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Prediction of the 5/1-Year Adjustable Rate Mortgage Average in the United States using the Federal Reserve Beige Book

ABSTRACT

The beige book is a qualitative report published eight times per year. It is a grouping of anecdotal information on current economic conditions in Each Federal Reserve Bank's District through reports obtained from Bank and Branch directors and interviews with key business contacts, economists, market experts, and other sources. The Beige Book summarizes this information by District and sector[1]. A designated Federal Reserve Bank prepares an overall summary of the twelve district reports on a rotating basis. Commonly called the "ask your uncle" survey[2], the survey used to produce the beige book is not conducted as a scientific survey. The survey employs different contacts and methods, questions vary across Districts, and the timing may differ slightly. In addition, there is the potential for news reports and events to influence respondents' perceptions of regional economic conditions. Many consider the beige book summaries as a complement tool used in tandem with quantitative statistical data by the Federal reserve authorities to make decisions. However, of the two reports published for the FOMC, the Beige Book is the only one available to the public. Then, it can be advantageous to find a way to decipher and quantify the information contained in this report. Many tools, such as text mining with sentiment analysis, have been developed in data sciences and data mining to quantify qualitative information in a way that can be scientifically and empirically exploited. The purpose of my paper is to show that the beige book national summaries can be used to anticipate and predict, to a certain extent, adjustable rate mortgages (ARMs) that experience a surge in demand in 2022 due to the increase in interest rates. In my paper, I found a correlation between the polarity[3] of the beige book in terms of sentiment and the 5/1-Year Adjustable Rate Mortgage Average in the United States.

[1] Beige Book - Federal Reserve Bank of Kansas City. https://www.kansascityfed.org/surveys/beige-book/

[2] Education. (2013, June 7). What is the beige book, and what role does it play in setting interest rates for monetary policy? Federal Reserve Bank of San Francisco. Retrieved June 15, 2022, from https://www.frbsf.org/education/publications/doctor-econ/2003/november/monetary-policy-beige-book-interest-rates/

[3] The key aspect of sentiment analysis is to analyze a body of text for understanding the opinion expressed by it. Typically, this sentiment is quantify with a positive or negative value, called polarity. The overall sentiment is often inferred as positive, neutral or negative from the sign of the polarity score. https://www.kdnuggets.com/2018/08/emotion-sentiment-analysis-practitioners-guide-nlp-5.html

INTRODUCTION

The 5/1 ARM is the most popular type of adjustable-rate mortgage. Homeowners with a 5/1 ARM have interest rates that don't change for the first 60 months of the loan's life. After that initial five-year period, interest rates can either increase or decrease once every 12 months.[4] Like other mortgages, the 5/1 ARM is backed by an index. ARMs in the past had been tied to either the yield on 1-year Treasury bills, the 11th District cost of funds index (COFI), or the London Interbank Offered Rate (LIBOR). LIBOR has been phased out in favor of a new index: the Secured Overnight Financing Rate, also known as SOFR.

When Libor-based ARMs eventually hit reset, the rate is adjusted once a year. By contrast, when SOFR ARMs reset, they will be changed every six months. The reason is that the 1-year Libor looks forward while SOFR looks backward. Libor reflects where interest rates are expected to go in the next 12 months, while SOFR reflects an average of short-term rates during a recent 30-day period. From investors' viewpoint, SOFR rates go out of date more quickly, so they'll be refreshed more frequently. Due to these characteristics of the SOFR ARMs, it can be helpful, especially for the public, to anticipate the future average values of the ARMs so that they can adjust their loans accordingly. Thus, the beige book, a summary of information from multiple economic sectors, can be an essential tool that can help predict the future ARMs rates as the SOFR is backward looking. While the beige book is a qualitative and subjective document, some meaningful information can be extracted thanks to some machine learning tools and algorithms. These machine learning and algorithms tools can extract the overall sentiment of a text-based document through powerful preestablished dictionaries such as the Natural Language ToolKit[5].

In addition, as the public's access to some information is limited, a model that can relatively predict the average 5/1 ARMs partially will help people decide on whether or not they should choose a Fixed Rate Mortgage (FRM) or an ARM.

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[4] Compare today's 5/1 arm mortgage rates. SmartAsset. (n.d.). Retrieved August 5, 2022, from https://smartasset.com/mortgage/5-1-arm-mortgage-rates

[5] NLTK is a leading platform for building Python programs to work with human language data. It provides easy-to-use interfaces to over 50 corpora and lexical resources such as WordNet, along with a suite of text processing libraries for classification, tokenization, stemming, tagging, parsing, and semantic reasoning, wrappers for industrial-strength NLP libraries, and an active discussion forum.(NLTK. (n.d.). Retrieved August 15, 2022, from https://www.nltk.org/

I. Data

The dataset used in this paper is a time series dataset. To obtain the final dataset, many adjustments have been made.

First, the different national summaries of the beige books have been stored in some "txt" files for each quarter per year. Once these files have been stored in this link, I used them to create a data frame using the software Python. The result is a final table containing the Beige book texts per quarter.

Secondly, another table has been obtained through the website kaggle.com(see the link here.). This table contains the Federal Reserve governors' speeches from 1996 – 2020.

To compare the weight of the Beige Book and the governors' speeches in terms of impact on the adjustable rate mortgages, the two tables previously mentioned will be concatenated to obtain a new data frame.

Finally, this Beige book and governors' speeches data frame will be associated with other macroeconomics, financial and variables of the U.S. economy that may potentially impact the adjustable rate mortgages.

This leads to the final data frame that can be found here.

This data frame is a quarterly dataset from 2005 to 2020 as many variables are available for this timespan.

The dataset will also be normalized and made stationary to use specific methodologies. This required me to remove the columns containing some texts related to the Beige Book or the governors' speeches and keep the polarity of these texts.

The final data frame can be found here.

Abbreviations[6]

ARM		Adjustable Rate Mortgage
polarityBeigebook		The measure of how negative or how positive a text is using the Natural Language toolkit
PCEPI_PCH		Percent change Personal consumption expenditures price index
CPIAUCSL_PCH		Percent change The Consumer Price Index for All Urban Consumers: All Items
LNS11027662_PCH		Percent change Civilian Labor Force Level - Bachelor's Degree and Higher, 25 Yrs. & over
FEDFUNDS_PCH		Percent change Federal Funds Effective Rate
GCEC1_PCH		Percent change Real Government Consumption Expenditures and Gross Investment
Homes_Sold		Quantity of homes sold or supplied in the United States
Goods[7]		Personal consumption expenditures of Goods
Nonresidential:		Expenditures by firms on capital such as commercial real estate, tools, machinery, and factories.
Exports		Total exports
Nondefense[7]		Nondefense Government consumption expenditures and gross investment
MORTMRGN5US_PCH		Percent change margin for 5/1-Year Adjustable Rate Mortgage in the United States. The Margin is the number of percentage points added to the index by the mortgage lender to set your interest rate on an adjustable-rate mortgage (ARM) after the initial rate period ends.
ECIALLCIV_PCH		Percent change Employment Cost Index: Total compensation: All Civilian. This is the change over time in labor costs
PPIACO_PCH		Percent change Producer Price Index by Commodity: All Commodities
MORTGAGE5US_PCH		Percent change 5/1-Year Adjustable Rate Mortgage Average in the United States

[6] The majority of these variables are obtained in the website https://fred.stlouisfed.org/

[7] Sign in register help E-mail address password register forgot your password? E-mail address password verify password sign in forgot your password? E-mail address sign in Register National Data National Income and Product Accounts. BEA. (n.d.). Retrieved August 15, 2022, from https://apps.bea.gov/iTable/iTable.cfm?reqid=19&step=2#reqid=19&step=2&isuri=1&1921=survey

II. Empirical Specification and methodology

Our main empirical Specification takes the following form:

MORTGAGE5US = **Intercept + β1***polarity_Beige_book + **β2***PCEPI_PCH - **β3***CPIAUCSL_PCH + **β4***LNS11027662_PCH + **β5***FEDFUNDS_PCH + **β6***GCEC1_PCH - **β6***Homes_Sold + **β7***Goods - **β8***Nonresidential + **β9***Exports + **β10***Nondefense + **β11***MORTMRGN5US_PCH + **β12***ECIALLCIV_PCH + **β13***PPIACO_PCH

III. Results

Multivariate Linear Regression Model

MODEL

OLS Regression Results

Dep. Variable:	MORTGAGE5US_PCH	R-squared:	0.592
Model:	OLS	Adj. R-squared:	**0.470**
Method:	Least Squares	F-statistic:	4.867
Date:	Mon, 15 Aug 2022	Prob (F-statistic):	1.96e-05
Time:	00:20:01	Log-Likelihood[8]:	-164.19
No. Observations:	62	AIC[9]:	358.4
Df Residuals:	47	BIC[10]:	390.3
Df Model:	14		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|		[0.025	0.975]
const	-23.1450	3.538	-6.542	0.000		-30.262	-16.028
polarity_Beige_book	213.6158	46.136	4.630	**0.000**	***	120.803	306.429
PCEPI_PCH	-9.0694	6.829	-1.328	0.191		-22.807	4.668
CPIAUCSL_PCH	7.9361	4.826	1.644	0.107		-1.773	17.646
LNS11027662_PCH	-3.4511	0.995	-3.470	**0.001**	***	-5.452	-1.450
FEDFUNDS_PCH	0.0358	0.022	1.595	0.117		-0.009	0.081
GCEC1_PCH	-4.2124	1.209	-3.485	**0.001**	***	-6.644	-1.781
Homes_Sold	-11.5696	8.024	-1.442	0.156		-27.711	4.572
Goods	-153.0100	42.726	-3.581	**0.001**	***	-238.963	-67.057
Nonresidential	-152.2455	41.530	-3.666	**0.001**	***	-235.792	-68.699
Exports	46.6365	30.069	1.551	0.128		-13.855	107.128
Nondefense	53.6359	45.756	1.172	0.247		-38.413	145.684
MORTMRGN5US_PCH	7.1938	2.430	2.961	**0.005**	**	2.306	12.082

[8] The log-likelihood function identifies a distribution that fits best with the sampled data. While it's useful, AIC and BIC punish the model for complexity, which helps make our ARIMA model parsimonious.

[9] Akaike's Information Criterion (AIC) helps determine the strength of the linear regression model. The AIC penalizes a model for adding parameters since adding more parameters will always increase the maximum likelihood value.

[10] Bayesian Information Criterion (BIC), like the AIC, also punishes a model for complexity, but it also incorporates the number of rows in the data.

ECIALLCIV_PCH	17.6133	4.566	3.858	**0.000**	8.428	26.798
PPIACO_PCH	-0.8033	0.227	-3.545	**0.001**	-1.259	-0.347

Omnibus:	18.332	Durbin-Watson:	1.697
Prob(Omnibus):	0.000	Jarque-Bera (JB):	24.600
Skew:	1.155	Prob(JB):	4.55e-06
Kurtosis:	5.047	Cond. No.	4.05e+03

Linear model: **MORTGAGE5US** = **Intercept +** 213.6158***polarity_Beige_book** - 9.0694***PCEPI_PCH** - 7.9361***CPIAUCSL_PCH** - 3.4511***LNS11027662_PCH** + 0.0358***FEDFUNDS_PCH** - 4.2124***GCEC1_PCH** - 11.5696***Homes_Sold** - 153.0100***Goods** -152.2455***Nonresidential** + 46.6365***Exports** + 53.6359***Nondefense** + 7.1938***MORTMRGN5US_PCH** + 17.6133***ECIALLCIV_PCH** - 0.8033***PPIACO_PCH**

Interpretation

Based on the results of the Linear Model, we can say the following for each variable:

polarityBeigebook: An increase in the polarity of the national summary of the Beige Book of the United States by 1% leads to a rise in the 5/1-Year Adjustable Rate Mortgage Average in the United States by **213.6158%**, holding other variables constant. This relationship can also be verified with the model shown in the appendix (Figure 1.)

The result is astonishing as the coefficient of the variable polarityBeigebook is very high, while this variable is not highly correlated with the endogenous variable MORTGAGE5US. The fact that there is not a high correlation between the two variables makes the result not exaggerated, but as we are using a simple linear model for a time series dataset, this can explain that result. However, this result allows us to keep an eye on that variable when using the other method.

PCEPI_PCH: An increase in the Personal Consumption Expenditures (Chain-type Price Index) for the United States by 1% leads to a decrease in the 5/1-Year Adjustable Rate Mortgage Average in the United States by **9.07%**, holding other variables constant. However, this variable is not significant in the simple linear model.

This result is not surprising because an increase in food, housing (rents), energy, clothing, health, leisure, education, communication, transport, hotels, and restaurant services will decrease demand for these real estate. This decrease in real estate demand means fewer people are willing to contract some mortgages. The reduction in the demand for mortgages will lead to a decline in the Adjustable Rate of Mortgages.

CPIAUCSL_PCH: An increase in the Consumer Price Index for All Urban Consumers: All Items in the U.S. City Average for the United States by 1% leads to a decrease in the 5/1-Year Adjustable Rate Mortgage Average in the United States by **7.94%**, holding other variables constant. However, this variable is not significant in the simple linear model.

This is surprising because the inflation brought by the increase in the CPI is supposed to increase the ARM. "While inflation doesn't directly affect mortgage rates, it can indirectly cause mortgage rates to increase," says Amy Shunick, corporate financial controller at Bennett Packaging in Lee's Summit, Missouri.[11]

LNS11027662_PCH: An increase in the Civilian Labor Force Level (Bachelor's Degree and Higher, 25 Yrs. & over) of the United States by 1% leads to a decrease in the 5/1-Year Adjustable Rate Mortgage Average in the United States by **3.45%**, holding other variables constant.

This is not surprising because an increase in the number of people in the labor force with a bachelor's degree or higher means more people with primary financial education and less risk of default. The more a client is financially educated, the less the risk of default should be, as that client will be able to manage the mortgage efficiently. The higher the risk, the more inclined the bankers will be to increase the mortgage rate.

[11] How does inflation affect mortgage rates? How Does Inflation Affect Mortgage Rates? | Rocket Mortgage. (n.d.). Retrieved August 15, 2022, from https://www.rocketmortgage.com/learn/inflation-and-mortgage rates#:~:text=In%20periods%20of%20higher%20inflation,higher%20monthly%20home%20loan%20payments.

FEDFUNDS_PCH: An increase in the Federal Funds Effective Rate of the United States by 1% leads to a rise in the 5/1-Year Adjustable Rate Mortgage Average in the United States by **0.04%**, holding other variables constant. However, this variable is not significant in the simple linear model.

The result is not surprising as the ARM is set by using the LIBOR as a benchmark for the rate. The Libor (London Interbank Offered Rate) is the equivalent of the Federal Funds Effective Rate used worldwide by financial institutions to determine the interest rate charged on various loans. Even if these two interest rates are very close, only the LIBOR is used to set the 5/1 ARM rate. However, the use of LIBOR as a benchmark will be discontinued soon. "By June 2023, the LIBOR indexes that have historically been used to set interest rates for many adjustable-rate loans will be phased out. For consumers with adjustable-rate mortgages, reverse mortgages, student loans, HELOCs, or credit cards, this may change how your lenders and loan servicers calculate the interest rate."[12]

GCEC1_PCH: An increase in the Real Government Consumption Expenditures and Gross Investment of the United States by 1% leads to a decrease in the 5/1-Year Adjustable Rate Mortgage Average in the United States by **4.21%**, holding other variables constant.

This is not surprising in the sense that previous empirical studies showed, for instance, that rising in the department of defense outlays in a community are associated with lower auto and home equity loan rates, perhaps because they increase expected future income and wealth. In the same perspective, we can paraphrase by saying that an increase in the real government consumption expenditure and gross investment leads to economic growth and that economic growth leads to a decrease in the 5/1 ARM as there will be a more positive expectation from the economic agents.

[12] Davida Farrar–. (2021, December 7). The LIBOR index for adjustable-rate loans is being discontinued: Here's what to watch for. Consumer Financial Protection Bureau. Retrieved August 15, 2022, from https://www.consumerfinance.gov/about-us/blog/the-libor-index-for-adjustable-rate-loans-is-being-discontinued-heres-what-to-watch-for/#:~:text=Blog-,The%20LIBOR%20index%20for%20adjustable%2Drate%20loans%20is%20being%20discontinued,here's%20what%20to%20watch%20for&text=By%20June%202023%2C%20the%20LIBOR,loans%20will%20be%20phased%20out.

Homes_Sold: An increase in the number of homes sold in the United States by 1% leads to a decrease in the 5/1-Year Adjustable Rate Mortgage Average in the United States by **11.57%**, holding other variables constant. However, this variable is not significant in the simple linear model.

This is not surprising as this increase in the homes sold leads to a rise in the supply of homes which reduces the price of homes sold and then the interest rate on these home mortgages.

Goods: An increase in the Commercial Real Estate Prices for the United States by 1% leads to a decrease in the 5/1-Year Adjustable Rate Mortgage Average in the United States by **153.01%**, holding other variables constant.

This is not surprising because an increase in the consumption of goods leads to an increase in aggregate demand. The increase in the aggregate demand leads to a rise in economic growth and then a positive expectation for future income and wealth. This results in a decrease in the interest rates generally and then the 5/1-Year Adjustable Rate Mortgage Average in the United States.

Nonresidential[13]: An increase in the Expenditure by firms on capital such as commercial real estate, tools, machinery, and factories in the United States by 1% leads to a decrease in the 5/1-Year Adjustable Rate Mortgage Average in the United States by **152.25%**, holding other variables constant.

This is not surprising because an increase in firms' Expenditure presages economic growth and then positive expectations about future income and wealth. These optimistic expectations in the future lead to a decrease in the interest rates generally and then the 5/1-Year Adjustable Rate Mortgage Average in the United States.

[13] Mathews, R. (2012, September 22). US GDP: How three types of Investments Impact Economic Growth. Mic. Retrieved August 15, 2022, from https://www.mic.com/articles/15168/us-gdp-how-three-types-of-investments-impact-economic-growth

Exports: An increase in the exports of the United States by 1% leads to a rise in the 5/1-Year Adjustable Rate Mortgage Average in the United States by **46.64%**, holding other variables constant. However, this variable is not significant in the simple linear model.

This result is quite surprising as an increase the exports leads to a rise in aggregate demand ceteris paribus. This increase in agate demand should lead to a surge in economic growth. This, in turn, should have led to a general decrease in interest rates and the 5/1-Year Adjustable Rate Mortgage Average in the United States. One explanation might be since the considerable contribution that exports have to the aggregate demand might also bring some inflation to the economy forcing the Federal Reserve to take action by rising interest rates and influencing, at the same time, the 5/1-Year Adjustable Rate Mortgage Average in the United States.

Nondefense: An increase in the nondefense government expenditure of the United States by 1% leads to a rise in the 5/1-Year Adjustable Rate Mortgage Average in the United States by **53.64%**, holding other variables constant. However, this variable is not significant in the simple linear model.

This is not surprising as the analogy can be made with the government consumption expenditures and gross investment variable. Then, an increase in the nondefense government consumption expenditure and gross investment leads to economic growth, and that economic growth leads to a decrease in the 5/1 ARM as there will be a more positive expectation from the economic agents.

MORTMRGN5US_PCH: An increase in the Margin for 5/1-Year Adjustable Rate Mortgage of the United States by 1% leads to a rise in the 5/1-Year Adjustable Rate Mortgage Average in the United States by **7.19%**, holding other variables constant. It is important to note that this variable does not have a high correlation with the ARM, which led us to include it in the model as it is significant.

ECIALLCIV_PCH: An increase in the Employment Cost Index(Total compensation: All Civilian) of the United States by 1% leads to a rise in the 5/1-Year Adjustable Rate Mortgage Average in the United States by **17.61%**, holding other variables constant.

This is not surprising because the Employment Cost Index is considered an inflationary tailwind when Employment Cost Index exhibits a steepening trend line or a more significant than expected increase for a given period. In addition, as inflation increases, yields and interest rates also rise, decreasing bond prices.

PPIACO_PCH: An increase in the Producer Price Index by Commodity (All Commodities) of the United States by 1% leads to a decrease in the 5/1-Year Adjustable Rate Mortgage Average in the United States by **0.80%**, holding other variables constant.

As developed in the real government consumption expenditures and gross investment case, the increase in the Producer Price Index by Commodity leads to economic growth. Economic growth leads to an increase in the expectation of future income and wealth. This, in turn, decreases the interest rates in general and the 5/1-Year Adjustable Rate Mortgage Average specifically.

Vector Auto-Regression (VAR) model[14]

The higher the value of the log-likelihood, the better a model fits a dataset

MODEL

```
  Summary of Regression Results
==================================
Model:                         VAR
Method:                        OLS
Date:           Mon,15, Aug, 2022
Time:                      01:51:00
--------------------------------------------------------------------
No. of Equations:         14.0000    BIC:                   -62.8108
Nobs:                     58.0000    HQIC:                  -75.8665
Log likelihood:           1891.53    FPE:                1.03199e-34
AIC:                     -84.1968    Det(Omega_mle):     4.37691e-38
--------------------------------------------------------------------


Results for equation MORTGAGE5US_PCH
================================================================================================
                            coefficient       std. error           t-stat            prob
------------------------------------------------------------------------------------------------
const                         1.239679         0.934995            1.326           0.185
L1.polarity_Beige_book        0.170361         0.172869            0.985           0.324
L1.PCEPI_PCH                 -0.014902         1.511171           -0.010           0.992
L1.CPIAUCSL_PCH              -1.157014         1.581769           -0.731           0.464
L1.LNS11027662_PCH           -0.175267         0.204983           -0.855           0.393
L1.FEDFUNDS_PCH              -1.005904         0.370056           -2.718           0.007***
L1.GCEC1_PCH                 -0.183638         0.220834           -0.832           0.406
L1.Homes_Sold                -0.658526         0.410456           -1.604           0.109
L1.Goods                      0.256943         0.909846            0.282           0.778
L1.Nonresidential             0.263408         0.498946            0.528           0.598
L1.Exports                    1.557145         1.182600            1.317           0.188
L1.Nondefense                 0.293126         0.495866            0.591           0.554
```

[14] Vector Autoregression (VAR) is a forecasting algorithm that can be used when two or more time series influence each other. That is, the relationship between the time series involved is bi-directional.(Prabhakaran, S. (2022, April 10). Vector autoregression (VAR) - comprehensive guide with examples in Python. Machine Learning Plus. Retrieved August 15, 2022, from https://www.machinelearningplus.com/time-series/vector-autoregression-examples-python/
)

L1.MORTMRGN5US_PCH	0.126093	0.308351	0.409	0.683
L1.PPIACO_PCH	-0.314158	0.264202	-1.189	0.234
L1.MORTGAGE5US_PCH	-0.580133	0.287537	-2.018	**0.044****
L2.polarity_Beige_book	0.358151	0.204017	1.755	**0.079****
L2.PCEPI_PCH	-2.034847	2.326529	-0.875	0.382
L2.CPIAUCSL_PCH	2.529278	2.084779	1.213	0.225
L2.LNS11027662_PCH	-0.009287	0.266468	-0.035	0.972
L2.FEDFUNDS_PCH	-0.762787	0.319957	-2.384	**0.017****
L2.GCEC1_PCH	-0.299686	0.284617	-1.053	0.292
L2.Homes_Sold	0.032144	0.518841	0.062	0.951
L2.Goods	0.388754	1.188398	0.327	0.744
L2.Nonresidential	0.107698	0.425397	0.253	0.800
L2.Exports	-0.541840	1.432059	-0.378	0.705
L2.Nondefense	0.203084	0.483616	0.420	0.675
L2.MORTMRGN5US_PCH	0.713212	0.358976	1.987	0.047
L2.PPIACO_PCH	0.782166	0.635874	1.230	0.219
L2.MORTGAGE5US_PCH	-0.478110	0.329752	-1.450	0.147
L3.polarity_Beige_book	-0.158306	0.209346	-0.756	0.450
L3.PCEPI_PCH	-1.490015	1.689493	-0.882	0.378
L3.CPIAUCSL_PCH	1.223639	1.608187	0.761	0.447
L3.LNS11027662_PCH	0.400682	0.276747	1.448	0.148
L3.FEDFUNDS_PCH	0.039099	0.300421	0.130	0.896
L3.GCEC1_PCH	-0.015149	0.284816	-0.053	0.958
L3.Homes_Sold	-0.689470	0.422536	-1.632	0.103
L3.Goods	-1.477220	0.995265	-1.484	0.138
L3.Nonresidential	0.375468	0.284222	1.321	0.186
L3.Exports	0.484700	1.266051	0.383	0.702
L3.Nondefense	1.443706	0.621014	2.325	**0.020****
L3.MORTMRGN5US_PCH	-0.200219	0.446774	-0.448	0.654
L3.PPIACO_PCH	-0.440755	0.614932	-0.717	0.474
L3.MORTGAGE5US_PCH	-0.120296	0.319354	-0.377	0.706

Correlation matrix of residuals

	polarity_Beige_book	PCEPI_PCH	CPIAUCSL_PCH	LNS11027662_PCH	FEDFUNDS_PCH	GCEC1_PCH	Homes_Sold	Goods	Nonresidential	Exports	Nondefense	MORTMRGN5US_PCH	PPIACO_PCH	MORTGAGE5US_PCH
polarity_Beige_book	1.000000	-0.454672	-0.533448	-0.192915	0.284026	0.087889	0.377626	0.492719	0.047848	0.341350	-0.026440	0.494297	0.009878	0.160954
PCEPI_PCH	-0.454672	1.000000	0.907844	0.020661	0.187436	-0.092716	0.239568	0.078500	0.438103	0.252209	-0.299313	-0.693375	-0.317875	-0.417613
CPIAUCSL_PCH	-0.533448	0.907844	1.000000	0.067063	0.123040	0.063665	0.209387	-0.082474	0.418328	0.245170	-0.174658	-0.579113	-0.335061	-0.246364
LNS11027662_PCH	-0.192915	0.020661	0.067063	1.000000	-0.185257	-0.785278	-0.321058	-0.030678	-0.170848	-0.024039	-0.278167	-0.171255	0.204626	-0.352034
FEDFUNDS_PCH	0.284026	0.187436	0.123040	-0.185257	1.000000	-0.095799	0.291221	0.609602	0.596320	0.694778	-0.236149	-0.213803	-0.293226	-0.077499
GCEC1_PCH	0.087889	-0.092716	0.063665	-0.785278	-0.095799	1.000000	0.150078	-0.248799	0.126258	-0.063580	0.385276	0.268726	0.013508	0.338307
Homes_Sold	0.377626	0.239568	0.209387	-0.321058	0.291221	0.150078	1.000000	0.612317	0.256020	0.614156	-0.087334	0.156994	-0.221977	0.219194
Goods	0.492719	0.078500	-0.082474	-0.030678	0.609602	-0.248799	0.612317	1.000000	0.307804	0.787176	-0.096308	-0.099086	-0.014263	-0.227059
Nonresidential	0.047848	0.438103	0.418328	-0.170848	0.596320	0.126258	0.256020	0.307804	1.000000	0.721279	-0.503341	-0.128970	-0.242799	-0.365764
Exports	0.341350	0.252209	0.245170	-0.024039	0.694778	-0.063580	0.614156	0.787176	0.721279	1.000000	-0.396646	-0.093450	-0.210910	-0.166960
Nondefense	-0.026440	-0.299313	-0.174658	-0.278167	-0.236149	0.385276	-0.087334	-0.096308	-0.503341	-0.396646	1.000000	0.227072	0.394958	0.239593
MORTMRGN5US_PCH	0.494297	-0.693375	-0.579113	-0.171255	-0.213803	0.268726	0.156994	-0.099086	-0.128970	-0.093450	0.227072	1.000000	0.106571	0.476597
PPIACO_PCH	0.009878	-0.317875	-0.335061	0.204626	-0.293226	0.013508	-0.221977	-0.014263	-0.242799	-0.210910	0.394958	0.106571	1.000000	-0.208272
MORTGAGE5US_PCH	0.160954	-0.417613	-0.246364	-0.352034	-0.077499	0.338307	0.219194	-0.227059	-0.365764	-0.166960	0.239593	0.476597	-0.208272	1.000000

This gives us the following model:

VAR model: MORTGAGE5US = **1.239679 -** 1.005904*FEDFUNDS_PCH**(t-1)** - 0.580133*MORTGAGE5US_PCH**(t-1)** + 0.358151*polarity_Beige_book**(t-2)** - 0.762787*FEDFUNDS_PCH**(t-2)** + 0.713212*MORTMRGN5US_PCH**(t-2)** + 1.443706*Nondefense**(t-3)**

- In this time series model, we can see that the Federal effective funds' rate becomes significant at one and two time lags.15
- The polarity_Beige_book variable is still significant in this time series model.
- In this model, the Nondefense variable also becomes significant at a time lag of three.
- The Percent change margin for 5/1-Year Adjustable Rate Mortgage in the United States is also significant in this model at one and two time lags.

[15] ARIMAX models. ARIMAX models - PyFlux 0.4.7 documentation. (n.d.). Retrieved August 15, 2022, from https://pyflux.readthedocs.io/en/latest/arimax.html

Interpretation[16]

- FEDFUNDS_PCH[17]: From the results, we can say that when the previous and the second previous quarter forecasts of the Federal Effective Rate are available, the public and economic actors can use that information to forecast the future 5/1-Year Adjustable Rate Mortgage in the United States.

- MORTGAGE5US_PCH: From the results, we can say that when the previous quarter forecasts of the 5/1-Year Adjustable Rate Mortgage in the United States are available, the public and economic actors can use that information to forecast the future 5/1-Year Adjustable Rate Mortgage in the United States.

- polarity_Beige_book: From the results, we can say that when the second previous quarter forecasts of the polarity of the Beige Book are available, the public and economic actors can use that information to forecast the future 5/1-Year Adjustable Rate Mortgage in the United States.

- MORTMRGN5US_PCH: From the results, we can say that when the second previous quarter forecast of the Margin for 5/1-Year Adjustable Rate Mortgage in the United States is available, the public and economic actors can use that information to forecast the future 5/1-Year Adjustable Rate Mortgage in the United States.

[16] Federal Reserve Information and the behavior of interest rates - JSTOR. (n.d.). Retrieved August 16, 2022, P.8-9 from https://www.jstor.org/stable/117337

[17] The ARIMAX model muddle. Portrait of the author. (2010, October 4). Retrieved August 15, 2022, from https://robjhyndman.com/hyndsight/arimax/

- Nondefense: From the results, we can say that when the third previous quarter forecast of the Margin for nondefense government expenditure of the United States is available, the public and economic actors can use that information to forecast the future 5/1-Year Adjustable Rate Mortgage in the United States.

Autoregressive integrated moving average (ARIMAX) model[18]

ARIMA Model Results

Dep. Variable:	D.MORTGAGE5US_PCH	No. Observations:	47
Model:	ARIMA(3, 1, 1)	Log Likelihood	25.873
Method:	css-mle	S.D. of innovations	0.131
Date:	Mon, 15 Aug 2022	AIC	-37.746
Time:	02:45:06	BIC	-24.795
Sample:	1	HQIC[19]	-32.873

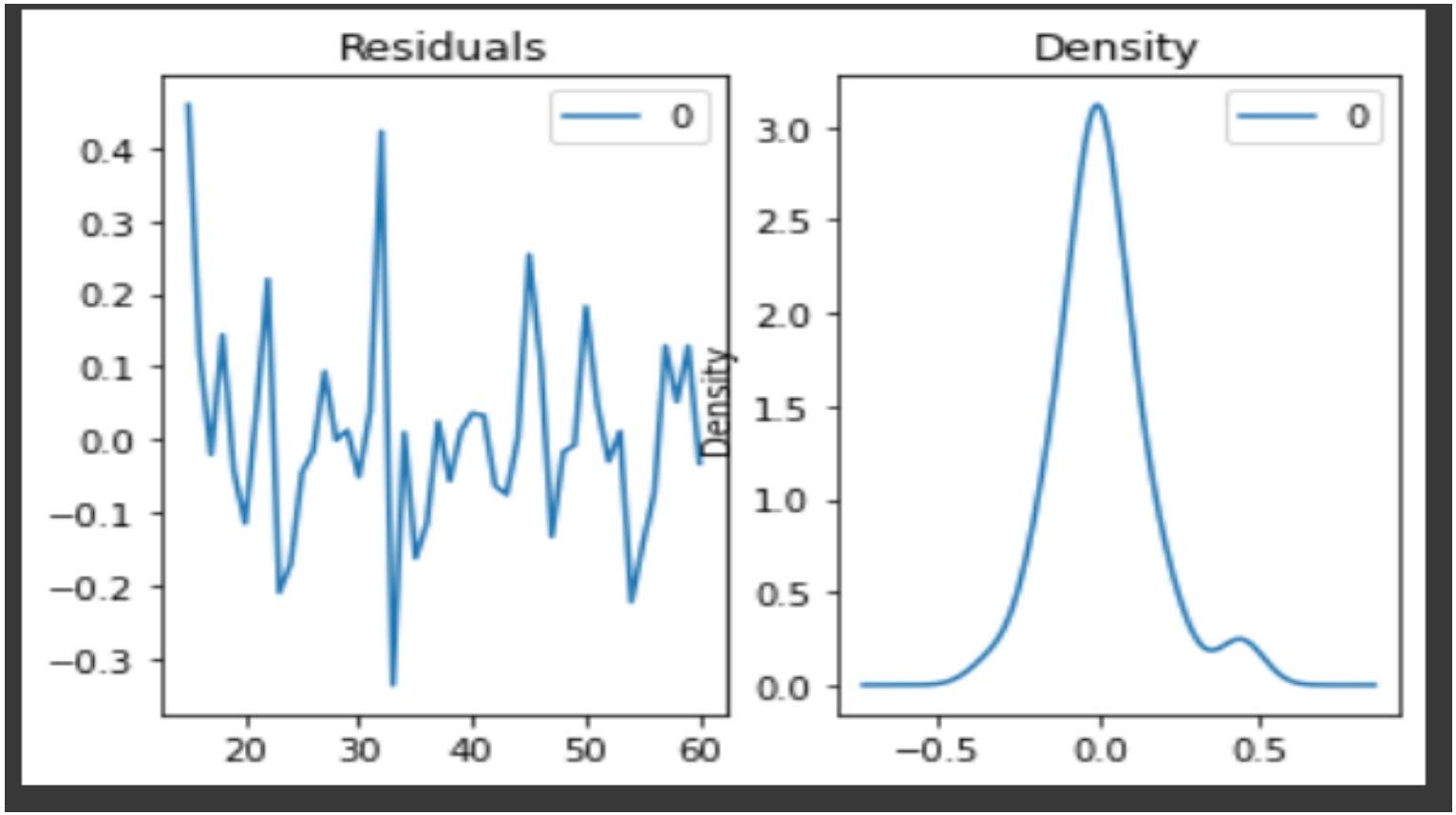
	coef	std err	z	P>|z|	[0.025	0.975]
const	-0.0353	0.020	-1.779	0.083	-0.074	0.004
polarity_Beige_book	0.0755	0.043	1.768	0.084	-0.008	0.159
ar.L1.D.MORTGAGE5US_PCH	-0.6579	0.144	-4.581	0.000	-0.939	-0.376
ar.L2.D.MORTGAGE5US_PCH	-0.5037	0.161	-3.137	0.003	-0.818	-0.189
ar.L3.D.MORTGAGE5US_PCH	-0.2643	0.145	-1.826	0.075	-0.548	0.019
ma.L1.D.MORTGAGE5US_PCH	-1.0000	0.058	-17.187	0.000	-1.114	-0.886

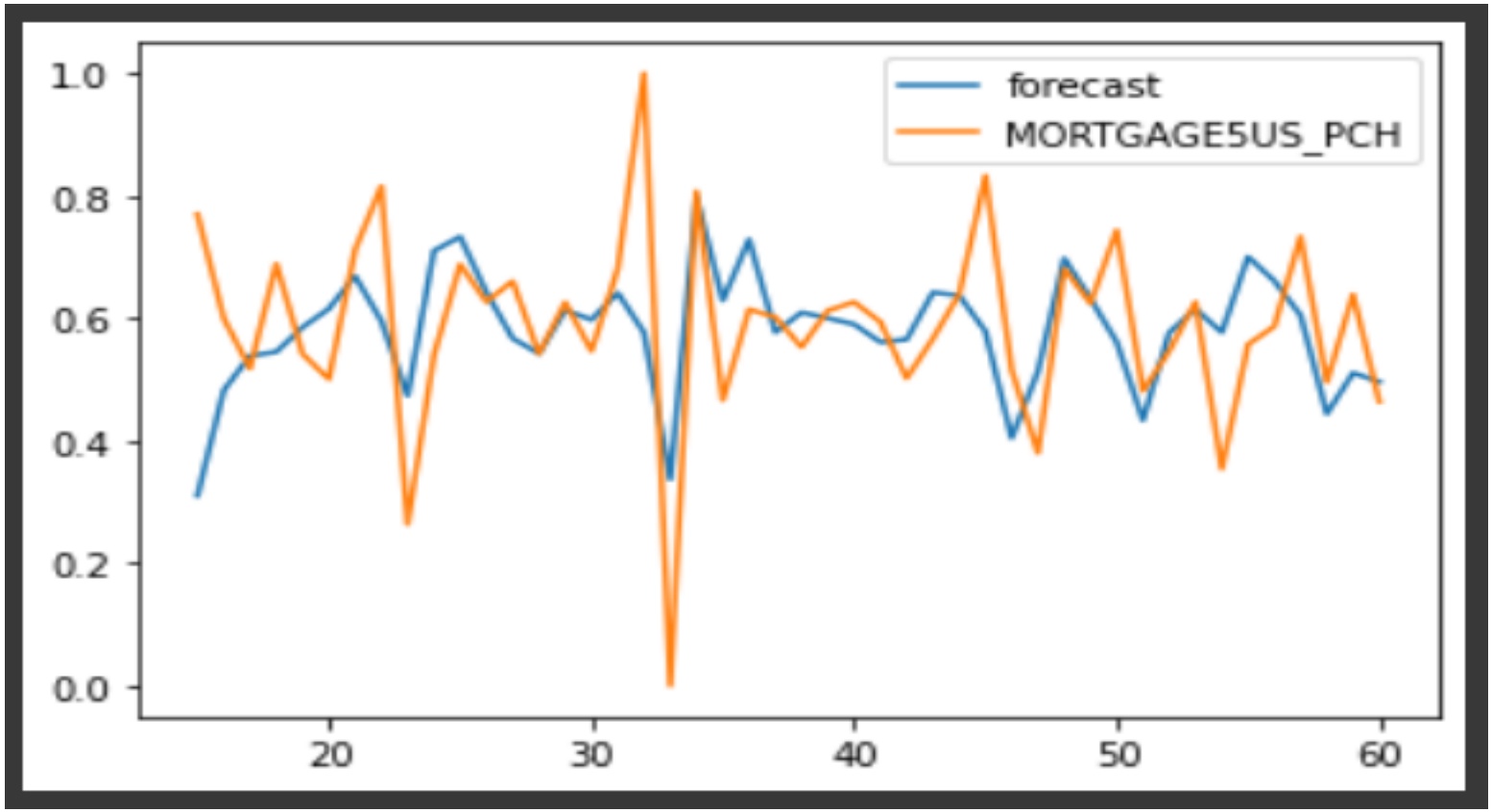
Roots

	Real	Imaginary	Modulus	Frequency
AR.1	-0.0876	-1.4760j	1.4786	-0.2594
AR.2	-0.0876	+1.4760j	1.4786	0.2594
AR.3	-1.7307	-0.0000j	1.7307	-0.5000
MA.1	1.0000	+0.0000j	1.0000	0.0000

[18] Autoregressive Integrated Moving Average with Explanatory Variable (ARIMAX) model can be viewed as a multiple regression model with one or more autoregressive (AR) terms and/or one or more moving average (MA) terms. This method is suitable for forecasting when data is stationary/non stationary, and multivariate with any type of data pattern, i.e., level/trend /seasonality/cyclicity.(What is ARIMAX forecasting and how is it used for enterprise analysis? ElegantJ BI Blog. (n.d.). Retrieved August 15, 2022, from https://www.elegantjbi.com/blog/what-is-arimax-forecasting-and-how-is-it-used-for-enterprise-analysis.htm)

[19] Hannan-Quinn Information Criterion (HQIC), like AIC and BIC, is another criterion for model selection; however, it's not used as often in practice.


Residuals
0
0.4
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
20
30
40
50
60
Density
Density
0
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
0.0
0.5


forecast
MORTGAGE5US_PCH
1.0
0.8
0.6
0.4
0.2
0.0
20
30
40
50
60

The regression gives us the following model:

ARIMAX model: MORTGAGE5US = **Intercept -** 0.0755*polarity_Beige_book - 0.6579*MORTGAGE5US_PCH **(t-1)** - 0.5037* MORTGAGE5US_PCH **(t-2)** -0.2643* MORTGAGE5US_PCH**(t-3)** - 1.0000*MORTGAGE5US_PCH**(t-4)**

Interpretation

- polarity_Beige_book: From the results, we can say that when the current quarter forecast of the polarity of the Beige Book is available, the public and economic actors can use that information to forecast the future 5/1-Year Adjustable Rate Mortgage in the United States.
- MORTGAGE5US_PCH: From the results, we can say that when the first, the second, and the third quarter forecasts of the 5/1-Year Adjustable Rate Mortgage in the United States are available, the public and economic actors can use that information to forecast the future 5/1-Year Adjustable Rate Mortgage in the United States. It is important to note that one of the previous quarter MORTGAGE5US_PCH variables is smoothed with a moving average and one time lag.

GRANGER CAUSALITY TEST

The polarity of the Beige Book VS ARM

As we can see, there is not a causality relationship between the Polarity of the Beige Book and the ARM

```
Polarity of the Beige Book VS ARM GRANGER CAUSALITY TEST

Granger Causality
number of lags (no zero) 1
ssr based F test:         F=0.3278  , p=0.5702  , df_denom=40, df_num=1
ssr based chi2 test:   chi2=0.3524  , p=0.5528  , df=1
likelihood ratio test: chi2=0.3509  , p=0.5536  , df=1
parameter F test:         F=0.3278  , p=0.5702  , df_denom=40, df_num=1

Granger Causality
number of lags (no zero) 2
ssr based F test:         F=0.9060  , p=0.4129  , df_denom=37, df_num=2
ssr based chi2 test:   chi2=2.0568  , p=0.3576  , df=2
likelihood ratio test: chi2=2.0081  , p=0.3664  , df=2
parameter F test:         F=0.9060  , p=0.4129  , df_denom=37, df_num=2

Granger Causality
number of lags (no zero) 3
ssr based F test:         F=0.8802  , p=0.4610  , df_denom=34, df_num=3
ssr based chi2 test:   chi2=3.1843  , p=0.3641  , df=3
likelihood ratio test: chi2=3.0667  , p=0.3815  , df=3
parameter F test:         F=0.8802  , p=0.4610  , df_denom=34, df_num=3
{1: ({'lrtest': (0.350942816533556436, 0.5553799091423851, 1),
    'params_ftest': (0.3277942544597725, 0.5701651249722766, 40.0, 1.0),
    'ssr_chi2test': (0.352378823544250 76, 0.5527696149149222, 1),
    'ssr_ftest': (0.3277942544597681, 0.5701651249722817, 40.0, 1)},
   [<statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef38dacd0>,
    <statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef38eb710>,
    array([[0., 1., 0.]])]),
  2: ({'lrtest': (2.0080508851457 07, 0.3664015402056879, 2),
    'params_ftest': (0.9059839093623202, 0.41292115833035237, 37.0, 2.0),
    'ssr_chi2test': (2.0568283347685323, 0.3575735630008261, 2),
    'ssr_ftest': (0.9059839093623296, 0.41292115833034 79, 37.0, 2)},
   [<statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef3965090>,
    <statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef38e3190>,
    array([[0., 0., 1., 0., 0.],
           [0., 0., 0., 1., 0.]])]),
  3: ({'lrtest': (3.0666681850430564, 0.38146003646698756, 3),
    'params_ftest': (0.8802048170125, 0.46104108978287 97, 34.0, 3.0),
    'ssr_chi2test': (3.184270367427531, 0.36407753979315133, 3),
    'ssr_ftest': (0.880204817012 4881, 0.46104108978288 58, 34.0, 3)},
   [<statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef38e3990>,
    <statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef3912a50>,
    array([[0., 0., 0., 1., 0., 0., 0.],
           [0., 0., 0., 0., 1., 0., 0.],
           [0., 0., 0., 0., 0., 1., 0.]])])}
```

Consumer Price Index for All Urban Consumers: All Items in the U.S. City Average VS ARM

As we can see, there is not a causality relationship between the Consumer Price Index for All Urban Consumers and the ARM

```
Consumer Price Index for All Urban Consumers: All Items in U.S. City Average VS ARM GRANGER CAUSALITY TEST

Granger Causality
number of lags (no zero) 1
ssr based F test:          F=0.3392  , p=0.5636  , df_denom=40, df_num=1
ssr based chi2 test:    chi2=0.3646  , p=0.5459  , df=1
likelihood ratio test: chi2=0.3631  , p=0.5468  , df=1
parameter F test:          F=0.3392  , p=0.5636  , df_denom=40, df_num=1

Granger Causality
number of lags (no zero) 2
ssr based F test:          F=1.0731  , p=0.3524  , df_denom=37, df_num=2
ssr based chi2 test:    chi2=2.4362  , p=0.2958  , df=2
likelihood ratio test: chi2=2.3681  , p=0.3060  , df=2
parameter F test:          F=1.0731  , p=0.3524  , df_denom=37, df_num=2

Granger Causality
number of lags (no zero) 3
ssr based F test:          F=0.7917  , p=0.5070  , df_denom=34, df_num=3
ssr based chi2 test:    chi2=2.8640  , p=0.4131  , df=3
likelihood ratio test: chi2=2.7684  , p=0.4287  , df=3
parameter F test:          F=0.7917  , p=0.5070  , df_denom=34, df_num=3
{1: ({'lrtest': (0.36310748084466127, 0.5467854648607077, 1),
    'params_ftest': (0.33920456788945935, 0.563557506521304, 40.0, 1.0),
    'ssr_chi2test': (0.36464491048116954, 0.5459378196911913, 1),
    'ssr_ftest': (0.33920456788946, 0.563557506521304, 40.0, 1)},
   [<statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef38c7d90>,
    <statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef3959310>,
    array([[0., 1., 0.]])]),
 2: ({'lrtest': (2.368128532870543, 0.3060324103581823, 2),
    'params_ftest': (1.073072014117912, 0.3523591768963692, 37.0, 2.0),
    'ssr_chi2test': (2.4361634915109223, 0.29579703697144344, 2),
    'ssr_ftest': (1.0730720141179062, 0.35235917689637153, 37.0, 2)},
   [<statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef38eb190>,
    <statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef38eb250>,
    array([[0., 0., 1., 0., 0.],
           [0., 0., 0., 1., 0.]])]),
 3: ({'lrtest': (2.7684294621206504, 0.4287233924316607, 3),
    'params_ftest': (0.79168447748419, 0.5070004940450585, 34.0, 3.0),
    'ssr_chi2test': (2.864035021486925, 0.4130668033571999, 3),
    'ssr_ftest': (0.7916844774841907, 0.5070004940450579, 34.0, 3)},
   [<statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef3b214d0>,
    <statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef38bc310>,
    array([[0., 0., 0., 1., 0., 0., 0.],
           [0., 0., 0., 0., 1., 0., 0.],
           [0., 0., 0., 0., 0., 1., 0.]])])}
```

Margin for 5/1-Year Adjustable Rate Mortgage in the United States VS ARM

As we can see, there is a causality relationship between the Margin for 5/1-Year Adjustable Rate Mortgage and the ARM with p=0.0515 and p=0.0689 for a number of lags equal to three.

```
Margin for 5/1-Year Adjustable Rate Mortgage in the United States VS ARM Granger Causality

Granger Causality
number of lags (no zero) 1
ssr based F test:          F=1.6527  , p=0.2060  , df_denom=40, df_num=1
ssr based chi2 test:    chi2=1.7766  , p=0.1826  , df=1
likelihood ratio test: chi2=1.7409  , p=0.1870  , df=1
parameter F test:          F=1.6527  , p=0.2060  , df_denom=40, df_num=1

Granger Causality
number of lags (no zero) 2
ssr based F test:          F=3.1747  , p=0.0534  , df_denom=37, df_num=2
ssr based chi2 test:    chi2=7.2074  , p=0.0272  , df=2
likelihood ratio test: chi2=6.6518  , p=0.0359  , df=2
parameter F test:          F=3.1747  , p=0.0534  , df_denom=37, df_num=2

Granger Causality
number of lags (no zero) 3
ssr based F test:          F=2.1420  , p=0.1131  , df_denom=34, df_num=3
ssr based chi2 test:    chi2=7.7489  , p=0.0515  , df=3
likelihood ratio test: chi2=7.0975  , p=0.0689  , df=3
parameter F test:          F=2.1420  , p=0.1131  , df_denom=34, df_num=3
{1: ({'lrtest': (1.7408990070735513, 0.18702495691331678, 1),
    'params_ftest': (1.6526702221679088, 0.20598907237395378, 40.0, 1.0),
    'ssr_chi2test': (1.7766204888304962, 0.18256485911514583, 1),
    'ssr_ftest': (1.6526702221679035, 0.20598907237395378, 40.0, 1)},
   [<statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef385bb50>,
    <statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef385bd90>,
    array([[0., 1., 0.]])]),
 2: ({'lrtest': (6.6517666099931 89, 0.03594075807712175, 2),
    'params_ftest': (3.1747096630155482, 0.05339998487228721, 37.0, 2.0),
    'ssr_chi2test': (7.207448964683947, 0.02722214500463 7925, 2),
    'ssr_ftest': (3.1747096630155482, 0.05339998487228721, 37.0, 2)},
   [<statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef38c0710>,
    <statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef38c0890>,
    array([[0., 0., 1., 0., 0.],
           [0., 0., 0., 1., 0.]])]),
 3: ({'lrtest': (7.0975482417866 54, 0.06885272253405228, 3),
    'params_ftest': (2.1419772943231 16, 0.11307725152652398, 34.0, 3.0),
    'ssr_chi2test': (7.748917858874801, 0.05149608333658112, 3),
    'ssr_ftest': (2.1419772943231 16, 0.11307725152652398, 34.0, 3)},
   [<statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef38c0fd0>,
    <statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef38c07d0>,
    array([[0., 0., 0., 1., 0., 0., 0.],
           [0., 0., 0., 0., 1., 0., 0.],
           [0., 0., 0., 0., 0., 1., 0.]])])}
```

Federal Funds Effective Rate VS ARM

As we can see, there is a causality relationship between the Federal Funds Effective Rate and the ARM with p=0.0905 for a number of lags equal to two.

```
Federal Funds Effective Rate VS ARM GRANGER CAUSALITY TEST

Granger Causality
number of lags (no zero) 1
ssr based F test:          F=0.2639  , p=0.6103  , df_denom=40, df_num=1
ssr based chi2 test:   chi2=0.2837  , p=0.5943  , df=1
likelihood ratio test: chi2=0.2828  , p=0.5949  , df=1
parameter F test:          F=0.2639  , p=0.6103  , df_denom=40, df_num=1

Granger Causality
number of lags (no zero) 2
ssr based F test:          F=2.1162  , p=0.1348  , df_denom=37, df_num=2
ssr based chi2 test:   chi2=4.8043  , p=0.0905  , df=2
likelihood ratio test: chi2=4.5489  , p=0.1029  , df=2
parameter F test:          F=2.1162  , p=0.1348  , df_denom=37, df_num=2

Granger Causality
number of lags (no zero) 3
ssr based F test:          F=1.2582  , p=0.3042  , df_denom=34, df_num=3
ssr based chi2 test:   chi2=4.5518  , p=0.2077  , df=3
likelihood ratio test: chi2=4.3164  , p=0.2293  , df=3
parameter F test:          F=1.2582  , p=0.3042  , df_denom=34, df_num=3
{1: ({'lrtest': (0.2828050533304065, 0.5946685518932613, 1),
    'params_ftest': (0.26394147008709123, 0.6102516490519193, 40.0, 1.0),
    'ssr_chi2test': (0.28373708034362916, 0.5942621980919613, 1),
    'ssr_ftest': (0.26394147008709684, 0.6102516490519163, 40.0, 1)},
   [<statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef38c7090>,
    <statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef38c7ed0>,
    array([[0., 1., 0.]])]),
 2: ({'lrtest': (4.548864132400524, 0.10285530685574405, 2),
    'params_ftest': (2.1161968342796804, 0.13484000601153368, 37.0, 2.0),
    'ssr_chi2test': (4.8043387589052235, 0.09052136494002509, 2),
    'ssr_ftest': (2.1161968342796817, 0.13484000601153368, 37.0, 2)},
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    array([[0., 0., 1., 0., 0.],
           [0., 0., 0., 1., 0.]])]),
 3: ({'lrtest': (4.3164398965666692, 0.22925953563118465, 3),
    'params_ftest': (1.2582330829726633, 0.3041614714591701, 34.0, 3.0),
    'ssr_chi2test': (4.55184321193051, 0.20771234539829764, 3),
    'ssr_ftest': (1.2582330829726618, 0.304161471459171, 34.0, 3)},
   [<statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef38c7510>,
    <statsmodels.regression.linear_model.RegressionResultsWrapper at 0x7fdef38c7b10>,
    array([[0., 0., 0., 1., 0., 0., 0.],
           [0., 0., 0., 0., 1., 0., 0.],
           [0., 0., 0., 0., 0., 1., 0.]])])}
```

IV. Limitations

Due to the discontinuation and change of many variables, training and testing the data for a protracted timeframe is challenging. In addition, the release time of the Beige Book and the geographical-oriented values of the ARMs make it very difficult to have some detailed data and results. Most of the variables have been averaged and set to a quarterly timeframe so they can match each other. The ARMs are set per "Freddie Mac regions," while the Beige book is released on a national or a district scale. Thus, to get some exploitable data, it was necessary to choose the global U.S ARMs average as the explained variable, and the other variables are the average value of the global U.S scale.

Conclusion

The majority of adjustable rate mortgages (ARMs) insured by the Federal Housing Administration (FHA) are based on the London Interbank Offered Rate (LIBOR), an interest rate index that is likely to become uncertain after December 31, 2021 and no longer be published after June 30, 2023. In reaction to this uncertainty, HUD has begun to transition away from LIBOR as an approved interest rate index. HUD has also approved the Secured Overnight Financing Rate (SOFR) index in some circumstances. HUD recognizes there may be operational difficulties for mortgagees to implement the change to a new index.[20]

The most crucial finding of this paper is that the polarity of the Beige Book does affect, to a certain extent, the adjustable rate mortgage. Using multiple methods allowed us to confirm that relationship. While the simple linear regression hints at that relationship, the time-series models like the VAR and ARIMAX demonstrate that relationship. The discontinuation of the LIBOR as a benchmark for the adjustable rate mortgages in 2023 makes it essential to know, especially for the public that has only access to the Beige Book as a tool to catch a glimpse of the future of the economy. In addition, our research led to a causal relationship between the Federal Effective Funds rate and the 5/1 ARM with a time lag of three and a causal relationship between the Margin for 5/1-Year Adjustable Rate Mortgage and the 5/1 ARM with a time lag of three.

Finally, not much literature addresses the possibility of using the Beige Book as a quantitative tool to forecast future economic variables. May the reason be that the Beige Book is initially considered a pooling of subjective opinions. Even though these opinions are deemed factual by some people, the fact remains that these opinions are based on observations (environment and data) by the actors of the economic and financial system. While data can be very reliable, they can be deadlocked in time as they are historical and may not account for recent economic changes. Thus, the Beige Book can be a crucial tool that, added to the other instruments, can be useful for the public as it represents a communication bridge from the Federal Reserve to the public. While this research aimed to demonstrate the relationship between the Beige Book and the 5/1 adjustable rate mortgages, this can be extended by including more variables in the models presented in this paper to make it more accurate in predicting the 5/1 ARM.

[20] The Federal Register. Federal Register :: Request Access. (n.d.). Retrieved August 15, 2022, from https://www.federalregister.gov/documents/2021/10/05/2021-21512/adjustable-rate-mortgages-transitioning-from-libor-to-alternate-indices

APPENDIX

Univariate Model

Univariate MODEL

The REG Procedure
Model: MODEL1
Dependent Variable: MORTGAGE5US

Number of Observations Read	62
Number of Observations Used	62

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	13.57440	13.57440	16.82	0.0001
Error	60	48.42560	0.80709		
Corrected Total	61	62.00000			

Root MSE	0.89838	R-Square	0.2189
Dependent Mean	1.6129E-11	Adj R-Sq	0.2059
Coeff Var	5.569986E12		

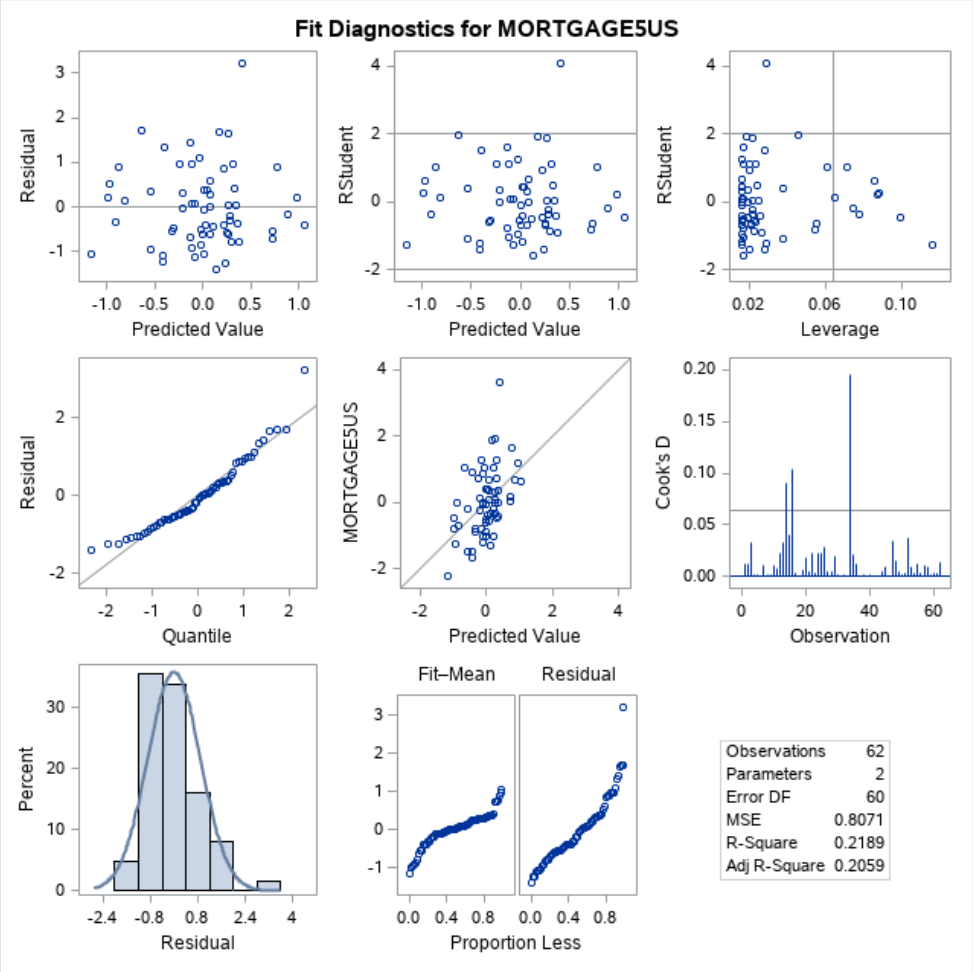
Parameter Estimates

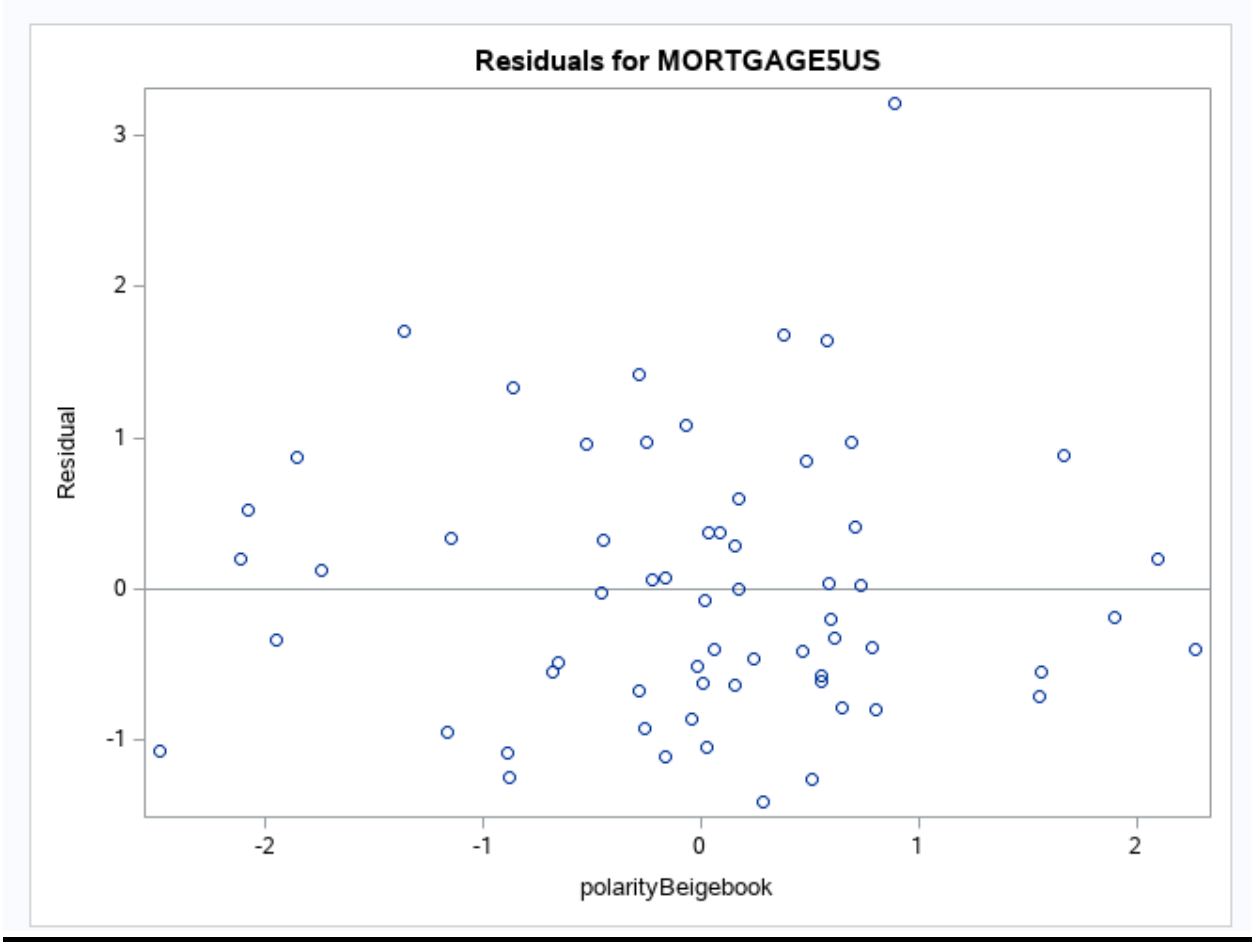
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-1.4059E-11	0.11409	-0.00	1.0000
polarityBeigebook	1	0.46791	0.11409	4.10	0.0001

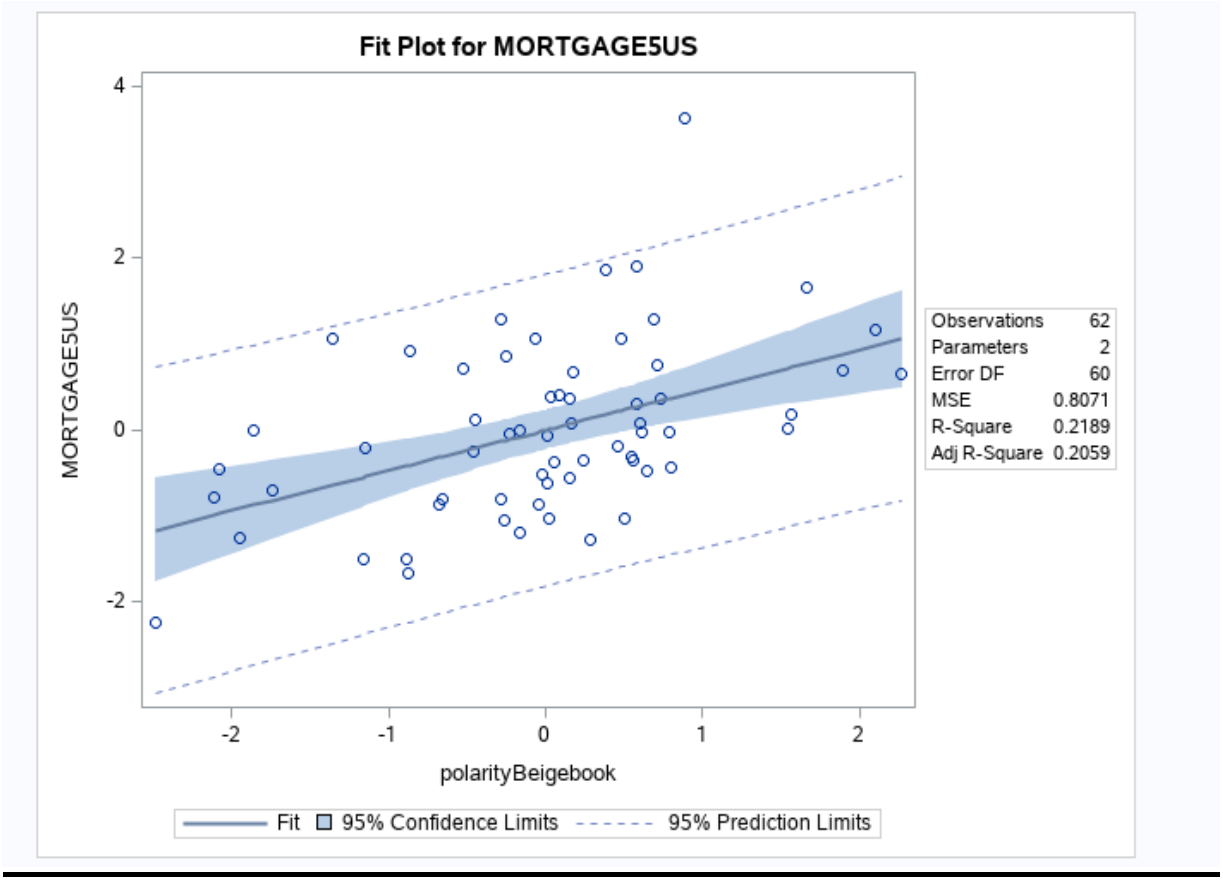
Figure 1

Univariate MODEL

The REG Procedure
Model: MODEL1
Dependent Variable: MORTGAGE5US




Residuals for MORTGAGE5US
Residual
3
2
1
0
-1
-2
-1
0
1
2
polarityBeigebook


Fit Plot for MORTGAGE5US
MORTGAGE5US
4
2
0
-2
-2
-1
0
1
2
polarityBeigebook
Observations 62
Parameters 2
Error DF 60
MSE 0.8071
R-Square 0.2189
Adj R-Square 0.2059
Fit
95% Confidence Limits
95% Prediction Limits

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The key aspect of sentiment analysis is to analyze a body of text for understanding the opinion expressed by it. Typically, this sentiment is quantify with a positive or negative value, called polarity. The overall sentiment is often inferred as positive, neutral or negative from the sign of the polarity score,https://www.kdnuggets.com/2018/08/emotion-sentiment-analysis-practitioners-guide-nlp-5.html

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NLTK is a leading platform for building Python programs to work with human language data. It provides easy-to-use interfaces to over 50 corpora and lexical resources such as WordNet, along with a suite of text processing libraries for classification, tokenization, stemming, tagging, parsing, and semantic reasoning, wrappers for industrial-strength NLP libraries, and an active discussion forum.(NLTK. (n.d.). Retrieved August 15, 2022, from https://www.nltk.org/

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