LEAD-LAG ASSOCIATION OF MORTGAGE RATE WITH HOUSING PRICE

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ABSTRACT

The current economic and financial crisis is an upshot of housing market episode that begun with subprime mortgage lending practice. The current housing market episode appears to be significant and may be the most severe one in history. The unsustainable incrementally sequential association of subprime mortgage rate, stepping into homeownership rate, and then spreading into housing price over time is the root cause of the plunge of housing market. Spillover effect of this housing crisis spread into other financial/economic markets and is likely to be prolonged due to their domino effect properties. Thus, this economic event has important implications for market participants and financial regulators for understanding the cross-correlation dynamics of housing market behavior. This study, thus explores the role of time delayed mortgage rate effect on the housing price with regard to the understanding of market dynamics. In general, housing price may depend on various internal and external factors and mortgage rate being one of them. Therefore, the purpose of this paper is to understand the cross-correlation dynamics of market behavior with particular emphasis placed upon the role of mortgage rate. Specifically, the present study attempts to identify and isolate the particular lead-lag association between mortgage rate and housing price in conjunction with economic cycle. Housing market plays a significant role as a leading indicator of the economy and therefore understanding the market dynamics cannot be overemphasized. The interesting observation of this research would be the findings of length of time delayed effect of mortgage rate on the housing price in the domain of complex housing market environment.

INTRODUCTION AND BACKGROUND

In this research we explore the association of internal factors and other information externalities in the determination of residential housing price to observe the cross-correlation dynamics of housing market. In recent years, the housing markets have experienced some episodes of large proportions as a result of persistent increase and then followed by significant decrease in housing demand and their prices. The current housing episode appears significantly worse and perhaps the most severe in the recent history of housing market. The current housing market episode arise with the subprime mortgage lending surge, which in turn increased the homeownership rates significantly and caused sharp appreciation in housing prices. This sequential association then reversed itself due to the economic capacity that is finite and limited.

Consequently, the subprime mortgage crisis weakened the housing market and eventually the economy as a whole. Since the peak of housing market (in 2006), the Home Price Index has declined considerably and created a domino effect of widespread mortgage defaults. In addition, the spillover effect of this housing crisis spread into other financial/economic markets and is likely to be prolonged due to their domino effect characteristics. Thus, this has important implications for market participants and regulators interested in identifying risk factors by understanding the cross-correlation dynamics of housing market.

Therefore, the objective of this research is to observe the nature of the cross-correlation dynamics of mortgage rate and its relationship with housing price over time. To this endeavor, we estimate the model of home values using several internal and external factors. These factors may contain physical characteristics of a home as well as economic characteristics of that time period. Thus, isolating the time delayed effect of mortgage rate on the housing price after controlling for relevant factors, primarily internal factors. In this study, we have considered only single family housing. Therefore, zoning differentials is not a major factor. Zoning differentiates land use as per its classifications. Different zoning classifications have different conditions and characteristics (see, Phoebe, Koenig, and Pynoos 2006; Shoked, 2011). Other aspects of zoneing and its effects on the price of house has been studied by researchers (Cho, Kim, and Lambert, 2009; Mukhija, Regus, Slovin, and Das, 2010). These suggest that zoning significantly affects housing prices (Glaeser and Gyourko, 2002).

Housing market plays a significant role as leading indicator of the economy, and therefore understanding the market dynamics cannot be overemphasized, especially in light of the recent housing market turmoil and its effect on the economy. Since, the movements in the housing market will likely continue to play an important role in the business and economy (Bernanke and Gertler, 1995), understanding the market mechanism, specifically the lead-lag relationship between factors can offer mortgage lenders and insurance providers among other participants a notion about the association of these factors, and thus, provides a better understanding for designing appropriate policies and products (Stanton and Wallace, 1998). This insight of such association may then be applied to the formation of new regulations and guidelines.

As a result of such importance of the housing market on the economy, researchers have devoted much of their effort to identify factors that determine the housing market mechanism (Sander & Testa 2009; Lyytikäinen, 2009; Fratantoni & Schuh, 2003; Taylor, 2007; Bradley, Gabriel, & Wohar, 1995; Vargas-Silva, 2008). Many factors have been cited (Ewing & Wang, 2005; Kearl, 1979) as sources of housing market dynamics; among these, housing price (Rapach & Strauss, 2009) and housing starts (Lyytikäinen, 2009; Ewing & Wang, 2005; Puri & Lierop, 1988; Huang, 1973) play a very important role. These studies have been primarily designed to examine particular aspects of these markets, such as the relationship between residential construction and credit accessibility (Rajan, 1994; Taylor, 2007).

Overall, empirical evidence suggest a contemporaneous positive association between number of houses sold and number of houses for sale, which is an inventory issue. However, time-series investigations invariably have delayed time dependent effect. Therefore, the purpose of this paper is to understand the cross-correlation dynamics of housing market with particular emphasis placed upon the role of housing price. Specifically, using the research design discussed in the following section, the present study attempts to isolate particular lead-lag association between mortgage rate and housing price in conjunction with economic cycle as specified in this paper.

Regression model of the housing price that takes serial correlation into consideration will be examined and estimated using multiple predictor variables. The interesting observation of this research would be the findings of length of time delayed effect of mortgage rate on the housing price. In addition, this study will also explore the impact of economic cycle (as defined in this paper) on the housing price after adjusted for inflation. Thus, the housing price and its value are considered to be time dependent.

Table-1A: Summary Statistics of single-family housing factors.

Variables	N	Mean	Std Dev	Minimum	Maximum
Price_Real	2329	175296.94	66962.98	13535.38	531264.38
MotgRate	2329	7.49	1.11	4.3500000	10.48
Condition	2329	0.90	0.085	0.34	0.99
Bedrooms	2329	3.30	0.65	1.00	8.00
Bathrooms	2329	2.48	0.90	1.00	9.00
Totbldgft	2329	1694.20	615.37	529.00	4860.00
Gsqft	2329	530.49	192.80	159.00	2136.00
Lotsqft	2329	11841.57	4052.50	1350.00	43740.00
Age	2329	35.82	19.32	1.00	153.00

DATA AND METHODOLOGY

The data includes sales price among other information, spanning from January, 1990 to October, 2010. The data types that we have used for our analysis are only single-family residential properties. Any observation that has missing data was eliminated from the analysis. Also, data that deemed outlier are eliminated to have a consistent less skewed distribution for a reliable estimation. For the estimation of the model, the sample includes only those residential properties with a single-family detached building.

Internal factors

Internal factors that are considered**:** Age of the house, Number of bedrooms, Number of bathrooms, Condition of the house (0.00 to 0.99), Lot square footage, Total building square footage, Garage square footage, and some of the second order terms of these factors.

External factors

External factors that are considered: Economic Cycle (as defined in this study), Monthly seasonality, and 30-year-mortgage rate.

Table-1B: Summary Statistics of Sales Price by Month.

Month	Median	Mean	Std	Min	Max	N
JAN	162811.71	179329.72	63411.61	43561.48	364960.27	123
FEB	156186.21	170210.36	59725.94	40096.22	370021.35	114
MAR	162166.80	175853.40	68178.79	36731.23	412471.06	156
APR	155681.12	169265.71	72893.76	34431.71	531264.38	156
MAY	157379.62	177216.79	62361.24	32611.77	431195.97	251
JUN	164058.01	172876.05	56527.72	35782.67	343620.66	268
JUL	153509.65	172391.80	68716.33	13535.38	495176.91	275
AUG	166344.29	176759.36	64176.93	29482.51	384344.49	254
SEP	159791.96	178298.89	68853.89	32475.21	459744.68	202
OCT	157828.83	176015.79	74252.64	32259.07	508080.32	212
NOV	158197.72	175603.89	75894.79	31473.54	510763.08	184
DEC	161153.32	180647.81	69785.67	49301.21	477498.55	134
Total	159721.23	175296.94	66962.98	13535.38	531264.38	2329

Variables and Analysis

To estimate the value of the house, we associate variety of internal factors, such as, age of the house, number of bedrooms, number of bathrooms, total building square footage, total lot square footage, condition of the building. Location characteristics, such as, recreational facilities, roads, shopping centers, etc. may be relevant in estimating the housing value. The influence of public good provision and the presence of amenities on the value of a house cannot be denied. They may generate appealing differences between properties and thus create differences in price value. But, they may impact the value of the house positively and/or negatively and thus will offset in its effect. Thus, these factors are not considered in this study. Conversely, mortgage rates that increases or decreases the purchasing power has influence on the selling price of a house and are correlated with the economy. Therefore, mortgage-rate is considered as an external factor in our study to observe any mortgage-rate dependent effect on the housing value.

Specifically, we study any lagged effect on the expected selling price. The data were ordered by year and by month to understand and identify the effect of external factors over time, such as, mortgage rate and economic cycle. It is expected that house prices increase during economic accession and decline during economic recession. However, nominal price of a house may increase steadily over time. Therefore, the selling price of houses was adjusted for inflation and the real price of houses was used in our analysis. Thus, data on these factors that are stated above are collected and analyzed using associative models. Our research considers modeling

single-family housing and the dependent variable is the selling price of houses that are adjusted for inflation.

Table-1C: Summary Statistics of Sales Price by Year.						
Year	**Median**	**Mean**	**Std**	**Min**	**Max**	**N**
1990	151203.90	157782.53	62398.05	33398.28	310136.00	83
1991	141829.48	153446.14	71829.84	32259.07	508080.32	120
1992	152301.02	167181.96	69023.36	31473.54	449227.20	168
1993	161948.86	181387.05	79566.86	36478.06	420502.45	140
1994	170978.14	190516.29	80920.11	37689.93	510763.08	177
1995	158325.69	177581.61	70996.87	41793.84	411724.25	127
1996	148425.53	176216.28	65894.05	95104.34	531264.38	124
1997	162173.67	181804.34	60869.84	42551.88	351900.03	124
1998	166643.96	185939.23	69166.59	34431.71	403248.27	192
1999	162644.14	183338.20	69072.68	38853.11	436775.33	217
2000	161981.54	177788.87	61440.94	27998.92	349778.09	200
2001	159721.23	177022.58	53558.95	54939.96	354057.49	204
2002	158572.24	161504.00	51016.07	13535.38	390154.95	69
2003	157616.06	160145.19	64533.53	29482.51	477498.55	78
2004	163482.98	172712.84	54807.40	59780.70	356100.61	53
2005	164401.38	176251.10	69219.44	60974.71	462407.79	58
2006	169586.19	180918.60	66682.46	63710.29	495176.91	42
2007	152081.69	160498.93	43974.89	63330.31	369170.89	55
2008	150924.29	171468.10	79215.45	64961.13	431195.97	32
2009	153953.16	159638.33	34358.15	89696.52	316088.84	41
2010	159257.93	159312.58	55512.22	60820.56	312044.06	25
Total	159721.23	175296.94	66962.98	13535.38	531264.38	2329

To understand the relationship between selling price and other factors considered in this paper; we first perform correlation analysis (see Table-2) to examine the direction of the association between factors. Next, housing price (selling price of the property adjusted for inflation) is regressed on the predictors to observe the association. In addition to the primary internal factors (house characteristics), we have also explored time delayed external factor to observe the effect of certain factor's length of time on the housing (selling) price. As for example, a decrease in mortgage rate (more/less) may affect to increase the attention of purchaser and thus result in increase in housing prices two to three months later. Thus, several lag periods (one month lag, two month lag, and three month lag) were introduced during the estimation process of the regression model to identify the proper time delay. In general, it is assumed that there is a difference in prices between good economic period and difficult economic period in the process of estimating the value of the house and therefore, economic cycle (a dummy variable) is introduced into the model as an independent variable.

We have used SAS software (see, SAS/STAT User's Guide, 1993) to run the multiple regression models on several different factors of single-family housing characteristics. These

analyses that are based on external factors are to observe the differential effect over time on the value of houses due to change in economic environment. This measure is designed to test the hypothesis that housing value fluctuation is economy and time dependent. Specification of the regression model is of the following form:

$$\Pr ice\_\mathrm{Re} al = \beta_0 + \beta_1 MtgRate\_Lag2 + \beta_2 Econ\_Cycle + \beta_3 Condition + \beta_4 Bedrooms + \beta_5 Bathrooms + \beta_6 Totbldgft + \beta_7 Gsft + \beta_8 LotSqft + \beta_9 Age + \beta_{10} Agesq + \beta_{11} Bedsq + \beta_{12} Bathsq + \beta_{13} Feb + ... + \beta_{23} Dec + \nu$$

where:

Price_Real: Selling price of the property (building and land) adjusted for inflation.
Age: The age of any building (number of years) included in the property.
Totbldgft: The area in square feet of all buildings on the property.
LotSqft: The land area in square feet of the property.
Gsft: The area in square feet of the garage.
Bathrooms: Number of bathrooms on the property.
Bedrooms: Number of bedrooms on the property.
Condition: Condition of the building ranges from 0.00 (poor) to 0.99 (excellent)
MtgRate The 30-year-mortgage rate.
Econ_Cycle: Economic Cycle; a dummy variable: coded 1 for years 1995-2006 and 0 otherwise.
Feb-Dec: Dummy variables: coded 1 for the month and 0 otherwise.
Agesq, Bedsq, Bathsq: These are quadratic terms in the model.

In general, one can expect that an increase land area/ building area should increase the value of a property and thus increase the selling price; however, the magnitude of this effect diminishes slowly. Similar effect can be observed with the number of bathrooms or bedrooms. Similarly, the value of the property is expected to decrease when the age of the property increases. However, these relationships are not linear and therefore may be better captured by introducing a quadratic term in the model estimation. We can also hypothesize that an increase in mortgage rate should decrease the price of the property, since higher debt burden will be capitalized into a lower value of housing. To test these hypotheses in our study we have employed associative models in our analysis.

Table-2: Correlation Matrix of single-family housing factors.

Sales Price	1.00	0.331	0.194	0.307	0.411	0.264	0.253	-0.331	-0.242	0.192	0.269	-0.023	0.051
		<.000	<.000	<.000	<.000	<.000	<.000	<.000	<.000	<.000	<.000	0.265	0.012
	2329	2232	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329
Condition	0.331	1.000	0.307	0.487	0.425	0.266	0.153	-0.903	-0.866	0.303	0.415	0.040	-0.008
	<.000		<.000	<.000	<.000	<.000	<.000	<.000	<.000	<.000	<.000	0.057	0.674
	2232	2232	2232	2232	2232	2232	2232	2232	2232	2232	2232	2232	2232
Bedrooms	0.194	0.307	1.000	0.462	0.525	0.354	0.114	-0.308	-0.245	0.984	0.389	0.031	-0.021
	<.000	<.000		<.000	<.000	<.000	<.000	<.000	<.000	<.000	<.000	0.126	0.295
	2329	2232	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329
Bathrooms	0.307	0.487	0.462	1.000	0.662	0.405	0.160	-0.525	-0.398	0.453	0.939	0.009	-0.012
	<.000	<.000	<.000		<.000	<.000	<.000	<.000	<.000	<.000	<.000	0.635	0.543
	2329	2232	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329
Totbldgft	0.411	0.425	0.525	0.662	1.000	0.522	0.259	-0.452	-0.284	0.522	0.610	0.049	-0.032
	<.000	<.000	<.000	<.000		<.000	<.000	<.000	<.000	<.000	<.000	0.016	0.121
	2329	2232	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329
Gsft	0.264	0.266	0.354	0.405	0.522	1.000	0.158	-0.266	-0.177	0.358	0.382	0.012	-0.000
	<.000	<.000	<.000	<.000	<.000		<.000	<.000	<.000	<.000	<.000	0.546	0.986
	2329	2232	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329
Lotsqft	0.253	0.153	0.114	0.160	0.259	0.158	1.000	-0.143	-0.087	0.118	0.143	0.021	0.002
	<.000	<.000	<.000	<.000	<.000	<.000		<.000	<.000	<.000	<.000	0.299	0.916
	2329	2232	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329
Age	-0.331	-0.90	-0.31	-0.53	-0.45	-0.26	-0.14	1.000	0.931	-0.308	-0.448	-0.038	0.003
	<.000	<.000	<.000	<.000	<.000	<.000	<.000		<.000	<.000	<.000	0.065	0.862
	2329	2232	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329
Agesq	-0.242	-0.86	-0.24	-0.39	-0.28	-0.17	-0.08	0.931	1.000	-0.240	-0.326	-0.025	0.004
	<.000	<.000	<.000	<.000	<.000	<.000	<.000	<.000		<.000	<.000	0.214	0.820
	2329	2232	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329
Bedsq	0.192	0.303	0.984	0.453	0.522	0.358	0.118	-0.308	-0.240	1.000	0.385	0.034	-0.024
	<.000	<.000	<.000	<.000	<.000	<.000	<.000	<.000	<.000		<.000	0.091	0.240
	2329	2232	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329
Bathsq	0.269	0.415	0.389	0.939	0.610	0.382	0.143	-0.448	-0.326	0.385	1.000	0.000	-0.006
	<.000	<.000	<.000	<.000	<.000	<.000	<.000	<.000	<.000	<.000		0.980	0.771
	2329	2232	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329
MtgRate_l2	-0.023	0.040	0.031	0.009	0.049	0.012	0.021	-0.038	-0.025	0.034	0.000	1.000	-0.323
	0.265	0.057	0.126	0.635	0.016	0.546	0.299	0.065	0.214	0.091	0.980		<.000
	2329	2232	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329
Econ_Cycle	0.051	-0.01	-0.02	-0.01	-0.03	-0.00	0.002	0.003	0.004	-0.024	-0.006	-0.323	1.000
	0.012	0.674	0.295	0.543	0.121	0.986	0.916	0.862	0.820	0.240	0.771	<.000	
	2329	2232	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329	2329

EMPIRICAL RESULTS

Larger standard deviation 66,962.98 of housing price with highest price being 531,264.38 and lowest of 13,535.38 (see Table-1A) does indicate much fluctuation in the property prices and thus, indicates a positively skewed distribution. Mortgage rate ranges from 4.35 to 10.48 (see Table-1A) during this time period reflect economic cycle that covers both up and downturn of the economy and may impact housing price. Similar differences also observed with other factors as well. In a similar context, there are also visible differences in frequency distribution of

number of houses sold in different months and thus exhibiting monthly seasonality in demand for houses. Highest frequency is observed in July and the lowest in February (see Table-1B). There also appears to be a declining trend in frequency (number) of houses sold over the years, specifically in recent years. Highest numbers of houses sold in 1999. This suggests that due to some unobservable factor(s) demand for houses and thus housing price may differ in different time periods over the years. Thus, the idea of this exploratory analysis is to observe the association between housing price and its related characteristics both with internal and external factors.

We observe that housing price is negatively impacted by the mortgage rate (see Table-2) during the time period considered in this study. However, the impact is much more for the two months lag than other time periods. Economic cycle has opposite (positive) impact on the housing price ($r = 0.051$, $p < 0.01$). Age of the property and the property price are negatively correlated both at first order ($r = -0.331$, $p < 0.000$) and second order ($r = -0.242$, $p < 0.000$). However, the rate of change decreases as the order increases, which is much visible in the regression model (see Table-3) and thus supporting our hypothesis of differences in housing price is due to differences in its characteristics that are time dependent. Similar but opposite results also observed between the relationship of housing price and the condition of the property ($r = 0.331$, $p < 0.000$).

The regression model that analyses the association of housing price with other factors has a coefficient of determination (R^2) is 0.25 with highly significant F value. Results indicate that age of the property in general impact the housing price negatively (see, Table 3). As for example, for each additional year the price of the house decreases about $921.90 dollars. On the other hand, better condition of the property impacts housing price much more positively. Analysis also reveals that in good economic cycle houses are sold about $7,358.91 more than in poor economic environment. There is some monthly seasonality also observed, however none of them were statistically significant.

In addition to the property characteristics, external factors also affect the housing price differently given that which time period they belong. Specifically, after controlling for lot size, bedrooms, bathrooms, square footage, etc., mortgage rate has impact on the price of the house negatively after two months delay. Another interesting finding is that economic cycle impact housing price differently at different time periods. For example, during 1998 and 1999 both the frequencies (quantities) and average price of houses were comparatively higher. A number of possible explanations can be explored for this time dependent quantity and price of houses. However, considering that most of the time series has some inherent serial correlation properties direct comparison may be complicated. Nonetheless, this study suggests that housing price is time dependent and more specifically the time effect is significantly substantial during good economic condition even after adjusted for inflation.

Table 3: Regression results of Sales Price on Internal/External Factors.					
Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	23	2.536255E12	1.102719E11	31.50	<.0001
Error	2208	7.72912E12	3500507115		
Corrected Total	2231	1.026537E13			
R-Square	0.2471		**Adj R-Sq**	0.2392	
Variables	**DF**	**Parameter Estimates**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	-391.10081	43013	-0.01	0.9927
MtgRate_Lag2	1	-2054.71089	1188.77212	-1.73	0.0841
Econ_Cycle	1	7358.90574	2767.20696	2.66	0.0079
Condition	1	119646	34976	3.42	0.0006
Bedrooms	1	6639.23710	11787	0.56	0.5733
Bathrooms	1	5801.81488	4757.86877	1.22	0.2228
Totbldgft	1	27.36675	3.27052	8.37	<.0001
Gsqft	1	26.73983	7.83324	3.41	0.0007
LotSqft	1	2.63922	0.32241	8.19	<.0001
Age	1	-921.90586	240.44101	-3.83	0.0001
AgeSq	1	7.67637	1.99204	3.85	0.0001
BedSq	1	-1696.04134	1700.98162	-1.00	0.3188
BathSq	1	-1102.29053	726.14302	-1.52	0.1292
FEB	1	-7637.12205	7840.85098	-0.97	0.3302
MAR	1	-4294.97492	7230.32434	-0.59	0.5526
APR	1	-7711.56225	7279.70209	-1.06	0.2896
MAY	1	-1783.92537	6588.65743	-0.27	0.7866
JUN	1	-3539.57184	6543.48015	-0.54	0.5886
JUL	1	-3256.49501	6527.49351	-0.50	0.6179
AUG	1	-2244.42051	6615.26948	-0.34	0.7344
SEP	1	119.46288	6863.64024	0.02	0.9861
OCT	1	-6787.02237	6797.18640	-1.00	0.3181
NOV	1	-1353.05201	6998.22811	-0.19	0.8467
DEC	1	1007.41377	7518.23227	0.13	0.8934

CONCLUSION

In this paper we study the complex nature of housing market dynamics and examine the factors' time dependent effect on the housing price. Specifically, we have observed statistical significance and magnitude of time dependent factors on the "selling price of a house". As expected, after controlling for lot sizes, bedrooms, bathrooms, square footage, etc., higher mortgage rate is found to be instrumental in affecting the housing price negatively with a two months delay and therefore unraveling some of the cross-correlation effect of market dynamics. This suggests that mortgage rate's influence on the housing value in this sub-population of

neighborhoods is time dependent. Therefore, the results indicate that in addition to the internal property characteristics, external factors also affect the housing price differently given that which time period they are considered. In particular, after adjusted for internal factors, mortgage rate impacts the price of the house negatively at two months lag. This specific lead-lag association between mortgage rate and housing price is an important finding of this paper. In addition, although the data indicate much variability in the property prices at different time periods, effect is substantially positive even after adjusted for inflation during economic accession. Therefore, we may conclude that after controlling for internal factors and adjusted for inflation, external factors affect the price of housing differently depending on the time period they exist. Thus, this research provides evidence for market participants and regulators to identify and understand some of the cross-correlation dynamics in the housing market environment and may be valuable to understand future possible economic turmoil.

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