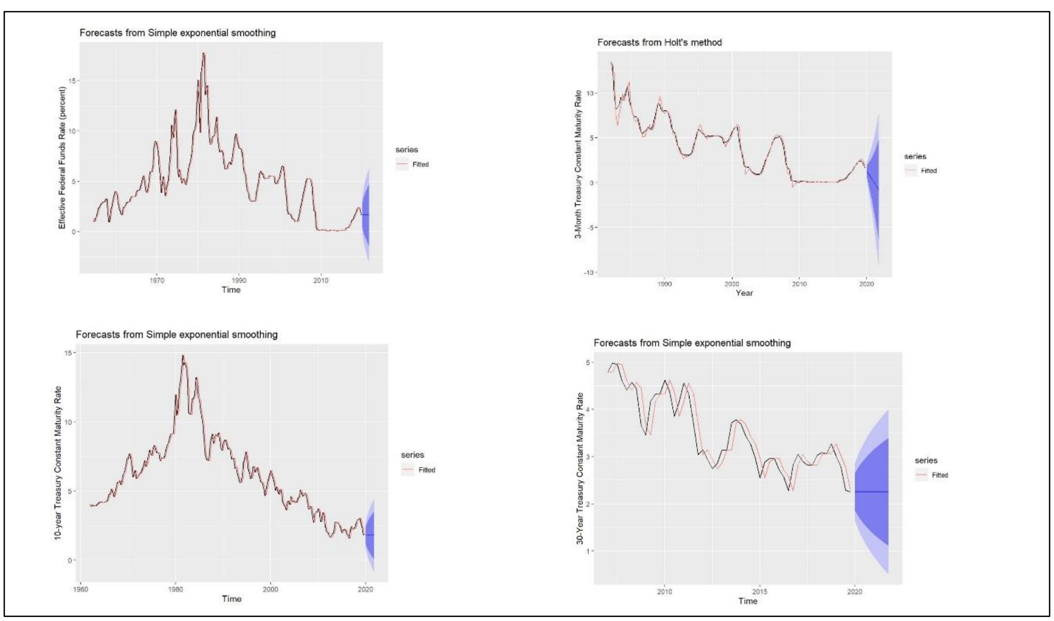
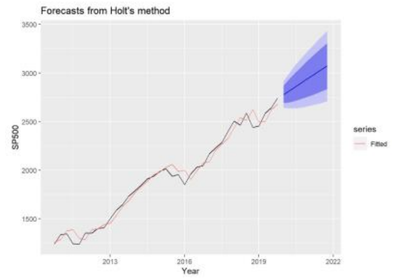


Table 12 Continued



6. Comparison of the Forecasts Across Models and to Professional Forecasts

For the forecasts to be comparable across different models, some calculations were completed. The effective federal funds rate, the 3-month, 10-year, and 30-year Treasury constant maturity rate forecasts from all models were converted to percentage point values, while the S&P 500 index was calculated as a unit value across all models. The results from all models in comparable terms were collected in table 16 on page 16.

There are some contrasts with the forecasted values between the models. For the effective federal funds rate, ARIMA and VAR models forecast a decline from the 2019Q4 value of 1.64, while the exponential smoothing model forecasts it to stay the same. For the 3-month Treasury constant maturity rate value of 1.61 in quarter 4 of 2019, we expect a gradual decline in the next 2 years according to all models, with some differences in values forecasted. For the 10-year Treasury constant maturity rate, we see some upward movement from the last quarter of 2019 value of 1.79, followed with stability over the next two years. In this case, also the extent of this increase is different across the models. For the 30-year Treasury constant maturity rate, we see a sustained increase from quarter four of 2019 value of 2.25 according to the VAR model, while the exponential smoothing forecasts an increase in quarter 1 of 2020 and stability after. The ARIMA model, in this case, predicts very little upward movement throughout the quarters of interest. Finally, for the S&P 500 index, we see very little change from the last observed value of 2,743 according to our best ARIMA model, while the two other models forecast a sustained increase of different magnitude.

For all variables, BIC was much lower for ARIMA modeling than for the exponential smoothing models, which suggests that ARIMA models are more likely to be the true models than the exponential smoothing models. Also, in the case of the 3-month Treasury constant maturity rate, the exponential smoothing model predicted negative percentage values, which has not occurred in our dataset beginning 1982, so it should be considered unlikely. We are faced with the same problem in VAR modeling for the effective federal funds rate and the 3-month Treasury constant maturity rate forecasts. Therefore, it would have to be assumed that the ARIMA models are more likely to be the true models in the case of the effective federal funds rate and the 3-month Treasury constant maturity rate. For the other variables, we would have to give the ARIMA and VAR models equal weight as there is no evidence to do otherwise without having access to the actual values in the years 2020 and 2021. We can still check the accuracy of the forecasts for 2020 quarter one by calculating the absolute percentage error for each of the forecasts of that period.

Table 13: Comparison of 2020 Quarter 1 Forecasts and Observed Values

Variable, Units	Actual Value	ARIMA		VAR		Exponential Smoothing	
		Forecast	MAPE	Forecast	MAPE	Forecast	MAPE
Effective Federal Funds Rate, Percent	1.26	0.890	29.37%	1.496	18.73%	1.643	30.40%
3-Month Treasury Constant Maturity Rate, Percent	1.10	1.432	30.18%	1.479	34.46%	1.305	18.64%
10-year Treasury Constant Maturity Rate, Percent	1.37	1.835	33.94%	2.051	49.71%	1.791	30.73%
30-year Treasury Constant Maturity Rate, Percent	1.87	2.253	20.48%	2.507	34.06%	2.254	20.54%
S&P 500, Real value	2,708.1	2,743.8	1.32%	2,804.8	3.57%	2,780.2	2.67%

As it turns out, the MAPE for the quarter 1 forecasts was always lower than 50%, meaning none of the forecasts were bad. We see excellent forecasting ability of our models when it comes to the S&P 500 values, with MAPE lower than 4% in all cases. According to this value, the best forecast for the effective federal funds rate was using the VAR model, while the exponential smoothing model provided the best forecasts for the 3-month and the 10-year Treasury constant maturity rates. The 30-year Treasury constant maturity rate and the S&P 500 values were best forecasted using the ARIMA models. However, it is worth noting that the inaccuracy of the forecast will probably increase for all of our forecasts in the later quarters, so these values are only accurate for quarter one of 2020 and do not represent a good measure of forecasting power for our 8-step-ahead models. This is just a good way to see how well our forecasts did in the first forecasted period.

It is interesting to also compare the values forecasted by our models to the December 2019 predictions of professional forecasters. For this to be possible, the year averages of our forecasts were calculated as most of the professional forecasts predicted yearly values. The table with yearly averages is table 15 on page 15.

The yearly professional forecasts for 2020 and 2021 are shown in table 14. The forecasts from the exponential smoothing model seem closest to the effective federal funds rate professional forecasts for 2020 and 2021, while the ARIMA and VAR models are much lower. It has to be noted that the actual values will probably be closer to the lower forecasts made with ARIMA and VAR models due to the unforecastable shocks the economy is experiencing during the global COVID-19 pandemic. However, this is more likely to be a coincidence than indicate a better forecasting power of our models. For the 3-month, 10-year, and 30-year Treasury constant maturity rates generally the professional forecasts are also much higher than the models in this paper have indicated. One surprising result is that the 10-year Treasury constant maturity rate for 2021 using exponential smoothing is the same as the forecast from WSJ Economic Survey. For the S&P 500 index, because the professional forecasts are in nominal values and our forecasted values are in real terms, it is harder to compare between the two. However, we can note that all professional forecasts indicate an increase in the nominal value of the index, whereas one of our models forecasts the S&P values to not change much. The other two models align with the idea that the index will increase in real terms. Overall, we see some similarities in the forecasts but mostly they are different in magnitude and direction.

Table 14: Professional Forecasts of Financial Variables

Variable, Units	Source A		Source B		Source C	
	2020	2021	2020	2021	2020	2021
Effective Federal Funds Rate, Percent	1.6[2]	1.7[3]	1.6[4]	1.9[5]	1.75[6]	1.75[7]
3-Month Treasury Constant Maturity Rate, Percent	1.60[8]	1.65[9]	1.60[10]	1.72[11]	1.4[12]	1.2[13]
10-year Treasury Constant Maturity Rate, Percent	2.2[14]	2.7[15]	2.05[16]	2.41[17]	2.03[18]	2.25[19]
30-year Treasury Constant Maturity Rate, Percent	1.9[20]	2.3[21]	2.7[22]	2.9[23]	2.52[24]	N/A
S&P500, Index	3,250[25]	N/A	3257.6[26]	3,400.0[27]	3,331[28]	N/A

Table 15: Yearly Averages of the Forecasts

Variable, Units		ARIMA	VAR	Exponential Smoothing
Effective Federal Funds Rate, Percent	2020	0.97325	0.95725	1.643
	2021	1.001	0.08725	1.643
3-Month Treasury Constant Maturity Rate, Percent	2020	1.328	0.8895	0.8505
	2021	1.22625	-0.0875	-0.363
10-year Treasury Constant Maturity Rate, Percent	2020	1.835	2.1265	1.791
	2021	1.835	2.2655	1.791
30-year Treasury Constant Maturity Rate, Percent	2020	2.256	2.5555	2.254
	2021	2.264	2.72675	2.254
S&P500, Index	2020	2,743.77	2904.225	2842.68
	2021	2,743.77	3122.645	3009.19

2 "Economic View."
3 ibid.
4 "2020, Release Tables: Summary of Economic Projections | FRED | St. Louis Fed."
5 ibid.
6 "Wells Fargo Economics Monthly Macro Manual."
7 ibid.
8 ibid.
9 ibid.
10 "The Livingston Survey."
11 ibid.
12 "Anderson Forecast."
13 ibid.
14 "Economic View."
15 ibid.
16 "The Livingston Survey."
17 ibid.
18 WSJ Economic Forecasting Survey
19 ibid.
20 "Anderson Forecast."
21 ibid.
22 "Wells Fargo Economics Monthly Macro Manual."
23 ibid.
24 "Financial Forecast Center - Financial Market and Economic Forecasts."
25 Wang, "Wall Street's Top S&P 500 Bull Tamps Down Optimism for 2020."
26 "The Livingston Survey."
27 ibid.
28 "2020 Outlook."

Table 16: Forecasted Values

Variable, units	Quarter	ARIMA		VAR	Exponential Smoothing	
		Forecast	BIC	Forecast	Forecast	BIC
Effective Federal Funds Rate, Percent	2020Q1	0.890	-142.87	1.496	1.643	1394.75
	2020Q2	1.001		1.100	1.643	
	2020Q3	1.001		0.737	1.643	
	2020Q4	1.001		0.496	1.643	
	2021Q1	1.001		0.310	1.643	
	2021Q2	1.001		0.095	1.643	
	2021Q3	1.001		-0.023	1.643	
	2021Q4	1.001		-0.033	1.643	
3-Month Treasury Constant Maturity Rate, Percent	2020Q1	1.432	201.770	1.479	1.305	569.06
	2020Q2	1.337		1.045	1.002	
	2020Q3	1.286		0.661	0.699	
	2020Q4	1.257		0.373	0.396	
	2021Q1	1.24		0.126	0.093	
	2021Q2	1.229		-0.108	-0.210	
	2021Q3	1.221		-0.197	-0.519	
	2021Q4	1.215		-0.171	-0.816	
10-Year Treasury Constant Maturity Rate, Percent	2020Q1	1.835	306.22	2.051	1.791	929.12
	2020Q2	1.835		2.216	1.791	
	2020Q3	1.835		2.079	1.791	
	2020Q4	1.835		2.160	1.791	
	2021Q1	1.835		2.217	1.791	
	2021Q2	1.835		2.219	1.791	
	2021Q3	1.835		2.263	1.791	
	2021Q4	1.835		2.363	1.791	
30-Year Treasury Constant Maturity Rate, Percent	2020Q1	2.253	32.32	2.507	2.254	95.27
	2020Q2	2.255		2.600	2.254	
	2020Q3	2.257		2.493	2.254	
	2020Q4	2.259		2.622	2.254	
	2021Q1	2.261		2.665	2.254	
	2021Q2	2.263		2.694	2.254	
	2021Q3	2.265		2.739	2.254	
	2021Q4	2.267		2.809	2.254	
S&P 500, Real Index	2020Q1	2,743.77	210.94	2,804.76	2,780.24	462.158
	2020Q2	2,743.76		2,879.14	2,821.87	
	2020Q3	2,743.76		2,940.61	2,863.49	
	2020Q4	2,743.76		2,992.39	2,905.12	
	2021Q1	2,743.76		3,042.36	2,946.75	
	2021Q2	2,743.76		3,092.99	2,988.38	
	2021Q3	2,743.76		3,141.11	3,030.00	
	2021Q4	2,743.76		3,214.12	3,071.63	

7. Conclusion

This study explored modeling and forecasting of five different financial variables using the Autoregressive Integrated Moving Average (ARIMA), Vector Autoregressive (VAR), and the exponential smoothing models. The Augmented Dickey-Fuller (ADF) and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests were conducted to test for unit roots in the time series. Autocorrelation (ACF) and Partial autocorrelation (PACF) functions were estimated to assist in deciding the orders of the Autoregressive model of order p (AR) and Moving Average model of order q (MA). The BIC test was conducted to choose from the best ARIMA models. The best ARIMA models based on BIC were ARIMA(0,1,1) for the effective federal funds rate variable, ARIMA(1,0,0) for the 3-month Treasury constant maturity rate, ARIMA(0,0,1) for the 10-year Treasury constant maturity rate, ARIMA(2,0,0) for the 30-year Treasury constant maturity rate and ARIMA(0,0,0) for the S&P 500 index. The residuals from the best ARIMA models of all variables showed to be white noise when tested using the Ljung-Box test. For VAR modeling, two VAR models were created. The first VAR model included the total monetary base, the S&P 500 index, and the total real estate loans owned and securitized by finance companies in real terms in the order specified above. The second VAR model contained the real personal consumption expenditure, federal funds rate, and the 30-year, 10-year, and 3-month Treasury constant maturity rates were related in that order. The impulse response functions were analyzed and the predictions of the five financial variables obtained using these two models. For the exponential smoothing models, we used the simple exponential smoothing, Holt exponential smoothing, and the Holt-Winters' double exponential smoothing methods. The alpha, beta, and gamma coefficients were optimized to reduce the sum of the squared estimate of errors. The best model for each variable was determined using the Bayesian information criterion. The best models were used to produce 8-step-ahead forecasts. The analysis showed that the best exponential smoothing model was the simple smoothing model in all cases apart from when modeling the 3-month Treasury constant maturity rate and the S&P 500 index. For these variables, the best model was Holt's exponential smoothing. It was assumed that the ARIMA models were more likely to be the true models in the case of the effective federal funds rate and the 3-month Treasury constant maturity rate as BIC was lower than the exponential smoothing model and it showed no negative values which is likely for interest rates. For the other variables, the ARIMA and VAR models were given equal weight as there was no evidence to urge us otherwise.

This analysis is of relevance to the financial industry stakeholders in determining what the future of investment returns will look like. It should be noted that in general financial variables are very hard to forecast as they are more likely to experience unexpected fluctuations. It is worth mentioning that all data and professional forecasts were obtained before the COVID-19 and the oil price fluctuations drew any attention, therefore it is likely that the observed values for 2020 and 2021 differ due to these shocks to the financial markets.

8. References

"2020 Outlook." Stifel, December 2019.

"2020, Release Tables: Summary of Economic Projections | FRED | St. Louis Fed." Accessed May 5, 2020. https://fred.stlouisfed.org/release/tables?rid=326&eid=783029&od=2020-01-01#.

"Anderson Forecast." UCLA, September 2019. https://sites.anderson.ucla.edu/data/forecast/uclaforecast_Sept2019.pdf.

"Economic View." Accessed May 5, 2020. https://www.economy.com/economicview/tracker/23/Forecast-By-Geography.

"Federal Reserve Economic Data | FRED | St. Louis Fed." Accessed May 5, 2020. https://fred.stlouisfed.org/.

"Financial Forecast Center - Financial Market and Economic Forecasts." Accessed May 5, 2020. https://www.forecasts.org/.

"The Livingston Survey." Philadelphia Fed, December 13, 2019. https://www.philadelphiafed.org/-/media/research-and-data/real-time-center/livingston-survey/2019/livdec19.pdf?la=en.

Wang, Lu. "Wall Street's Top S&P 500 Bull Tamps Down Optimism for 2020." *Bloomberg*, n.d. https://www.bloomberg.com/news/articles/2019-12-02/wall-street-s-top-s-p-500-bull-tamps-down-optimism-for-2020.

"Wells Fargo Economics Monthly Macro Manual." Wells Fargo Securities, January 15, 2020. https://www08.wellsfargomedia.com/assets/pdf/commercial/insights/economics/monthly-outlook/monthly-macro-manual-20200115.pdf.