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Abstract

This study examines the information diffusion process in the U.S. Real Estate Investment Trust (REIT) market with a focus on the impacts of changing market environments, information supply, and information demand on the lead-lag effect. The results suggest that a significant lead-lag relationship exists between the lagged returns of big REITs and the current returns of small REITs. This relationship has slightly decreased along with policy and environment changes that occurred in the U.S. REIT market during the study period from 1986 to 2012, while still remaining significant in the most recent REIT market. The process of information diffusion is becoming unstable in recent years and the reverse lead-lag effect from small REITs to big REITs is observed especially when REIT market liquidity and return volatility are high. The lead-lag effect among REITs is driven largely by slow adjustment to negative information, which is magnified by a lack of information supply, especially as demand for such information increases. Finally, information flow from REITs with more media coverage to those with less media coverage becomes even more sluggish than the information flow from big REITs to small REITs.

KEYWORDS: information diffusion, lead-lag effect, REIT, media coverage, information demand

Introduction

The spread of new information is assumed to take place instantaneously among assets via rational market participants involved in complete and frictionless financial markets. However, Hong and Stein (1999) posit that this information actually diffuses gradually among investors, causing an observed predictability of return (i.e., lead-lag effect). A number of studies (Lo & MacKinlay, 1990; Brennan, Jagadeesh, & Swaminathan, 1993; Badrinath, Kale, & Noe, 1995; Hou, 2007; Cohen & Frazzini, 2008; Chordia & Swaminathan, 2010; Menzly & Ozbas, 2010; Shahrur, Becker, & Rosenfeld, 2010) not only provide evidence of a slow diffusion of value-relevant information but also suggest that the factors that cause this phenomenon include incomplete markets and limited stock market participation, asymmetric information, noise traders, limited investor attention, transaction costs, short-sale constraints, and legal restrictions.

Hou (2007) found that the lead-lag effect caused by slow information diffusion between big firms and small firms is predominantly an intra-industry phenomenon. In fact, examination of the lead-lag effect could be contaminated if companies under study tend to respond to different sets of information; thus, it is important to examine the lead-lag effect with companies that are expected to share a substantial amount of value-relevant information. Hou (2007) also suggested that the lead-lag effect is more pronounced in industries that are smaller, less competitive, and often neglected (e.g., industries to which less analyst attention is directed), such as the REIT industry.[1] Moreover, as REIT stocks are relatively homogeneous, they provide a well-controlled laboratory to examine the intra-industry lead-lag effect caused by the slow diffusion of value-relevant information.

The structural changes experienced by the REIT industry in the past two decades further suggests the need for a closer examination of time-series changes regarding the process of information diffusion in the REIT market. The tax legislation included in the Omnibus Budget Reconciliation Act of 1993 (effective January 1, 1994) modified the "five or fewer" rule[2] to allow each institutional beneficiary (e.g., a pension plan beneficiary rather than the pension fund itself) to be considered an individual REIT shareholder, thus encouraging more institutional investors, such as pension funds, to make large investments in the REIT industry. Another important structural change in the REIT industry after 1993 was the increase in the number of REITs that specialized in distinct types of property (i.e., specialized REITs), a trend that may have affected the process of information diffusion in the REIT market. The National Association of Real Estate Investment Trusts (NAREIT) changed the accounting guideline for Funds from Operations (FFO), thus bringing increased transparency to the REIT industry (Higgins, Ott, & Van Ness, 2006). In addition, the REIT Modernization Act (RMA) of 1999 allowed REITs to own taxable REIT subsidiaries and provide additional services to tenants and others while also reducing the

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1 Chui, Titman, and Wei (2003) reported that the average market capitalization of REIT stocks was $166 million in the 1980s and $616 million in the 1990s, while the average market capitalization of common stocks was $9.9 billion in the 1980s and $27.0 billion in the 1990s. Moreover, the average number of analysts following REITs was found to be 2.17 in the 1980s and 2.45 in the 1990s, while that average for common stocks was 21.76 in the 1980s and 22.86 in the 1990s.

2 The "five or fewer" rule refers to the original 1960 REIT legislation, which stated that REIT income would be taxed if five or fewer individuals owned more than 50% of the REIT. This rule, which was intended to ensure diversified ownership, made it difficult for large investors, including institutions, to participate in REITs.

distribution requirement of REITs from 95% to 90%. This enactment of the RMA is expected to have a significant long-term impact on future growth, profitability, and risk in the REIT industry, as shown in Mori and Ziobrowski (2011).

It is plausible to expect that information supply (e.g., media coverage) and information demand (e.g., Internet searches) affect the process of information diffusion, especially in a more neglected industry such as the REIT industry, because finance studies have suggested that media coverage (Tetlock, 2007; Tetlock, Saar-Tsechansky, & Macskassy, 2008) and information demand (Veldkamp, 2006; Vlastakis & Markellos, 2012) affect levels of informational friction and security pricing.

This study examines (1) whether a significant lead-lag effect is evident among REIT stocks, (2) whether and how policy and environmental changes that have occurred over the last two decades in the REIT market have affected the ongoing process of information diffusion among REIT stocks over time, and (3) how information supply and information demand affect the process of information diffusion among REIT stocks. Implications from the finance literature on the topics of information diffusion, the unique characteristics of the REIT market, and the drastic policy and environmental changes that have occurred in the REIT market over the past two decades all clearly suggest the importance of precisely understanding the process of information diffusion in the REIT market. This study contributes to that gap in the existing literature by shedding new light on the information efficiency and transparency of the REIT market. Also, this study is the first to examine the time-series change of the information diffusion in the growth stage of the market and possible impacts of information supply and information demand on the process of information diffusion.

The results of this study suggest, first of all, that there is a significant lead-lag relationship between the lagged returns of big REITs and the current returns of small REITs, caused by the sluggish flow of information. This lead-lag relationship has slightly decreased along with policy and environment changes that are thought to have brought more informational efficiency to the U.S. REIT market. However, the lead-lag effect remains significant, suggesting that information continues to flow sluggishly from big REITs to small REITs, even at the level of informational efficiency apparent in the recent REIT market. It is found that market volatility, institutional investor participation, market liquidity, and size of REITs affect volatility of the lead-lag effect. When the REIT market liquidity and return volatility are high, the reverse lead-lag relationship from small REITs to big REITs is occasionally observed. The lead-lag effect among REITs is driven more by slow adjustment to negative information than by slow adjustment to positive information; this is most evident when the supply of information relevant to real estate and REIT markets is decreasing and the demand for such information is increasing. Finally, the information flow from REITs with more media coverage to REITs with less media coverage is even more sluggish than the flow from big REITs to small REITs.

Literature Review

Perhaps the first study to offer empirical evidence of the lead-lag effect and its importance to stock-price dynamics in the general stock market was that of Lo and MacKinlay (1990), who were able to show that stock returns are often positively cross-autocorrelated; specifically, the returns of large-capitalization stocks almost always lead to returns for smaller stocks. They also demonstrated that most of the lead-lag effect is actually not driven by market microstructure effects such as nonsynchronous trading or thin trading, thus implying that some stocks react faster than others to new information that offers value implications across a range of stocks.

Following Lo and MacKinlay (1990), other studies on the lead-lag effect have further examined factors that potentially drive that slow diffusion. For example, Brennan, Jegadeesh, and Swaminathan (1993) showed that returns on firms followed by many analysts tend to lead to returns on firms followed by fewer analysts, even when firms of the two types are of approximately the same size. Badrinath, Kale, and Noe (1995) found that returns on the portfolio of stocks having the highest level of institutional ownership led to returns on stocks with lower levels of institutional ownership, even after controlling for firm size. Cohen and Frazzini (2009) found evidence of significantly predictable returns across customer-supplier firms and showed that the monthly strategy of buying firms whose customers had the most positive returns in the previous month and selling short those firms whose customers had the most negative returns yielded abnormal returns of 1.55% per month. Chordia and Swaminathan (2000) found that trading volume can be a significant determinant of the lead-lag patterns observed in actual stock returns. Similarly, Menzly and Ozbas (2010) found cross-predictability between economically related suppliers and customers, which tends to be weaker for stocks with high levels of analyst coverage and institutional ownership. Shahrur, Becker, and Rosenfeld (2010) found international evidence of the customer-supplier/lead-lag effect; specifically, they found that equity returns of customer industries led the returns of supplier industries in 22 developed countries.

Hou (2007) provided an extensive understanding of the nature of the process of information diffusion in the general stock market. Interestingly, Hou found that big firms lead small firms within the same industry, that this unique intra-industry lead-lag effect drives the overall lead-lag effect, and that the intra-industry effect is stronger in small, neglected, and concentrated industries. Hou also suggested that industry market share and analyst dispersion affect the lead-lag effect and that the intra-industry lead-lag effect is primarily driven by the sluggish response of firms to negative news regarding other firms.

The REIT literature also has examined the process of information diffusion, with a focus on the linkage between REIT returns and private (unsecuritized) real estate returns and on the contemporaneous linkage between REIT stocks. While Tuluca, Myer, and Webb (2000) showed that the private real estate market seems to lead the REIT market informationally in the long term, most of the existing studies on the linkage between REIT returns and private real estate returns have found that lagged REIT returns are useful in predicting private real estate returns (Giliberto, 1990; Gyourko & Keim, 1992; Barkham & Geltner, 1995; Chiang, 2009). Chiang (2010) examined whether co-movement of equity REIT prices has changed from the vintage REIT era (1980-1991) to the new era (1992-2004). These results show that REIT co-movement within the same property type indeed increased during the new REIT era and suggest that this higher degree of co-movement is due mainly to increasing institutional participation in the new REIT era.

Chung, Fund, Shilling, and Simmons-Mosley (2011) also examined REIT stock price synchronicity for the years 1997 through 2006. Their results indicate that synchronicity appears to be quite high, even in the relatively recent study period, especially among those REITs that are larger and more liquid. This finding may be due to the fact that larger REITs tend to be more homogenous and exhibit less firm-specific fundamental variation than smaller and less liquid REITs. They also found that synchronicity negatively relates to hedge fund ownership and is highest among industrial and regional mall REITs. Zhang and Deng (2010) suggested that contrarian profits can be partially explained by the lead-lag effects for hotel real estate stocks.

Chui, Titman, and Wei (2003) examined the time-series change of momentum effect in REITs during the pre-1990 and post-1990 periods to test the following two hypotheses: (1) if speed of information is affected by investor overconfidence, then a stronger momentum effect should be evident during the post-1990 period than during the pre-1990 period, and (2) if speed of information is determined by efficient information diffusion, then a stronger momentum effect should be found during the pre-1990 period. They found a stronger and more prevalent momentum effect in REITs for the post-1990 period, thus supporting the overconfidence hypothesis that speed of information is more affected by investor overconfidence than informational efficiency.

Recent finance literature has suggested the importance of both information supply (media coverage) and information demand (Internet searches) in understanding asset price dynamics. Tetlock (2007) analyzed the content of newspaper articles and reported that pessimistic media contents predict downward price pressure and a subsequent reversal. Tetlock, Saar-Tsechansky, and Macskassy (2008) showed that the proportion of negative words used in newspaper articles predicts earnings and stock returns. Veldkamp's (2006) model suggests the importance of the interaction between information supply and information demand in the context of asset pricing, showing that the demand for information used to price the asset affects the attractiveness of the asset. Vlastakis and Markellos (2012) suggested that information demand, measured via Internet search volume from the Google Trends database, is significantly related to stock return volatility, trading volume, return, and risk.

Financial contagion seems to affect the process of information diffusion from time to time. Although there still is a disagreement over a precise definition of financial contagion, contagion in equity markets refers to the notion that markets move more closely together during periods of crisis (Bekaert, Harvey, & Ng, 2005). Hasler (2012) defines contagion as a situation where return and volatility spread from one market over other fundamentally unrelated markets. Some of empirical studies found evidence that trade links help explain the pattern of contagion (Glick & Rose, 1999; Kaminsky & Reinhart, 2000). Other studies showed evidence to support the idea that U.S.-based mutual funds and commercial banks have played an important role in spreading shocks (Kaminsky, Lyons, & Schmukler, 2004; Caramazza, Ricci, & Salgado, 2000). Most recently, Hasler (2012) proposes that as a negative shocks hits one market, investors pay more attention so that news transmits more rapidly to the estimation of the fundamental driving that market, suggesting the possible link between information diffusion and financial contagion.

Data

The sample of equity REITs is taken from CRSP data files. The study period runs from January 1987 to December 2012. The year 1987 was chosen as the start date for the analysis for two reasons. First, fewer than 100 equity REITs were listed before 1987, making empirical analysis practically infeasible before that date. Secondly, the Tax Reform Act of 1986 (effective January 1987) increased the popularity of REITs, thus allowing REITs to gain self-advised and/or self-managed status instead of externally advised status. This change in management status reduced some of the conflicts of interest that had existed between REITs and their shareholders. After 1987, the number of equity REITs ranged from 89 in 1987 to 217 in 1997. The full sample consists of 363 equity REITs that reported stock return data in the CRSP databases at some point during the study period.

The analyses used in this study are based on weekly returns to mitigate confounding microstructure influences, such as bid-ask bounce and nonsynchronous trading. To mitigate a confounding day-of-the-week effect, weekly returns were calculated by compounding daily returns between adjacent Wednesdays, as in Hou (2007), because high autocorrelations using Friday-to-Friday prices and low autocorrelations using Monday-to-Monday prices were reported by Hou and Moskowitz (2005). Other price related data such as market capitalization and bid-ask spread are also from CRSP. The data for institutional holdings is from CDA/Spectrum Institutional Money Manager (13f) Common Stock Holdings, issued by the Thomson Financial Network.

Two types of media coverage data are utilized: one for the overall REIT market and the other for individual REITs. First, information on the number of relevant articles that appeared in the *Wall Street Journal* (WSJ) was gathered from the ProQuest-ABI/INFORM database, using the keywords “Real Estate,” “Real Estate Investment Trust(s),” and “REIT(s)” for each month from January 1986 to December 2012. This information serves as a proxy for the media coverage relevant to the overall U.S. REIT market. To examine impacts of media content on information diffusion, the total number of words in WSJ articles and the number of “positive” and “negative” words in WSJ articles in each month were also collected. The lists of positive words (353 words) and negative words (2,337 words) were taken from Bill McDonald’s Word Lists Page (http://www.nd.edu/~mcdonald/Word_Lists.html), which was created by Loughran and McDonald (2011) to better reflect expressions used specifically in financial context. Figure 1 summarizes the number of WSJ articles relevant to REITs and the proportions of positive and negative words to the total number of words in WSJ articles. As shown in Panel A of Appendix A, the average number of REIT-relevant WSJ article in each month for the overall period is 200.85, while the maximum number of article is 344 and the minimum number of article is 95. Panel A of Appendix A also shows that the average monthly number of negative word (3,364) is much larger than that of positive word (1,341). Second, information on the number of articles on each individual REIT was collected, using the full company name of each REIT for each year from 1986 to 2012. For each REIT, articles appeared in all sources covered by ProQuest-ABI/INFORM were examined because the *Wall Street Journal* had too few articles on too many REITs. Figure 2 shows the number of such articles per REIT for each year, along with the number of equity REITs in the study sample. Panel B of Appendix A shows that, on average, there has been 14 articles about each REIT in each year, while, at maximum, there were over 800 articles on one REIT (Prologis) in the year of 2011.

Demand for information relevant to REITs was measured by the number of Internet searches conducted within the U.S. with the keywords "Real Estate," "Real Estate Investment Trust(s)," or "REIT(s)" for each month from January 2004 to December 2012 taken from Google Trends.[3]

Descriptive Statistics

The methodology used by Hou (2007) was also used in the present study; REITs were sorted into three sizes of portfolios according to their end-of-June market capitalizations. Equal-weighted weekly returns were calculated for each portfolio from July of year t to June of year t+1 (i.e., portfolio constituents are updated annually at the end of June). The first- through fourth-order cross-autocorrelations between lagged returns on big firms and current returns on small firms, as well as the same cross-autocorrelations between lagged

[3] Google Trends contains the Search Volume Index (SVI) of search keywords. The weekly SVI for a search keyword refers to the number of searches for that keyword, relative to the highest number of searches over time. Data are available beginning in the year 2004. Google search behavior is considered a good representative of Internet search behavior among the general population. For example, Google accounted for 65.3% of all search queries performed in the U.S. during the month of September 2011.

returns on small firms and current returns on big firms, were calculated to reveal possible symmetric and asymmetric cross-autocorrelations.

Table 1 reports the summary statistics for the portfolios of the smallest 30% and the largest 30% of the REITs. The average return for small REITs (0.30%) was higher than that for big REITs (0.22%) for the overall period from July 1987 to June 2012 and for all three sub-periods. Small REITs exhibited more than double the return (0.24% per week) exhibited by big REITs (0.11% per week) for the earliest period, from July 1987 to June 1994. This difference decreased after 1994; for the latest period, which ran from July 2001 to June 2012, and the return was only slightly higher for small REITs (0.31% per week) than for big REITs (0.29% per week). It is interesting to note that the standard deviation of return for small REITs was smaller than that for big REITs in the two sub-periods following July 1994. The first-order autocorrelation decreases with size; $\rho 1$(Small, Small) is bigger than $\rho 1$(Big, Big) for the overall period and for the two sub-periods after July 1994, while the first-order autocorrelation is much higher for big REITs (0.24) than for small REITs (0.01) during the earliest period, from July 1987 to June 1994. Table 1 also reports the first- through fourth-order cross-autocorrelations. Further, $\rho m(j, k)$, m = 0 to 4, refers to the *mth* order correlation coefficient between returns on the *j* size-ranked portfolio (*j* = Small or Big) and returns on the *k* size-ranked portfolio (*k* = Small or Big). The cross-autocorrelations between lagged returns on big REITs and current returns on small REITs ($\rho m(Small, Big)$) were almost always greater than those between lagged returns on small REITs and current returns on big REITs ($\rho m(Big, Small)$), regardless of the number of lags and the sample period. These results imply that significant lead-lag effects are caused by a sluggish information flow from big REITs to small REITs.

The Lead-Lag Effect of Size Portfolios for the Overall Period

Finding evidence of asymmetric cross-autocorrelations is not sufficient to strongly support the information-based hypothesis for the lead-lag effect, because these cross-autocorrelation patterns could also be consistent with an alternative hypothesis based on time-varying expected returns (Conrad & Kaul, 1988; Boudoukh, Richardson, & Whitelaw, 1994; Hameed, 1997). The time-varying expected returns hypothesis explains that cross-autocorrelations between big firms and small firms (i.e., between lagged returns of big firms and the returns of small firms) are caused by a combination of high autocorrelations of small firms and a high contemporaneous correlation between big and small firms. This explanation suggests that the lead-lag effect will disappear once the lagged small-firm returns are controlled for effectively. To incorporate that control, the following vector autoregressions (VARs) were estimated:

$$R_{Small}(t) = \alpha_0 + \sum_{k=1}^{K} \alpha_k R_{Small}(t-k) + \sum_{k=1}^{K} b_k R_{Big}(t-k) + e_{Small}(t), \quad (1)$$

$$R_{Big}(t) = c_0 + \sum_{k=1}^{K} c_k R_{Small}(t-k) + \sum_{k=1}^{K} d_k R_{Big}(t-k) + e_{Big}(t). \quad (2)$$

In Equations (1) and (2), $R_{Small}(t)$ is the week **t** return on the portfolio of the smallest 30% of the REITs. $R_{Big}(t)$ is the week **t** return on the portfolio of the biggest 30% of the REITs. Equations (1) and (2) are estimated with one (K = 1) and four (K = 4) lags, following Hou (2007). Estimations with higher lags were done as a robustness check, which resulting the finding that there were no significant effects with lags beyond four lags in any model. If the lead-lag effect (if any) is driven by a sluggish diffusion of information from big firms to small firms, then lagged returns on big firms should predict current returns on small firms, even after controlling for the lagged returns of small firms (i.e., Granger causality), as evidenced by the significant positive coefficient of *b* in Equation (1). Also, the sum of the coefficients of R_{Big} (t-1 : t-k) in Equation (1) should be significantly different from zero and should be greater than the sum of the coefficients of R_{Small} (t-1 : t-k) in Equation (2); that is, $\sum_{k=1}^{K} b_k > \sum_{k=1}^{K} c_k$.

Table 2 summarizes the results of the VAR estimations. Table 2 shows that the sum of b_k is positive and statistically significant at the 1% level for both the four-lag (0.284, F = 16.270) and one-lag (0.199, t = 6.300) regressions for the full study period. This statistically significant positive relationship between the lagged return on big REITs and current return on small REITs is economically significant as well. For example, a 1% decrease in the previous week's return of big REITs leads to a 19.9 basis point decrease in the return of small REITs in the current week. Since the average standard deviation of the return on big REITs is 2.84% (see Table 1), a one standard deviation decrease in the return of big REITs leads to a decrease of more than 50 basis points in the weekly return of small REITs.

The F-statistic for the test, $\sum_{k=1}^{K} b_k = \sum_{k=1}^{K} c_k$, was also rejected at the 1% level and the 5% level for the four-lag (F = 7.100) and one-lag regressions (F = 16.250), respectively.

These results strongly suggest the existence of a statistically and economically significant lead-lag effect between big firms and small firms among U.S. REITs.

Time Series Change of Lead-Lag Effect of Size Portfolios

To examine whether and how the policy and environmental changes that occurred over the last two decades in the REIT market affected the process of information diffusion over time among REIT stocks, the lead-lag effect is estimated for each quarter, following one-lag vector autoregressions based on the weekly return on the size of portfolios:

$$R_{Small}(t) = \alpha_0 + \alpha_1 R_{Small}(t-1) + b_1 R_{Big}(t-1) + e_{Small}(t), \quad (3)$$

$$R_{Big}(t) = c_0 + c_1 R_{Small}(t-1) + d_1 R_{Big}(t-1) + e_{Big}(t). \quad (4)$$

Then, the time series of the lead-lag effect is measured by taking the difference between b_1 in Equation (3) and c_1 in Equation (4), which measures size of the expected lead-lag effect from big REITs to small REITs, while controlling for the reverse lead-lag effect from small REITs to big REITs. The results are summarized in Figure 3 and Table 3 for three sub-periods, defined by using July 1994 (considering the Omnibus Budget Reconciliation Act of 1993) and July 2001 (considering the change in the guidelines for FFO calculation in 2000 and the REIT Modernization Act of 1999) as the two break points. Table 3 shows that the expected lead-lag relationship between big REITs and small REITs was strongest during the earliest period (July 1987 to June 1994). Before 1994, the U.S. REIT industry was dominated by individual investors, and it is natural to imagine that the level of informational efficiency was very low at that time. Also, the information supply for U.S. REITs was very limited, as shown in Figure 2. Thus, information must have been diffused only slowly among REITs, resulting in a strongly significant lead-lag effect from big REITs to small REITs. During the second sub-period, from July 1994 to June 2001, the lead-lag effect declined by 47%. This result may indicate that information efficiency and transparency in the U.S. REIT market have increased over time, along with greater participation of institutional investors, an increased number of REITs, and increased media attention in the U.S. REIT market. However, Table 3 shows that the lead-lag relationship increased again for the period between July 2001 and June 2012. In fact, the ANOVA comparison of the mean of the lead-lag effect reveals no difference among three sub-periods ($F = 0.08$, $p = 0.926$), thus suggesting that information still flows sluggishly from big REITs to small REITs, even at the level of informational efficiency seen in the recent REIT market.

It is interesting to note that the standard deviation of the lead-lag effect is much larger (1.258) in the most recent period (between July 2001 and June 2012) than in earlier two sub-periods (0.777 and 0.768, respectively), as shown in Figure 3 and Table 3. In the most recent period, small REITs lead big REITs significantly in some quarters, while the expected lead-lag effect from big REITs to small REITs is also strongly evident in other quarters (Figure 3).

Reasons Behind Time Series Change of Lead-Lag Effect

To examine possible reasons behind this increased volatility of the lead-lag effect, Table 4 compares the lead-lag effect along with REIT market condition variables between the period after the second quarter of 2001 (Panel B) and the earlier period (Panel A). In fact, the two-group variance-comparison test finds that the variance of the lead-lag effect is significantly greater at the 1% level (F = 2.689) in the recent period than the earlier period, while there is no statistically significant difference in mean (t = 0.132). As shown in Panel B of Table 4, in the most recent period, the U.S. REIT market experienced increased market return volatility (***Index_std***), increased institutional investor share holdings (***Inst_ratio***), and decreased liquidity (***bidask***),[4] suggesting that the growing turmoil in the recent REIT market may have complicated the process of information diffusion among REIT stocks. Also, the size of the REIT market (***Mktcap***) as well as the size of individual REITs (***Small_size***, ***Big_size***) became significantly larger in the most recent period, implying that even relatively small REITs became big enough so that they attract investor attentions, occasionally leading bigger REITs.

The reverse lead-lag effect from small REITs to big REITs, represented by negative values of ***Diff_lead-lag***, is worth detailed investigation, since it has not been reported by prior studies and it occurs from time to time throughout the study period as shown in Figure 3. A regression is run focusing only on quarters in which small REITs lead big REITs (i.e., a dependent variable, ***Diff_lea-lag,*** takes negative values). Table 5 shows the result of the regression. The result shows that small REITs tend to lead big REITs when the market volatility is higher, institutional investor participation is lower, and the market liquidity is higher. In addition, this reverse lead-lag effect is more evident when the size of REITs including small REITs is larger. The result suggests that the reverse lead-lag effect is

[4] The bid-ask spread has widened especially during the credit crisis.

observed probably because some small REITs are big enough to attract investor attention (especially individual investors' attention) when the liquidity and volatility are generally high.

Impacts of Media Coverage and Media Content on the Lead-Lag Effect

To examine possible impacts of media coverage and content on the observed lead-lag effect, the whole sample period was first divided into two sub-periods based on media coverage, defined using the monthly number of REIT-relevant articles that appeared in the *Wall Street Journal* (WSJ) with the keywords "Real Estate," "Real Estate Investment Trust(s)," or "REIT(s)." All weeks within those months in which the number of articles increased from the previous month were defined as INCREASING media coverage weeks. Weeks of other months were defined as DECREASING media coverage weeks. The whole sample period was also divided into two sub-periods based on the media content, which was defined using the monthly proportion of positive (negative) words to the total words contained in REIT-relevant articles in the WSJ. All weeks within months in which the proportion of positive (negative) words increased from the previous month and the change in the proportion of positive (negative) was higher than the change in the proportion of negative (positive) words are defined as POSITIVE (NEGATIVE) news weeks. In Panel C, four sub-periods are defined based both on market media coverage (INCREASING or DECREASING) and media content (POSITIVE and NEGATIVE). For each sub-period, the following one-lag vector autoregressions (VARs), based on the weekly return on the size of portfolios, are estimated for the overall study period from July 1987 to June 2012:

$$R_{Small}(t) = \alpha_0 + \alpha_1 R_{Small}(t-1) + b_1 R_{Big}(t-1) + e_{Small}(t), \quad (5)$$

$$R_{Big}(t) = c_0 + c_1 R_{Small}(t-1) + d_1 R_{Big}(t-1) + e_{Big}(t). \quad (6)$$

Panel A of Table 6 first divides the whole sample period into two sub-periods based on the media coverage that is relevant to the overall REIT market. The relationship between the lagged return of big REITs and the current return of small REITs is statistically significantly greater than the relationship between the lagged return of small REITs and the current return of big REITs at the 1% level, only when the REIT market-wide media coverage is decreasing (F = 23.30, Panel A-2). This result implies that when the REIT market-wide media coverage is decreasing, information diffuses quickly more toward big REITs than toward small REITs, resulting in a significant lead-lag effect between big REITs and small REITs. At the same time, the speed of information diffusion becomes more homogeneous among all REITs when the market-wide media coverage is increasing, as indicated by the symmetric lead-lag relationship between big REITs and small REITs (Panel A-1). Note also that a significant negative relationship exists between lagged small REITs and current big REITs in Panel A-2. This negative relationship is simply a result of the fact that the relative speed of adjustment is measured for two portfolios. Brennan, Jagadeesh, and Swaminathan (1993) show that if returns on a small portfolio adjust more slowly to common information than returns on a big portfolio, then the slope coefficient for the lagged return on the small portfolio could be negative in regressions involving the big portfolio return as the dependent variable.

Panel B in Table 6 shows the results of VARs for two sub-samples as defined by the media content – a POSITIVE news sample (Panel B-1) and a NEGATIVE news sample (Panel B-2). The coefficient b_1 is positive and significant at the 1% level in both cases (0.179, t = 3.15 for POSITIVE; 0.134, t = 2.710 for NEGATIVE). The test $b_1 = c_1$ is also rejected in both cases (F = 5.800, significant at the 5% level for POSITIVE; F = 11.370, significant at the 1% level for NEGATIVE). The significance is greater with the NEGATIVE news sample in which the REIT-relevant WSJ articles contain an increasing number of negative words, suggesting that the lead-lag effect among REITs is driven more by a slow adjustment to negative information than a slow adjustment to positive information. This result is, to some extent, consistent with Diamond and Verracchia (1987) and Hou (2007), who argue that it takes longer for negative information than positive information to be fully incorporated into stock prices because investors cannot immediately short sell an overpriced security due to short-sale constraints and prohibitive shorting costs. In fact, short-sale constraints seem to be evident among REIT stocks, as Blau, Hill, and Wang (2011) showed that REITs are shorted less frequently than non-REITs and Chen, Downs, and Patterson (2012) showed that overvaluation of REITs is associated with greater short interest and less transparency. This slower price response to negative information may also be due to the fact that investors tend to become risk-seeking and hold losing stocks for too long (Odean, 1998).

Panel C of Table 6 defines four sub-periods based on both market-wide media coverage (INCREASING or DECREASING) and media content (POSITIVE or NEGATIVE). The results for VARs show that the lead-lag relationship between big REITs and small REITs is by far most significant when the market-wide media coverage is decreasing and the media reports more negative news (Panel C-4). The test $b_1 = c_1$ is rejected at the 1% level (F = 19.21). Thus, among small REITs, REIT prices show slow adjustment especially to negative information; further, this asymmetric information flow is magnified when REIT market-wide media coverage is decreasing (i.e., information supply is lacking).

Impacts of Media Coverage and Google Search on the Lead-Lag Effect

The finance literature suggests the importance of interaction between information supply (e.g., media coverage) and information demand (e.g., Internet searches) in asset pricings. Table 7 first divides the whole sample period into two sub-periods based on the media coverage, as was done in Table 6 (Panel A). Note that the analysis period for Table 7 is limited to the period between January 2004 and December 2012 due to the availability of Google Trends data. In Panel B, the whole sample period is divided into two sub-periods based on the information demand, which is defined using the monthly number of Internet searches conducted within the U.S. with the keywords “Real Estate,” “Real Estate Investment Trust(s),” or “REIT(s),” taken from the Google Trends database. All weeks within months in which the number of Google searches increased from the last month are defined as INCREASING Google search weeks. Weeks of other months are defined as DECREASING Google search weeks.

Panel A of Table 7 confirms, with a different analysis period, the robustness of the result that the slow diffusion of information, resulting in a significant lead-lag effect between big REITs and small REITs, is evident when the REIT market-wide media coverage is decreasing, as reported in Panel A of Table 6. Interestingly, Panel B of Table 7 shows the opposite impact of Google searches (information demand) on the information diffusion. As evident in the F1 that tests $b_1 = c_1$, the asymmetric lead-lag effect from big REITs to small REITs is significant at the 1% level only when demand for REIT-relevant information is increasing (Panel B-1). Panel C further reveals that the significant lead-lag effect is strongly evident when the media coverage is decreasing and Google searches are increasing. This result suggests that information diffuses sluggishly and selectively rather than symmetrically when investors demand relevant information that is lacking in markets. Even when information supply is decreasing, asymmetric information diffusion is not observed if investors do not demand such information.

The Lead-Lag Effect Among Media Coverage-Ranked Portfolios

Considering the general lack of media attention (i.e., information supply) in the REIT market compared to the general stock market, media coverage is expected to play an important role in the process of information diffusion, especially in the REIT market. Thus, to further examine the role of media coverage as a determinant of the lead-lag effect among REITs, REITs were first sorted into three size-ranked portfolios (bottom 30%, middle 40%, and top 30%) based on market capitalization at the end of June of each year **t**. Next, each size portfolio was sorted into three portfolios based on the number of articles found in the ABI/INFORM database that contained the company name of each REIT (bottom 30%, middle 40%, and top 30%) during each year **t-1**. Finally, the REITs from the three size portfolios with the same media coverage ranking were placed into a single portfolio. This process generated three media coverage-ranked portfolios while controlling for size. Equal-weighted weekly returns were computed for each portfolio from July of year **t** to June of year **t+1**. Four-lag (k = 4) and one-lag (k = 1) vector auto-regressions (VARs) were estimated based on the weekly return on the media coverage portfolios for the overall study period from July 1987 to June 2012:

$$R_{Less}(t) = \alpha_0 + \sum_{k=1}^{K} \alpha_k R_{Less}(t-k) + \sum_{k=1}^{K} b_k R_{More}(t-k) + e_{Less}(t), \tag{7}$$

$$R_{More}(t) = c_0 + \sum_{k=1}^{K} c_k R_{Less}(t-k) + \sum_{k=1}^{K} d_k R_{More}(t-k) + e_{More}(t). \tag{8}$$

In Equations (7) and (8), R_{Less}(t) is the week **t** return on the portfolio of REITs with the least media coverage at 30% (low coverage REITs), while R_{More}(t) is the week **t** return on the portfolio of REITs with the most 30% media coverage at 30% (high coverage REITs).

Table 8 shows that the lead-lag effect is significant at the 5% level, as evidenced in the *F*-statistic (4.42) for the test, $\sum_{k=1}^{K} b_k = \sum_{k=1}^{K} c_k$, with four-lag regressions, further suggesting that high-coverage REITs significantly lead low-coverage REITs when controlling for size. It is interesting to note here that this lead-lag effect for media coverage-ranked portfolios is not evident when only one lag is included (see Table 8), while the lead-lag effect with size-ranked portfolios is significant for both four-lag regressions and one-lag regressions (see Table 2). These results suggest that information will flow even more sluggishly from REITs with more media coverage to REITs with less media coverage than from large REITs to small REITs. Figure 4 confirms this argument. Figure 4 also shows impulse responses where the impulse variable is returns on big REITs (high coverage REITs) and the response variable is returns on small REITs (low coverage REITs) in Panels A and B, respectively. Panel A suggests that information flows from big REITs to small REITs with a one-week or three-week lag. Panel B suggests that information flows from high coverage REITs to low coverage REITs with both two-week and three-week lags.

Robustness Checks

Several additional analyses were conducted as robustness checks. First, analyses were done including all equity REITs, mortgage REITs, and hybrid REITs (total sample size = 476 REITs). Second, equal-weighted size-ranked and media coverage-ranked portfolios were replaced with value-weighted portfolios. These different sample and portfolio formations did not change any major conclusions or interpretations of the study.

In examining roles of information supply and information demand on the process of information diffusion, the keywords of “Real Estate,” “Real Estate Investment Trust(s),” or “REIT(s) were used. Information attached to the keyword of “Real Estate” may be too general and may not be relevant to REITs. The analyses were done excluding the keyword of “Real Estate” in counting the numbers of WSJ articles and google searches. These analyses did not change the conclusions.

Finally, Tables 6 and 7 show the results based on one-lag vector autoregressions. Since market conditions are defined using monthly data (e.g., monthly numbers of WSJ articles and google searches), it is possible to estimate four-lag vector autoregressions for these sub-samples. The robustness checks based on four-lag vector autoregressions show the same results in examining impacts of media coverage and media content on the lead-lag effect (Table 6). The four-lag based analysis that examines impacts of media coverage and Google search on the lead-lag Effect (Table 7) shows the same results except for one situation. In Panel C-4 of Table 7, there is no significant expected lead-lag effect from big REITs to small REITs when both media coverage and google search are decreasing based on the one-lag analysis as shown by small F-value (0.160). However, the four-lag analysis for the same situation shows that small REITs significantly lead big REITs when both media coverage and google search are decreasing.

Discussion and Conclusions

Given the unique characteristics of the REIT market and the drastic policy and environmental changes that have occurred within it over the last two decades, this study examined (1) whether a significant lead-lag effect is evident among REIT stocks, (2) whether and how policy and environmental changes in the REIT market over the last two decades have affected the ongoing process of information diffusion among REIT stocks over time, and (3) how information supply and information demand affect the process of information diffusion among REIT stocks. The results first suggest that there is a significant lead-lag relationship, driven by the sluggish flow of information, between the lagged returns of big REITs and the current returns of small REITs. This significant lead-lag relationship is evident even in the most recent period, from 2001 to 2012, while the process of information diffusion is becoming unstable, sometimes resulting in the reverse lead-lag relationship from small REITs to big REITs especially when the liquidity and volatility are high. The lead-lag effect among REITs was found to be driven more by a slow adjustment to negative information than by a slow adjustment to positive information, probably due to short-sale constraints (Diamond & Verracchia, 1987) and investors' risk-seeking behavior in a loss situation (Odean, 1998). This slow adjustment to negative information is most evident when the supply of information relevant to real estate and REIT markets is decreasing and the demand for such information is increasing. Finally, the information flow from REITs with more media coverage to REITs with less media coverage is even more sluggish than the flow from big REITs to small REITs.

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Table 1: Summary statistics for size portfolios

	Period	Overall period: 1987.7 - 2012.6		Subperiod 1987.7 - 1994.6		Subperiod: 1994.7 - 2001.6		Subperiod: 2001.7 - 2012.6	
	Size Portfolio	Small	Big	Small	Big	Small	Big	Small	Big
	N	51	49	36	37	67	64	51	47
	Mean return	0.003	0.002	0.002	0.001	0.003	0.002	0.003	0.003
	Std. dev. Return	0.024	0.028	0.022	0.016	0.012	0.018	0.030	0.038
	Mean size	0.093	2.501	0.010	0.264	0.048	1.257	0.174	4.712
	Median size	0.062	1.896	0.011	0.233	0.053	1.237	0.188	4.721
Autocorrelations	ρ0(j,Small)	1.00	0.69	1.00	0.37	1.00	0.43	1.00	0.80
	ρ0(j,Big)	0.69	1.00	0.37	1.00	0.43	1.00	0.80	1.00
	ρ1(j,Small)	0.05	-0.06	0.01	0.09	0.14	0.02	0.06	-0.10
	ρ1(j,Big)	0.16	-0.04	0.22	0.24	0.24	0.03	0.15	-0.08
	ρ2(j,Small)	0.10	0.02	0.21	0.00	0.09	-0.07	0.07	0.03
	ρ2(j,Big)	0.03	0.03	0.14	0.01	0.01	-0.07	0.02	0.04
	ρ3(j,Small)	0.12	0.05	0.20	0.05	0.09	-0.04	0.10	0.06
	ρ3(j,Big)	0.15	0.06	0.10	0.04	0.07	-0.01	0.17	0.08
	ρ4(j,Small)	0.02	-0.04	0.08	0.00	0.00	0.00	0.00	-0.05
	ρ4(j,Big)	0.01	-0.04	0.18	0.04	0.08	0.03	-0.04	-0.06

Table 1 reports summary statistics for size-sorted portfolios. The overall study period is from July 1987 to June 2012. Results are also shown for three sub-periods: July 1987 to June 1994, July 1994 to June 2001, and July 2001 to June 2012. I sort REITs into three size portfolios (bottom 30%, middle 40%, and top 30%) based on their end-of-June market capitalization. I compute equal-weighted weekly returns for each portfolio from July of year t to June of year $t + 1$. Portfolio 'Small' refers to the portfolio of the smallest 30% REITs, and Portfolio 'Big' refers to the portfolio of the largest 30% REITs. *N* is the average number of REITs in each portfolio. Mean size and median size are reported in billions of dollars. $\rho m(j, k)$, $m = 0$ to 4, refers to the *mth* order correlation coefficient between returns on the *j* size-ranked portfolio (j = Small or Big) and returns on the *k* size-ranked portfolio (k = Small or Big). For example, $\rho 1$(Small, Big) represents the correlation between week t return on the small size portfolio and week $t - 1$ return on the big size portfolio, and $\rho 1$(Big, Small) represents the correlation between week t return on the big size portfolio and week $t - 1$ return on the small size portfolio.

Table 2: Lead-lag effect of size portfolios

	Four-lag regressions			One-lag regressions		
LHS	R_{Small} (t-1 : t-4)	R_{Big} (t-1 : t-4)	F1	R_{Small} (t-1)	R_{Big} (t-1)	F1
R_{Small} (t)	0.050	0.284	7.100***	-0.109	0.199	16.250***
	0.440	*16.270****		*-2.890****	*6.300****	
R_{Big} (t)	-0.097	0.103		-0.071	0.004	
	1.100	*1.430*		*-1.550*	*0.120*	

Table 2 summarizes the results of the following four-lag (K = 4) and one-lag (K = 1) vector autoregressions (VARs) based on weekly return on the size portfolios for the period between 1987.7 and 2012.6 (1,292 weeks):

$$R_{Small}(t) = \alpha_0 + \sum_{k=1}^{K} \alpha_k R_{Small}(t-k) + \sum_{k=1}^{K} b_k R_{Big}(t-k) + e_{Small}(t), \qquad \text{(T2-1)}$$

$$R_{Big}(t) = c_0 + \sum_{k=1}^{K} c_k R_{Small}(t-k) + \sum_{k=1}^{K} d_k R_{Big}(t-k) + e_{Big}(t). \qquad \text{(T2-2)}$$

In Equations (T2-1) and (T2-2), $R_{Small}(t)$ is the week t return on the portfolio of the smallest 30% REITs. $R_{Big}(t)$ is the week t return on the portfolio of the biggest 30% REITs. R_{small} (t-1 : t-k), k = 1 or 4 reports $\sum_{k=1}^{K} \alpha_k$ from Equation (T2-1) or $\sum_{k=1}^{K} c_k$ from Equation (T2-2), depending on the left-hand side variable. R_{big} (t-1 : t-k), k = 1 or 4 reports $\sum_{k=1}^{K} b_k$ from Equation (T2-1) or $\sum_{k=1}^{K} d_k$ from Equation (T2-2). Italics indicate the F-statistics (t-statistics) for the hypothesis that the sum of the coefficients equals zero in the four-lag (one-lag) regressions. F1 reports the F-statistic for the cross-equation hypothesis that R_{Big} (t-1 : t-k) from Equation (T2-1) equals R_{Small} (t-1 : t-k) from Equation (T2-2), testing $\sum_{k=1}^{K} b_k = \sum_{k=1}^{K} c_k$. Finally, ***, **, and * denote significance at the 1, 5, and 10% levels, respectively.

Table 3: Time series change of lead-lag effect of size portfolios

Diff_lead-lag	Mean	Std.	Min	Max	*Diff-test*
1987.7 to 1994.6 (28 quarters)	0.215	0.777	-1.452	2.042	
1994.7 to 2001.6 (28 quarters)	0.115	0.768	-1.446	1.973	
2001.7 to 2012.6 (44 quarters)	0.194	1.258	-2.668	3.558	***0.08***

This table summarizes the time series change of the lead-lag effect estimated quarterly for the period from the third quarter of 1987 to the second quarter of 2012 as shown in Figure 3, following one-lag vector autoregressions (VARs) based on the weekly return on the size of portfolios:

$$R_{Small}(t) = \alpha_0 + \alpha_1 R_{Small}(t-1) + b_1 R_{Big}(t-1) + e_{Small}(t), \quad \text{(T3-1)}$$

$$R_{Big}(t) = c_0 + c_1 R_{Small}(t-1) + d_1 R_{Big}(t-1) + e_{Big}(t). \quad \text{(T3-2)}$$

In Equations (F3-1) and (F3-2), $R_{Small}(t)$ is the week t return on the portfolio of the smallest 30% REITs. $R_{Big}(t)$ is the week t return on the portfolio of the biggest 30% REITs. The coefficient b_1 represents the lead-lag from big portfolio to small portfolio and the coefficient c_1 represents the lead-lag from small portfolio to big portfolio. The variable, **Diff_lead_lag,** is the difference between b_1 and c_1, which measures size of the expected lead-lag effect from big portfolio to small portfolio while controlling for the reverse lead-lag effect. Statistics are summarized for three sub-periods: 1987.7 to 1994.6; 1994.7 to 2001.6; and 2001.7 to 2012.6. The last column (***Diff-test***) shows the result (*f*-value) of ANOVA comparison of the mean of **Diff_lead_lag** among three sub-periods.

Table 4: Comparison of market condition between two sub-periods

Variable	Mean	Std.	Min	Max	Diff (B vs. A) Mean	Diff (B vs. A) Variance
Panel A: 1987.7 to 2001.6 (56 quarters)						
Diff_lead-lag	0.165	0.767	-1.452	2.042		
Index_ret	0.026	0.070	-0.146	0.227		
Index_std	0.013	0.007	0.005	0.037		
Inst_ratio	0.290	0.085	0.173	0.417		
Bidask	0.346	0.065	0.232	0.534		
Nofreit	136	57	53	201		
Mktcap	116,810	122,885	4,759	335,843		
Wsj	620	138	373	911		
Small_ret	0.041	0.108	-0.184	0.423		
Big_ret	0.022	0.074	-0.117	0.255		
Small_size	28,908	24,287	7,574	78,924		
Big_size	759,534	664,666	220,200	1,969,051		
Panel B: 2001.7 to 2012.6 (44 quarters)						
Diff_lead-lag	0.194	1.258	-2.668	3.558	0.132	2.689 ***
Index_ret	0.035	0.128	-0.388	0.333	0.425	
Index_std	0.030	0.021	0.011	0.120	5.193 ***	
Inst_ratio	0.553	0.090	0.352	0.656	14.885 ***	
Bidask	0.690	0.360	0.311	2.104	6.250 ***	
Nofreit	144	14	124	164	1.064	
Mktcap	573,003	143,599	331,409	872,523	16.789 ***	
Wsj	585	149	355	824	-1.227	
Small_ret	0.042	0.121	-0.387	0.374	0.034	
Big_ret	0.038	0.133	-0.394	0.390	0.709	
Small_size	173,768	74,598	60,565	293,421	12.376 ***	
Big_size	4,702,099	1,725,966	2,233,029	7,933,868	14.340 ***	

This table compares statistics of the U.S. REIT market between the period from 1987.7 to 2001.6 and the period from 2001.7 to 2012.6. **Diff_lead-lag** is the difference between b_1 and c_1, which measures size of the expected lead-lag effect from big portfolio to small portfolio while controlling for the reverse lead-lag effect, as defined in Table 3. **Index_ret** is the total return of the FTSE NAREIT U.S. Real estate index (REIT index), **Index_std** is the standard deviation of the REIT index, **Inst_ratio** is the average proportion of shares of REITs owned by institutional investors, **Bidask** is the average bid-ask spread of REITs, **Nofreit** is the number of equity REITs, **Mktcap** is the average market capitalization of REITs, **Wsj** is the number of REIT relevant articles appeared in the Wall Street Journal, **Small_ret** (**Big_ret**) is the total return on the portfolio of the smallest (biggest) 30% REITs, and **Small_size** (**Big_size**) is the average market capitalization of the portfolio of the smallest (biggest) 30% REITs. The last two columns (Diff (B vs.A)) show the t-statistics (f-statistic) for the two-group mean-comparison (variance-comparison) tests, respectively. *** denotes significance at the 1% level.

Table 5: Summary of regression for quarters when small REITs lead big REITs

	Coef.	t	
Index_ret	1.151	0.41	
Index_std	-30.737	-1.86	*
Inst_ratio	5.177	2.48	**
Bidask	2.266	2.21	**
Noofreit	0.001	0.19	
Mktcap	0.000	-2.71	**
Wsj	0.002	1.44	
Small_ret	-1.436	-0.97	
Big_ret	0.107	0.04	
Small_size	0.000	-2.53	**
Big_size	0.000	2.43	**
_cons	-3.057	-2.58	**

This table summarizes the result of the regression for the sub-sample of quarters in which small REITs lead big REITs (i.e., Diff_lead-lag takes negative values). A dependent variable is **Diff_lead-lag** that measures the difference between the expected lead-lag effect from big portfolio to small portfolio and the reverse lead-lag effect from small portfolio to big portfolio, as defined in Table 3. **Index_ret** is the total return of the FTSE NAREIT U.S. Real estate index (REIT index), **Index_std** is the standard deviation of the REIT index, **Inst_ratio** is the average proportion of shares of REITs owned by institutional investors, **Bidask** is the average bid-ask spread of REITs, **Nofreit** is the number of equity REITs, **Mktcap** is the average market capitalization of REITs, **Wsj** is the number of REIT relevant articles appeared in the Wall Street Journal, **Small_ret** (**Big_ret**) is the total return on the portfolio of the smallest (biggest) 30% REITs, and **Small_size** (**Big_size**) is the average market capitalization of the portfolio of the smallest (biggest) 30% REITs. The last column in Panel B (Diff (B-A)) shows the t-statistics for the two-group mean-comparison tests. **, and * denote significance at the 5, and 10% levels, respectively.

Table 6: Lead-lag effect of size portfolios, media coverage and media content

Panel A: Media coverage

Panel A-1: INCREASING media coverage (653 weeks)

LHS	R_{Small} (*t*-1)	R_{Big} (*t*-1)	F1
R_{Small} (*t*)	-0.041	0.183	0.150
	-0.790	*4.480****	
R_{Big} (*t*)	0.147	-0.084	
	*2.170***	*-1.580*	

Panel A-2: DECREASING media coverage (639 weeks)

LHS	R_{Small} (*t*-1)	R_{Big} (*t*-1)	F1
R_{Small} (*t*)	-0.161	0.212	23.300***
	*-2.930****	*4.360****	
R_{Big} (*t*)	-0.247	0.089	
	*-4.050****	*1.650**	

Panel B: Media content

Panel B-1: POSITIVE news (439 weeks)

LHS	R_{Small} (*t*-1)	R_{Big} (*t*-1)	F1
R_{Small} (*t*)	-0.116	0.179	5.800**
	*-1.700**	*3.150****	
R_{Big} (*t*)	-0.112	0.031	
	-1.360	*0.460*	

Panel B-2: NEGATIVE news (485 weeks)

LHS	R_{Small} (*t*-1)	R_{Big} (*t*-1)	F1
R_{Small} (*t*)	-0.080	0.134	11.370***
	-1.320	*2.710****	
R_{Big} (*t*)	-0.229	0.020	
	*-3.030****	*0.330*	

Panel C: Market coverage x media content

Panel C-1: INCREASING media coverage x POSITIVE news (233 weeks)

LHS	R_{Small} (*t*-1)	R_{Big} (*t*-1)	F1
$R_{Small}(t)$	-0.039	0.145	0.360
	-0.420	*1.890**	
$R_{Big}(t)$	0.046	-0.075	
	0.400	*-0.790*	

Panel C-2: INCREASING media coverage x NEGATIVE news (242 weeks)

LHS	R_{Small} (*t*-1)	R_{Big} (*t*-1)	F1
$R_{Small}(t)$	0.030	0.055	0.070
	0.340	*0.910*	
$R_{Big}(t)$	0.097	-0.168	
	0.770	*-1.920**	

Panel C-3: DECREASING media coverage x POSITIVE news (206 weeks)

LHS	R_{Small} (*t*-1)	R_{Big} (*t*-1)	F1
$R_{Small}(t)$	-0.204	0.226	9.030***
	*-2.080***	*2.700****	
$R_{Big}(t)$	-0.297	0.168	
	*-2.590****	*1.710**	

Panel C-4: DECREASING media coverage x NEGATIVE news (243 weeks)

LHS	R_{Small} (*t*-1)	R_{Big} (*t*-1)	F1
$R_{Small}(t)$	-0.167	0.215	19.210***
	*-1.940**	*2.740****	
$R_{Big}(t)$	-0.432	0.181	
	*-4.610****	*2.120***	

In Panel A, I divide the whole sample period into two sub-periods based on the media coverage, which is defined using the monthly number of articles appearing in the *Wall Street Journal* (WSJ) with the keywords “Real Estate,” “Real Estate Investment Trust(s),” or “REIT(s).” All weeks within months in which the number of articles increased from the last month are defined as INCREASING media coverage weeks. Weeks of other months are defined as DECREASING media coverage weeks. In Panel B, I divide the whole sample period into two sub-periods based on the media content, which is defined using the monthly proportion of positive (negative) words to the total number of words contained in WSJ articles. All weeks within months in which the proportion of positive (negative) words increased and the change in the proportion is higher than the change in the proportion of negative (positive) words are defined as POSITIVE (NEGATIVE) news weeks. In Panel C, four sub-periods are defined based both on market media coverage (INCREASING or DECREASING) and media content (POSITIVE and NEGATIVE). For each sub-period, I estimate the following one-lag vector autoregressions (VARs) based on the weekly return on the size of portfolios for the overall study period from July 1987 to June 2012:

$$R_{Small}(t) = \alpha_0 + \alpha_1 R_{Small}(t-1) + b_1 R_{Big}(t-1) + e_{Small}(t), \qquad \text{(T6-1)}$$

$$R_{Big}(t) = c_0 + c_1 R_{Small}(t-1) + d_1 R_{Big}(t-1) + e_{Big}(t). \qquad \text{(T6-2)}$$

In Equations (T6-1) and (T6-2), $R_{Small}(t)$ is the week t return on the portfolio of the smallest 30% REITs. $R_{Big}(t)$ is the week t return on the portfolio of the biggest 30% REITs. Italics indicate the t-statistics. F1 reports the F-statistic for the test, $b_1 = c_1$. Finally, ***, **, and * denote significance at the 1, 5, and 10% levels, respectively.

Table 7: Lead-lag effect of size portfolios, media coverage and Google search

Panel A: Media coverage

Panel A-1: INCREASING media coverage (222 weeks)

LHS	R_{Small} (*t*-1)	R_{Big} (*t*-1)	F1
R_{Small} (*t*)	0.070	0.111	0.760
	0.690	*1.460*	
R_{Big} (*t*)	0.280	-0.205	
	*2.030***	*-1.980***	

Panel A-2: DECREASING media coverage (219 weeks)

LHS	R_{Small} (*t*-1)	R_{Big} (*t*-1)	F1
R_{Small} (*t*)	-0.389	0.377	13.330***
	*-3.200****	*3.670****	
R_{Big} (*t*)	-0.452	0.219	
	*-3.160****	*1.810**	

Panel B: Google search

Panel B-1: INCREASING Google search (199 weeks)

LHS	R_{Small} (*t*-1)	R_{Big} (*t*-1)	F1
R_{Small} (*t*)	-0.220	0.248	10.930***
	*-1.880**	*2.550***	
R_{Big} (*t*)	-0.453	0.159	
	-3.330 ***	*1.410*	

Panel B-2: DECREASING Google search (242 weeks)

LHS	R_{Small} (*t*-1)	R_{Big} (*t*-1)	F1
R_{Small} (*t*)	-0.154	0.241	0.090
	-1.430	*2.890****	
R_{Big} (*t*)	0.179	-0.132	
	1.250	*-1.190*	

Panel C: Market coverage x Google search

Panel C-1: INCREASING media coverage x INCREASING Google search (96 weeks)

LHS	R_{Small} (*t*-1)	R_{Big} (*t*-1)	F1
R_{Small} (*t*)	0.215	-0.079	1.760
	1.340	*-0.640*	
R_{Big} (*t*)	0.297	-0.381	
	1.560	*-2.600***	

Panel C-2: INCREASING media coverage x DECREASING Google search (126 weeks)

LHS	R_{Small} (*t*-1)	R_{Big} (*t*-1)	F1
R_{Small} (*t*)	-0.033	0.216	0.040
	-0.250	*2.250***	
R_{Big} (*t*)	0.270	-0.127	
	1.400	*-0.900*	

Panel C-3: DECREASING media coverage x INCREASING Google search (103 weeks)

LHS	R_{Small} (*t*-1)	R_{Big} (*t*-1)	F1
R_{Small}(*t*)	-0.485	0.473	22.310***
	*-2.990****	*3.360****	
R_{Big} (*t*)	-0.900	0.525	
	*-5.050****	*3.400****	

Panel C-4: DECREASING media coverage x DECREASING Google search (116 weeks)

LHS	R_{Small} (*t*-1)	R_{Big} (*t*-1)	F1
R_{Small} (*t*)	-0.287	0.279	0.160
	-1.560	*1.840**	
R_{Big} (*t*)	0.141	-0.192	
	0.640	*-1.060*	

In this table, the sample period is from January 2004 to December 2012 due to the availability of Google Trends data. In Panel A, I divide the sample period into two sub-periods based on the media coverage, as in Panel A of Table 6. In Panel B, I divide the whole sample period into two sub-periods based on the information demand, which is defined using the monthly number of Google searches conducted within the U.S. with the keywords "Real Estate," "Real Estate Investment Trust(s)," or "REIT(s)," taken from the Google Trends database. All weeks within months in which the number of Google searches increased from the last month are defined as INCREASING Google search weeks. Weeks of other months are defined as DECREASING Google search weeks. $R_{Small}(t)$ is the week t return on the portfolio of the smallest 30% REITs. $R_{Big}(t)$ is the week t return on the portfolio of the biggest 30% REITs. Italics indicate the t-statistics. F1 reports the F-statistic for the test, $b_1 = c_1$. Finally, ***, **, and * denote significance at the 1, 5, and 10% levels, respectively.

Table 8: Lead-lag effect of media coverage portfolios

	Four-lag regressions						One-lag regressions		
LHS	R_{Less} (t-1 : t-4)		R_{More} (t-1 : t-4)		F1		R_{Less} (t-1)	R_{More} (t-1)	F1
R_{Less} (t)	-0.205		0.319		4.420	**	0.017	0.012	0.810
	2.740	*	*11.070*	***			*0.280*	*0.270*	
R_{More} (t)	-0.201		0.252				0.118	-0.078	
	1.510		*3.980*	**			*1.500*	*-1.320*	

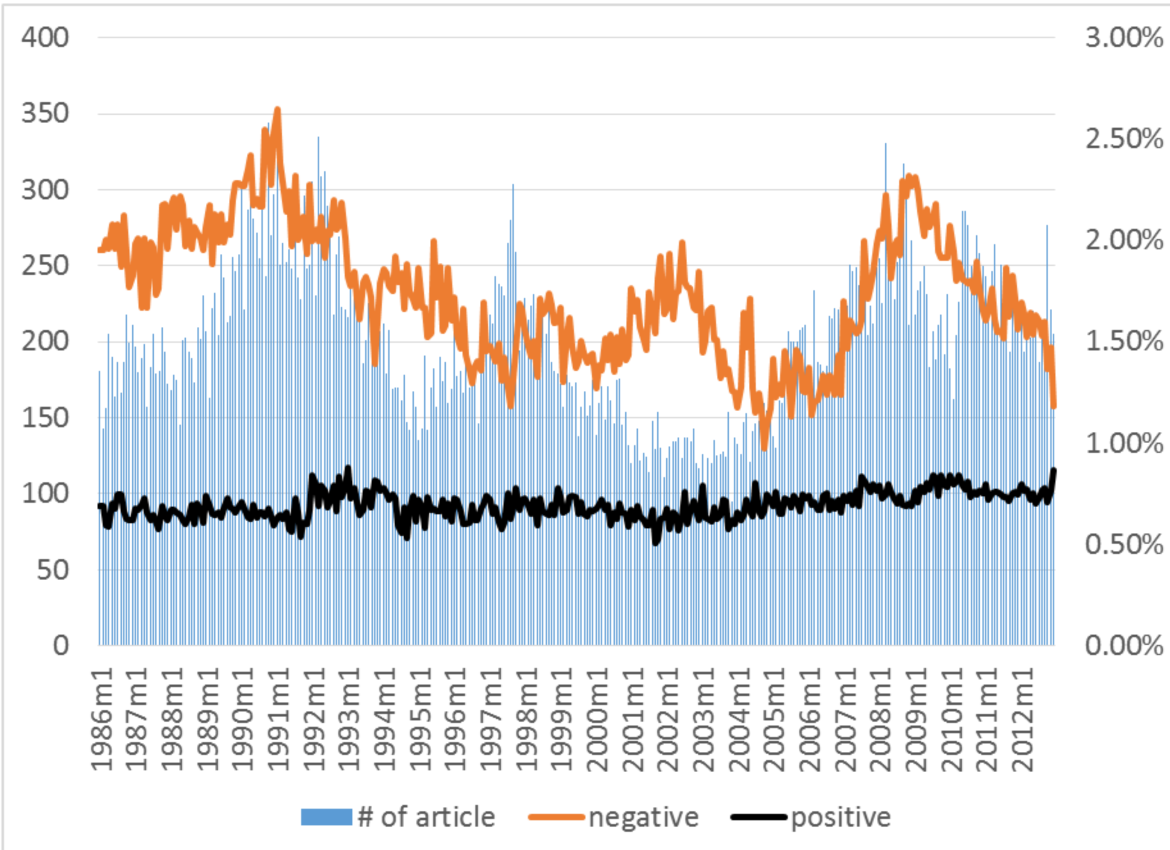
REITs are first sorted into three size-ranked portfolios (bottom 30%, middle 40%, and top 30%) based on market capitalization at the end of June of each year **t**. Then each size portfolio is sorted into three portfolios based on the number of articles found in ABI/INFORM database that contains the name of each REIT (bottom 30%, middle 40%, and top 30%) during each year t-1. Then REITs from the three size portfolios that have the same media coverage ranking are placed into a single portfolio. This process generates three media coverage-ranked portfolios while holding size approximately the same. Equal-weighted weekly returns were computed for each portfolio from July of year **t** to June of year t+1. The study estimates following four-lag and one-lag vector autoregressions (VARs) based on weekly return on the media coverage portfolios for the full study period from July 1987 to June 2012:

$$R_{Less}(t) = \alpha_0 + \sum_{k=1}^{K} \alpha_k R_{Less}(t-k) + \sum_{k=1}^{K} b_k R_{More}(t-k) + e_{Less}(t), \quad \text{(T8-1)}$$

$$R_{More}(t) = c_0 + \sum_{k=1}^{K} c_k R_{Less}(t-k) + \sum_{k=1}^{K} d_k R_{More}(t-k) + e_{More}(t). \quad \text{(T8-2)}$$

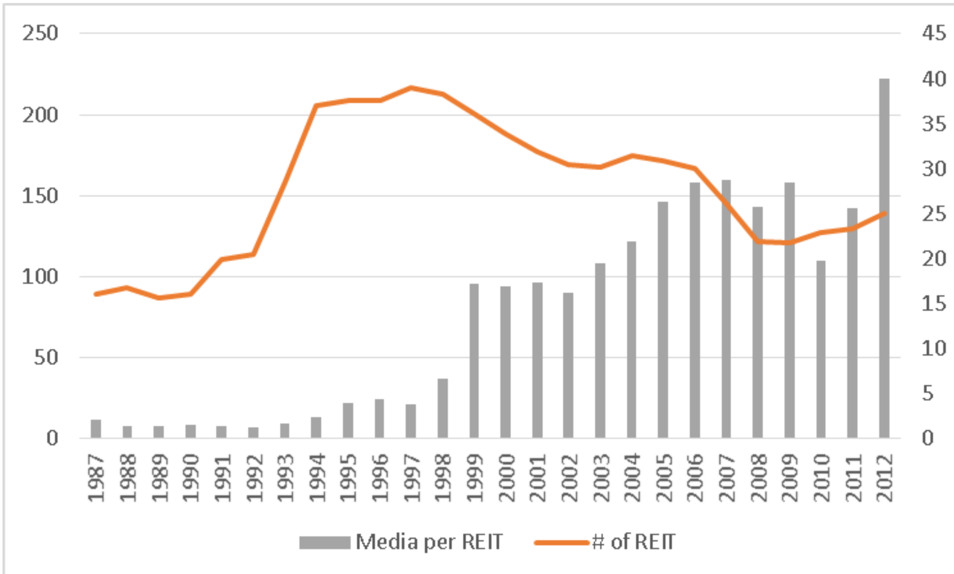
In Equations (T8-1) and (T8-2), R_{Less}(t) is the week ***t*** return on the portfolio of REITs with the least 30% media coverage. R_{More}(t) is the week **t** return on the portfolio of REITs with the most 30% media coverage. R_{Less} (t-1 : t-k), k = 1 or 4, reports $\sum_{k=1}^{K} \alpha_k$ from Equation (T8-1) or $\sum_{k=1}^{K} c_k$ from Equation (T8-2), depending on the left-hand side variable. R_{More} (t-1 : t-k), k =1 or 4, reports $\sum_{k=1}^{K} b_k$ from Equation (T8-1) or $\sum_{k=1}^{K} d_k$ from Equation (T8-2). Italics indicates the F-Statistics (t-statistics) for the hypothesis, namely, that the sum of the coefficients equals zero for the four-lag (one-lag) regressions. F1 reports the F-statistic for the cross-equation hypothesis that R_{More} (t-1 : t-k) from Equation (T8-1) equals R_{Less} (t-1 : t-k) from Equation (T8-2), testing $\sum_{k=1}^{K} b_k = \sum_{k=1}^{K} c_k$. Finally, ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Figure 1: The number of REIT-relevant articles in the *Wall Street Journal* and the proportions of positive and negative words to total words in the articles



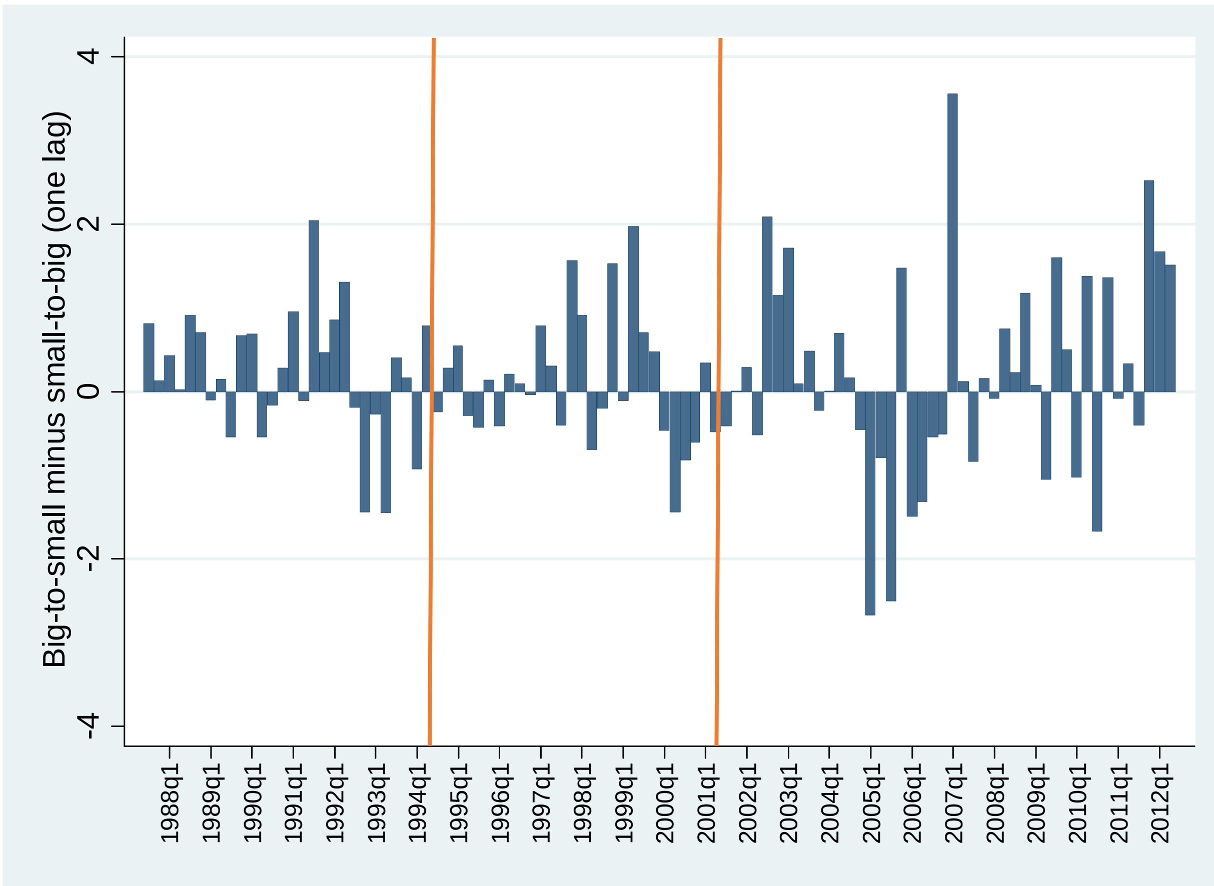
This figure summrizes the REIT-relevant articles appearing in the *Wall Street Journal* (number of words in the WSJ articles (negative, right axis) in each month from 1987.01 to 2012.12.WSJ) (# of articles, left axis), the proportion of positive words to the total number of words in the WSJ articles (positive, right axis), and the proportion of negative words to the total

Figure 2: The number of equity REIT and the average number of media articles per REIT



This figure summrizes the number of equity REIT (# of REIT, left axis) in the study sample and the average number of articles per REIT found in ProQuest-ABI/INFORM database (Media per REIT, right axis) in each year from 1987 to 2012.

Figure 3: Time-Series Change in the Information Diffusion Process



This figure shows the time series change of the lead-lag effect estimated quarterly for the period from the third quarter of 1987 to the second quarter of 2012, following one-lag vector autoregressions (VARs) based on the weekly return on the size of portfolios:

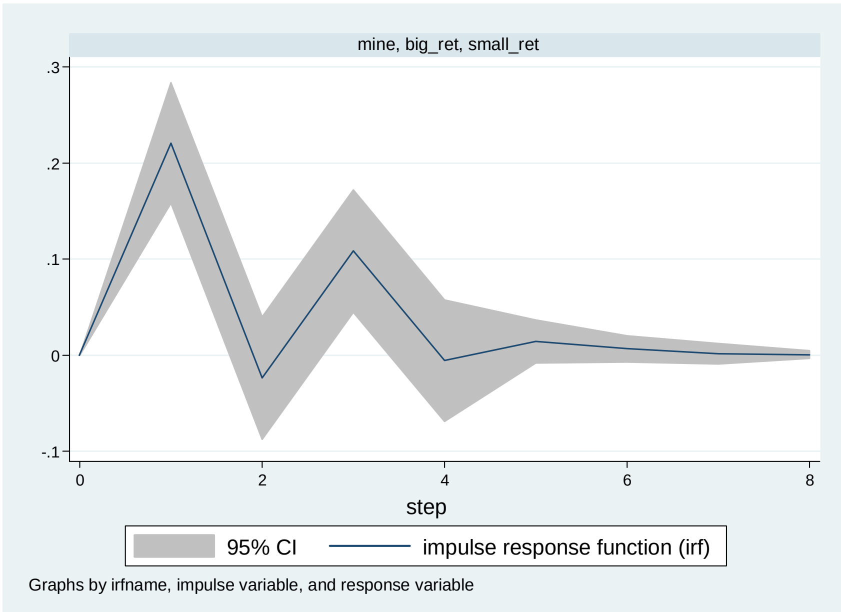
$$R_{Small}(t) = \alpha_0 + \alpha_1 R_{Small}(t-1) + b_1 R_{Big}(t-1) + e_{Small}(t), \quad \text{(F3-1)}$$

$$R_{Big}(t) = c_0 + c_1 R_{Small}(t-1) + d_1 R_{Big}(t-1) + e_{Big}(t). \quad \text{(F3-2)}$$

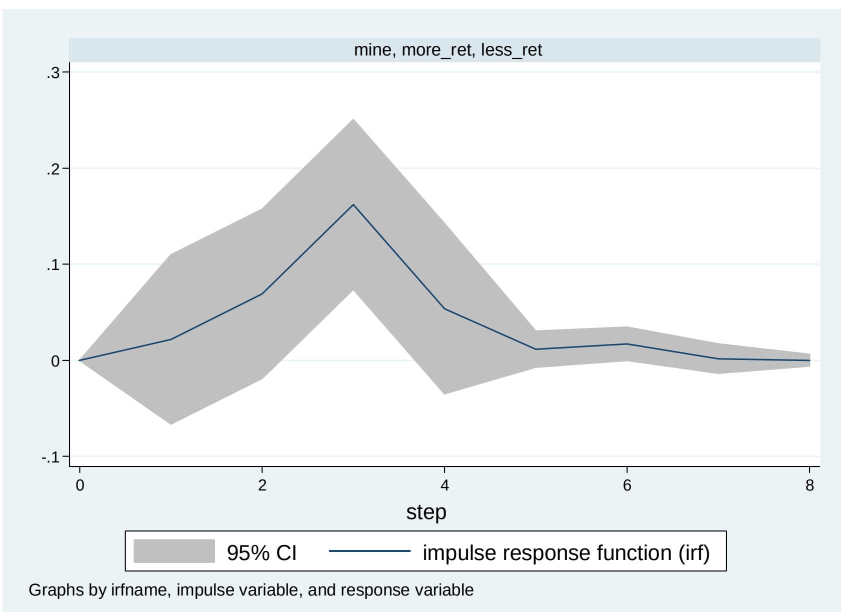
In Equations (F3-1) and (F3-2), $R_{Small}(t)$ is the week t return on the portfolio of the smallest 30% REITs. $R_{Big}(t)$ is the week t return on the portfolio of the biggest 30% REITs. The coefficient b_1 represents the lead-lag from big portfolio to small portfolio and the coefficient c_1 represents the lead-lag from small portfolio to big portfolio. The bar chart in Figure 3 shows the difference between b_1 and c_1, which measures size of the expected lead-lag effect from big portfolio to small portfolio while controlling for the reverse lead-lag effect. Horizontal lines divide the overall study period into three sub-periods: 1987.7 to 1994.6; 1994.7 to 2001.6; and 2001.7 to 2012.6.

Figure 4: Impulse responses

Panel A: Size portfolio, impulse = biggest 30% REITs, response = smallest 30% REITs



Panel B: Media coverage portfolio, impulse = most 30% covered REITs, response = least 30% covered REITs



Appendix A: Descriptive statistics for media coverage data

Panel A: REIT-relevant Wall Street Journal articles

	Mean	Std. Dev.	Max	Min
Number of articles	200.85	49.26	344.00	95.00
Total number of words	192,285.80	45,231.60	326,051.00	101,301.00
Number of positive words	1,341.07	389.91	2,601.00	43.00
Number of negative word	3,363.51	1,179.92	7,403.00	121.00
Ratio of positive words	0.0069	0.0008	0.0088	0.0003
Ratio of negative words	0.0173	0.0034	0.0265	0.0009

Panel B: Articles on individual REITs

	Mean	Std. Dev.	Max	Min
Number of articles per RE	14.03	41.70	837	0

Panel A summrizes the REIT-relevant articles appearing in the *Wall Street Journal* in each month from 1987.01 to 2012.12. Panel B summarizes the number of articles per REIT found in ProQuest-ABI/INFORM database in each year from 1987 to 2012.