Does Property Transaction Matter in Price Discovery in Real Estate Markets?

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Abstract

We study the cointegration relationship(s) between public and private market pricing of real estate using U.S. data from December 2001 to December 2013. Unlike earlier studies in the literature, we employ a unique dataset of property transaction to form public and private price series pairs around transaction windows, not by regular calendar days. We estimate the normalized Gonzalo and Granger (1995) common factor loadings of the public and private real estate markets by vector error-correction models and find significant proportion of price discovery from the private markets, in contrast to previous studies. However we also find significant heterogeneity across property types and individual firms within each type. Our results are robust to the property types and the length of transaction windows.

Keywords: Public and private real estate, transaction window, REITs, NAV, property types, VECM, Gonzalo and Granger price discovery, common factor loadings

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1. Introduction

Recent studies examine the long-run cointegration relation between public securitized real estate prices and private direct real estate prices. Public real estate markets such as real estate investment trusts (REITs) are liquid and have low transaction costs. Private real estate markets are important to portfolio diversification but have low liquidity and high transaction costs. Yunus et al. suggest that public market lead the private market, but not the other way round, while Tuluca et al. find that unsecuritized real estate market weakly leads the securitized real estate market. Hoesli and Oikarinen (2013) show that public real estate returns are a close substitute of private real estate returns. Evidences of cointegration relations between securitized and direct real estate returns are yet to be conclusive.

We study the cointegrating relationships and price discovery contributions between public and private market pricing of real estate using the data for U.S market from 2001 to 2013. We employ a unique dataset of property transactions to form synchronized public and private return pairs around transaction windows, not by regular calendar days as in earlier studies in the literature. Transaction data allows us to estimate long-run relation between public and private real estate markets with respect to information generated by property transactions in the underlying property market. Property transaction information matters in cointegration relation between public and private markets because transactions in property markets are infrequent relative to public real estate securities. Under the assumption of efficient markets, price discovery of public and private real estate markets around property transactions dates should measure information generated by trading of properties rather than (stock market) noise in periods without any property transactions.

We estimate the normalized Gonzalo and Granger (1995) common factor loadings of the public and private real estate markets by vector error-correction models using synchronized public and private return pairs around transaction windows. Our main finding is that the common factor loading of private real estate market increases relative to the public real estate market with property transaction information. Property types such as diversified, office, hotel, and industrial all show significant increase in common factor loadings of private market when we examine a 50-day window around a property transaction. These results are robust to different property types and transaction windows.

Our major contribution is to estimate precisely information incorporated into prices around property transactions rather than noise in stock markets with the property transaction information. While property transactions are infrequent, information from these transactions should be more relevant to real estate returns than stock market noise that is uncorrelated with property market fundamentals. It has been shown that in US, public real estate returns have higher correlation with general stock markets movement than private real estate returns (Mueller and Muller, 2003; Brounen and Eichholtz, 2003; Ross and Zisler, 1991). Hoesli and Oikarinen (2013) find that REITs and direct real estate returns are closely link in the long-run responses to shocks in an international setting. Our analysis of property transaction may provide another angle to reconcile the mixed evidence in long-run relation of public and private real estate returns.

Next section we review related literature. Section 3 explains our econometric analysis. Section 4 describes the data. Section 5 discusses our empirical results and Section 6 concludes.

2. Literature Review

The relationship between securitized and unsecuritized real estate markets has been explored by many studies and the results of the correlation between them are mixed. Sagalyn (1990) does not see that REIT and its underlying property returns are concurrently correlated. She proposes that REIT income reflects underlying real estate property because 95% of earnings must be paid out. But she also argues that, for capital returns, REITs perform more like stocks than direct real estate, because of their nature--part stock. Ling and Naranjo (1999) find that REITs are integrated with stocks and that the degree of integration has significantly increased during the 1990s. At the same time, they find that REITs deviate from direct real estate. However, Clayton and MacKinnon (2001) document the relationship between REIT returns and unsecuritized real estate has changed over time. Through examining the data spanning from 1978 to 1998, they find that, during the 1990s, REITs began to exhibit a direct link to real estate returns. With the setup of the model which is on short-term basis, MacKinnon and AI Zaman (2009) make the similar conclusion that the correlation between REITs and direct real estate is time-varying. The correlation between them increases with horizon, but never exceeds 0.54.Myer and Webb (1993) states that intertemporally REIT returns are much more strongly related to unsecuritized real estate returns than are the returns on stocks or closed-end funds. By constructing REIT-based pure-play portfolios, replicating the performance of target real estate, Geltner and Kluge (1998) claim that there appears to be substantially more closely linked between public and private markets.

There are also some recent studies exploring the long-term dynamics between securitized and unsecuritized real estate markets. Pagliari et al. (2005) indicate that public and private real estate markets display a long-run synchronicity. Oikarinen, Hoesli, and Serrano (2011) find the long-run cointegrating relationship between securitizedand direct real estate markets. Stefek and Suryanarayanan (2012) focus on core real estate in the U.K. market, analyzing data spanning more than two decades and demonstrate tight link between public and private real estate markets in the U.K after accounting for appraisal smoothing and lead-lag relationship. Moreover, the link becomes stronger at longer horizons. In order to avoid bias resulting from appraisal smoothing, Boudry et al. (2012) use transaction based price indexes, MIT TBI indexes, and find that REITs and their underlying direct real estate market are cointegrated in the U.S. market. Yunus et al. (2012) examine the international markets and discover that in addition to the U.S. and U.K. markets, Australia, Netherlands also exhibit the long-run relationships between the public and private real estate markets. Incoporating economic fundamentals and sector level data, Hoesli and Oikarinen (2012) suggest that public and private real estate markets are tightly linked in the long run. Časni and Vizek (2014) study the long-run cointegration relationship between equity and real estate prices in 30 developed and emerging economies find that equity price and real estate prices are closely correlated, synchronized, and codependent in the long-run. The level of long-run codependence hinges on the levels of national incomes and the structure of financial markets of national incomes and the structure of financial markets.

Most of studies support the notion that public real estate returns lead private real estate returns. Early studies by Gyourko and Keim (1992) and Barkham and Geltner (1995) and Eichholtz and Hartzell (1996) and Geltner and Kluge (1998) and Geltner et al. (2002)claim that securitized real estate returns tend to lead direct private real estate returns. In order to address the possibly biased estimation of the short-run dynamics, Oikarinen et al. include the transaction-based NCREIF Index in the analysis and conclude that REIT returns dominate private real estate returns. Yunus et al. (2012) suggest the public market lead the private market, but not the other way round, by Granger causality test. Having accounting for economic fundamentals and leverage, Hoesli and Oikarinen (2012) use sector level indices and find that REIT market predicts direct real estate market. In addition to accounting for property-type and leverage, Oikarinen et al. (2013) consider the impact of escrow lags on the reported lead-lag relations between public and private markets and find that REIT returns lead private real estate returns. Yavas and Yildirim (2011) use DCC GARCH model to try to illustrate that the correlations between public and private real estate markets are time varying. They also suggest price discovery generally take place in the securitized public market. However, the dominant role may change across property types and individual firms within each type.

Though it is generally believed that securitized real estate market, which is more liquid, incorporates the new information more quickly and efficiently than direct real estate market, direct real estate market may lead public market. Examining the five assets, including T-bills, bonds, stocks, and both public and private real estate, Tuluca et al. (2000) find that these five assets are nonstationary and cointegrated and that the unsecuritized real estate market weakly leads the securitized real estate market. They explain that the definition of market efficiency in real estate market is different. As defined by Ross (1987), a market is efficient if there exists a lack of arbitrage opportunities. According to this definition, private real estate market can be regarded as efficient market because of the illiquidity.

We also derive the similar results to Tuluca et al. (2000) that private real estate market lead public real estate market. However, we concentrate on exploring whether the private real estate market matters in price discovery. We employ a unique dataset of infrequent daily property transaction to form public and private price pairs around transaction windows, not by regular calendar days, and investigate the change in common factor loadings of private market. If the common factor loadings of private market increase around transaction windows, as compared with full samples of regular calendar days, we may conclude that private market does matter in price discovery.

3. Research Methodology

3.1. Johansen Cointegration

The primary objective of this study is to investigate the long-run dynamics between securitized real estate market and underlying direct property market and test the relative magnitude of price discovery attributable to any given market. We are to apply vector error correction model (VECM) to reveal the long-run dynamics. Before that, Johansen conintegration test is applied to test for the existence of cointegrating relationship between public and private real estate markets. Johansen's technique starts from vector autoregression (VAR) of order p given by

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + \epsilon_t \quad (1)$$

where y_t is a $k \times 1$ vector of I(1) non-stationary time series, c is $k \times 1$ vector of constants, ε_t is $k \times 1$ vector of innovations. If all the time series in the VAR have a one-unit root that can be removed by taking the first difference, the VAR(p) model can be written as

$$\Delta y_t = \prod y_{t-1} + \sum_{j=1}^{p-1} \Gamma_j \Delta y_{t-j} + \epsilon_t \quad (2)$$

In this model, we test the cointegrating hypothesis by examining the rank of the long-run impact matrix Π. If the coefficient matrix Πis equal to zero, then there is no cointegration. If Π has full rank, then all y_t must be stationary since the left hand side and the right hand side variables are stationary.When Π has reduced rank $0 < r < n$, in this case, it is considered to be cointegrated such that $\Pi = \alpha \times \beta'.r$ is number of cointegrating vectors which is equal to the rank of Π, α is the error correction (or equilibrium adjustment) matrix in the vector error correction model and β is the cointegrating vector.

Johansen formulates likelihood ratio (LR) statistics for the number of cointegrating relationships as LR statistics for determining the rank of Π: the trace and maximum eigenvalue statistics, shown in equations (3) and (4), respectively.

$$LR_{trace}(r_0) = -T \sum_{i=r_0+1}^{n} \ln(1 - \widehat{\lambda_l}) \quad (3)$$

$$LR_{max}(r_0) = -T\ln(1 - \widehat{\lambda_{r_0+1}}) \quad (4)$$

While the trace statistic tests the null hypothesis $H_0(r_0): r = r_0$vs. $H_1(r_0): r > r_0$, the maximum eigenvalue statistic tests the null hypothesis $H_0(r_0): r = r_0$vs. $H_1(r_0): r_0 + 1$.In this study, we apply the trace test statistics to determine the number of cointegrating vectors (r).

3.2. Price Discovery

In finance, currently, there are two popular common factor models that are used to investigate the mechanics of price discovery: Hasbrouck (1995) and Gonzalo and Granger (1995), namely information shares (IS) and permanent-transitory (PT), respectively. Both models are primarily derived from vector error correction model (VECM). In our study, we adopt the Granger and Gonzalo's permanent-transitory procedure to estimate our model.

The VECM(p) form with the cointegration rank $r(\leq k)$ is written as

$$\Delta y_t = \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \Gamma_3 \Delta y_{t-3} + \cdots + \Gamma_k \Delta y_{t-k} + \alpha\beta' y_{t-1} + \epsilon_t \quad (5)$$

where Γ_i are (2×2) square matrices of coefficients for the lagged differences, α is the error correction (or equilibrium adjustment) matrix, β is the cointegrating vector which represents the long-run relationship between the public and the private real estate markets, and e_t denotes the vector regression residual.

In our study, we estimate the vector error correction model (VECM) with the following equations

$$\Delta Total\_return_t = \alpha_1 Z_{t-1} + \sum_{j=1}^{p} \tau_{1j} \Delta Total\_return_{t-j} + \sum_{j=1}^{p} \varphi_{1j} \Delta NAV_{t-j} + \epsilon_{Total\_return} \quad (6)$$

$$\Delta NAV_t = \alpha_2 Z_{t-1} + \sum_{j=1}^{p} \tau_{2j} \Delta Total\_return_{t-j} + \sum_{j=1}^{p} \varphi_{2j} \Delta NAV_{t-j} + \epsilon_{NAV} \quad (7)$$

where $\Delta Total\_return$ and ΔNAV are the change of total return index and net asset value (NAV) in period t, respectively, $Z_{t-1} = Total\_return_{t-1} - \beta NAV_{t-1}$ is the long-term relationship between total return index and NAV, ϵ_{Total_return} and ϵ_{NAV} are i.i.d. innovations.

Gonzalo and Granger's (1995) price discovery focus on the error correction process. The model estimates the common factor weights that reflect the permanent contribution to the common factor (efficient price). The common factor weights are derived from each market's error correction coefficients, α_1 and α_2. Following the approach of Gonzalo and Granger (1995), the respective contribution of REITs and direct real estate property to price discovery are defined by the following GG ratios

$$GG_{reits} = \frac{\alpha_2}{\alpha_2 - \alpha_1} \quad \text{and} \quad GG_{NAV} = \frac{\alpha_1}{\alpha_1 - \alpha_2} \qquad (8)$$

The ratio denotes the portion of contribution to price discovery. The sum of GG_{reits} and GG_{NAV} equals to 100%.According to Upper and Werner (2007), the point estimate for the GG common factor loading can be negative, as the coefficients on the error correction term are of the same sign in both equations of the VECM. They suggest that only one market adjusts toward the equilibrium, while another market moves away from it. Put it another way, this happens when all adjustment is made by only one market. [2]The lag length is selected based on Hannan-Quinn Information Criteria (HQ) as suggested by Johansen et al. (2000).

It is generally believed that REIT market takes the dominant role in price discovery with respect to direct real estate market. Using the sector level data, Oikarinen et al. (2013) find evidence that price discovery mainly takes place in the public market (securitized real estate market) because of the slow reaction of private market returns to shocks in REIT returns. Following to Hasbrouck (1995), we apply the price series, total return index and NAV values, to the VECM for the price discovery analysis. Through comparing the GG ratios of full sample and transaction windows, we find that the GG ratio of private market increases, indicating that private market matters in price discovery.

4. Data

[2]Negative common factor loadings can also be arisen if price series are not cointegtrated.

For the full sample, spanning from December 2000 to December 2013, our dataset includes REIT total return index and NAV values which are in daily frequency, obtained from SNL financial. The total return index calculation assumes that dividends paid by the company are reinvested. The construction of transaction windows is as follows: we populate the records of property transaction dates (both acquisition and sold dates) of a company from SNL financial and merge these transaction dates with the full sample, under the same company and calendar dates. Based on these transaction dates, we take the 'lead and lag' dates of the full sample. For example, there was a property transaction on 11/07/2003 of Highwoods Properties Inc. To construct the transaction window of Highwoods Properties Inc., based on 11/07/2003, we take the observations of the 'lead' 25 days and 'lag' 25 days. The NAV values from SNL financial are appraisal-based, which may result in estimation bias. Nonetheless, according to Lai and Wang (1998), Corgel and deRoos (1999) and Childs, Ott and Riddiough (2002), the magnitude of the appraisal-smoothing problem and the procedures for correcting it are not universally agreed upon. In addition, though NAV values are derived from analyst's estimation, they should reflect the values of underlying properties and should not deviate too much from properties' true values.

There are 12 property types included in the samples which are diversified, healthcare, hotel, industrial, manufactured homes, multi-family, regional mall, retail, self-storage, shopping center, and specialty. Total number of REITs amounts to 164. The sample periods covered in the dataset are different across different firms. For example, the data's availability of Cedar Realty Trust Inc. begins at November 2003 and ends at December 2013, while Cousins Properties Incorporated starts at May 2001 and ends at December 2013. In the econometric analysis, following Hasbrouck (1995), we only apply real indices of total return index and NAV values. Table 1 exhibits the summary statistics of the difference of total return index, $\Delta total\ return_t$ $(total\ return_t - total\ return_{t-1})$ and the difference of NAV, ΔNAV_t $(NAV_t - NAV_{t-1})$. As suggested by table 1, in the U.S. market, REIT is more volatile than NAV at the daily level. NAV exhibits larger values than REIT, implying that NAV is of less normality than is REIT.

5. Empirical Results

5.1. Long-term relation

We examine the long-term cointegrating relationship between REIT total return index and NAV at firm level within each property type. The results exhibited in table 2 are the average statistics of each firm within each property type. In fact, the results of long-term dynamics between total return index and NAV present heterogeneity across different property types and firms. As table 2 exhibited, all twelve property types demonstrate tight cointegrating relationships between REIT total return index and NAV. By checking the trace test statistics, we find that there is only one long-term cointegrating relationship between REIT total return index and NAV of each property type. The results of Johansen cointegration test are critically dependent on the selected lag length. We select the lag lengths based on Hannan-Quinn Information Criteria (HQ) across different firms. Therefore, our selected lag lengths are different across different firms. We normalize the cointegrating vector β and derive the long-run equilibrium relationships between REIT total return index and NAV. Across all the property types in Table 2, regional mall, self-storage, and retail have the same sign in both equations of the VECM. Since price discovery is attributed to the market reacting least to price movements in the other market, this suggests that, for regional mall, self-storage and retail, only NAV adjusts toward the equilibrium, while the total return index moves away from it. Our results indicate that adjustment takes place in the private market of property types of regional mall, self-storage, and retail.

Table 1: Descriptive statistics of differenced series. The table presents the summary statistics of the differenced series of total return index and NAV. The data periods covered in the dataset are different across different firms, depending on the availability of observations. For example, the available observations of Cedar Realty Trust Inc. begin at November 2003 and end at December 2013, while Cousins Properties Incorporated starts at May 2001 and ends at December 2013.

Property_type	Diversified		Healthcare		Hotel		Industrial		Manufactured homes		Multi-family	
Category	1		2		3		4		5		6	
	REIT	NAV	REIT	NAV	REIT	NAV	REIT	NAV	REIT	NAV	REIT	NAV
Number of Firms	24		15		26		8		3		13	
Sample Size	106801	106801	34819	34819	46762	46762	21245	21245	6394	6394	47297	47297
Mean	-0.063	0.003	0.172	0.005	0.062	0.001	0.124	0.002	0.203	0.007	0.306	0.009
Median	0.000	0.0x00	0.000	0.000	0.000	0.000	0.000	0.000	0.135	0.000	0.020	0.000
Std_Dev	27.133	0.305	8.298	0.196	5.672	0.290	7.832	0.177	8.903	0.272	17.953	0.273
Skewness	-3.482	1.306	-0.143	2.891	0.000	-1.114	0.145	-0.867	-0.158	2.962	0.150	-1.296
Kurtosis	228.068	300.811	11.884	142.578	15.371	186.054	16.204	125.472	7.761	121.017	25.189	100.406

Property_type	Office		Regional Mall		Retail: other		Self-storage		Shopping Center		Specialty	
Category	7		8		9		10		11		12	
	REIT	NAV	REIT	NAV	REIT	NAV	REIT	NAV	REIT	NAV	REIT	NAV
Number of Firms	19		7		7		4		19		19	
Sample Size	69661	69661	23155	23155	23511	23511	12012	12012	56456	56456	19394	19394
Mean	0.136	0.004	0.227	0.011	0.259	0.003	0.277	0.015	0.174	0.003	0.143	0.008
Median	0.020	0.000	0.230	0.000	0.100	0.000	0.120	0.000	0.090	0.000	0.090	0.000
Std_Dev	10.596	0.311	12.385	0.344	12.292	0.167	11.621	0.234	12.079	0.179	6.849	0.252
Skewness	0.058	-0.712	-0.124	0.062	-0.067	-0.959	0.265	2.182	-0.102	-0.633	-0.365	2.828
Kurtosis	23.886	159.178	12.644	98.072	11.188	196.575	18.849	59.336	15.406	104.161	12.669	131.813

Table 2: Cointegration test statistics and the estimated long-run relations for the U.S. market. The table presents the average estimates of error correction coefficients, trace test statistics, and cointegration relation coefficients of non-stationary total return index and NAV. The lag length is selected based on Hannan-Quinn Information Criteria (HQ) and may be different across different firms.

Diversified		
Hypothesis	$r = 0$ (critical value = 12.21)	$r > 1$ (critical value = 4.14)
Trace test statistics	19.567	1.335
Long-run relation	Adjustment speed of *Total return*	Adjustment speed of *NAV*
NAV = 0.143 total_return_index	*0.051675*	*-0.00895*
Office		
Hypothesis	$r = 0$ (critical value = 12.21)	$r > 1$ (critical value = 4.14)
Trace test statistics	41.621	0.193
Long-run relation	Adjustment speed of *Total return*	Adjustment speed of *NAV*
NAV = 0.111 total_return_index	*0.1594*	*-0.00264*
Hotel		
Hypothesis	$r = 0$ (critical value = 12.21)	$r > 1$ (critical value = 4.14)
Trace test statistics	25.856	0.751

Long-run relation	Adjustment speed of *Total return*	Adjustment speed of *NAV*
NAV = 0.139 total_return_index	*0.0125*	*-0.0094*
Shopping Center		
Hypothesis	$r = 0$ (critical value = 12.21)	$r > 1$ (critical value = 4.14)
Trace test statistics	44.037	0.550
Long-run relation	Adjustment speed of *Total return*	Adjustment speed of *NAV*
NAV = 0.075 total_return_index	*0.0350*	*-0.00588*
Healthcare		
Hypothesis	$r = 0$ (critical value = 12.21)	$r > 1$ (critical value = 4.14)
Trace test statistics	18.808	1.485
Long-run relation	Adjustment speed of *Total return*	Adjustment speed of *NAV*
NAV = 0.187 total_return_index	*0.09025*	*-0.00557*
Multi-family		
Hypothesis	$r = 0$ (critical value = 12.21)	$r > 1$ (critical value = 4.14)
Trace test statistics	50.955	0.753
Long-run relation	Adjustment speed of *Total return*	Adjustment speed of *NAV*
NAV = 0.087 total_return_index	*0.04578*	*-0.00308*

Table 2: (continued)

Industrial		
Hypothesis	$r = 0$ (critical value = 12.21)	$r > 1$ (critical value = 4.14)
Trace test statistics	35.553	3.347
Long-run relation	Adjustment speed of *Total return*	Adjustment speed of *NAV*
NAV = 0.123 total_return_index	*0.1772*	*-0.00807*
Regional mall		
Hypothesis	$r = 0$ (critical value = 12.21)	$r > 1$ (critical value = 4.14)
Trace test statistics	54.253	0.325
Long-run relation		Adjustment speed of *NAV*
NAV = 0.073 total_return_index		*-0.00507*
Self-storage		
Hypothesis	$r = 0$ (critical value = 12.21)	$r > 1$ (critical value = 4.14)
Trace test statistics	76.581	1.191
Long-run relation		Adjustment speed of *NAV*

NAV = 0.108 total_return_index		*-0.0038*
Specialty		
Hypothesis	$r = 0$ (critical value = 12.21)	$r > 1$ (critical value = 4.14)
Trace test statistics	20.447	0.513
Long-run relation	Adjustment speed of *Total return*	Adjustment speed of *NAV*
NAV = 0.137 total_return_index	*0.02992*	*-0.00498*
Manufactured homes		
Hypothesis	$r = 0$ (critical value = 12.21)	$r > 1$ (critical value = 4.14)
Trace test statistics	26.033	3.691
Long-run relation	Adjustment speed of *Total return*	Adjustment speed of *NAV*
NAV = 0.046 total_return_index	*0.05637*	*-0.00407*
Retail		
Hypothesis	$r = 0$ (critical value = 12.21)	$r > 1$ (critical value = 4.14)
Trace test statistics	19.696	2.240
Long-run relation		Adjustment speed of *NAV*
NAV = 0.037 total_return_index		*-0.00104*

5.2. Transaction Windows

It is generally believed that private real estate market is relatively illiquid compared to public market, therefore, private market is considered taking less important role in price discovery. Theoretically, NAV should become more important in contributing to price discovery near property transaction dates, because new information about the move to acquire or sell properties may appear to change the value of them, and hence reflected on the new estimated NAV. To test the speculation, we construct the transaction windows and examine the GG ratios of full sample and transaction windows to see whether GG_{NAV} ratios become larger. If GG_{NAV} ratios of transaction windows are as expected to be larger, we could say NAV, namely private market, does matter in price discovery.

Table 3 shows the GG ratios of full samples and transaction windows of "lead and lag" 25 days. For the diversified, office, hotel and industrial, both in the full samples and the transaction windows show that common factor loading of private market is greater than that of public market. Tuluca et al. (2000) make the similar conclusion that private market informationally leads the public market. To their knowledge, a possible explanation lays on the definition of market efficiency. Ross (1987) defined a market as efficient if there is a lack of arbitrage opportunities. However, for private property market, it is commonly believed that it is quite illiquid and, hence, there is no way to arbitrage. Therefore, we may view private real estate market as an efficient market.

Comparing the GG ratios of full samples and transaction windows of "lead and lag" 25 days, we find that, of transaction windows, GG ratios of property types of diversified, office, hotel, and industrial increase to some extent. Among the four property types, the common factor loading of industrial increases the most by 24%, while that of office increases the least by 5%. The GG_{NAV} ratios of property types of diversified and hotel increase by 11% and 16% respectively. These indicate that private market of these four property types plays an important role in price discovery around transaction dates. According to Pagliari et al. (2005), diversified, office, and industrial are classified as core property types. The results do support our notion that, in the long-run, around infrequent daily property transaction dates, private real estate market is likely to incorporate new information regarding property transaction into NAV, therefore pulling up the common factor loading of NAV. Put differently, private market does matter in price discovery with respect to public market.

Table 3: GG ratios of full samples and transaction windows of "lead and lag" 25 days. Except for office, the common factor loadings of the four property types of transaction windows increase to some extent as compared to full samples.

Property_type	Full sample		Lead_lag_25 days	
	Total_return	NAV	Total_return	NAV
Diversified	29%	71%	18%	82%
Office	16%	84%	11%	89%
Hotel	33%	67%	17%	83%
Industrial	40%	60%	16%	84%

5.3. Robustness

In order to further support our notion that NAV does matter in price discovery around property transaction dates, we check the robustness of other transaction windows of "lead and lag" 30 days. As indicated in table 4, except for office, other three property types exhibit similar results to transaction windows of "lead and lag" 25 days. The common factor loadings of diversified of NAV increase the most from 71% to 93%. For hotel and industrial, GG_{NAV} ratios increase by 4% and 15%, respectively.

There are evidences in equity markets that option trading one week before corporate announcement are informative about the underlying price direction. We adopt this idea and test whether the results are robust to simply "lead and lag" 25 days. We first lag the property transaction date to one week before, then construct the transaction windows by taking "lead and lag" 25 days. For example, there was a move of property transaction of Hyatt Hotels Corporation on 06/30/2011. To construct the transaction window around 06/30/2011, following the literatures in finance studying equity market, we first lag the transaction date of 06/30/2011 to 06/23/2011, then take the "lead and lag" 25 days based on 06/23/2011. Table 5 exhibits the results of GG ratios of lagging transaction dates to one week, and at the same time, taking "lead and lag" of 25 days. The results are also robust to transaction windows of simply "lead and lag" 25 days. The GG_{NAV} ratios of all of the four property types increase, with no exception, as compared with those of full samples. The GG_{NAV} ratio of diversified increases the most by 9%, while those of office, hotel, and industrial increase by 4.5%, 3.4%, and 5%, respectively. As our expected, private market does play an important role in price with respect to public market.

Table 4: GG ratios of full samples and transaction windows of "lead and lag" 30 days. The common factor loadings of the four property types of transaction windows increase to some extent as compared to full samples.

Property_type	Full sample		Lead_lag_30 days	
	Total_return	NAV	Total_return	NAV
Diversified	29%	71%	7%	93%
Office	16%	84%	25%	75%
Hotel	33%	67%	29%	71%
Industrial	40%	60%	25%	75%

Table 5: GG ratios of full samples and transaction windows of lagging transaction dates to one week and taking "lead and lag" 25 days. The common factor loadings of the four property types of transaction windows increase to some extent as compared to full samples.

Property_type	Full sample		Transaction_date_lag_5 days & Lead_lag_25 days	
	Total_return	NAV	Total_return	NAV
Diversified	29%	71%	20%	80%
Office	16%	84%	11.5%	88.5%
Hotel	33%	67%	29.6%	70.4%
Industrial	40%	60%	35%	65%

6. Conclusion

We study the cointegrating relationship(s) between public and private market pricing of real estate. By using vector error correction model, we estimate long-run relation between public and private real estate markets. We find that like some of the previous studies (e.g. Oikarinen et al. (2011), Hoesli et al. (2012)), public market and private market exhibit long-term cointegrating relationship.

Next, we explore whether private market matters in price discovery with respect to public market. To test this notion, we employ a unique dataset of daily property transactions to form synchronized public and private price series around transaction windows, not by regular calendar days. We estimate the normalized Gonzalo and Granger (1995) common factor loadings of the public and private markets, and find whether there are the contributions to price discovery from the private market. Using synchronized public and private return pairs around transaction windows we find that the common factor loading of private real estate market increases further relative to the public real estate market. The results are robust to length of transaction windows and property types.

We also find that the common factor loadings of private market of property types of diversified, office, hotel, and industrial are greater than those of public market. The results are somehow similar to Tuluca et al. (2000) that the private market informationally leads the public market. They find this can be attributable to the understanding of the definition of efficient market. Ross (1987) defined a market as efficient if there is a lack of arbitrage opportunities. For real estate properties, they are commonly viewed as illiquid assets and cannot be short sale, and hence, there is no way to arbitrage. Therefore, we may view private real estate market as an efficient market.

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