Bridging the Gap: Forecasting Interest Rates with Macro Trends

Gil De La Cruz Vazquez

Gilberto De La Cruz Vazquez
Econ 513

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Introduction

Predicting interest rates has always been challenging, with even the basic random walk model proving tough to surpass. However, macroeconomics can offer insight. The long-term pattern of interest rates is shaped by inflation trends and the equilibrium real interest rate. By assuming that the disparity between current rates and this long-term trend narrows as we look further ahead, we can achieve significant accuracy when predicting rates for several years ahead. This underlines the importance of factoring in macroeconomic trends when attempting to comprehend, model, and forecast interest rates.

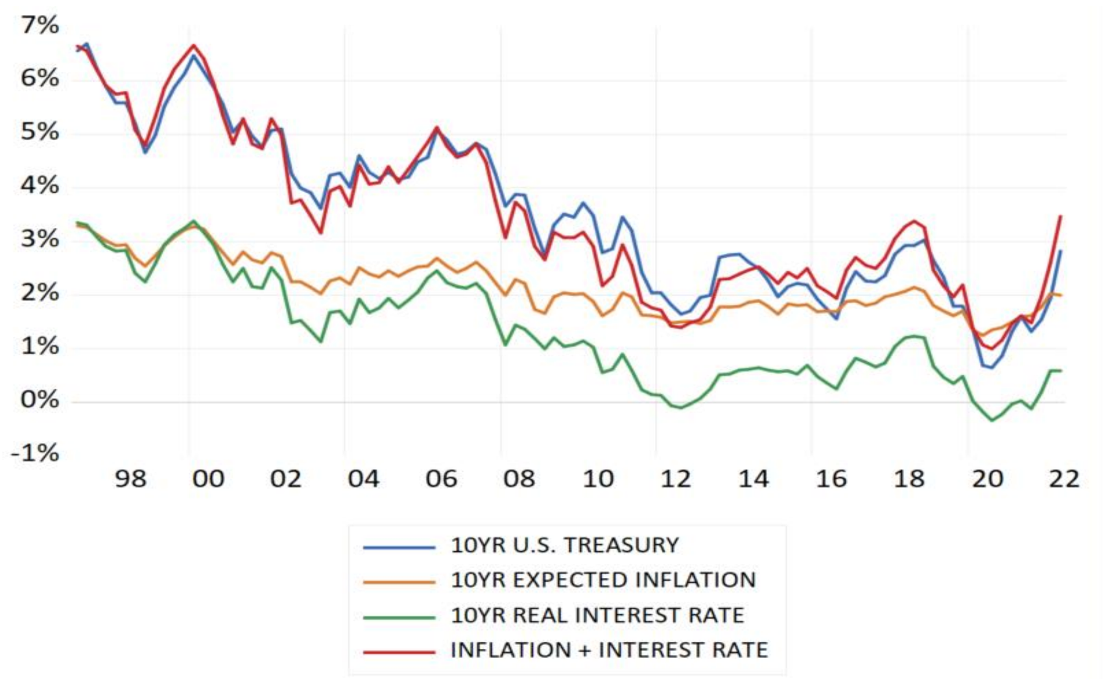
For investors, forecasting interest rate shifts is paramount. This is also significant for policymakers, forecast professionals, and scholars since interest rates influence household finances, business financing costs, state debt, and the broader economic well-being. Much like the stock market, predicting interest rates remains an arduous task. Astonishingly, the rudimentary forecast that suggests interest rates will remain unchanged is hard to surpass, and advanced models don't always outshine it.

While short-term predictions, like those for daily, weekly, or yearly rates, are often off-mark, economic theories can enhance the accuracy of long-term interest rate forecasts. Analogous to how economic activities ebb and flow around a consistent growth trend, interest rates also oscillate around a trend steered by enduring or structural influences. This Economic Letter elucidates how principles that drive forecasts for macroeconomic indicators, such as growth in output or inflation, are pertinent to interest rates. Expanding on the details and evidence provided by Bauer and Rudebusch (2017), the crux here is that the trend governing interest rate shifts is intrinsically tied to two pivotal macroeconomic factors: the consistent trend in inflation and the equilibrium real interest rate.

Overview

The difficulty of predicting changes in interest rates mainly arises from two features that characterize their evolution over time. First, like other financial variables, interest rates vary widely from day to day, which makes them difficult to link to economic fundamentals such as monetary or fiscal policy. This well-documented “excess volatility,” was first pointed out in Shiller (1979), and it reflects the importance of frequent changes in investor sentiment due to a never-ending stream of economic data releases and other news.

However, economic theory suggests a relatively simple way to model interest rates, based on the insight that interest rates can be viewed as the sum of inflation expectations and inflation-adjusted, “real” interest rates. Long run inflation trends can be estimated from surveys and models provided by the Federal Reserve. The figure below plots the publicly available and mostly survey-based inflation trend estimate (Gold line) from the Federal Reserve Board’s structural model of the U.S. economy, FRB/US. For the trend in the real interest rate, also called the natural or equilibrium real interest rate, Laubach and Williams (2003) suggested a way to estimate it from macroeconomic data and popularized its use in policy analysis (see also Bekaert et al. 2016). Figure below includes an estimate of the equilibrium real interest rate (green line) taken as the average of several popular estimates, as discussed in Bauer and Rudebusch (2017).



Data Review & Stochastic Properties

The 10 Year U.S. is the most important yield in the world. It is the starting point for the database. Yields for the 10-year treasury were obtained from the Board of Governors of the Federal reserve system. The main sources of the data have been government data depositories. The 10 Year expected inflation and 10-year Real Interest rate come from the Federal Reserve of Cleveland. They are both at a monthly frequency and have a range from January 1982 to April 2022.

The 10year U.S. Treasury Yield, monthly data is obtained from the Federal reserve bank of St. Lois and has a range from January 1981 to June 2022. The Fed Funds Rates is interest rate at which banks and other depository institutions lend money to each other, usually on an overnight basis. It is set by the Federal Reserve bank and is often used as a monetary tool to guide economic activity. Data for the FFR is in monthly frequency with a range from July 1954 to May 2022, obtained from the Board of Governors of the Federal Reserve System. The 10 Year Inflation Expectation Forecast is obtained from the Federal Reserve of Philadelphia Livingston survey. This is a median forecast of CPI inflation over the next ten years made by the approximately 40 participants surveyed twice per year. The data used for the model ranges from January 1997 to June 2022 at a quarterly frequency. Another important variable being used to model 10-year real rates is the yield from corporate bonds. For this we can use moodys corporate bond index corporate for AAA and BAA bonds. The corporate bond data is set at a monthly frequency with a range from January 1984 to June 2022. The 10-year breakeven inflation rate represents a measure of expected inflation derived from the spread between 10-Year Treasuries and 10 Year Treasury Inflation Indexed bonds (TIPS). The breakeven rate serves as an indication of the markets' inflation expectations over the 10-year horizon. TIPS yield data from the Board of Governors of the Federal Reserve System starts in 2003 shortening the number of observations available for our model. However, yields on the 10-year TIPS are also known as real yields because they subtract projected inflation from the nominal yield on Treasury securities. Due to this relationship between TIPS and real yields we can use previous real historical inflation data to interpolate additional observations. Our final range is from December 1981 to June 2022, set at a monthly frequency.

Both the consumer price index, real and real potential gdp and non-farm Labor Productivity Index were extracted from the U.S. Bureau of Labor statistics, with a monthly range from 1981 to 2022. The CPI is a price index, the price of a weighted average market basket of consumer goods and services purchased by households. Changes in CPI provide a measure of inflation. While the Labor Productivity Index is the amount of goods and services that a group of workers produce. Nonfarm Productivity measures the annualized change in labor efficiency when producing goods and services, excluding the farming industry. Productivity and labor-related inflation are directly linked-a drop in a worker's productivity is equivalent to a rise in their wage.

Expected 10YR Inflation	ACF(1)	ADF Test Statistic	DF-GLS Test Statistic	KPSS Test Statistic
Levels	0.941	-3.023	0.879	1.096
Growth	0.019	-13.354	-10.258	0.561
I(0), I(1), or I(2)?	I(1)	I(1)	I(1)	I(1)
Seasonal Lags	0	0	0	0

Although inflation and interest rates are theoretically stationary, we found some different observations. The Expected 10 YR Inflation was not stationary at level but became stationary when looking at its growth. This falls in line with previous research performed by Ng and Perron (2001), in which a wide variety of unit root tests are applied to quarterly inflation data of G7 countries and do not reach a firm conclusion on inflation stationarity. It is important to note that rolling window stationary tests reveal that not all outcomes are consistent with all periods and thus a likely driver of the data's non-stationarity.

Real 10YR Yield	ACF(1)	ADF Test Statistic	DF-GLS Test Statistic	KPSS Test Statistic
Levels	0.952	-3.023	0.879	1.107
Growth	0.142	-10.354	-10.258	0.385
I(0), I(1), or I(2)?	I(1)	I(1)	I(1)	I(1)
Seasonal Lags	0	0	0	0

The Real 10 YR Yield was not stationary at level but became stationary when looking at its growth rate. We are also unable to observe any seasonal patterns in the data. The model uses a quarterly frequency, with the aid of Eviews it is easy to convert the monthly data to quarterly frequency by measuring the changes between the beginning and end of the quarterly periods. Normalization of yields was also a key step in preparing the data for the model. FFR and AAA_Yields had to be normalized using year over year changes in quarterly CPI. Most of the data collection was facilitated thanks to FRED, the Federal Reserve Excel Plug-in. This application allows you to look up data series and easily download them to Excel.

Theory

Causal modeling requires the researcher to construct a model to explain the relationships among concepts related to a specific phenomenon (Asher, 1983). A causal model is a diagram of the relationships between independent, control, and dependent variables. Causal modeling can be used to represent very complex relationships among a set of variables, including direct and indirect effects, which increases the model's correspondence with reality. On the other hand, correlation is simply a relationship and does not automatically mean that the change in one variable is the cause of the change in the values of the other variable. In this model we use Economic Theory to propose the causal relationships between the dependent and independent variables in our models.

$$EXPINF\ 10YR\ = f(\ Yield\ Spread, CPI\ , FFR)$$

Understanding expected inflation is pivotal when evaluating long-term trends in nominal rates. However, there's a paucity of direct observations on expected inflation. Utilizing market-derived data like the spread between nominal and real bond yields (Yield Spread) offers a causal factor for forecasting expected inflation. As highlighted by Dion, and Reid (2004), market-oriented indicators for expected inflation, exemplified by the spread between nominal and real return bond yields, tend to be on average more elevated and erratic than survey measures. This discrepancy is attributed to the fluctuating risk premiums and various other elements not intrinsically associated with inflation expectations. Thus, a more comprehensive approach is essential. Structural shifts can be seamlessly integrated into assessments, influencing the immediate sentiments reflected in survey measures (Kozicki and Tinsley, 2012). The Federal funds rate (FFR) serves as a structural factor when forecasting future expected inflation. The FFR, set by the Federal Reserve, can influence expectations about future inflation. When the Federal Reserve raises the FFR, it often signals an intent to curb inflation, which can adjust market expectations accordingly. Conversely, a lower FFR might indicate a more accommodative stance, which can lead markets to anticipate higher future inflation. Understanding the relationship between the FFR and inflation expectations is crucial for comprehensive economic forecasting. Compared to econometric and yield-based indicators, the enhanced predictive capability of surveys as presented by Ang, Bekaert, and Wei (2007) and Chernov and Mueller (2008) underlines the value of survey metrics as a reliable source of expected inflation data. For this reason The Consumer Price Index (CPI) stands as a primary gauge for tracking inflation. Analyzing prevailing inflation patterns affords us a perspective on prospective inflation. Prolonged high inflation suggests a higher likelihood of it surpassing the average in upcoming periods..

$$AAA\ YIELD\ = f(FFR, Labor\ P, Shock, R\ GDP, BAA\ Yield)$$

$$REAL\ 10YR\ = f(AAA\ YIELD, RP\ GDP)$$

The model for real interest rates is split into two. First, we model AAA Corporate yields using the fed fund rate and labor productivity BAA yields and Real GDP as our economic drivers. Then we drive our 10year real interest rate model using the AAA yields and Real Potential GDP. As monetary policy changes the corporate space must adapt. This means issuing new securities that reflect the future expected benchmark rate, FFR, in order to remain competitive in the debt market. When the Fed decides to increase the FFR, corporate yields will reflect these changes and in addition will also price in the future expected monetary policy. One long-run factor popular for explaining real interest rates is the productivity growth in the economy. Textbook macroeconomic theory predicts a positive relationship between productivity and real interest rates, implying that a lower trend in productivity growth will lead to persistently lower real interest rates. Quarterly GDP and year over year changes in quarterly labor productivity will help us track the rate of productive growth in the economy and the accompanied changes in real rates. The shock variable we are using controls for the volatility in the market during the Great Financial Crisis in 2008 and the remnants of the dotcom bubble in the early 2000's, these tend to be periods of Monetary intervention.

The forecast of the nominal 10 year interest rate is straight forward, based on the insight that nominal interest rates can be viewed as the sum of inflation expectations and real interest rates.

$$Nominal\ 10\ Year\ Rate\ = REAL\ 10YR + EXPINF\ 10YR$$

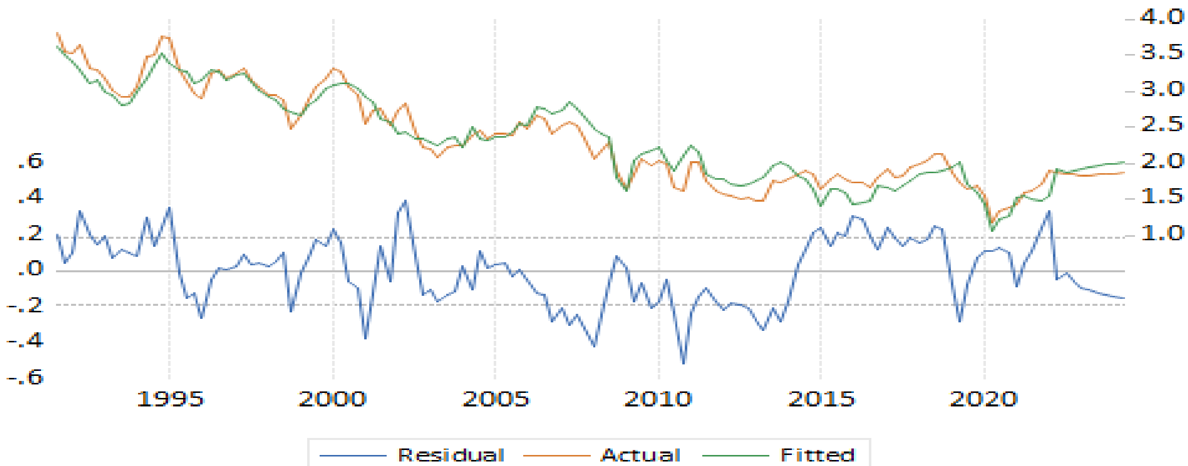
Structural Regression

The model contains 3 regressions. The first is a least squares regression for expected 10-year inflation. CPI change is lagged by 3 periods by lagging the variables accordingly, we are still able to extract some statistical significant prediction power from these two variables. Meanwhile the yield (SPREAD) is extremely important and statistical significant as it is the markets expectations of expected inflation. The model obtained a R-squared of .9211.

$$\text{EXPINF 10YR}_t = \alpha_0 + \alpha_1\text{SPREAD}_t + \alpha_2\Delta\text{CPI}_{t-3} + \alpha_3\text{FFR}_t$$

Dependent Variable: EXPINF_10YR
Method: Least Squares
Date: 09/15/23 Time: 12:46
Sample: 1991Q3 2024Q2
Included observations: 132
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 5.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.568936	0.111208	5.115976	0.0000
SPREAD	0.633982	0.054439	11.64576	0.0000
@PCA(CPI_Q(-3))	-0.003144	0.007321	-0.429426	0.6683
FFR	0.107932	0.018383	5.871247	0.0000



The second regression is a combination of 2 structural regressions first we model real AAA yields as a dependent variable with FFR, Labor Productivity, Real Potential GDP and BAA yields. We also included a shock variable to account for market volatility and central bank intervention during recessionary periods. The model obtained a R-squared of .6379.

$$\text{AAA YIELD\$}_t = \alpha_0 + \alpha_1\text{FFR\$}_t + \alpha_2\Delta\text{LABOR P}_{t-2} + \alpha_3\text{SHOCK}_t + \alpha_4\text{R\_GDP}_t + \alpha_5\text{BAA\_YIELD}_t$$

Dependent Variable: AA_YIELD$
Method: Least Squares
Date: 09/15/23 Time: 12:46
Sample: 1991Q3 2024Q2
Included observations: 132
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 5.0000)

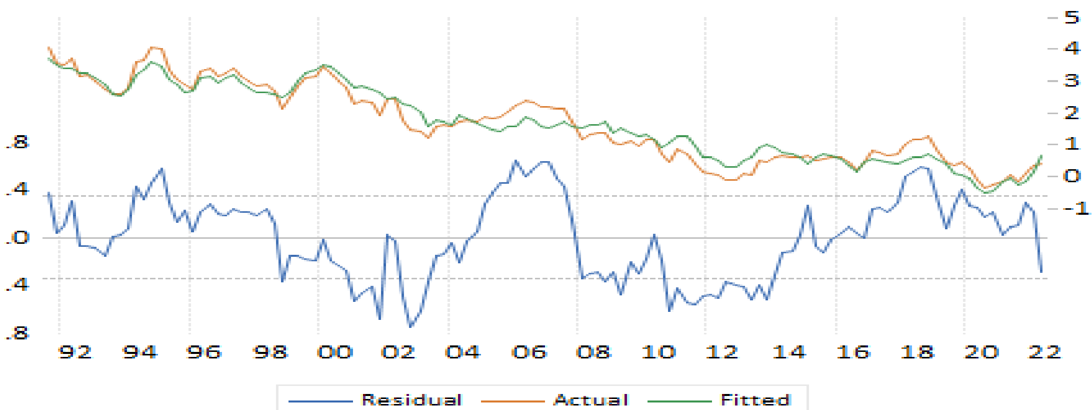
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-3.274480	1.418700	-2.308085	0.0226
FFR$	0.223276	0.096575	2.311951	0.0224
@PCY(LABOR_P(-2))	0.138408	0.132585	1.043921	0.2985
R_GDP	0.017028	0.020464	0.832102	0.4069
SHOCK	-0.781253	0.319282	-2.446901	0.0158
BA_YIELD	0.899289	0.181673	4.950039	0.0000

Once the regression and forecast for real AAA yields is complete, we use it to regress the Real 10-year interest rates. Since the corporate market is forward looking and real rates tend to lag high quality bond yields. It made AAA yields a great candidate to aid in the forecast of real rates. Additionally, we use the Real Potential GDP model created by the Federal Reserve as a forward-looking indicator of economy productivity. This model obtained an R-squared value of .9203.

$$\text{REAL\_10YR}_t = \alpha_0 + \alpha_1\text{AAA\_YIELD}_t + \alpha_2\text{RP\_GDP}$$

Dependent Variable: REAL_10YR
Method: Least Squares
Date: 09/15/23 Time: 12:46
Sample (adjusted): 1991Q3 2022Q2
Included observations: 124 after adjustments
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 5.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.190406	0.192585	-11.37371	0.0000
AA_YIELD	0.621755	0.036886	16.85625	0.0000
RP_GDP	0.179446	0.064648	2.775734	0.0064



VAR

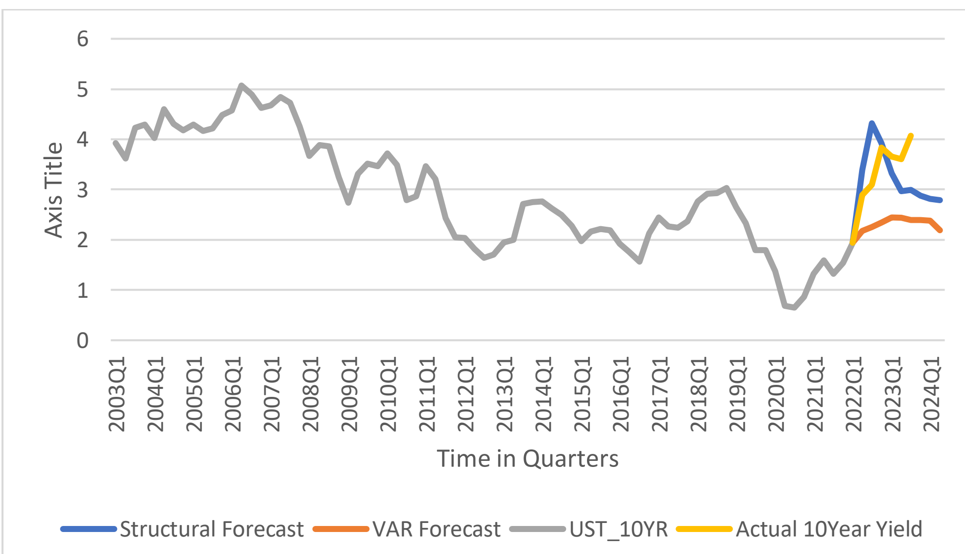
Vector auto regressions is a statistical model used to capture the relationship between multiple quantities as they change over time. This is a great alternative model because we are using multiple time series that vary across time. Using Economic theory in picking our time series we should be able to extract insight from our regression.

The first Var focuses on interest rate predicting variables in the righthand side. It is stable and stationary. The model uses the same variables used in the structural model previously discussed for the real yields. Labor Production growth and AAA Corporate Yields are used as our economic drivers for real rates, in addition to a shock variable controlling for market volatility.

Endogenous Variable: REAL_10YR
Exogenous Varibale: EXPINF_10R, FFR, AA_YIELDS, SCHOCK

	Stable(Y?N)	Estimation Lag-Lengh used	Variables that are in levels, dirrerences or growth rate	Number of Estimated Parameters?
Estimated VAR	YES	1	N/A	108
	LR	**FPE**	**AIC**	**HQ**
Lag Length Criteria Resuls	5	5	18	2
	61.17335*	8.84e-06*	-0.142124*	3.615536*

The VAR model for expected inflation forecast a slight decrease in 10yr expected inflation rates with little to no volatility during this period. The Structural Model forecast a higher increase in the expected inflation rate over same period, with slightly more volatility. Both models have relatively low volatility in comparison to historical figures.

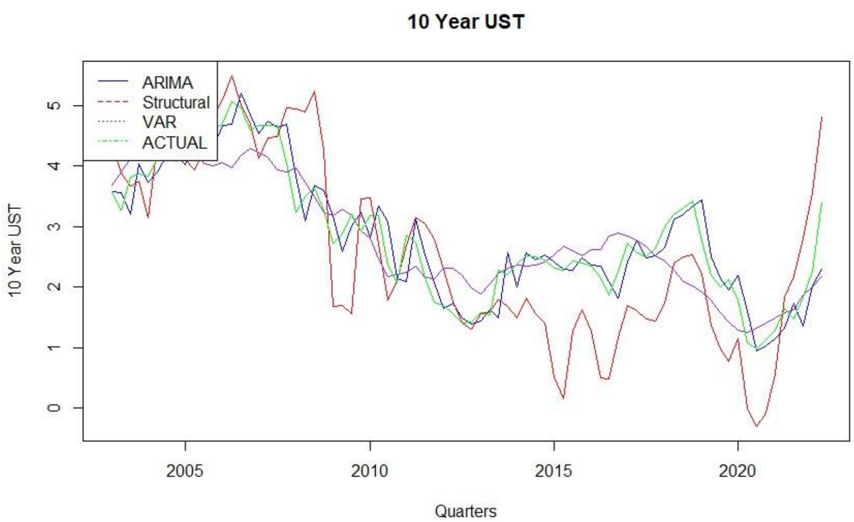


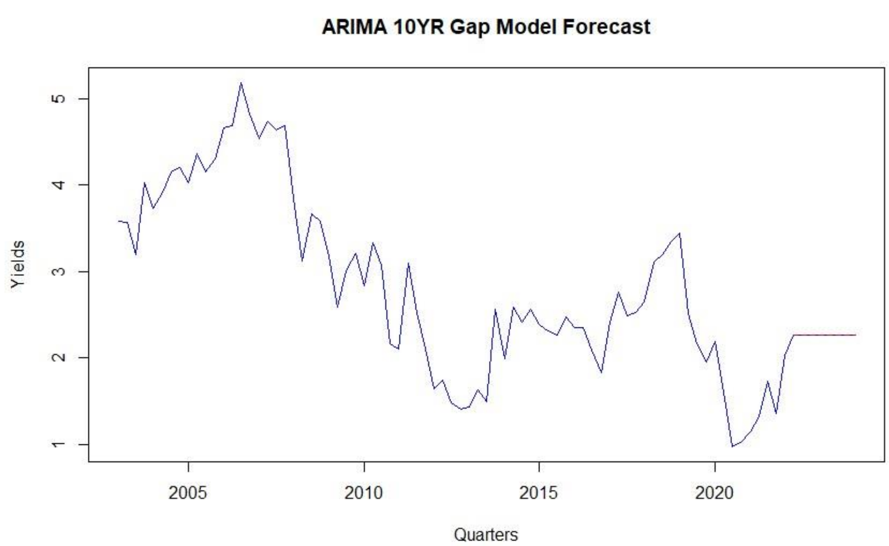
ARIMA

In addition to the VAR and Structural model an ARIMA has also been constructed to forecast 10YR Treasuries gap model, sum of real yields and expected inflation. It is difficult for many models to outperform a simple moving average and thus the additional ARIMA model can helps further improve the accuracy of our overall forecast. Because expected inflation rates are stationary and lacking seasonality, we performed the regression using the following specification (1,1,1).

$$10YR\_GAP_t = \alpha_0 + \alpha_1\ 10YR\_GAP_{t-1} + \alpha_2\varepsilon_{t-1} + \varepsilon_t$$

The forecast of the ARIMA model results in a constant 10 year expected inflation around 1.85 over the out of sample period. This forecast is linear in comparison to the volatility of historical inflation expectations. It remains inline with recent history as we can observe expective inflation on a slow downward tend post 2021 Q3.





The figure above clearing shows the ARIMA model being the closest at tracking the historical values followed the VAR Model and Structural Regression. The Structural model has some difficulty tracking data, especially during periods of Fed intervention. This may be caused by

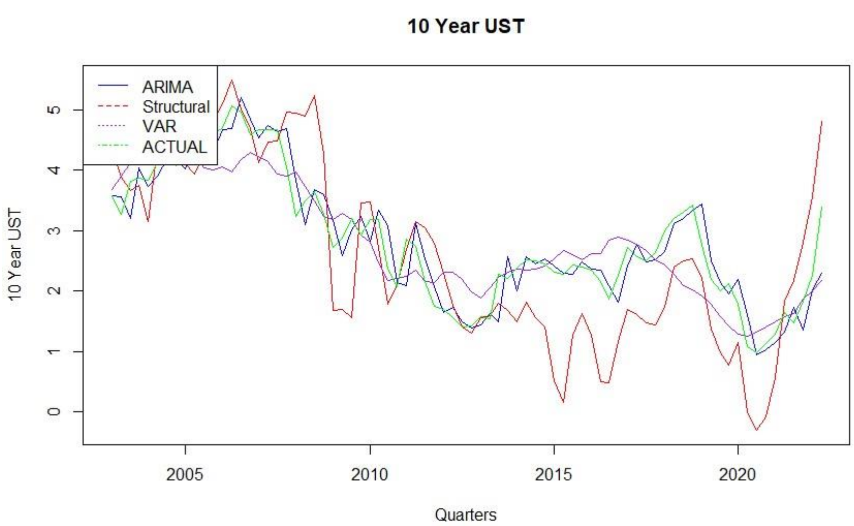
Measuring Tracking Error

In order to measure the accuracy of our models we performed an in sample forecast of our models. The in-sample range is from 2003 Q1 to 2002 Q2. This data encompasses 95% of all observed observations used in the original models. The in-sample forecast analysis is performed in order to assess the ability of the models to forecast known values. We will be using two different analysis techniques; root mean squared errors (RMSE) and mean absolute percentage error (MAPE). For RMSE each residual is squared; these are then summed and divided by the number of observations. Lastly the root of the mean value is taken.

$$RMSE = \sqrt{\frac{1}{n}\sum_{t=1}^{n}(y_t - \hat{y}_t)^2}$$

The MAPE is computed by finding the absolute error in each period, dividing by the actual observed value for the period, and averaging these absolute errors. The result can then be multiplied by 100 and expressed as a percentage.

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\frac{|y_t - \hat{y}_t|}{y_t}$$



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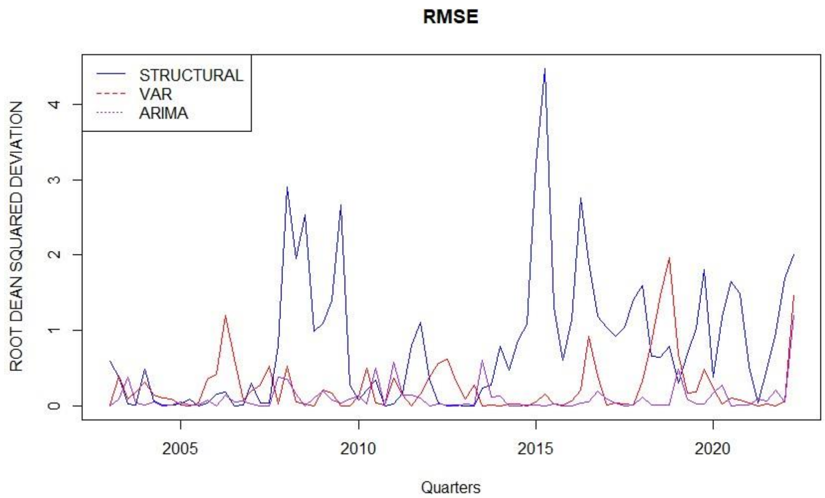
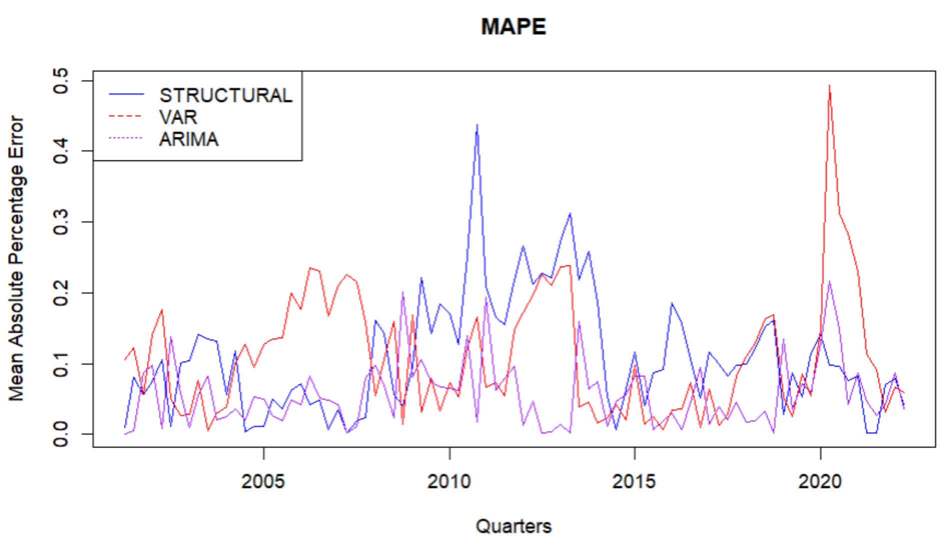


Method	ARIMA	Structural	VAR
RMSE	0.44	0.89	0.5

Using RMSE we can see that the ARIMA model has the smallest root mean error with 44% followed by VAR at 50% and Structural model at 89%%. In the RMSE graph we can observe a spike in error deviation around the 2008-2010 period like previously mentioned. This shows weakness in our model during this period. This is an important as it falls within the great recession. There may be additional data during the recessionary period that our structural model fails to capture and thus expands error deviation during this time frame.



Method	*ARIMA*	*Structural*	*VAR*
MAPE	0.09	0.31	0.15

The MAPE analysis also shows ARIMA as the strongest model at 9% mean absolute percentage error, followed by VAR at 15% and Structural at 31%. In the structural model we see the similar error increases during the Great Recession starting in 2008. For the VAR model there is a bigger gap in error percentage during the pandemic between 2019 to 2022 than previously observed in the RMSE analysis. From this we can assume that the VAR model is underestimating during this time frame. RMSE and MAPE error analysis for our models largely agree with each other and provide further insights than the visuals inspection of in sample forecast.

Conclusion

All models except the structural forecast see long term inflation remain along historical averages below 2 percent. This seems like the most likely outcome for the United States and all the models are similar in this regard. Although 10 year expected inflation should remain relatively low in the long run, our current inflation bout will more than likely increase 10-year nominal rates in the future. If a one forecast had to be chosen, I would choose the structural model. Although this model is not the strongest when it comes to error-analysis. Its forecast still falls inline with historical averages and its slight increase in future expected inflation and interest rates more clearly reflects the facts in the real economy. It is extremely difficult to forecast long term rates specially when inflation has barely begun to show itself in the real economy. No matter how strong the current data is; it is only for a few quarters. This limits our forecasting ability, and the current inflation bout is seen like a shock by our model and not a lasting trend. It will be very important to revisit this model in the future once we are able to acquire more current inflation data. It is still my believe that inflation will remain relatively high and 10-year Expected Inflation will go back to above 2%.

Reference

Bauer, M. D., & Rudebusch, G. D. (2017). Interest rates under falling stars. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3001508

Bekaert, G., Engstrom, E., & Ermolov, A. (2016). Macro risks and the term structure of interest rates. https://doi.org/10.3386/w22839

Laubach, T., & Williams, J. C. (2003). Measuring the natural rate of interest. *Review of Economics and Statistics*, *85*(4), 1063–1070. https://doi.org/10.1162/003465303772815934

Gopinath, G. (2021, July 27). *Transcript of the world economic outlook update press briefing*. IMF. https://www.imf.org/en/News/Articles/2021/07/27/tr072721-transcript-of-the-world-economic-outlook-update-press-briefing.

Grant, J. (2021). (rep.). *'I've failed,' said William McChesney Martin*. Grant's INterest Rate Observer.

Roubini, N. (2021, July 2). *Conditions are ripe for repeat of 1970s stagflation and 2008 debt crisis | Nouriel Roubini*. The Guardian. https://www.theguardian.com/business/2021/jul/02/1970s-stagflation-2008-debt-crisis-global-economy.