Mortgage Default Risks and High-Frequency Predictability of the US Housing Market: A Reconsideration

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Abstract

Recent evidence, based on a linear framework, tend to suggest that while mortgage default risks can predict weekly and monthly housing returns of the United States, the same does not hold at the daily frequency. We however indicate that, the relationship between daily housing returns with mortgage default risks is in fact nonlinear, and hence a linear predictive model is misspecified. Given this, we use a *k*-th order nonparametric causality-in-quantiles test, which in turn, allows us to test for predictability over the entire conditional distribution of not only housing returns, but also volatility, by controlling for misspecification due to nonlinearity. Based on this model, we show that mortgage default risks do indeed predict housing returns and volatility, barring at the extreme upper end of the respective conditional distributions.

Keywords: Mortgage Default Risks, Housing Returns and Volatility; Higher-Order Nonparametric Causality in Quantiles Test

JEL Codes: C22, R30

1. Introduction

Aggregate and regional house price movement in the United States (US) is known to predict overall and regional business cycles (Balcilar *et al*. 2014; Nyakabawo *et al*. 2015; Emirmahmutoglu *et al*. 2016). Naturally, there exists a large literature that aims to predict housing market returns and volatility using a wide-variety of econometric techniques and predictors (see for example, Miller and Peng (2006), Li (2012), Bork and Møller (2015, 2018), Plakandaras *et al*. (2015) and André *et al*. (2017) for detailed reviews). This line of research primarily relies on low-frequency, i.e., monthly and quarterly data. However, given that house price movements lead business cycles, and information as to where the house price is headed at higher frequency would be more valuable to policymakers, recent studies have aimed to develop regional and aggregate housing price indices at daily frequency and have also aimed to predict their returns and volatility using high-frequency predictors (Bollerslev *et al*. 2016; Nyakabawo *et al*. forthcoming).

In this regard, more recently Chauvet *et al*. (2016) use Google search query data to develop a broad-based and real-time index of mortgage default risk (MDRI), and shows that the index predicts US housing returns at low (weekly and monthly) frequencies, but not at the highest possible daily frequency of data available for house price. Our paper aims to build on this observation related to the daily data,[1] by highlighting the fact that the relationship between

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[1] When we applied the linear Granger causality test, we found that the null that MDRI does not Granger cause housing returns could not be rejected even at the 10 percent level of significance, given a $\chi^2(6)$ statistic of 3.7396 with *p*-value 0.7119. Note the lag-length was chosen to be 6 based on the Schwarz Information Criterion and matches that of Chauvet et al., (2016). Interestingly, when we used an exponential generalized autoregressive

daily housing returns (as given by CME-S&P/Case-Shiller HPI Continuous Futures (CS CME)) with MDRI is in fact nonlinear,[2] and hence the linear predictive model of Chauvet *et al.* (2016) is misspecified. For our purpose, we use the recently developed k-th order nonparametric causality-in-quantiles framework of Balcilar *et al.* (2018), which in turn, allows us to test for predictability over the entire conditional distributions of both housing returns and volatility simultaneously by controlling for misspecification due to uncaptured nonlinearity. To the best of our knowledge, this is the first paper that evaluates the predictive power of MDRI for US housing returns and volatility based on a nonparametric causality-in-quantiles framework. And as we show that in fact, based on this testing methodology, MDRI does predict US housing returns and volatility, barring the extreme upper end of the respective conditional distributions. The remainder of the paper is organized as follows: Section 2 outlines the methodology, while Section 3 discusses the data and econometric results, with Section 4 concluding the paper.

2. Econometric Methodology

In this section, we briefly present the methodology for testing nonlinear causality via a hybrid approach as developed by Balcilar *et al.* (2018), which is based on the frameworks of Nishiyama *et al.* (2011) and Jeong *et al.* (2012). Let y_t denote housing returns and x_t the MDRI. Further, let $Y_{t-1} \equiv (y_{t-1}, \dots, y_{t-p})$, $X_{t-1} \equiv (x_{t-1}, \dots, x_{t-p})$, $Z_t = (X_t, Y_t)$, and $F_{y_t|\cdot}(y_t| \bullet)$ denote the conditional distribution of y_t given $\bullet$. Defining $Q_\theta(Z_{t-1}) \equiv Q_\theta(y_t|Z_{t-1})$ and $Q_\theta(Y_{t-1}) \equiv Q_\theta(y_t|Y_{t-1})$, we have $F_{y_t|Z_{t-1}}\{Q_\theta(Z_{t-1})|Z_{t-1}\} = \theta$ with probability one. The (non)causality in the θ-th quantile hypotheses to be tested are:

$$H_0:\ P\{F_{y_t|Z_{t-1}}\{Q_\theta(Y_{t-1})|Z_{t-1}\} = \theta\} = 1 \tag{1}$$

$$H_1:\ P\{F_{y_t|Z_{t-1}}\{Q_\theta(Y_{t-1})|Z_{t-1}\} = \theta\} < 1 \tag{2}$$

Jeong *et al.* (2012) show that the feasible kernel-based test statistics has the following format:

$$\hat{J}_T = \frac{1}{T(T-1)h^{2p}} \sum_{t=p+1}^{T} \sum_{s=p+1, s\neq t}^{T} K\left(\frac{Z_{t-1} - Z_{s-1}}{h}\right) \hat{\varepsilon}_t \hat{\varepsilon}_s \tag{3}$$

where $K(\bullet)$ is the kernel function with bandwidth h, T is the sample size, p is the lag order, and $\hat{\varepsilon}_t = \mathbf{1}\{y_t \leq \hat{Q}_\theta(Y_{t-1})\} - \theta$ is the regression error, where $\hat{Q}_\theta(Y_{t-1})$ is an estimate of the θ-th conditional quantile and $\mathbf{1}\{\bullet\}$ is the indicator function. The *Nadarya-Watson* kernel estimator of $\hat{Q}_\theta(Y_{t-1})$ is given by

$$\hat{Q}_\theta(Y_{t-1}) = \frac{\sum_{s=p+1, s\neq t}^{T} L\left(\frac{Y_{t-1} - Y_{s-1}}{h}\right) \mathbf{1}\{y_s \leq y_t\}}{\sum_{s=p+1, s\neq t}^{T} L\left(\frac{Y_{t-1} - Y_{s-1}}{h}\right)} \tag{4}$$

with $L(\bullet)$ denoting the kernel function.

Balcilar *et al.* (2018) extend Jeong *et al.* (2012)'s framework, based on Nishiyama *et al.* (2011), to the *second* (or higher) moment which allows us to test the causality between the MDRI and housing returns volatility. In this case, the null and alternative hypotheses are given by:

$$H_0:\ P\left\{F_{y_t^k|Z_{t-1}}\{Q_\theta(Y_{t-1})|Z_{t-1}\} = \theta\right\} = 1, \quad k = 1,2, \dots, K \tag{5}$$

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conditional heteroscedasticity (EGARCH) model, MDRI was found to significantly increase both returns and volatility at the one percent level of significance. Complete details of the linear Granger causality and EGARCH results are available upon request from the authors.

[2] The Brock et al., (BDS, 1996) test of nonlinearity when applied to the residuals from the housing returns equation used to test the linear Granger causality, rejected the null of *i.i.d.* residuals at the highest possible level of significance and across all dimensions. This result, highlighting nonlinearity between housing returns and the MDRI, has been reported in Table A1 in the Appendix of the paper.

$$H_1\text{: } P\left\{F_{y_t^k|Z_{t-1}}\{Q_\theta(Y_{t-1})|Z_{t-1}\}=\theta\right\}<1, \quad k=1,2,\ldots,K \tag{6}$$

The causality-in-variance test can then be calculated by replacing y_t in Eqs. (3) and (4) with y_t^2. As pointed out by Balcilar *et al*. (2018) a rescaled version of the $\hat{J}_T$ has the standard normal distribution. Testing approach is sequential and failing to reject the test for $k=1$ does not automatically lead to no-causality in the *second* moment; one can still construct the test for $k=2$.

The empirical implementation of causality testing via quantiles entails specifying three key parameters: the bandwidth (h), the lag order (p), and the kernel types for $K(\cdot)$ and $L(\cdot)$. We use a lag order of six based on the SIC. We determine h by the leave-one-out least-squares cross validation. Finally, for $K(\cdot)$ and $L(\cdot)$, we use Gaussian kernels.

3. Data and Results

Daily data on the MDRI for the U.S. is obtained from Chauvet *et al*. (2016)[3], who uses Google data to collect sensitive information directly from individuals seeking assistance via internet search on issues of mortgage default and home foreclosure. Specifically, Chauvet *et al*. (2016) aggregate Google search queries for terms like "foreclosure help" and "government mortgage help" to compile a novel MDRI in real-time. As far as daily house prices are concerned, from which log-returns are computed,[4] we use the CME-S&P/Case-Shiller HPI Continuous Futures (CS CME) derived from Datastream. Our sample ranges from 2nd August, 2007 to 31st May, 2018, i.e., 2704 observations, based on data availability of these two variables of concern.

In Table 1, we present the results for the k-th order causality-in-quantiles test for housing returns and squared housing returns, i.e., volatility, emanating from the MDRI over the quantile range of 0.05 to 0.95. As can be seen, unlike the results reported by Chauvet *et al*. (2016), MDRI causes return at one percent level of significance over all the quantiles of the conditional distribution considered, barring the extreme quantile of 0.95, with the strongest effect felt at the lowest quantile of 0.05. As far as volatility is considered, we draw a similar observation as return, with the slight difference that now, causality from MDRI is absent at the quantile of 0.90 over and above 0.95. In other words, MDRI causes both housing return and volatility, barring the extreme ends of the conditional distribution, corresponding to highest possible conditional return and variance. Understandably, this result originates from the ability of our approach to control for the presence of nonlinearity (as shown in Table A1) via the usage of data-driven nonparametric functional forms defining the relationship between housing market movements and mortgage default risks.[5]

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[3] The data can be accessed at: https://chandlerlutz.shinyapps.io/mdri-app/.

[4] The log-returns ensure that the house price data is mean-reverting, while the MDRI is stationary in levels, which in turn meets the data requirements of the test employed.

[5] As part of further analysis, we reconducted our test based on housing returns derived from a new set of daily housing price series constructed by Bollerslev et al., (2016). The daily housing price series covered ten US metropolitan statistical areas (MSAs). Following Wang (2014), we use the daily composite housing index ($P_{c,t}=\sum_{i=1}^{10} w_i\, P_{i,t}$) as a proxy for the aggregate US housing price, which in turn is computed as a weighted average. The 10 MSAs and the specific values of the weights (w_i) used were: Boston (0.212), Chicago (0.074), Denver (0.089), Las Vegas (0.037), Los Angeles (0.050), Miami (0.015), New York (0.055), San Diego (0.118), San Francisco (0.272), and Washington D.C. (0.078), representing the total aggregate value of the housing stock in the 10 MSAs in the year 2000 (Wang, 2014). In Table A2 in the Appendix of the paper, we report the result of the k-th order causality-in-quantiles test from the MDRI on the housing return and volatility of the aggregate US as well as the 10 MSAs, covering the period of 3rd January, 2006 till 10th October, 2012. As can be seen, for the aggregate housing return, causality ranges between quantiles of 0.10 to 0.30 and then from 0.45 to 0.85 of the conditional distribution, while volatility is predictable by MDRI over the quantile range of 0.30 to 0.90. As far as the MSAs are concerned, barring the case of Boston and San Diego, MDRI predicts returns and/or volatility of

[INSERT TABLE 1]

4. Conclusion

Recently, Chauvet *et al*. (2016) use Google search query data to develop a broad-based and real-time index of mortgage default risk (MDRI), and show that the index predicts US weekly and monthly housing returns, but not at the daily frequency, based on a linear predictive framework. We however indicate that, the relationship between daily housing returns with MDRI is in fact nonlinear, and hence the linear model of Chauvet *et al*. (2016) is misspecified. Given this, we use the recently developed *k*-th order nonparametric causality-in-quantiles test of Balcilar *et al*. (2018), which in turn, allows us to test for predictability over the entire conditional distribution of not only housing returns, but also volatility, by controlling for misspecification due to uncaptured nonlinearity. Our results point out that MDRI does predict US housing returns and volatility, barring the extreme upper end of the respective conditional distributions. Our results can be used by policymakers to obtain daily information as to where the housing market is headed due to changes in mortgage default risks, and in the process, use this knowledge to predict the future path of economic activity at daily frequency, given that house price movements are known to lead US business cycles.

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Table 1. *k*-th Order Causality-in-Quantiles Test Results

Quantile	Housing Return	Squared Housing Return (Volatility)
0.05	6722.0130***	6245.3800***
0.10	4319.6780***	4015.1300***
0.15	3197.1010***	2961.7700***
0.20	2497.5900***	2300.4440***
0.25	2002.4350***	1829.8880***
0.30	1626.0370***	1471.0380***
0.35	1326.8890***	1185.4470***
0.40	1082.0320***	951.7969***
0.45	877.5810***	757.1879***
0.50	704.5925***	593.3177***
0.55	557.0375***	454.6185******
0.60	430.7287***	337.2712***
0.65	322.7174***	238.6611***
0.70	230.9500***	157.0872***
0.75	154.0866***	92.0001***
0.80	91.4564***	42.9158******
0.85	43.2053***	10.7462***
0.90	10.9501***	0.0057
0.95	0.0980	0.0035

Note: *** indicate rejection of the null hypothesis of no Granger causality at one percent level of significance (critical value of 2.575) from MDRI to return and volatility for a particular quantile.

APPENDIX:

Table A1. Brock *et al*. (1996, BDS) Test of Nonlinearity

Independent Variable	Dimension				
	2	3	4	5	6
MDRI	11.0376^{***}	10.7708^{***}	10.8950^{***}	11.5228^{***}	12.1176^{***}

Note: Entries correspond to the *z*-statistic of the BDS test with the null of *i.i.d.* residuals, with the test applied to the residuals recovered from the housing return equation with six lags each of housing return and MDRI; * indicates rejection of the null hypothesis at 1 percent level of significance.

Table A2(a). *k*-th Order Causality-in-Quantiles Test Results for Housing Return

Quantile	Boston	Chicago	Denver	Las Vegas	LA	Miami	NY	San Diego	San Francisco	Washington DC	US
0.05	0.0026	1.6375	1.2623	0.8772	0.0931	0.8177	0.0026	0.1642	1.7909*	0.0026	0.9485
0.10	0.0001	4.0475***	1.5132	1.442	0.3476	2.2904**	0.0024	0.1375	4.2299***	0.0024	2.2809**
0.15	0.0002	6.3473***	2.0513**	1.9529*	0.5509	2.9816***	0.0002	0.5307	4.7231***	0.0002	2.6694***
0.20	0.0027	7.2375***	2.2194**	2.1781**	0.5186	4.2222***	0.0027	0.2948	4.8491***	0.0004	2.0163**
0.25	0.0006	7.5823***	2.1289**	2.1807**	0.3352	4.4717***	0.0006	0.386	4.6526***	0.0015	2.4264**
0.30	0.0034	6.2831***	2.4677**	2.2337**	0.2626	4.7042***	0.0008	0.3914	4.2503***	0.0000	2.3894**
0.35	0.0000	4.2421***	2.5232**	2.0213**	0.1682	5.0594***	0.001	0.4151	4.7532***	0.001	1.2158
0.40	0.0000	2.8415***	2.6086***	2.2767**	0.1215	3.7245***	0.0013	0.423	4.7372***	0.0013	1.1526
0.45	0.0016	1.9596**	2.4711**	1.8462*	0.2221	2.4375**	0.0004	0.3034	5.1721***	0.0001	1.8169
0.50	0.0019	0.5588	2.4085**	1.6666*	0.3016	2.0990**	0.0019	0.1792	5.7453***	0.0019	2.4071**
0.55	0.0001	0.7418	2.8144***	1.4079	0.3635	1.0928	0.0016	0.1649	5.9061***	0.0004	2.8094***
0.60	0.0006	1.7045*	3.1149***	1.3052	0.5678	1.0561	0.0006	0.1431	5.4303***	0.0006	3.4462***
0.65	0.0008	3.6635***	2.9399***	1.4673	0.5329	2.1172**	0.0008	0.1761	5.1220***	0.0008	3.1424***
0.70	0.0011	4.5806***	2.8034***	1.7701*	0.5152	2.4865**	0.0011	0.1671	4.6202***	0.0000	3.5839***
0.75	0.0015	4.8559***	2.6135***	1.6373	0.6953	3.5676***	0.0015	0.375	4.2574***	0.0015	3.6094***
0.80	0.0021	4.8105***	2.0165**	1.8627*	0.5971	3.1223***	0.0021	0.5474	4.2941***	0.0021	2.5545**
0.85	0.0004	4.8692***	1.8461*	1.8515*	0.3440	2.5056**	0.0004	0.4383	3.8153***	0.0004	2.4224**
0.90	0.0007	2.4239**	1.6783*	1.3744	0.2402	2.6573***	0.0041	0.3435	2.7872***	0.0007	1.367
0.95	0.0014	1.1234	0.9889	0.6792	0.1211	1.3003	0.0014	0.0501	1.6172*	0.0014	0.7333

Note: ***, **, * indicate rejection of the null hypothesis of no Granger causality at one, five and ten percent levels of significance (i.e., critical values of 2.575, 1.96 and 1.645) respectively from MDRI to return for a particular quantile.

Table A2(b). *k*-th Order Causality-in-Quantiles Test Results for Squared Housing Return (Volatility)

Quantile	Boston	Chicago	Denver	Las Vegas	LA	Miami	NY	San Diego	San Francisco	Washington DC	US
0.05	0.0103	0.4567	0.2476	0.1161	0.4417	0.2834	2.8615***	0.0400	0.7117	1.2785	0.2284
0.10	0.0047	1.9521*	0.6279	0.2005	0.4854	0.7469	3.8107***	0.0905	1.8120*	1.7129*	0.6584
0.15	0.0081	4.0575***	0.6005	0.6224	1.1708	1.5731	4.4621***	0.0984	3.1117***	2.2432**	1.2577
0.20	0.0109	4.8007***	0.5753	1.0839	0.5623	2.7728***	5.3079***	0.0854	3.5230***	2.6744***	1.3682
0.25	0.0138	6.1496***	1.1139	2.3075**	1.2669	4.2101***	5.8549***	0.2964	3.3524***	3.9590***	1.5402
0.30	0.0373	8.1566***	1.5144	2.5184**	1.5065	5.5053***	6.7122***	0.3833	4.3705***	4.9193***	2.4781**
0.35	0.0259	10.0819***	1.5206	2.0303**	2.9860***	6.2338***	7.5028***	0.4845	4.8183***	5.4760***	3.2279***
0.40	0.0517	12.3420***	1.7051*	2.5206**	3.1708***	6.6631***	7.8151***	0.6057	4.9506***	5.6629***	4.7073******
0.45	0.0360	13.4977***	2.1336**	3.0488***	3.4102***	8.4314***	8.4283***	0.8105	6.1786***	5.3364***	6.7645***
0.50	0.0235	14.2116***	2.2167**	3.1557***	4.0982***	7.7034***	8.2722***	1.0617	6.6111***	5.4611***	6.6123***
0.55	0.0333	14.3870***	2.4325**	3.3332***	4.3039***	7.3493***	7.7785***	0.7933	7.3324***	5.1126***	6.7698***
0.60	0.0383	13.0912***	2.1551**	2.8885***	2.9129***	6.8999***	7.9675***	0.9765	8.4741***	4.9078***	7.6609***
0.65	0.0656	13.5170***	2.0421**	3.3352***	2.9080***	6.8319***	7.9757***	0.6202	8.4261***	5.7290***	6.7620***
0.70	0.1005	12.5342***	1.2266	3.3541***	2.5432**	6.9677***	7.7883***	0.9462	7.6292***	5.1065***	6.1510***
0.75	0.0953	10.2796***	1.2603	2.3811**	3.0557***	5.6584***	6.8033***	0.9640	7.7420***	4.7333***	5.1592***
0.80	0.1012	7.9944***	1.1754	1.9062*	2.8101***	4.8909***	6.1654***	0.6934	5.8078***	3.9274***	4.4776***
0.85	0.0693	5.7361***	1.0195	1.6621*	1.7792*	3.3819***	5.6846***	0.3527	3.4228***	2.9565***	3.7105***
0.90	0.0355	3.2281***	0.4738	1.4363	0.6248	1.7567*	4.8273***	0.2460	2.3832**	1.9647**	1.9388*
0.95	0.0211	0.8996	0.5711	0.4397	0.4543	0.5609	3.0081***	0.1034	0.7599	1.5936	1.5956

Note: ***, **, * indicate rejection of the null hypothesis of no Granger causality at one, five and ten percent levels of significance (i.e., critical values of 2.575, 1.96 and 1.645) respectively from MDRI to volatility for a particular quantile.