VEE Time Series Project

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Introduction

The purpose of this project is to identify a time-series model for the weekly conventional 30-year mortgage rate of U.S. from January 8, 2004 to April 3, 2008. The data are obtained from Federal Reserve Bank at St Louis. The software used to perform the data analysis is STATA. This document describes the data work I conducted to arrive the conclusion. Please refer to the rest of the files I sent along for detailed analysis work, including raw data set and the STATA code.

I perform the following steps to build a model for the series.

- Describe data
- Diagnose data to determine the order of AR, MA and the order of potential unit root.
- Fit the model
- Perform model checking for residuals

Describe Data

Figure 1 on the next page presents the data of mortgage rate of U.S. from January 8, 2004 to April 3, 2008. It shows that the general level of mortgage rate elevated between 2006 -2008 for the period of 2004-2005, indicating that the time series is not stationary.

Figure 1.

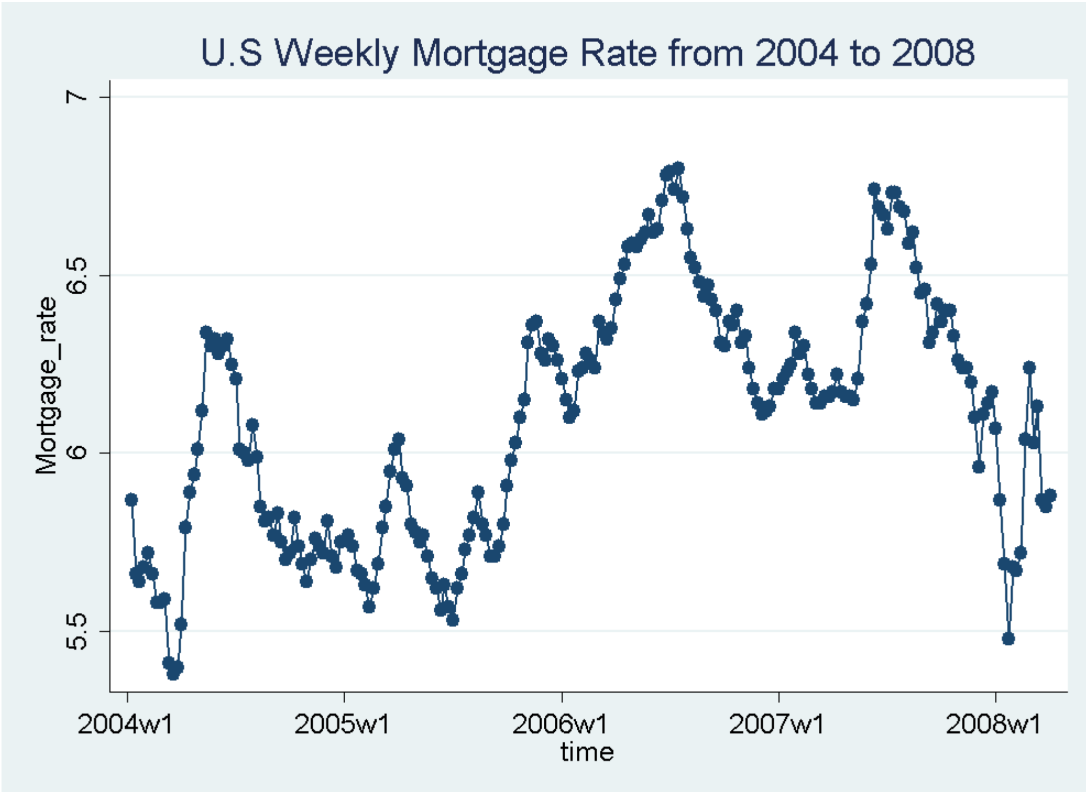


Figure 2. Log (Mortgage_Rate)

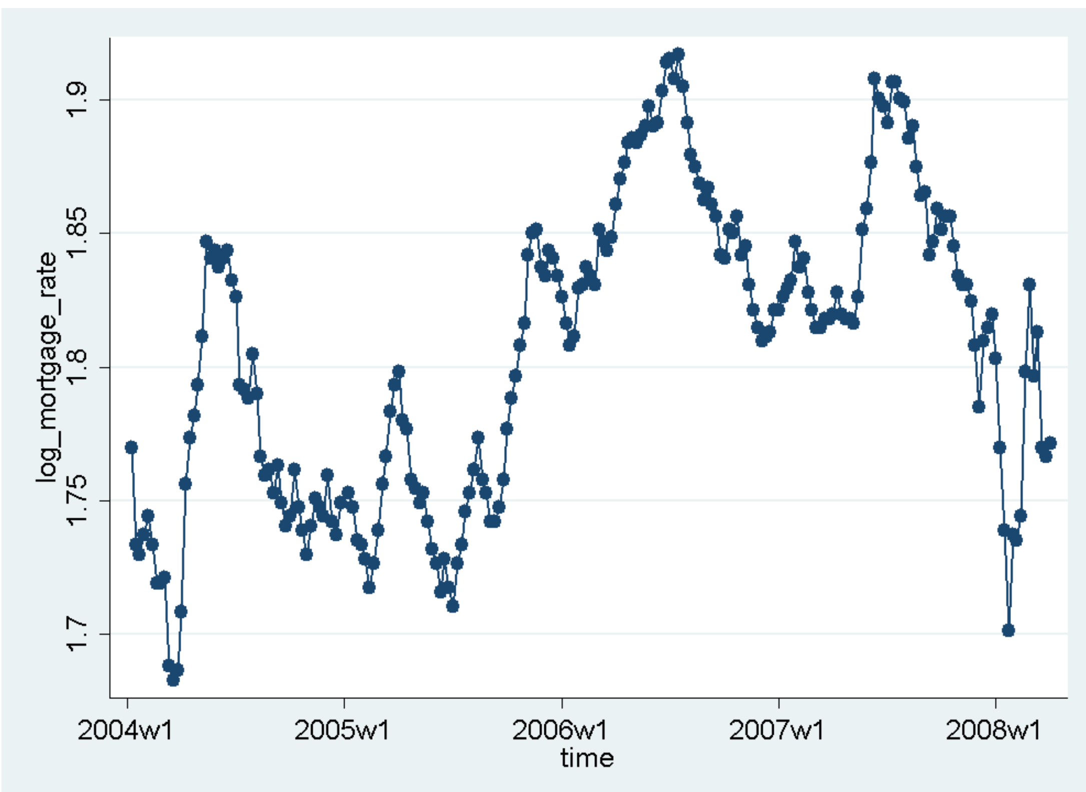
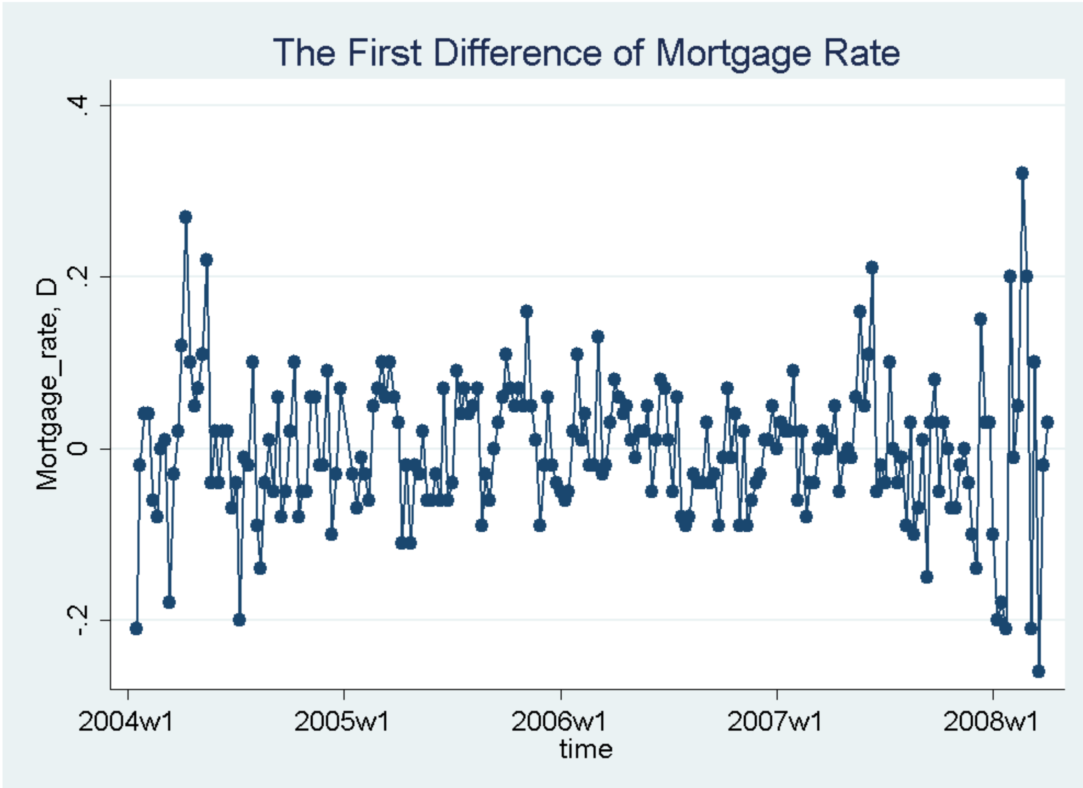


Figure 3. First Differenced Mortgage Rate



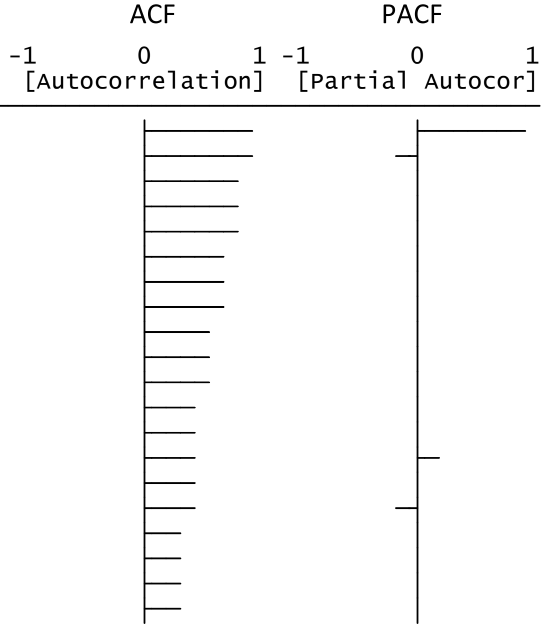
To get a quick examination, I take log of the mortgage rate (Figure 2) and plot the first difference of the series, i.e. $mortgage\_rate_t$-$mortgage\_rate_{t-1}$, (Figure 3). Figure 2 shows a very similar pattern as Figure 1, suggesting that the logarithm of the series does not change the trend of the data, and is still nonstationary. As a result, we use the original data in the following analysis. In Figure 3, the first differenced series is more balanced around constant mean of zero, suggesting that the series contains a unit root.

Identify the order of AR, MA and Potential Unit Root.

Let's now move on to diagnose and check the autocorrelation of the series. A common way to detect the order of autocorrelation is to examine autocorrelation function (ACF) and partial autocorrelation function (PACF). STATA output below shows the statistics and distribution of ACF and PACF.

Table 1. ACF and PACF of Mortgage Rate

LAG	AC	PAC	Q	Prob>Q
1	0.9655	0.9719	207.9	0.0000
2	0.9204	-0.2274	397.71	0.0000
3	0.8698	-0.1001	568	0.0000
4	0.8219	-0.0173	720.75	0.0000
5	0.7749	0.0680	857.17	0.0000
6	0.7312	-0.0484	979.18	0.0000
7	0.6890	0.0069	1088	0.0000
8	0.6471	0.0221	1184.5	0.0000
9	0.6067	-0.0236	1269.7	0.0000
10	0.5661	-0.0609	1344.2	0.0000
11	0.5217	-0.1093	1407.8	0.0000
12	0.4801	0.0283	1462	0.0000
13	0.4425	0.1154	1508.2	0.0000
14	0.4181	0.2313	1549.6	0.0000
15	0.4027	-0.0146	1588.2	0.0000
16	0.3861	-0.1387	1623.9	0.0000
17	0.3686	-0.0128	1656.6	0.0000
18	0.3518	0.0320	1686.5	0.0000
19	0.3391	-0.0087	1714.5	0.0000
20	0.3240	-0.1047	1740.1	0.0000



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Because PACF clearly cuts off at lag 1, it suggests an AR(1) series.

ACF is useful in identifying the order of MA model. For a time series, if ACF cuts off at lag q, or equivalently, ACF approaches to zero for time after q, then the series is a MA(q) model. As shown in Table 1, there is no clear cut off in ACF, indicating no move average in the series.

In the next, I perform the well-know augmented Dickey-Fuller (ADF) test for unit root. Table 2 reports the STATA output for the first order unit root test. The ADF statistics is -1.749 with a p-value 0.4062, which indicates that the unit-root hypothesis cannot be rejected.

Table 2. Unit Root Test for Mortgage Rate

Dickey-Fuller test for unit root   Number of obs   =   218

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-1.749	-3.471	-2.882	-2.572

MacKinnon approximate p-value for Z(t) = 0.4062

D. mortgage_r~e	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
mortgage_r~e						
L1.	-.0280966	.0160667	-1.75	0.082	-.0597643	.003571
_cons	.1714081	.0981996	1.75	0.082	-.0221441	.3649602

Taking all the above into consideration, I conclude that U.S. 30-year Mortgage rate follows a ARIMA (1,1,0) model. The specific model is generated in the following section.

Fitted Model

After knowing the model structure, we can fit the ARIMA (1,1,0) model for the series. Table 3 reports the STATA output for the estimation.

Table 3 Model Estimation

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ARIMA regression

Sample:  2004w3 - 2008w14, but with a gap       Number of obs      =       218
                                                Wald chi2(1)       =     17.78
Log likelihood =  241.2429                      Prob > chi2        =    0.0000
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D. mortgage_r~e	Coef.	OPG Std. Err.	z	P>|z|	[95% Conf.	Interval]
mortgage_r~e						
_cons	-.0002185	.0068928	-0.03	0.975	-.0137282	.0132912
ARMA						
ar L1.	.2120367	.0502878	4.22	0.000	.1134745	.310599
/sigma	.0799951	.0027499	29.09	0.000	.0746053	.0853849

The fitted model is

$$(1 - 0.21B)(1 - B)m_t = a_t, \quad \delta_a^2 = 0.0027$$

where m_t denotes the weekly mortgage rate. The standard error of the AR(1) coefficient is 0.05 so that the estimate is significant at the 1% level.

Postregression Model Checking

Lastly, using the fitted model, I performed a Portmanteau white noise test for residuals to check fitness of the model. The Portmanteau statistic is 27.859 with a p-value of 0.9263, accepting the white noise hypothesis. This result confirms that the ARIMA (1,1,0) model is correctly identified for the time series.

Conclusion

Based on my data analysis, I conclude that the time series of U.S. 30 year mortgage rates follows a ARIMA(1,1,0) model. The fitted model is as follows:

$$(1 - 0.21B)(1 - B)m_t = a_t, \quad \delta_a^2 = 0.0027$$