Short Sales and Price Discovery in Real Estate Markets

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Abstract

Indirect real estate (IRE) returns are often shown to lead direct real estate (DRE) returns. Apart from differences in liquidity, transaction costs, and management skills, the DRE market is also less complete than the IRE market – when negative shocks arrive, one can only short IRE (e.g. real estate stocks or REITs), but not DRE. This study investigates if short sales in the IRE market convey any information to the DRE market. Based on high-frequency (weekly) property price data in Hong Kong from 1999 to 2011, we found that short sales in the IRE market led DRE returns, even after controlling for the lagged IRE returns in a VAR model. This suggests that short sales contain private information on the real estate market that is not fully reflected in IRE returns. The spillover effect of short sales, however, weakened after the 2007 global financial crisis because increased uncertainty over the credibility of individual firms made short sales carry more firm-specific information than market-wide news.

Keywords: short sales, price discovery, real estate markets

JEL Codes: G12, G14

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The previous research on short selling focused on two issues: 1) if short sellers possess private information and 2) if short sale constraints cause stock overvaluation. For the first issue, several studies showed that short interest predicted future returns. Senchak and Starks (1993) and Desai *et al.* (2002) found that short sales predicted negative future returns for NYSE and NASDAQ industrial stocks, respectively. Asquith *et al.* (2005) found greater predictive power in smaller stocks and suggested that short sales reflect negative, non-public information about a firm. Using daily NYSE order data, Boehmer *et al.* (2008) revealed that heavily-shorted stocks significantly underperformed lightly-shorted stocks, especially those shorted by non-program institutional traders. These findings generally supported the notion that short sellers have an information advantage over other traders, while Diether *et al.* (2008) also identified a feedback relationship – not only do prices follow short sales, but short sales also follow prices.

As for the second issue, a number of papers tested if restricting short sales would reduce market efficiency and cause firms to be overvalued (e.g., Boehmer *et al.*, 2009; Jones and Lamont, 2002; Chang *et al.*, 2007; Asquith and Meulbroek, 1996). Boehme *et al.* (2006) found that different beliefs are a necessary condition for short sale constraints to cause overvaluation. Chang *et al.* (2007) obtained similar findings in Hong Kong and added that overvaluation is more dramatic for stocks with a wider dispersion of investor opinions. These findings are consistent with Miller's (1997) theoretical model on differences in beliefs, but are at odd with Diamond and Verrecchia (1987), who argued that prices should be unbiased, since markets will adjust to the truncated bad news.

While most studies confirmed that short sales contain information on the stock being shorted, little is known about the spillover of such information to the underlying asset market where short sales are prohibited. This is a typical setting of the real estate market, where underlying assets can be traded in parallel with their securities – the former in the private

market as direct real estate (DRE) and the latter in the public market as indirect real estate (IRE). The most common type of IRE consists of shares of real estate companies and REITs listed on a stock market. Apart from variations in liquidity, transaction costs, and management skills, a major institutional difference between the two markets is that DRE cannot be sold short. Even if one knows that bad news is arriving, not much can be done in the DRE market. For property owners (especially owner-occupiers), it is costly and time-consuming to sell a property, while non-property owners can do nothing but wait. However, in a parallel IRE market, it is possible for informed traders to short sell IRE without changing their DRE positions. This paper seeks to examine if short sales enhance price discovery between the DRE and IRE markets (i.e., if short selling in the IRE market conveys information to the DRE market).

There were a few short sale studies in the real estate literature, but they are concerned only with the relationship between shorting and returns within the IRE market, not with spillover to the DRE market. Li and Yung (2004) examined if REIT short interest was driven by security-specific information or market-wide information and found that short interest was associated with future underperformance, which hinted that REIT short sellers may be informed. French *et al.* (2012) conducted a similar study using intraday short sales data and found that the negative relationship held more strongly for larger short positions. Their analysis further revealed a strong positive relationship between shorting and volatility. Chen *et al.* (2011) used REITs to test Miller's (1977) overvaluation hypothesis and found that consistent with an overvaluation story, heavily-shorted REITs experienced significantly lower abnormal returns. In contrast, Blau *et al.* (2011) found that REITs' short sales contained less information than those of non-REITs because REITs were more transparent and made informed trading more difficult. As a result, the role of short sellers in the REIT market remains inconclusive.

The parallel trading mechanism of real estate has attracted many studies on price discovery between the DRE and IRE markets, but none focused on short sales except for Brounen *et al.* (2012), who explained REIT NAV premiums by way of short sales. Most of the prior work (e.g., Giliberto, 1990, 1993; Myer and Webb, 1993; Newell and Chau, 1996; Chau *et al.*, 2001) studied DRE and IRE returns and found that they had low contemporaneous correlations, but high lagged correlations. These findings underlay the price discovery literature, which postulates that the IRE market is more efficient than the DRE market in revealing information on real estate prices. For instance, Barkham and Geltner (1995) modeled the price discovery process and established the predictability of DRE returns in the US and the UK. Schwann and Chau (2003), using Hong Kong data from 1986 to 1999, found that there was less information transferred from the IRE to the DRE market when news was external to the real estate sector. Geltner *et al.* (2003) reviewed the price discovery literature and summarized how the opinions of traders in the DRE and IRE markets combined to establish market prices.

By examining the role of short sales in price discovery between the DRE and IRE markets, this article contributes to the literature in at least three ways. First, to our knowledge, this is the first study to examine the spillover effect of short sales from one market (i.e., IRE) to another market in which short sales are restricted (i.e., DRE). Second, it provides a new direction to real estate price discovery research, which has typically ignored the potential contribution of short sellers in the relationship between the DRE and IRE markets. Third, it draws on the recent credit crisis and tests if short sales' spillover effect has changed. With increased information asymmetry between managers (insiders) and investors (outsiders) after the crisis, short sales may contain more firm-specific information than news on the real estate market, and hence, would convey less information to the DRE market. The information spillover mechanism will be further explained in the next section.

Hypotheses

Short selling is an obvious, though not the only, action to take if one holds a negative view on a stock. For short selling to affect future stock prices, market participants have to believe that it is more than pure speculation. There are different ways in which short selling may carry credible information. A typical way is for short sellers to have access to private information that has not yet been reflected in current prices. It could be based on insider information (e.g. future company announcements) or different interpretations of public information (e.g. market overreaction to good news about a company). Either way, the action of short selling is considered informative and could move future stock prices. This is so even if short sellers are consistently wrong.

Whether or not short selling can create information spillover to another market is not so straightforward. If a firm is sold short due to private information on its poor management, nothing on other firms could be directly inferred and spillover would not occur. Similar logic applies to the IRE and DRE markets. Short selling a real estate stock due to firm-specific factors does not carry any information on the DRE market and should not affect future property prices. For short selling in the IRE market to affect the DRE market, private information has to be more general in nature and have the potential to affect the market as a whole. It could come from insider information on changes in government policy and interest rates that affect aggregate real estate demand or supply, or from proprietary strategies to identify systematic mispricing opportunities in the IRE or DRE markets (e.g. through comparing aggregate share prices to NAV premiums).

The problem for investors is that short sellers' motivations are unobservable. What investors could reliably observe is the amount of short sales. To differentiate between market and firm-specific information, one strategy DRE investors may employ is to examine the

short selling pattern of the entire IRE market instead of individual real estate stocks. If only one or two stocks are heavily shorted, it is more likely that short sellers' private information is firm-specific and would not spill over to the DRE market. On the other hand, if short selling in the IRE market becomes more active, investors may infer that short sellers' private information is market-wide and DRE market prices will adjust accordingly. Since the DRE market is not as liquid as the stock market and disallows short sales, its price adjustments are expected to take longer. This leads to our first information spillover hypothesis:

Hypothesis 1: Short sales in the IRE market lead price movements in the DRE market.

Another way to test information spillover is to draw on the change in the information environment brought about by the 2007-08 credit crisis. While the credit crisis might have originated from the US real estate bubble (Shiller, 2008), its consequences were profound and subsequently affected (and continue to affect) the global financial markets. After the collapse of some major financial institutions, an important consequence is increased uncertainty over the credibility of individual firms. For instance, Longstaff (2010) found that ABX indices had much stronger predictive power on bond and stock returns after the crisis. Real estate firms (except REITs) could be highly-leveraged and could invest in financial products, so they are also not immune to changes in the information environment.

If the crisis has made information more asymmetric between managers (insiders) and investors (outsiders), it is reasonable to expect more opportunities to trade private information on a firm. This means the information revealed by short sellers is more likely to be firm-specific than market-wide, thereby weakening the spillover effect on the DRE market. This leads to our second hypothesis:

Hypothesis 2: The relationship between short sales in the IRE market and prices in the DRE market weakened after the credit crisis.

Data and Methodology

Hong Kong's real estate market is chosen to test the hypotheses for two reasons. First, thanks to the homogeneous and liquid DRE market in Hong Kong, weekly data are available to capture quality-adjusted price changes. This is critical for studying the price discovery role of short sales because short sellers' information advantage, if it exists, could be short-lived.[1] Second, the IRE market in Hong Kong is dominated by listed real estate companies, not REITs. This reduces Blau *et al.*'s (2011) concern that REITs, which are more transparent, are less vulnerable to informed trading. An informed trading of real estate stocks remains plausible.

Our data runs weekly from January 1, 1999 through August 31, 2011. The IRE market in Hong Kong consists of real estate stocks covered by the Hang Seng Property Sub-Index, which is the most widely used benchmark of IRE performance (see Fig.1). Short selling transactions were obtained from the Stock Exchange of Hong Kong (SEHK). Daily prices, total transaction amounts, and short sales amount data for each company are included in the dataset. To measure short selling activities, some prior studies used shorting flow data (e.g., Christophe *et al.*, 2004; Boehmer *et al.*, 2008; Diether *et al.*, 2008), while more recent works used short interest (e.g., Asquith *et al.*, 2005; Boehmer *et al.*, 2010; Blau, 2012). We follow the more recent works and adopt the short interest ratio as a proxy of short sale intensity: the total value of shares shorted divided by the total value of shares traded (see

[1] In Hong Kong, only covered short selling is allowed. Holding short positions for a longer period may incur a higher borrowing cost.

Fig.2). There were noticeably more short sales after 2007, which suggest that the credit crisis might have led to more opportunities for informed trading or a higher demand for hedging (Securities and Futures Commission, 2008).

Insert Figure 1

Insert Figure 2

For the DRE market, the Centa-City Leading (CCL) Index is used to capture its performance (see Fig.3). It is a transaction-based hedonic price index that aims to measure weekly price movements in the private residential market. Its sample came from the transactions recorded by Centaline Property Agency Limited – one of the largest property

agents in Hong Kong. The CCL index shares a similar trend with other established indices, notably those constructed by the government and the University of Hong Kong (Chau *et al.*, 2005).

Insert Figure 3

From the data described above, three key variables used for analysis are defined: 1) S_{IRE} refers to the short interest ratio of real estate stocks; 2) R_{DRE} refers to the weekly returns on the DRE market; 3) R_{IRE} refers to the weekly returns on the IRE market. Their descriptive statistics will be provided in the next section.

Prior to testing for possible relationships between these variables, it is necessary to ensure that they meet the stationarity conditions (Engle and Granger, 1987). The Augmented Dickey-Fuller (ADF) procedure is applied to test if the variables contain any unit root. Denoting the time series variables under investigation (S_{IRE}, R_{DRE}, and R_{IRE}) as Y_t, the ADF test takes on the following form, with μ and ϕ the coefficients to be estimated:

$$\Delta Y_t = \mu + \emptyset Y_{t-1} + \sum_{j=1}^{p} \Delta Y_{t-j} + \varepsilon_t \qquad (1)$$

The null hypothesis of a unit root is rejected (i.e., the variable is stationary) if the t-statistic of ϕ is less than the critical value. If not, the variable would be non-stationary and first-differencing or co-integration might be needed.

After stationarity is established, the next step is to investigate if the short sales on real estate stocks contain useful information that could help predict DRE and IRE returns. Granger causality tests are used to test if each pair of the three variables has any lead-lag relationship:

$$Y_t = \sum_{i=1}^{n} \alpha_i X_{t-i} + \sum_{i=1}^{n} \beta_i Y_{t-i} + \mu_{1t}$$
$$X_t = \sum_{i=1}^{n} \lambda_i Y_{t-i} + \sum_{i=1}^{n} \delta_i X_{t-i} + \mu_{2t} \qquad (2)$$

where Y_t and X_t are each pair of S_{IRE}, R_{DRE}, and $R_{IRE;}$ Y_{t-i} and X_{t-i} are the lagged term of Y_t and X_t respectively; and μ_{1t} and μ_{2t} are the error terms. If $\alpha_i \neq 0$ and λ_i=0, X Granger-causes Y and Y does not Granger-cause X. If α_i = 0 and $\lambda_i \neq 0$, Y Granger-causes X and X does not Granger-causes Y. If $\alpha_i \neq 0$ and $\lambda_i \neq 0$, then X and Y are said to Granger-cause each other. If α_i = 0 and λ_i=0, then X and Y have no Granger causality. F-statistics are employed to test the significance of these coefficients. According to Hypothesis 1, if short sales contain useful price information for the DRE market, S_{IRE} should Granger-cause R_{DRE}. From previous price discovery studies, R_{IRE} should Granger-cause R_{DRE} too.

Since Granger causality is only performed on a pairwise basis, we also use a vector autoregression (VAR) framework to examine the three variables together. The advantage of this approach is that all three variables are endogenous to the system and both short sales and IRE returns are allowed to affect DRE returns at the same time. This is a stronger test of Hypothesis 1 because short sales can predict DRE returns only if they carry more information

than IRE returns. If short sales carry the same information as IRE returns, the predictive power of short sales should become less significant. The VAR model is expressed as:

$$Y_t = A + \sum_{k=1}^{p} B_k Y_{t-k} + \varepsilon_t \qquad (3)$$

Specifically, Y_t is a 3x1 vector of the three variables in the system (S_{IRE}, R_{DRE}, and R_{IRE}); A is a 3x1 vector of constants; B_k is a 3xp matrix of coefficients on the lagged variables, with p being the lag order. Wald tests will be used to test the joint significance of each set of lagged variables. Hypothesis 1 holds if short selling activities are able to forecast DRE returns.

To test the crisis effect in Hypothesis 2, the VAR model in Equation (3) is estimated separately with samples before and after the crisis. As discussed before, the crisis is expected to change the information environment and make short selling reveal more firm-specific information than market-wide news. Therefore, the relationship between short selling and DRE returns should be weakened after the crisis.

Empirical Results

Summary statistics

Panel A of Table 1 reports the summary statistics of the three variables (S_{IRE}, R_{DRE}, and R_{IRE}) during 1999-2011. The average weekly returns to the Hang Seng Property Sub-index (the IRE market) and CCL index (the DRE market) were positive during the sample period, with the former (0.11%) outperforming the latter (0.09%). The difference amounted to about 100 basis points p.a. At the same time, the IRE returns had higher volatility than the

DRE returns: the standard deviation of IRE returns was 4.82%, whereas that for the DRE returns was 1.13%. Thus, higher returns came with higher volatility in the real estate markets concerned. The last column of Table 1 shows the short interest ratio of real estate stocks. The ratio shows a considerable amount of variation from 0.82% to 25.36%, with the average being 9.5%. This is comparable to the average short interest ratio of 9.7% for the mainboard of the Hong Kong Stock Exchange, but is lower than that of some other markets (e.g. 12.9% for NYSE-listed common stocks, according to Boehmer *et al.*, 2008).

Insert Table 1

Further down Panel A of Table 1 shows the Augmented Dickey-Fuller (ADF) test statistics. They indicate that all three variables during the full sample period, as well as the two sub-periods (in Panel B), have achieved stationarity at the 1% level. This means the variables are I(0) and can be directly used for time series analysis.

Panel A of Table 2 shows how the three variables were contemporaneously correlated. Consistent with the price discovery literature, the correlation between IRE and DRE returns was very low (only 0.03) and statistically insignificant. The correlation between short

interest ratios and IRE returns was also weak (-0.01). In contrast, there was a significant correlation (0.08) between short interest ratios and DRE returns. This provides initial evidence that short sales may play an important role in the price discovery process between the IRE and DRE markets.

Insert Table 2

Panel B of Tables 1 and 2 splits the sample period into two and presents the descriptive statistics before and after the credit crisis (i.e. 1999-2006 and 2007-2011). It is noted that the average return of the DRE market grew sharply from -0.01% to 0.26%, whereas the IRE market had similar average returns in both sub-periods but higher volatility after the crisis. This could be explained by the nature of the crisis, which generated much uncertainty about the credibility of individual firms (including real estate companies in the IRE market) but not the brick and mortar in the DRE market. There was also a corresponding increase in short selling activities from 9.24% before the crisis to 13.01% after the crisis, suggesting that the crisis might have created more opportunities for informed trading or higher demand for hedging. In terms of correlations, the sub-period results are similar to the full-period ones – the only significant correlation detected is between short interest ratios and DRE returns.

Granger causality results

Given the weak contemporaneous correlations between the three variables, pairwise Granger causality tests are used to identify any lead-lag relationships between them. The results are shown in Table 3. First, as expected from the price discovery literature, we find that the IRE market led the DRE market, but not vice versa. Second, the short sales of real estate stocks led the DRE market, but not vice versa, thereby supporting the information spillover argument in Hypothesis 1. The third result is interesting: IRE returns led short sales of real estate stocks, but not vice versa. While this is not the focus of this paper, it seems to suggest that short sellers are trend followers rather than insiders.

Insert Table 3

Full-period VAR results

Table 4 presents the full-period results of our VAR model, which estimates the dynamic relationships between the three variables simultaneously. Based on the Schwarz criteria, an optimal lag order of two weeks is chosen. Several significant coefficients are found. First, the DRE market was driven by variables, including short interest ratios, IRE returns, and its own past returns, that lagged by two weeks. This reflects that the DRE market is rather sluggish and takes two weeks to capitalize on any new information revealed by the shorting and prices of the IRE. On the other hand, the IRE market was driven only by its own one-week lagged returns, which suggest that the IRE market is relatively efficient and not affected by past short selling activities. The negative coefficient indicates the presence of a mean reversion in IRE returns. This could imply opportunities for short sellers to trade on

overreactions and is consistent with the finding (in the last column) that IRE returns lead short sales by one week. Short sales are also found to be strongly autocorrelated with their own past values.

Insert Table 4

Table 5 shows the results of the Wald tests for the joint significance of each set of lagged variables in the VAR model. Basically, they confirm the dynamic relationships discussed before. The DRE returns were significantly led by the past IRE returns and short sales of real estate stocks. The IRE returns could neither be forecasted by the past DRE returns nor past short selling activities. The short sales were significantly led by the past IRE returns but not the DRE returns. Therefore, our full-sample (1999-2011) analysis confirms Hypothesis 1 and concludes that price discovery does not occur only through IRE returns. The short selling of real estate stocks conveys additional information to the DRE market.

Insert Table 5

Sub-period VAR results

In this section, the full sample is split into two periods: before and after the credit crisis (i.e., 1999-2006 and 2007-2011). Tables 6 and 7 produce the sub-period VAR results and Wald statistics, respectively. The most important finding is that short selling had a different effect on the DRE market during the two periods. Before the crisis, short selling significantly led DRE returns; after the crisis, such a relationship was no longer significant. This confirms Hypothesis 2, which predicts a weakened relationship between short selling and IRE returns after the crisis. The increased uncertainty over the credibility of individual firms has made short selling carry more firm-specific information than market-wide news, thus limiting information spillover to the DRE market. Nevertheless, IRE returns still led DRE returns during both periods, implying that the traditional price discovery channel was unaffected by the crisis.

Within the IRE market, an interesting change in the interactions between short selling and IRE returns is observed. Before the crisis, there was a significant feedback relationship between short selling and IRE returns – not only did IRE returns affect short sales, but short sales also affected IRE returns. This means short selling could have been used as a strategy to correct mispricing in the IRE market. For example, after a sharp rise in share prices, investors who think the market has overreacted may take a short position in order to profit from subsequent price adjustments. However, after the crisis, IRE returns are found to follow short selling, but not vice versa. This is more consistent with an insider information story, in which insiders "release" bad news though short selling and cause subsequent price drops. Whatever strategies short sellers were using, the sub-period results suggest a changing relationship between short selling and IRE returns, which may warrant further research.

Insert Table 6

Insert Table 7

Conclusion

Combining a unique dataset of weekly returns of direct real estate with the returns and short sales of real estate stocks, we re-visited the price discovery channel between direct and indirect real estate markets. The evidence presented in this paper suggests that short sales in the indirect market convey price information to the direct market. Such information is different from that revealed by stock prices, as information spillover exists even after accounting for indirect real estate returns in our VAR model. Therefore, short sellers in the indirect market provide direct real estate investors with an additional channel for price discovery, which enhances the efficiency of the non-shortable direct market.

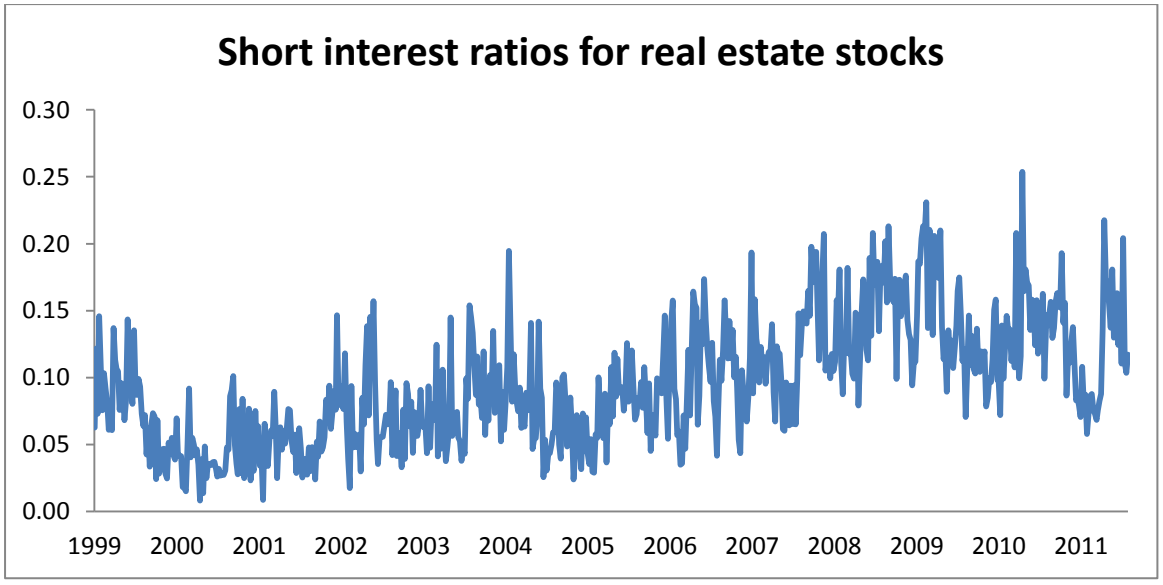
Our findings also shed light on the short selling literature by clarifying the type of private information needed for cross-market spillover to occur. We argued that the information has to be related to the entire real estate market rather than to individual firms. To verify our argument, we assumed the 2007-08 credit crisis caused major change in the information environment, in which the credibility of individual firms became much more

uncertain. Our results showed that the spillover effect of short selling weakened substantially after the crisis, which confirms that firm-specific information is not relevant to the direct market. In other words, the credit crisis did not only adversely affect the stock and bond markets, but it also indirectly reduced the efficiency of the direct real estate market.

Figure 1 Hang Seng Property Sub-index

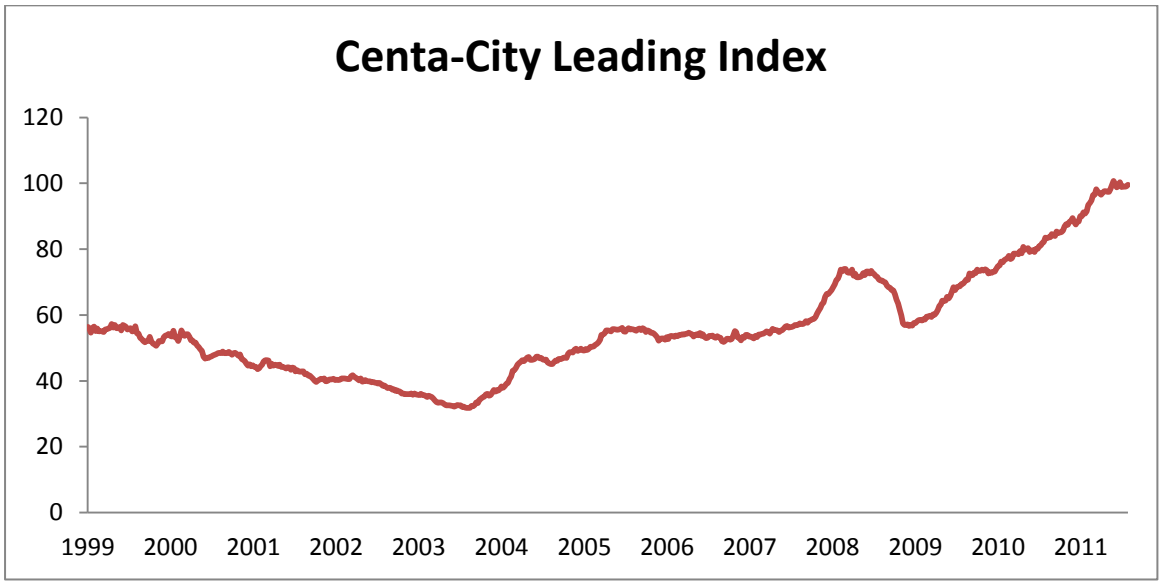
Source: Datastream

Figure 2 Short interest ratios for real estate stocks



Source: Calculated from SEHK's short sales data

Figure 3 Centa-City Leading Index



Source: Centaline Property Agency

Table 1. Descriptive Statistics

Variable	R_{DRE}	R_{IRE}	S_{IRE}
Panel A			
Mean (%)	0.09	0.11	9.50
Maximum (%)	4.05	22.97	25.36
Minimum (%)	-4.26	-22.03	0.82
Std. Dev. (%)	1.13	4.82	4.59
ADF (levels)	-7.52 ***	-28.18 ***	-5.77 ***
Observations	656	656	656
Panel B	R_{DRE}	R_{IRE}	S_{IRE}
Pre-Crisis			
Mean (%)	-0.01	0.12	9.24
Maximum (%)	4.05	15.34	28.23
Minimum (%)	-3.95	-16.46	1.81
Std. Dev. (%)	1.18	4.29	4.19
ADF (levels)	-9.32 ***	-20.87 ***	-7.16 ***
Observations	416	416	416
Post-Crisis			
Mean (%)	0.26	0.11	13.01
Maximum (%)	2.69	22.97	24.85
Minimum (%)	-4.26	-22.03	6.07
Std. Dev. (%)	1.00	5.63	3.38
ADF (levels)	-5.07 ***	-18.30 ***	-5.52 ***
Observations	240	240	240

Note: All rates are weekly. *** represents the 1% level of significance.

Table 2. Correlations

Panel A	R_{DRE}	R_{IRE}	S_{IRE}
R_{DRE}	1.00		
R_{IRE}	0.03	1.00	
S_{IRE}	0.08 **	-0.01	1.00
Panel B	R_{DRE}	R_{IRE}	S_{IRE}
Pre-Crisis			
R_{DRE}	1.00		
R_{IRE}	0.07	1.00	
S_{IRE}	0.09 *	0.06	1.00
Post-Crisis			
R_{DRE}	1.00		
R_{IRE}	-0.03	1.00	
S_{IRE}	-0.13 **	-0.08	1.00

Note: ***, **, and * represent the 1%, 5%, and 10% levels of significance.

Table 3: Summary of Granger Causality Tests

			F-Statistic	p-value
R_{IRE}	→	R_{DRE}	11.092	0.00 ***
R_{DRE}	→	R_{IRE}	0.588	0.56
S_{IRE}	→	R_{DRE}	3.595	0.03 **
R_{DRE}	→	S_{IRE}	0.334	0.72
S_{IRE}	→	R_{IRE}	0.026	0.97
R_{IRE}	→	S_{IRE}	3.704	0.03 **

Note: X → Y means the null hypothesis that X does not Granger causes Y
***, **, and * represent the 1%, 5%, and 10% levels of significance.

Table 4. VAR Estimation results

	R_{DRE}	R_{IRE}	S_{IRE}
$R_{IRE\,(-1)}$	0.008831	-0.094637 **	0.063233 ***
	[0.99644]	[-2.40595]	[2.66964]
$R_{IRE\,(-2)}$	0.042354 ***	0.012941	0.01221
	[4.77112]	[0.32845]	[0.51462]
$S_{IRE\,(-1)}$	-0.007352	-0.016109	0.467817 ***
	[-0.53715]	[-0.26515]	[12.7876]
$S_{IRE\,(-2)}$	0.031322 **	0.005531	0.361824 ***
	[2.29229]	[0.09119]	[9.90744]
$R_{DRE\,(-1)}$	0.028711	0.168503	0.067766
	[0.75966]	[1.00449]	[0.67086]
$R_{DRE\,(-2)}$	0.180504 ***	0.067856	0.012091
	[4.78032]	[0.40488]	[0.11980]
Adj. R-squared	0.075503	0.00175	0.602424

Note: The value in each cell is the coefficient estimate for each parameter
t-statistics in [ ]. ***, **, and * represent the 1%, 5%, and 10% levels of significance.

Table 5: Wald Tests

Dependent Variable: $R_{DRE,t}$	Chi-square	p-value
Coefficients of $R_{IRE,t-1}$ & $R_{IRE,t-2}$ jointly = 0	23.043	0.000 ***
Coefficients of $S_{IRE,t-1}$ & $S_{IRE,t-2}$ jointly = 0	8.074	0.018 **
Dependent Variable: $R_{IRE,t}$		
Coefficients of $R_{DRE,t-1}$ & $R_{DRE,t-2}$ jointly = 0	1.213	0.545
Coefficients of $S_{IRE,t-1}$ & $S_{IRE,t-2}$ jointly = 0	0.093	0.954
Dependent Variable: $S_{IRE,t}$		
Coefficients of $R_{DRE,t-1}$ & $R_{DRE,t-2}$ jointly = 0	0.473	0.789
Coefficients of $R_{IRE,t-1}$ & $R_{IRE,t-2}$ jointly = 0	7.191	0.028 **

Note: ***, **, and * represent the 1%, 5%, and 10% levels of significance.

Table 6. VAR Estimation results (Pre- / Post- Crisis)

	Pre-Crisis			Post-Crisis		
	R_{DRE}	R_{IRE}	S_{IRE}	R_{DRE}	R_{IRE}	S_{IRE}
$R_{IRE\,(-1)}$	0.002668	-0.017447	0.079997	0.010403	-0.175986	0.045188
	[0.20085]	[-0.35330]	[2.63082] ***	[0.95041]	[-2.70244] ***	[1.22502]
$R_{IRE\,(-2)}$	0.053691	0.015829	0.026877	0.030902	-0.000417	0.004795
	[4.02723] ***	[0.31939]	[0.88073]	[2.82508] ***	[-0.00641]	[0.13007]
$S_{IRE\,(-1)}$	0.002276	0.166029	0.385221	-0.023847	-0.238407	0.388935
	[0.10948]	[2.14809] **	[8.09400] ***	[-1.27514]	[-2.14265] **	[6.17103] ***
$S_{IRE\,(-2)}$	0.039010	-0.148264	0.280705	0.020169	0.199366	0.285638
	[1.89508] *	[-1.93758] *	[5.95743] ***	[1.07463]	[1.78541] *	[4.51595] ***
$R_{DRE\,(-1)}$	-0.020677	0.030901	0.055291	0.097086	0.329316	-0.029536
	[-0.42948]	[0.17266]	[0.50173]	[1.58685]	[0.90470]	[-0.14325]
$R_{DRE\,(-2)}$	0.095402	-0.054970	-0.004028	0.331940	0.368093	-0.083113
	[1.98317] **	[-0.30740]	[-0.03658]	[5.43562] ***	[1.01311]	[-0.40384]
Adj. R-squared	0.053804	0.000039	0.363894	0.144709	0.035380	0.338531

Note: The value in each cell is the coefficient estimate for each parameter
t-statistics in [ ]. ***, **, and * represent the 1%, 5%, and 10% levels of significance.

Table 7: Wald Tests (Pre-/Post- Crisis)

	Pre-Crisis		Post-Crisis	
Dependent Variable: $R_{DRE,t}$	Chi-square	p-value	Chi-square	p-value
Coefficients of $R_{IRE,t-1}$ & $R_{IRE,t-2}$ jointly = 0	16.225	0.00 ***	8.201	0.02 **
Coefficients of $S_{IRE,t-1}$ & $S_{IRE,t-2}$ jointly = 0	5.395	0.07 *	1.845	0.40
Dependent Variable: $R_{IRE,t}$				
Coefficients of $R_{DRE,t-1}$ & $R_{DRE,t-2}$ jointly = 0	0.126	0.94	2.177	0.34
Coefficients of $S_{IRE,t-1}$ & $S_{IRE,t-2}$ jointly = 0	5.471	0.06 *	5.172	0.08 *
Dependent Variable: $S_{IRE,t}$				
Coefficients of $R_{DRE,t-1}$ & $R_{DRE,t-2}$ jointly = 0	0.254	0.88	0.206	0.90
Coefficients of $R_{IRE,t-1}$ & $R_{IRE,t-2}$ jointly = 0	7.567	0.02 **	1.508	0.47

Note: ***, **, and * represent the 1%, 5%, and 10% levels of significance.

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