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# *The Spillover Effect of Stock Market Sentiment Intensity and Uncertainty on Housing Market in the United States*

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***Abstract:*** Investor sentiment is a key indicator of market performance. Many have studied how investor sentiment affects market returns or returns of different categories of stocks. Besides, many also studied how information revealed in media can affect the housing market. This paper focuses on the sentiment revealed in social media, Tweet, by combining these two key factors that have not been studied. This paper studies the spillover effect of stock market sentiment on the housing market by applying Vector Autoregression. The VAR model helps explain the relationship between housing prices and stock market sentiment from tweets, where sentiments are divided into sentiment intensity and sentiment uncertainty. The series of sentiment intensity and series of housing prices interact with each other, and the change in sentiment in the last period spills over to the housing market which affects housing prices, but the change in housing price does not affect sentiment in reverse. Similarly, the series of sentiment uncertainty and the series of housing prices interact with each other, and the change in sentiment diversity in the last period also spills over to the housing market which affects housing prices, but the change in housing price does not affect sentiment in reverse.

***Keywords:*** Sentiment intensity, Sentiment Uncertainty, Stock market, Housing price, Spillovers

## 1. Introduction

Investment sentiment is an essential aspect of investment decisions. There are many literatures study how investor sentiment affects the financial market. Brown and Cliff studied how investor sentiment affects the near-term future stock return, Baker, Wurgler, &Yuan focused on how global and local sentiment can be a contrarian predictor of market returns [1,2]. Besides the stock market, many other literatures studied the effect of investing sentiment on more general international stock market and specific markets including the bond markets in different countries [3-5]. Zheng & Osmer were the first to connect investor sentiment to housing market and studied the spillover effect of the stock market sentiment on housing prices [6]. They used the Baker and Wurgler index as a proxy for investors' sentiment, which measures the stock market sentiment felt by both institutional and individual investment [7].

Besides investor sentiment, information revealed in media is also a key factor that will affect the housing market. Soo quantified sentiment in news media to study the predictive power of sentiment on housing prices and found that housing media sentiment have predictive power for future housing prices [8]. With social media becoming an indispensable part of everyday life, it becomes increasingly

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used as a new factor in studying its implication for the financial market, for example, Gjerstad, Meyn, & Molnar studied the impact of President Trump's on the US and Chinese financial markets [9].

By combining social media and investor sentiment, this paper studies the spillover effect of stock market sentiment revealed in social media on the housing market. Different from Zheng & Osmer, this paper quantifies sentiment in stock market tweets from 2015 to 2019 as a measure of sentiment, and adopts a vector autoregressive method to measure the relationship between stock market sentiment and house prices [6]. This paper can supplement the existing literature and open up a new perspective for studying the impact of emotion on the housing market. Different from the sentiment measured by the Baker and Wurgler index which contains views from professional institutional and individual investors, the sentiment collected from stock market tweets not only reflects institution and individual investors' sentiments, but also contains perspectives from people who did not invest but simply a bystander. In this way, the sentiment measured from stock market tweets may reflect more comprehensive sentiment towards the stock market, and is less likely biased by investors' emotions.

## 2. Methodology

### 2.1. Research design

This paper studies the spillover effect of the stock market sentiment on housing markets by using the housing price index from Federal Reserve Economic Data following Zheng & Osmer. However, when using the sentiment index collected from investors, this sentiment includes information about the general stock market, which can affect housing prices because both will be affected by macroeconomic conditions. This paper collects sentiment from stock market tweets from the Hugging Face website, by using sentiments that not only include investors' but also bystanders', for example, some may post tweets simply to attract more attention to their posts. Therefore, this sentiment reflected in the stock market tweet is more than the general market condition, but still, sentiment can affect other people's decisions and thus affect housing prices. This paper uses the VAR Model to first check the relationship between sentiment and housing prices, and checks their causal relationships with the Granger Causality Test.

### 2.2. Data Collection

The three primary data are the housing price index, stock market sentiment intensity, and stock market sentiment uncertainty. For the housing price data at the national level, this paper uses the S&P/Case-Shiller U.S. National Home Price Index from 2015 to 2019 from Federal Reserve Economic Data, which can represent aggregate housing price change in the United States. This paper uses this data for housing prices because it is used in much previous literature. Moreover, this is monthly data that allows the spillovers to generate effect and also catches the changes in the market.

For data on stock market sentiment in the United States, this paper uses the sentiment collected from stock market tweets from 2015 to 2019 from Hugging Face website. There are three reasons for choosing sentiment collected from stock market tweets. First, social media now plays an important role in monitoring the latest public opinion. Second, social media can reflect a more factual sentiment of the stock market directly from people's comments about it. Third, stock market tweets include the opinions of people who did not invest themselves. These sentiments are more objective because these non-investors will not be affected by personal emotion; for example, when the money lost is the majority of the asset owned by an investor, he may be more pessimistic about the market.

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## 2.3. Data processing

To extract sentiment from the stock market tweets, python TextBlob library is applied for sentiment analysis. To exclude noises in the tweets that do not provide sentiment related to the market, all special symbols, including mentions symbols, URLs, and any additional white spaces, are removed. After getting the clean text, the TextBlob package is used to do the sentiment analysis. TextBlob breaks down text into smaller units and analyzes each element to determine the sentiment expressed. TextBlob measures sentiment ranging from -1, very negative, to 1, very positive.

The monthly average of all sentiments is used to measure the sentiment intensity. As there are many tweets in one day, the mean of all sentiment in a month represents the overall distribution of the sentiment. The sentiment uncertainty is measured by the variance of all tweets in one month. This is because the variance represents the diversity of people's sentiments. The users will have different opinions about the stock market, which will cause uncertainty, so this will affect the market prediction, making it harder to have a consistent conclusion about the stock market. Table 1 shows the summary statistics of the three key variables in this paper.

Table 1: Summary of Key Variables

| Variables | Observation | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| Housing Index | 61 | 190.913 | 14.209 | 168.052 | 213.906 |
| Sentiment Intensity | 60 | 0.0857 | 0.00602 | 0.0723 | 0.0985 |
| Sentiment Uncertainty | 60 | 0.0638 | 0.00195 | 0.0600 | 0.0690 |

To show the change in sentiment intensity and uncertainty more clearly, Figure 1 and Figure 2 are the changes in these two variables over the 5 years form 2015 to 2019.

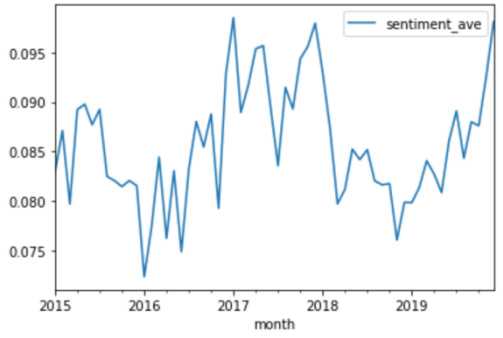


Figure 1: Change in sentiment intensity

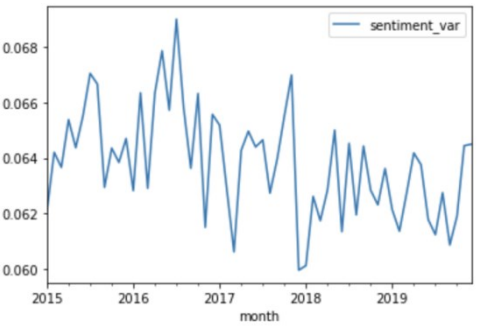


Figure 2: Change in sentiment uncertainty

From Table 1, the minimum value for sentiment intensity is 0.0723, which means all monthly average values of sentiment intensity are positive. This implies that the overall sentiment revealed in the stock market tweets is positive, and there are more positive opinions compared to negative opinions towards the market. Figure 1 shows that in 2017 and 2018, the average sentiment was higher, showing during this period, the general economic condition was good, and the market performed better. Moreover, Figure 2 shows that the variance of sentiment fluctuates a lot, meaning the diversity of people's sentiment changes quickly, showing the uncertainty of the market.

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### 2.4. Model

Since housing returns and sentiment affect each other over time, this paper uses a vector autoregressive model, which can test whether changes in sentiment affect housing returns and whether such changes in housing returns affect consumer sentiment. The model is written as a linear equation with housing return ($y_t$) and sentiment ($x_t$):

$$y_t = C_{10} + \sum_{j=1}^{6} \beta_{1j} y_{t-j} + \sum_{j=1}^{6} \gamma_{1j} x_{t-j} + \epsilon_{yt} \quad (1)$$

$$x_t = C_{20} + \sum_{j=1}^{6} \beta_{2j} y_{t-j} + \sum_{j=1}^{6} \gamma_{2j} x_{t-j} + \epsilon_{xt} \quad (2)$$

Sentiment intensity and sentiment uncertainty are used as independent variables and run the VAR with housing returns respectively. The lag of 6 used in the model is the optimal lag selected through AIC. And Granger's Causality Test is used to test if the two variable series will influence each other. Moreover, to make sure the data of the housing index and sentiment are stationary, both housing index and sentiment have dealt with the first differencing twice.

The result of VAR shows if the change in sentiment and the change in housing price are related to each other, which proves the interaction of stock market sentiment on the housing market. And the result of Granger's Causality Test proves the past value of stock market sentiment caused the change in the housing price today.

## 3. Results

### 3.1. Result analysis of sentiment intensity

#### 3.1.1. Vector Autoregression Analysis of Relationship Between Sentiment Intensity and Housing Price Index

Table 2: General VAR Result of Sentiment Intensity and Housing Price Index

| Equation | Parms | RMSE | R-sq | Chi2 | P>chi2 |
|---|---|---|---|---|---|
| Housing Price | 13 | 0.140 | 0.3564 | 28.800 | 0.004 |
| Sentiment Intensity | 13 | 0.005 | 0.7087 | 126.501 | 0.000 |

Table 2 shows the general result of the Vector Autoregression of the housing index against sentiment intensity. The overall p-value of the housing index is 0.004, and the p-value of sentiment intensity is 0.00, showing the series of housing index and series of sentiment intensity have a direct interaction. This means the distribution of overall stock market sentiment has a significant relationship with the housing price. One explanation for this interaction is that investors may view housing as a safer asset during times of pessimism, thus shifting their investment in the stock market to the real estate market. This result proves the assumption that the spillover of stock market sentiment will affect the housing market significantly.

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Table 3: Coefficients and p-values of VAR of Sentiment Intensity and Housing Price Index

| Dependent Var | Housing Price Index | | | | Sentiment Intensity | | | |
|---|---|---|---|---|---|---|---|---|
| Independent Var | Housing Price | | Sentiment Intensity | | Housing Price | | Sentiment Intensity | |
| | coefficient | P>\|z\| | coefficient | P>\|z\| | coefficient | P>\|z\| | coefficient | P>\|z\| |
| Lag 1 | -0.039 | 0.761 | 8.488 | 0.019 | -0.003 | 0.552 | -0.997 | 0.000 |
| Lag 2 | 0.084 | 0.497 | 2.048 | 0.697 | 0.001 | 0.893 | -0.989 | 0.000 |
| Lag 3 | -0.133 | 0.275 | 5.066 | 0.385 | -0.009 | 0.050 | -0.765 | 0.000 |
| Lag 4 | 0.201 | 0.109 | 3.264 | 0.572 | 0.007 | 0.137 | -0.616 | 0.004 |
| Lag 5 | -0.258 | 0.048 | 4.941 | 0.324 | 0.005 | 0.302 | -0.273 | 0.138 |
| Lag 6 | -0.358 | 0.005 | 2.311 | 0.502 | -0.008 | 0.103 | -0.209 | 0.098 |

To find how specifically a lag value of x_j affects the y_j in the equation, the p-values of each lag tell if there is a significant relationship between y_j and a particular lag value of x_j. First, the change in the housing price today is significantly related to the change in housing prices five and six months ago at a 95% significance level. The coefficients of lag 5 and lag 6 show the increase in housing prices five months ago of 1% is associated with a 25.8% decrease in housing prices today, and the increase in housing prices six months ago of 1 percent is associated with a 35.8% decrease of housing price today. This relationship can be explained as that in real life, when the housing price increases, it may take some time for consumers to realize the price increases and start buying less. Therefore, after several months, the housing price drops due to a decrease in demand.

Second, the changes in housing prices are significantly related to the changes in sentiment intensity a month ago at a 95% significant level. The coefficient of housing price on sentiment in lag 1 shows the increase in sentiment intensity change of 1% one month ago is associated with an increase in housing price change of 8.5%. This means a little increase in positivity towards the stock market in the past month is related to a lot of increases in housing prices today. Unlike the housing price in responding to past housing prices, the stock market sentiment quickly transmits into the housing market. This can be due to the fact that social media will spread the market sentiment to consumers quickly and thus affect people's decisions in the housing market. For example, when the stock market situation is optimistic and investors earn more money, they may spend in the real estate market, raising housing prices.

Third, the change in sentiment intensity is significantly related to the third lag of change in housing price at a 95% significant level, and the coefficient shows the increase of housing price of 1% is associated with the decrease of sentiment change for 0.009%. Even though this is a slight change in sentiment, this implies the change in housing price will have some lagged effect on stock market sentiment. Finally, most of the lagged sentiment values are significant, meaning the past sentiment will affect the sentiment today. This is true in real life, that consumer sentiment will affect their future expectation, and thus also affect the future sentiment towards the stock market.

### 3.1.2. Analysis of Granger test results of Sentiment intensity and housing index

Table 4: Granger Causality Test of Sentiment Intensity and Housing Price Index

| Equation | Excluded | Chi2 | Df | P>Chi2 |
|---|---|---|---|---|
| Housing Price | Sentiment Intensity | 12.08 | 6 | 0.06 |
| Sentiment Intensity | Housing Price | 9.5199 | 6 | 0.146 |

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The result of Granger Causality Test in Table 4 shows that at a 90% significant level, changes in the stock market sentiment causes changes in housing prices. That is, the prediction of change in the housing index is improved by incorporating changes in stock market sentiment. As the other direction is not significant, a change in housing prices does not cause a change in stock market sentiment, but a change in stock market sentiment leads to a change in housing prices. This is reasonable because a high positive sentiment implies the stock market performs well, which brings the general economy better, and as housing can be seen as a business cycle, housing prices will increase [10]. Therefore, this Granger Causality Test proves that overall, the past value of stock market sentiment is a good predictor of the housing price.

## 3.2. Result analysis of sentiment uncertainty

### 3.2.1. Vector Autoregression Analysis of Relationship Between Sentiment Uncertainty and Housing Price Index

Table 5: General VAR Result of Sentiment Uncertainty and Housing Price Index

| Equation | Parms | RMSE | R-sq | Chi2 | P>Chi2 |
|---|---|---|---|---|---|
| Housing Price | 13 | 0.135 | 0.4017 | 34.9071 | 0.001 |
| Sentiment Intensity | 13 | 0.0023 | 0.7559 | 161.0566 | 0.000 |

From Table 5, the overall p-value of both the change in housing price and the change in sentiment uncertainty is 0.00, showing the series of housing index and series of sentiment uncertainty has a direct interaction. This means the change in the housing price index is significantly related to the change in stock market sentiment diversity, in which a change in one of them is associated with a change in another. This proves the assumption that the spillover of stock market sentiment will affect the housing market.

Table 6: Coefficient and p-values of VAR of Sentiment Uncertainty and Housing Price Index

| Dependent Variables | Housing Price Index | | | | Sentiment uncertainty | | | |
|---|---|---|---|---|---|---|---|---|
| Independent Variables | Housing Price | | Sentiment uncertainty | | Housing Price | | Sentiment uncertainty | |
| | coefficient | P>\|z\| | coefficient | P>\|z\| | coefficient | P>\|z\| | coefficient | P>\|z\| |
| Lag 1 | 0.155 | 0.209 | 15.815 | 0.051 | 0.000 | 0.922 | -1.456 | 0.000 |
| Lag 2 | -0.117 | 0.348 | 4.697 | 0.734 | -0.005 | 0.029 | -1.592 | 0.000 |
| Lag 3 | 0.103 | 0.444 | 22.618 | 0.186 | -0.003 | 0.235 | -1.390 | 0.000 |
| Lag 4 | -0.012 | 0.932 | 9.451 | 0.588 | -0.001 | 0.601 | -1.126 | 0.000 |
| Lag 5 | 0.029 | 0.812 | 9.697 | 0.500 | -0.002 | 0.234 | -0.665 | 0.007 |
| Lag 6 | -0.440 | 0.000 | -3.575 | 0.708 | 0.002 | 0.256 | -0.138 | 0.399 |

To find how specifically a lag value of x_j, sentiment uncertainty, affects the y_j, housing price, in equation (1), the p-values of each lag in Table 6 tell if there is a significant relationship between y_j and a certain lag value of x_j. First, the sixth lag value of housing price is significantly related to the housing price today with a p-value of 0.00. This correspondence with the result in Table 3 that the fifth and sixth lag values of housing prices are significantly related to housing prices today. Both results imply the past housing price will affect future housing prices with a lag of about six months.

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Second, the first lag of sentiment uncertainty is significantly associated with the change in housing price at a 90% significant level, which means an increase in the change of sentiment uncertainty of 1% is associated with the increase in housing price of 15.8%. When people have different opinions towards the stock market situation, housing prices will increase in the very near future. This relationship can be interpreted as that high diversity of opinion usually accompanies the uncertain market situation, so people would like to invest in a more stable asset, which is real estate. Thus, housing prices increase quickly with rising demand.

While Table 6 shows that the lagged values of housing prices do not influence the sentiment uncertainty, it is worth noticing that the sentiment uncertainty today is significantly related to sentiment uncertainty in the past up to 5 months. Moreover, the coefficient of sentiment uncertainty becomes smaller when the lag value decreases, showing that the past uncertainty towards the stock market will lead to more uncertainty in the future. This is reasonable in real life because high uncertainty means that the stock market is very volatile or the market is not so optimistic. Therefore, with this low expectation, the future market conditions will become worse, resulting in higher uncertainty.

### 3.2.2. Analysis of Granger test results of Sentiment Uncertainty and housing index

Table 7: Granger Causality Test of Sentiment Uncertainty and Housing Price Index

| Equation | Excluded | Chi2 | Df | P>Chi2 |
|---|---|---|---|---|
| Housing Price | Sentiment Intensity | 16.923 | 6 | 0.010 |
| Sentiment Intensity | Housing Price | 10.523 | 6 | 0.104 |

The result of the Granger Causality Test in Table 7 shows that at a 99% significant level, changes in stock market sentiment uncertainty cause changes in housing prices. In summary, the change in housing price does not cause a change in stock market sentiment uncertainty, but a change in stock market sentiment uncertainty leads to a change in housing price. Therefore, the prediction of change in the housing index is improved by incorporating change in stock market sentiment uncertainty. One explanation for this pattern is that when stock market sentiment is uncertain and changes a lot, this implies the whole market is experiencing volatility. And under this situation, investors will seek more stable assets like real estate and thus cause the change in housing prices.

## 4. Conclusion

This paper studies the spillover effect of stock market sentiment on the housing market by using Vector Autoregression. Different from existing literature, this paper uses the stock market tweets to extract sentiment values, and specially divides the sentiment into two different categories: sentiment intensity and sentiment uncertainty. First, this study finds that sentiment intensity and housing prices have a direct interaction with each other. However, only a change in sentiment intensity will cause the change in housing prices, that more positive sentiments will cause the housing prices to increase. This is reasonable because a high positive sentiment implies the stock market preforms good, which bring the general economy preforms better, and as housing can be seen as business cycle, so housing price will increase. Second, this study shows sentiment uncertainty and housing prices have a direct interaction with each other, but only a change in sentiment uncertainty causes a change in housing price. The result shows when sentiment is more diverse, housing prices will increase. One explanation for this is when sentiments are very diverse, the market situation is uncertain, so people may invest in more stable assets, such as real estate, which drives up housing prices.

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This paper studies the effect of average sentiment intensity and sentiment uncertainty on housing prices, for how specially changes in negative sentiment and changes in positive sentiment affect the housing prices differently, this needs future research. Moreover, imposed response analysis will be used in the future to find the time path of housing prices and the stock market sentiment in response to shocks in the economy.

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