Do public real estate returns really lead private returns?

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Abstract

We use sector level REIT and transaction-based direct real estate data for the period 1994-2010 to provide a clearer understanding of the dynamic relations between public and private real estate returns. We add leverage to private returns to make the private data more comparable with the REIT data. We also include economic fundamentals in the analysis to take account of the influence of fundamentals on real estate market dynamics. Moreover, we consider the influence of the 'escrow lag' in the recording of private market prices. The estimated vector error-correction and vector autoregressive models, Granger causality tests, impulse response functions and variance decompositions all provide evidence of REIT returns leading private returns in the office, retail, and apartment sectors. These lead-lag relations appear to be due to the slow reaction of private market returns to shocks in REIT returns and in some economic fundamentals. In the industrial sector, such lead-lag relation cannot be observed, however.

Keywords Direct real estate, Securitized real estate, REITs, Vector error-correction models, Generalized impulse response function, Dynamics, Escrow lag

Introduction

The securitized or 'public' real estate market is generally assumed to be more informationally efficient than the direct or 'private' real estate market. This is due to the greater liquidity, larger number of market participants, smaller transaction costs, and the existence of a public market place for real estate securities. Therefore, the price of securitized real estate investments is expected to react faster to shocks in the fundamentals than that of direct real estate. In line with this hypothesis, empirical evidence suggests that public market returns lead direct market returns (e.g., Gyourko and Keim, 1992; Myer and Webb, 1993; Barkham and Geltner, 1995; Eichholtz and Hartzell, 1996; Li et al., 2009; Oikarinen et al., 2011).

However, since the reported lead-lag relations are generally based on data that do not correct for a number of complications present in the real estate return data, the empirical evidence is not conclusive. These complications include appraisal-based direct market price data, the different property-type mixes of securitized and direct real estate indices, leverage of public real estate returns, and the 'escrow lag' in the recording of direct market transaction prices. Several studies (e.g., Myer and Webb, 1994; Barkham and Geltner, 1995; Geltner and Kluger, 1998; Pagliari et al., 2005;

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Yavas and Yildirim, 2011; Oikarinen et al., 2011; Hoesli and Oikarinen, forthcoming) have addressed some of these data complications but never all of them simultaneously. In particular, no study so far has considered the impact of escrow lags on the reported lead-lag relations between the securitized and direct real estate markets. In the NCREIF indices that track direct real estate market performance in the U.S., the recorded price might represent the agreed price based on the meeting of minds that occurred a few weeks prior to recording [1]. This delay, which could potentially explain the lead-lag relations observed in the literature, is commonly referred to as the escrow period during which the due diligence process takes place.

The aim of this study is to provide a clearer picture of the dynamic relations between public and private real estate returns by catering for all the aforementioned data complications. Thus, the aim is to investigate whether the assumed leading role of REIT returns with respect to direct real estate returns could be an artifact of the problematic data or whether the lead-lag relation remains even after taking account of these data problems. This appears to be the first examination on the theme that uses transaction-based direct real estate indices and caters for the property-type, leverage, and escrow period issues in the data.

We use sector level REIT (NAREIT) and direct real estate (transaction-based NCREIF, i.e. TBI) total return data for the period 1994Q1-2010Q4 to study the reaction patterns of public and private real estate returns to economic shocks and to examine the lead-lag relations between the public and private real estate markets. To avoid the potential influence of leverage in the REIT data on our conclusions, we add leverage to direct real estate returns to make the direct market data more comparable with the REIT data. We also add economic fundamentals in the analysis to cater for the influence of fundamentals on real estate market dynamics. Moreover, we 'lag' the direct market data to take the escrow lags into account; market price levels will thus better reflect those which prevailed at the time of the meetings of minds.

We find tight long-term relations in terms of cointegration in three (retail, apartments, and industrial) out of the four sectors (the exception is office) included in the analysis. Based on the estimated vector error-correction and vector autoregressive models, the results show that REIT returns lead private real estate returns even after catering for the property type, leverage, influence of fundamentals, and a 90-day escrow lag. An exception is the industrial sector, where such lead-lag relation is not observed after catering for the 90-day escrow lag.

Our findings also suggest that the perceived lead-lag relations cannot be explained by the potentially slower adjustment of sellers' reservation prices than of demand in the direct real estate market. That is, with the exception of the industrial sector, REIT returns lead direct market returns even when the TBI demand indices are used in the analysis instead of the conventional TBI indices.

The findings have several practical implications. It appears that REIT returns can indeed be used to predict the actual direct real estate returns. The results also show that REIT returns have predictable components. Furthermore, the positive lead-lag relations indicate that over the long horizon the co-movement between securitized and direct real estate markets is stronger than the contemporaneous quarterly correlation coefficients between NAREIT and TBI returns suggest. Importantly, as the observed TBI returns are likely to include notable recording lag due to the escrow period, the perceived contemporaneous correlation between REIT and TBI index returns can be significantly weaker than the actual co-movement between public and private real estate returns even in the short horizon. Therefore, the benefits of including securitized real estate in a portfolio containing already direct real estate (or *vice versa*) are more limited than what the analysis of quarterly index return correlations would imply.

The results also show that there are some differences across real estate sectors regarding the return dynamics. Therefore, it is reasonable to use sector level data when evaluating the return and price dynamics in the REIT and direct real estate markets and when making forecasts concerning future price development in the markets.

A review of the literature on the lead-lag relations between securitized and direct real estate markets is presented in the next section. The third section describes the data used in the empirical analysis, while the fourth section delineates our econometric methodology. Empirical results are reported in the fifth section, and robustness checks using demand indices and alternative escrow periods for the direct real estate market are contained in the following section. A final section concludes.

Review of the literature

Numerous studies have reported results indicating that securitized real estate returns tend to lead returns in the direct real estate market. Empirical research thus suggests that there is a price discovery mechanism between public and private real estate markets [2]. It is a common view that this lead-lag relationship is due to the more rapid response of the securitized market to shocks in the fundamentals. The greater liquidity, larger number of market participants, lower transaction costs, and the existence of a public market place have been seen as the factors behind the quicker adjustment of the securitized real estate market.

Among the several studies that have provided empirical evidence supporting the leading role of securitized real estate with respect to direct real estate in the U.S. or U.K. markets are those by Gyourko and Keim (1992), Myer and Webb (1993), Barkham and Geltner (1995), Eichholtz and Hartzell (1996), Li et al. (2009), Oikarinen et al. (2011), and Yunus, et al. (2012). Newell and Chau (1996) report a short-term leading relationship for real estate companies over commercial real estate in Hong Kong, while Ong (1994, 1995) and Liow (2001) reach similar conclusions for Singapore. On the other hand, Myer and Webb (1994) and Newell et al. (2005) do not find significant Granger causality between securitized and direct commercial real estate. However, both of these examinations are based on short sample periods: 1983-1991 in the former study and 1995-2002 in the latter one.

The results by Geltner and Kluger (1998), Seiler and Webb (1999), Pagliari et al. (2005), Li et al. (2009), Yavas and Yildirim (2011), and Hoesli and Oikarinen (forthcoming) suggest that REIT returns lead direct returns even after making adjustments for the property-type mix. Geltner and Kluger (1998) base their analysis simply on contemporaneous and lagged correlation coefficients. Pagliari et al. (2005) mention their finding in a footnote without describing the analysis in more detail, while Seiler and Webb (1999), Yavas and Yildirim (2011), and Li et al. (2009) use data that potentially suffer from appraisal smoothing as a proxy for direct real estate returns. Hoesli and Oikarinen (forthcoming), in turn, focus on examining the long-term dynamic relations between REITs and private real estate without formally investigating the lead-lag relationships. Chau et al. (2001) also consider sector level direct real estate data in their analysis. However, their securitized real estate data are at the aggregate level and these authors do not study the lead-lag relations nor the dynamics between the securitized and direct markets. Finally, Pavlov and Wachter (2011) contribute to the literature by adjusting portfolio returns for both property type and location by constructing‘ shadow portfolios’ that match direct market returns with REIT returns. They only find a statistically significant relationship between REIT and real estate returns in the office sector. While shedding more light on the simultaneous relationship between REIT and direct real estate returns, their empirical analysis does not consider the potential lagging relationship of direct market returns with respect to REIT returns. That is, their model implicitly assumes that the public market returns do not lead private market returns. Also, their results only concern a short time period (2001-2007).

An important issue regarding the dynamics between public and private real estate markets is the potential existence of long-term dynamics, in terms of cointegration, between the securitized and direct real estate returns. In an early study, Ong (1995) does not find support for cointegration between indirect and direct real estate return indices in Singapore. More recently, Oikarinen et al. (2011), Boudry et al. (2012), and Hoesli and Oikarinen (forthcoming) find cointegration between REIT and direct real estate markets in the U.S. Hoesli and Oikarinen (forthcoming) also detect cointegration relations in the U.K. market and Yunus et al. (2012) in several countries. These analyses generally suggest that only direct real estate returns are predictable by deviations from the cointegrating relation. However, the results by Boudry et al. (2012) suggest that both securitized and direct markets are predictable by the deviations in the U.S., while Hoesli and Oikarinen (forthcoming) report similar findings for the U.K. The latter authors also derive impulse responses and variance decompositions to study the dynamics, finding that the public and private market reactions to economic shocks are generally similar over the long (3 to 4 years) horizon.

In a study that is closely related to ours, Chiang (2009) explores the dynamic relationship between REIT net asset values (‘real returns’) and REIT premiums/discounts (‘public returns’). The results show that ‘public returns’ predict future ‘real returns’, therefore suggesting that REIT price movements lead those in the private real estate market. However, as the net asset value data used in the analysis are appraisal-based, the results are potentially somewhat biased due to appraisal smoothing.

The recent findings by Yavas and Yildirim (2011) imply that there are differences across property types as well as across firms within a real estate sector. We acknowledge the possibility of different reaction speeds across firms. However, this study concentrates on examining the price discovery at the market (sector) level, since our aim is to investigate whether the REIT market generally reacts faster than the direct market to shocks or whether the findings contained in much of the extant literature can be attributed to market level data complications.

This study's aim is to investigate whether the previously reported leading role of REIT returns with respect to direct real estate returns could be an artifact of the problematic data or whether the lead-lag relation remains even after taking account of a number of data complications. Our analysis contributes to the literature by being the first one that uses transaction-based direct real estate data and caters for the property-type, leverage, and escrow lag issues in the data. In particular, it appears that no study before has considered the influence of escrow lags when investigating the dynamic relations between public and private real estate markets. To the best of our knowledge, this is also the first analysis to derive impulse response functions to specifically examine the lead-lag relations between the real estate markets. We additionally examine whether the time-varying liquidity in TBI data contributes to the observed lead-lag relations between NAREIT and TBI returns.

Data description

For securitized real estate, we use the FTSE/NAREIT Equity REIT sector level indices and for direct real estate the sector level transaction-based NCREIF (TBI) indices. We consider the four sectors for which TBI indices are available: Apartments, offices, industrial property, and retail property. The sample period is 1994Q1-2010Q4.All real estate indices employed in the analysis are total return indices. To get series that are more comparable with direct real estate data (the TBI indices show the average quarterly values by construction), the quarterly REIT figures are computed from arithmetic averages of the monthly index values.

While NAREIT includes the impact of leverage, the TBI indices consist of unleveraged properties. The magnitude of leverage naturally affects the mean and volatility of returns. Moreover, time-variation in the leverage may hinder the cointegration tests and distort the estimated long-run parameters. Therefore, we restate the TBI returns for the effect of leverage to make the direct market data more comparable with the REIT data. In contrast with Pagliari et al. (2005), we add leverage to direct market data rather than compute unlevered REIT indices. This adjustment makes the direct returns closer to returns which investors would earn given that investors typically lever their direct real estate investments. The levered direct real estate returns are computed using the formula that is based on the well-known proposition of Modigliani and Miller (1958):

$$r_{lit} = (r_{uit} - r_{dt} LTV_{it}) / (1 - LTV_{it}), \qquad (1)$$

where r_{lit} = the levered direct real estate return of sector i in period t, r_{uit} = the corresponding unlevered return, r_{dt} = the cost of debt in period t, and LTV_{it} = the loan-to-value ratio of sector i REITs in period t. The leverage values are computed as the total debt of all the REITs in sector i divided by the total market value of these REITs. The average leverage of REITs during the sample period is 48% in the apartment and office sectors, 43% in the industrial sector, and 51% in the retail sector. The leverage is quite volatile, being at the lowest around 30% in the mid 1990s and at the highest some 70-75% in 2009. The cost of debt used in the computations is the Moody's Baa rated corporate bond yield.

The TBI and NAREIT indices may of course also exhibit differences with respect to the geographic distribution of the properties. We performed Granger causality tests across the four TBI regions (East, West, South, and Midwest) and found no evidence of lead-lag relations. This indicates that differences in the geographical distribution of the properties, at least at the four-region level, are unlikely to have a notable influence on our findings [3]. Locational differences may of course be more subtle than portfolio composition dissimilarities across broadly-defined geographical areas. For instance, there may be differences between REIT and institutional investors with respect to the quality and size of the cities in which they invest. Empirical evidence by Malpezzi and Shilling (2000) suggests that private investor holdings are more heavily tilted towards high quality metropolitan areas (i.e., areas with higher average employment and real per capita income and with greater growth in these two variables) and towards areas with greater density, higher average human capital accumulation, and less stringently regulated real estate markets than those of public investors. Given that such metropolitan areas should react relatively fast to changes in fundamentals (Clapp, 1995; Malpezzi, 1999; Capozza et al., 2004), such effects may make it easier to reject the existence of lead-lag relationships between public and private real estate returns.

In addition to the real estate data, the analysis includes several variables that may affect significantly real estate returns according to theory and previous empirical evidence. These variables concern economic growth (Ling and Naranjo, 1997; Payne, 2003; Ewing and Payne, 2005), general price levels (Chan et al., 1990;Ling and Naranjo, 1997; Payne, 2003; Ewing and Payne, 2005), short-term interest rates and the term structure of interest rates (Chan et al., 1990; Ling and Naranjo, 1997; Hoesli and Oikarinen, forthcoming), the default risk premium (Chan et al., 1990; Karolyi and Sanders, 1998; Hoesli and Oikarinen, forthcoming), and the economic sentiment (Berkovec and Goodman, 1996; Hoesli and Oikarinen, forthcoming). We measure economic growth with the change in U.S. *GDP*. The economic sentiment (*SE*), that gives a more forward looking measure of growth in economic activity, is captured by the University of Michigan consumer sentiment index regarding the five year economic outlook. Changes in the consumer price index are used to track movements in the general price level (*INF*), while the three month T-bill rate and the spread between the 10-year government Treasury bond yield and the three month T-bill rate measure the short-term interest rates (*IR*) and the term structure of interest rates (*S*), respectively. Finally, the spread between low-grade corporate bond (Baa, Moody's) and the 10-year government Treasury bond yields is used as the measure for the default risk premium (*D*) as suggested by Chen et al. (1986), Bernanke and Blinder (1992), and Ewing (2001). We also checked whether the inclusion of overall stock market returns would bring significant additional information to the estimated models, which it does not. These data are sourced from Thomson Datastream.

In the econometric analysis, we use only real indices regarding NAREIT, TBI and *GDP*. The (unlevered) real estate indices and *GDP* are deflated using CPI to get the real indices. Furthermore, the real estate and *GDP* indices are used in the natural log form. Also the short-term interest rate is deflated by CPI.

Table 1 presents descriptive statistics regarding the levered office (*Off_TBI, Off_REIT*), retail sector (*Ret_TBI, Ret_REIT*) apartment (*Apt_TBI, Apt_REIT*), and industrial sector (*Ind_TBI, Ind_REIT*) total returns. The means and volatilities of

REIT and levered TBI returns do not notably differ from each other at the quarterly level. An exception is the office sector, where TBI returns have been more volatile and substantially lower than REIT returns.

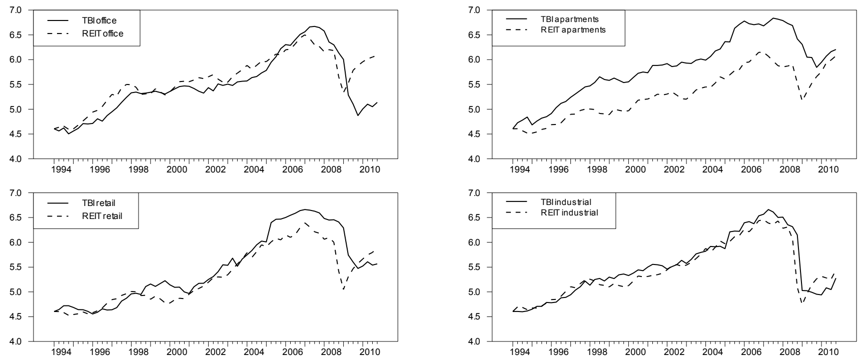
Table 1. Descriptive statistics of levered sector level real estate returns, 1994Q1-2010Q4

Variable	Mean (annualised %)	Standard deviation (annualised %)	Jarque-Bera test for normality (p-value)	Ljung-box test for auto-correlation (p-value, 4 lags)
Apt_TBI	9.5	17.9	.02	.00
Apt_REIT	8.8	18.9	.00	.04
Ind_TBI	4.0	32.2	.00	.31
Ind_REIT	5.0	30.4	.00	.02
Off_TBI	3.2	28.9	.00	.00
Off_REIT	8.9	22.0	.00	.02
Ret_TBI	5.7	22.1	.00	.02
Ret_REIT	7.7	23.1	.00	.05

TBI denotes direct market returns, and *REIT* stands for REIT returns; *Apt* = apartments, *Ind* = industrial property, *Off* = offices, and *Ret* = retail property.

Figure 1 shows that the office sector total return indices tracked each other closely until 2009. In 2009, REIT prices started to bounce back after the drastic drop due to the subprime crisis, whereas the TBI index dropped further. That is, the notable difference between the average returns in the office sector during the sample period is largely due to the aftermaths of the financial crisis and the slower recovery of the direct market. Figure 1 also shows that the retail and industrial NAREIT and levered TBI total return indices have followed each other closely throughout the sample period. In the apartment sector, a notable deviation between the public and private market indices occurred until the late 2000s, when the REIT index caught up with the TBI during the aftermath of the financial crisis. The deviation before the crisis potentially indicates overvaluation in the private market or undervaluation in the public market. Of course, the valuation of REITs relative to their underlying direct real estate assets is likely to be time-varying in the short term (see, e.g., Carlson et al., 2010). Also, during the 2000s there was a big condominium boom, which resulted in a quasi-arbitrage from buying apartments and converting them to condos and selling the condos. This drove up the price of apartments in the direct market. As apartment REITs are long-run rental investors not involved in the condo-conversion business, the condo-conversion premium did not get priced into REITs. This development in the apartment sector may also somewhat affect the results of our empirical analysis.

Figure 1. Sector level (levered) NAREIT and TBI total return indices, 1994Q1-2010Q4



A major complication, when using the TBI indices to study the dynamics between the public and private markets, is that the recorded price might represent the agreed price based on the meeting of minds that occurred a few weeks prior to recording. This delay is commonly referred to as the 'escrow period' or 'escrow lag' during which the due diligence process takes place. The duration of the escrow period can vary considerably across property types. Based on the findings reported by Crosby and McAllister (2004), the median escrow lag in the U.K. commercial real estate markets is approximately 80 days in the industrial sector, 50 days in the office market, and 90 days for retail property. Unfortunately, there does not appear to be any study reporting corresponding values for the U.S. According to expert opinions, the escrow period can be as long as 90 days for apartments and up to 180 days for the other property types. The average escrow periods are likely to be shorter than these maximum values, however, and in some cases the price is renegotiated during the due diligence process.

Given the expert opinions, our best estimate for the escrow lag in TBI indices is 90 days. Although in the apartment sector the lag is likely to be somewhat shorter than that, we use the 90-day escrow lag assumption in our baseline estimations in the econometric analysis for all four sectors. In the 90-dayescrow period case, the TBI index return for quarter t actually reflects the direct market price change that took place during quarter t-1. Therefore, to make the return timings of REITs and private real estate comparable, we lag the nominal TBI indices by one quarter and deflate these indices by the CPI to study the dynamics. The escrow lag is potentially time-varying. However, our diagnostic checks suggest that the estimated model parameters are stable over the sample period, suggesting that the potential time-variation in the escrow lag should not have notable effects on our findings.

In the robustness checks section, we explore the robustness of our findings to the escrow lag length by considering 45-day, 135-day, and 180-day escrow periods. Such robustness checks are useful as the 90-day figure is a typical duration for the escrow lag but the escrow period is likely to vary with location and size of the property. The estimations regarding 0.5 and 1.5 quarter escrow periods are conducted by using the securitized returns calculated based on the beginning and end of period values rather than average quarterly values. This is analogous to leading the NAREIT indices by approximately 45 days. For instance, if we assume a 45-day escrow lag, the first return observation for REITs is computed as the change in the return index during 1.1.1994 –

31.3.1994, while the TBI return is based on the observed average quarterly values, i.e., returns approximately during 15.2.1994 – 15.5.1994 (which are assumed to reflect the returns 45 days earlier, i.e., during 1.1.1994 – 31.3.1994, due to the escrow period).The 135-day escrow period results are obtained by combining a 90-day lag in the TBI index and a 45-day lead in the REIT index.

Contemporaneous quarterly correlations between the returns are reported in Table 2. The table contains the correlations of NAREIT returns with both the (levered) standard TBI index returns and (levered) 90-day lagged TBI index returns. Within each sector, the correlation is greater when the escrow period is catered for, i.e., the escrow lag in TBI data reduces the observed correlation between REIT and direct real estate returns. Table 2 also reveals that direct market returns, especially in the industrial sector, are highly correlated with REIT returns in the other sectors.

Table 2. Contemporaneous quarterly correlations between the levered returns, 1994Q1-2010Q4

	Apt_TBI	*Apt_TBIe*	*Ind_TBI*	*Ind_TBIe*	*Off_TBI*	*Off_TBIe*	*Ret_TBI*	*Ret_TBIe*
Apt_REIT	**.26***	**.33****	.58**	.47**	.05	.43**	-.02	.27*
Ind_REIT	.79**	.34**	**.39****	**.76****	.11	.38**	.01	.26*
Off_REIT	.27*	.30*	.45**	.60**	**.06**	**.39****	-.01	.20
Ret_REIT	.26*	.38**	.51**	.62**	.04	.42**	**.02**	**.33****

* and ** denote statistical significance at the 5% and 1% level, respectively. *TBI* denotes TBI index returns, *TBIe* stands for 90-day lagged TBI index returns due to the escrow lag, and *REIT* stands for REIT returns; *Apt* = apartments, *Ind* = industrial property, *Off* = offices, and *Ret* = retail property. Within sector correlations are bolded.

All return indices, as expected, appear to be non-stationary in levels and stationary in differences, and also the fundamental variables are I [4]. Therefore, all the fundamental variables are used only in differences in the forthcoming analysis.

Econometric methodology

As there are sound *a priori* theoretical reasons to expect that the securitized and direct real estate total return indices might be cointegrated (see the discussion in Oikarinen et al., 2011, for instance) and cointegrating long-term relations between the indices would have important implications regarding the asset return dynamics, we investigate the existence of such relationships by employing the Johansen (1996) Trace test for cointegration. The cointegration tests are conducted separately for each sector. The Vector Error-Correction Model (VECM) used in the Trace test is the following:

$$\Delta X_t = \mu + \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-l} + \alpha\beta' X_{t-1} + \Omega D_t + \varepsilon_t, \qquad (2)$$

where ΔX_t is $X_t - X_{t-1}$, X_t is a two-dimensional vector of return index values in period t, μ is a two-dimensional vector of drift terms, Γ_i is a 2 x 2 matrix of coefficients for the lagged differences of the return indices at lag i, l is the number of lags in differences included in the model, α is a vector of the speed of adjustment parameters,β' forms the cointegrating vector, and ε is a vector of white noise error terms. β includes the public and private market return indices and no deterministic variables. All the tested models also include one or more point dummy variables (D) to cater for some outlier observations and thereby to fulfil the assumption of normally distributed residuals. Based on the Schwarz information Criteria (SIC), seasonal dummy variables are not needed in any of the tested models.

The lag length is selected based on Hannan-Quin information criteria (HQ) as suggested by Johansen et al. (2000). The selection of the number of cointegrating vectors (r), in turn, is done by comparing the estimated Trace statistics with the quantiles approximated by the Γ-distribution (Doornik, 1998).Because asymptotic distributions can be rather bad approximations of the finite sample distributions, the Bartlett small sample corrected values suggested by Johansen (2002) are employed. The inclusion of dummy variable(s) that take the value of one only for one point in time and are zero otherwise is usually asymptotically negligible (Doornik et al., 1998). However, as some of the tested models include several point dummies, we also report Trace test p-values based on the simulated statistics computed with the program CATS2 (see Dennis, 2006).As a diagnostic check, we examine the stability of the long-term relations by the recursive and backwards recursive Max Test statistics (in the R-form) of constancy of the estimated long-run relation (Juselius, 2006).

To study the dynamics of real estate returns, we estimate Vector Error-Correction Models (VECMs):

$$\Delta Z_t = \mu + \Gamma_1 \Delta Z_{t-1} + \ldots + \Gamma_{k-1} \Delta Z_{t-l} + \alpha(TBI_{t-1} - TBI^*_{t-1}) + \Omega D_t + \varepsilon_t, \tag{3}$$

where ΔZ_t is Z_t - Z_{t-1}, Z_t is a 2+F-dimensional vector including both the return index values and the fundamentals in the model (F is the number of fundamentals included in the model) in period t, μ is a 2+F-dimensional vector of drift terms, Γ_i is a (2+F) x (2+F)matrix of coefficients for the lagged differences of the stochastic variables at lag *i*, and ε is a 2+F-dimensional vector of white noise error terms.$\alpha(TBI_{t-1} - TBI^*_{t-1})$ forms the error-correction mechanism, where α is a 2+F-dimensional vector of the speed of adjustment parameters and $TBI_{t-1} - TBI^*_{t-1}$ is the deviation of TBI value from its cointegrating relation (TBI*) with NAREIT index in period t-1. Since only the real estate indices can be assumed to adjust towards a cointegrating relation between them, the alpha is restricted to equal zero in the equations for the fundamentals. Furthermore, if we do not detect cointegration between the return indices in a given sector, the alpha is zero for the real estate returns as well, i.e., we estimate a conventional Vector Autoregressive (VAR) model. In addition to the multiple variable models including the fundamentals, we estimate a pairwise VECM/VAR for each property sector. In the pairwise models, F=0.

The fundamental variables that are included in the models are selected by the block exogeneity test using Sim's small-sample corrected Likelihood Ratio test values. All of the four multiple variable models incorporate *GDP* and the economic sentiment. Otherwise, the models differ from each other to some extent. This is not unexpected given that the return dynamics between various real estate sectors may vary substantially (Wheaton, 1999; Yavas and Yildirim, 2011; Hoesli and Oikarinen, forthcoming). The economic sentiment, *GDP*and inflation cater for the expectations concerning real cash flow growth, whereas the other fundamentals in the model (and the inflation rate, to some extent) represent the current and expected future movements in the discount factor. The lag length in the models is decided by SIC.SIC tends to select relatively parsimonious models. This is desirable in this analysis due to the relatively small number of observations.

The direction of the possible Granger causality is tested by a standard F-test (equivalent to a t-test if the lag length is one) to examine the existence of lead-lag relations between the assets. The multiple variable models are also used to derive the impulse responses of real estate returns to unanticipated changes in the fundamentals and in the real estate returns themselves. This paper employs the 'generalized' impulse response functions (GIRFs) developed by Pesaran and Shin (1998). The GIRFs do not require orthogonalization of shocks and are invariant to the ordering of the variables in the VAR. This is desirable, since the theory does not give clear guidance as to which of many possible parameterizations one should use in the traditional impulse response analysis and the ordering may notably affect the observed reaction patterns of the real estate returns to the shocks.

Finally, we compute and study the variance decomposition for the real estate returns based on the multiple variable models. As the 'generalized method' is not available for variance decomposition, we use the Choleski decomposition. In our baseline models, the ordering is *INF-GDP-IR-SE-D-S-REIT-TBI* (none of the models includes all the fundamentals, though). The inflation rate is placed first in the ordering, since shocks in the inflation rate are expected to affect simultaneously all the variables that are measured in real terms. It is also assumed that *GDP* shocks influence all of the variables except for inflation simultaneously, and all fundamentals are allowed to affect the asset returns instantaneously. Inflation shocks are the only ones allowed to have an immediate impact on *GDP*. Given the sluggishness of the real economy, it seems reasonable to assume that *GDP* does not react to changes in the other variables immediately. *IR*, in turn, should be placed before *S*, since *IR* affects directly one component in the term spread. We also check for the robustness of the return decompositions with respect to the ordering between REITs and TBI.

Empirical results

In our baseline estimations, we assume that the escrow lag in the recording of direct market transaction prices is 90 days. Therefore, the findings reported in this section are based on the one-quarter lagged TBI indices.

Table 3 reports the cointegration test statistics and estimated long-run relations between the levered TBI index and NAREIT index for each sector. The Trace test statistics, the simulated ones in particular, provide evidence of a cointegrating relation in all the sectors except for offices. The stability of the long-run parameters in the retail, apartment, and industrial sectors cannot be rejected based on the Max Test. Given the cointegration test statistics, the results below are based on VAR models for offices and on VECMs for the other sectors.

Table 3. Cointegration test statistics and the estimated long-run relations

OFFICES (l=2)		
Hypothesis	r=0	r≤1
Trace test p-values	.89	.38
Simulated Trace test p-values	.40	
RETAIL (l=1)		
Hypothesis	r=0	r≤1
Trace test p-values	.12	.47
Simulated Trace test p-values	.01	
Long-run relation (standard error): $Ret\_TBI = 1.13 Ret\_REIT$ (.073)		
APARTMENTS (l=2)		
Hypothesis	r=0	r≤1
Trace test p-values	.12	.68
Simulated Trace test p-values	.02	
Long-run relation(standard error): $Apt\_TBI = 1.16 Apt\_REIT$ (.087)		
INDUSTRIAL (l=1)		
Hypothesis	r=0	r≤1
Trace test p-values	.05	.65
Simulated Trace test p-values	.01	
Long-run relation (standard error): $Ind\_TBI = 1.12 Ind\_REIT$ (.057)		

The Trace test values are Bartlett small-sample corrected. The Trace test values simulated by CATS2 are not available for r≤1.The tested models include one or more point dummy variables to fulfill to assumption of normally distributed residuals. The lag length (l) is selected by the Schwarz information Criteria. The sample period is 1994Q1-2010Q3, 2010Q4 observation is lost due to lagging TBI by one quarter.

The Granger causality test results are provided in Tables 4to7.As it is the pairwise models that show whether there are lead-lag relations between two series, the test statistics from the pairwise models are of main interest here. Nevertheless, since the statistics from the multiple variable models shed more light on the return dynamics and indicate whether the lead-lag relations perceived in the pairwise tests are due to a more sluggish reaction of one return series to changes in the fundamentals or to the other real estate type's returns, we also report the statistics from the multiple variable models. In particular, if Granger causality was perceived in a pairwise model but not in a multiple variable model, this would suggest that the lead-lag relation observed in the pairwise model is likely due to a slow response of the direct market (in the typical case) to shocks in the fundamentals rather than to a significant lagged reaction to a shock in REITs.

Table 4. Granger causality test results, office sector

Dependent Variable	Explanatory variable					
	ΔTBI	$\Delta REIT$	ΔGDP	ΔSE	ΔIR	ΔS
Pairwise model						
ΔOff_TBI	5.2*	5.9*				
ΔOff_REIT	0.5	3.0*				
Multiple variable model						
ΔOff_TBI	0.4	5.2*	2.1*	0.7	2.8*	0.7
ΔOff_REIT	1.2	2.6*	0.6	1.7*	1.4	0.6

The table shows the F-values in the pairwise tests and the t-values (in absolute terms) from the multiple variable model.* denotes statistical significance at the 10% level. The null hypothesis in the tests is that of no Granger causality between the variables. ΔOff_TBI stands for direct returns and ΔOff_REIT for securitized returns in the apartment sector. The pairwise model includes two lags, while the multiple variable model has one lag. To fulfill the assumption of normally distributed residuals, the models also contain one or more dummy variables that take the value one in a single period and are zero otherwise. *SE* is the economic sentiment *IR* is the real t-bill rate, and *S* is the term spread. The sample period is 1994Q1-2010Q3, 2010Q4 observation is lost due to lagging TBI by one quarter.

Table 5. Granger causality test results, retail sector

Dependent Variable	Explanatory variable						
	eqe	ΔTBI	$\Delta REIT$	ΔGDP	ΔSE	ΔINF	ΔD
Pairwise model							
ΔRet_TBI	2.9*	0.8	2.0*				
ΔRet_REIT	0.9	1.4	3.2*				
Multiple variable model							
ΔRet_TBI	2.2*	1.1	0.9	1.0	0.5	2.3*	0.7
ΔRet_REIT	0.1	0.5	1.3	0.5	1.0	1.8*	1.6

The table shows the t-values (in absolute terms) in the Granger causality tests.* denotes statistical significance at the 10% level. The null hypothesis in the t-test is that of no Granger causality between the variables. ΔRet_TBI stands for direct returns and ΔRet_REIT for securitized returns in the retail sector. *eqe* is the deviation from the cointegrating relationship. The models include one lag. To fulfill the assumption of normally distributed residuals, the models also contain one or more dummy variables that take the value one in a single period and are zero otherwise. *SE* is the economic sentiment, *INF* is the inflation rate, and *D* is the default risk premium. The sample period is 1994Q1-2010Q3, 2010Q4 observation is lost due to lagging TBI by one quarter.

Table 6. Granger causality test results, apartment sector

Dependent Variable	Explanatory variable					
	eqe	ΔTBI	$\Delta REIT$	ΔGDP	ΔSE	ΔIR
Pairwise model						
ΔApt_TBI	2.5*	0.9	0.7			
ΔApt_REIT	1.2	1.3	2.1*			
Multiple variable model						
ΔApt_TBI	2.1*	0.9	2.1*	1.8*	0.6	2.8*
ΔApt_REIT	1.3	1.1	2.1*	1.3	1.1	3.4*

The table shows the t-values (in absolute terms) in the Granger causality tests.* denotes statistical significance at the 10% level. The null hypothesis in the t-test is that of no Granger causality between the variables.Δ *Apt_TBI* stands for direct returns and ΔApt_REIT for securitized returns in the apartment sector. *eqe* is the deviation from the cointegrating relationship. The models include one lag. To fulfill the assumption of normally distributed residuals, the models also contain one or more dummy variables that take the value one in a single period and are zero otherwise. *SE* is the economic sentiment and *IR* is the real t-bill rate. The sample period is 1994Q1-2010Q3, 2010Q4 observation is lost due to lagging TBI by one quarter.

Table 7. Granger causality test results, industrial sector

Dependent Variable	Explanatory variable					
	eqe	Δ*TBI*	Δ*REIT*	Δ*GDP*	Δ*SE*	Δ*INF*
Pairwise model						
Δ*Ind_TBI*	1.9*	0.1	0.4			
Δ*Ind_REIT*	2.5*	0.9	1.7*			
Multiple variable model						
Δ*Ind_TBI*	1.8*	0.5	0.5	1.8*	0.4	0.2
Δ*Ind_REIT*	2.0*	1.3	1.1	0.9	2.7*	0.3

The table shows the F-values in the pairwise tests and the t-values (in absolute terms) from the multiple variable model.* denotes statistical significance at the 10% level. The null hypothesis in the t-test is that of no Granger causality between the variables. Δ*Ind_TBI* stands for direct returns and Δ*Ind_REIT* for securitized returns in the industrial sector. The models include one lag. To fulfill the assumption of normally distributed residuals, the models also contain one or more dummy variables that take the value one in a single period and are zero otherwise. *SE* is the economic sentiment and *INF* is the inflation rate. The sample period is 1994Q1-2010Q3, 2010Q4 observation is lost due to lagging TBI by one quarter.

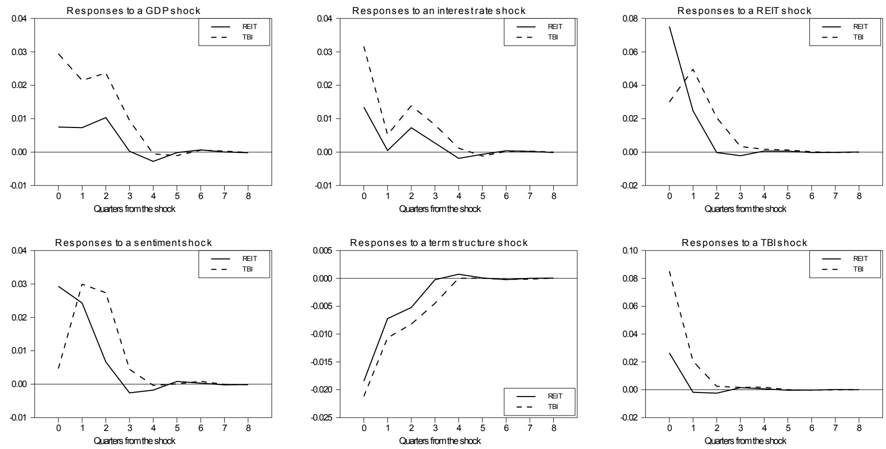
The results indicate that in the office, retail, and apartment sectors REIT returns lead direct real estate returns even after catering for property type, leverage, and the escrow lag. Moreover, REIT data appear to have significant predictive power with respect to direct market returns even when fundamentals are included in the model. This emphasizes the predictive power of REIT returns with respect to TBI returns. In particular, within all the three cointegrated sectors TBI returns adjust towards the long-run relation, i.e., can be predicted by past deviation (*eqe*) from the cointegrating relation and thereby by REIT market performance. Retail and apartment REITs do not show significant adjustment towards the long-run relations. In the industrial sector, in contrast, also REITs react to *eqe*, and neither of the returns can be predicted directly by each other's previous period returns. Therefore, the Granger causality tests do not imply lead-lag relations between public and private real estate returns in this sector.

In the office sector, where the model does not include an error-correction mechanism, the parameter on lagged REIT returns in the equation for TBI returns is especially large, 0.63, while the parameter on own lag is as small as 0.05 and the parameter on lagged TBI in the REIT equation is negative and relatively small in magnitude (-0.11). This signifies a substantial uni-directional predictive relationship between the returns. In the other sectors' TBI equations, the parameter on REIT returns is considerably smaller than that of the office sector (0.20, 0.16, and 0.13 in the apartment, industrial and retail sectors, respectively). However, these parameters are not directly comparable with the office model, because the error-correction mechanism is present in these sectors: A notable part of the direct market sluggish response to REIT price movements takes place through the long-run relation. The adjustment towards the long-run relations is slow, since the adjustment parameters of TBI are as small as0.15 for retail and industrial and 0.10 for apartments. Except for the industrial sector, where the adjustment speed of REITs is 0.16, the REIT market alphas are insignificant and close to zero.

According to the Granger causality tests, also the REIT returns contain predictable elements. In addition to the predictability through *eqe* in the industrial sector, REIT returns seem to be predictable by their own past values and sentiment changes in the office sector, inflation movements in the retail sector, their own values and interest rate movements in the apartment sector, and by sentiment changes in the industrial sector. Nevertheless, the Granger causality tests do not necessarily imply arbitrage opportunities. Out-of-sample forecasts are unlikely to allow arbitrage opportunities given the transaction costs and relatively low liquidity especially in the direct market. Moreover, the lead-lag relations are at the index level, not necessarily at the individual fund or property level, and the TBI indices may exhibit complications due to which the direct market performance may look somewhat more predictable than it is in reality (these complications are discussed in more detail in the section on robustness checks). Note that we do not report any statistics concerning the fits of the models, since the presence of point dummy variables in the models makes the interpretation of fit statistics problematic.

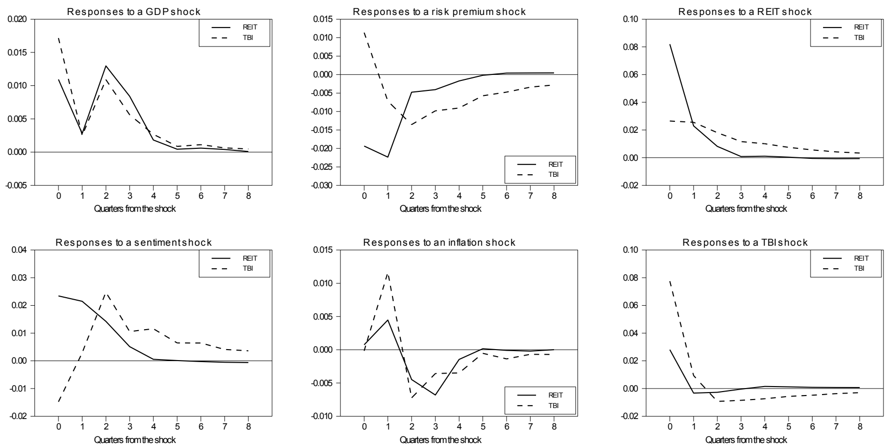
The Granger causality tests examine the predictability of and the lead-lag relations between real estate returns. They do not give details about the reaction patterns and speeds of the real estate prices to various shocks, however. Therefore, we derive impulse responses of the returns to shocks in the fundamentals and in the returns themselves employing the same multiple variable models as in the Granger causality tests. The alpha for retail and apartment REITs is restricted to equal zero, though, as the test statistics suggest that these REITs do not react to deviations from the long-run relation. The generalized impulse responses up to eight quarters from the shock are exhibited in Figures 2-5. In all the figures, the impulse responses correspond to reactions to shocks that are one standard error in magnitude. Therefore, the estimated responses show the economic significance of the shocks. That is, the impulse responses essentially summarize the dynamics of the models. Note also that the Hansen stability test accepts the stability of the estimated parameters over the sample period in all these models.

Figure 2. Reactions of public and private real estate returns to shocks in the fundamentals, office sector



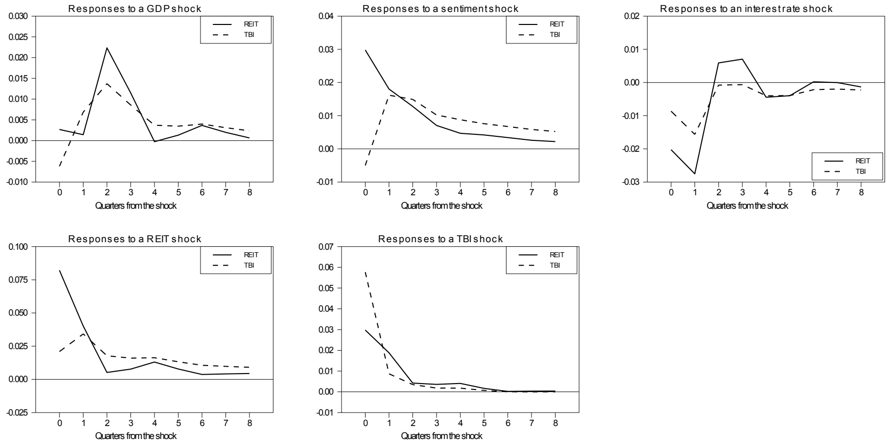
The Figure shows the generalized impulse response functions of private real estate returns (TBI) and public real estate returns (REIT) to shocks that are of one standard error in magnitude.

Figure 3. Reactions of public and private real estate returns to shocks in the fundamentals, retail sector



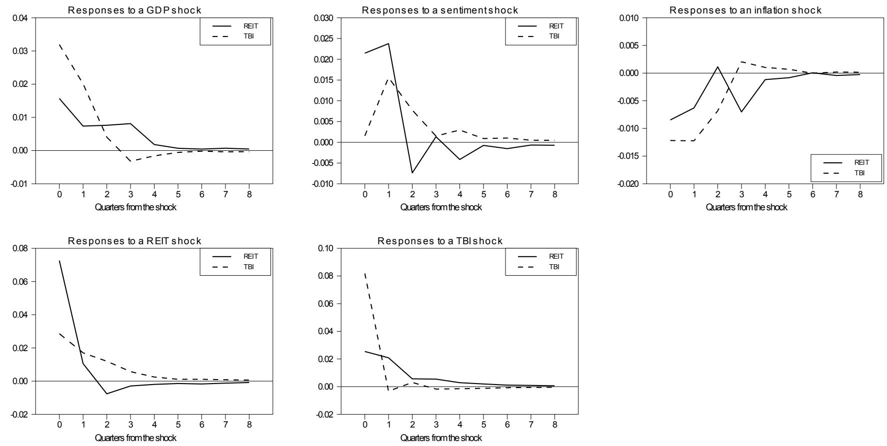
The Figure shows the generalized impulse response functions of private real estate returns (TBI) and public real estate returns (REIT) to shocks that are of one standard error in magnitude.

Figure 4. Reactions of public and private real estate returns to shocks in the fundamentals, apartment sector



The Figure shows the generalized impulse response functions of private real estate returns (TBI) and public real estate returns (REIT) to shocks that are of one standard error in magnitude.

Figure 5. Reactions of public and private real estate returns to shocks in the fundamentals, industrial sector



The Figure shows the generalized impulse response functions of private real estate returns (TBI) and public real estate returns (REIT) to shocks that are of one standard error in magnitude.

The estimated reactions look sensible and have the expected signs. An exception is the positive impact of an interest rate shock on real estate returns in the office sector model. Also the initial positive reaction of retail real estate prices to an inflation shock may be considered as somewhat surprising. *A priori*, we would expect an inflation shock to have a negative short-term influence on current real property prices since rental prices typically adjust only sluggishly to changes in the general price level while the impact of inflation on the discount factor is typically somewhat faster and positive. While the empirical literature presents mixed results regarding the inflation hedging qualities of direct real estate, empirical evidence has generally suggested that securitized real estate does not provide a hedge against inflation (see Hoesli et al., 2008, for a review of the inflation hedging literature). Our estimations show mixed results regarding the inflation hedging capabilities of real estate investments.

After an unexpected increase in the T-bill rate, in turn, we would expect a decline in real estate prices due to an increase in the discount factor. A potential explanation for the observed positive reaction to a T-bill shock in the office sector is given by the expectations theory of the term structure together with the Fisher hypothesis. Generally, higher short-term interest rates are expected to diminish economic activity thereby reducing inflation pressures. Lower inflation expectations, in turn, induce lower long-term interest rates (Howells and Bain, 2008). Given that real estate is a long-horizon investment vehicle, the long-term expectations (regarding interest rates and inflation) may well dominate the short-term effects in some markets. The observed negative impact of a term spread shock on office sector prices is expected since a greater spread relates to greater expected increases in the level of interest rates and therefore in the discount factor.

Expectedly, the reactions to shocks in economic growth and growth expectations are positive. Both of these shocks anticipate larger cash flows for real estate investments. The fact that the forward-looking variable regarding economic growth (i.e., the sentiment) belongs in all the multiple variable models is an indication that the real estate prices embody notable forward-looking components concerning economic growth.

Growth in the risk premium increases the discount factor for risky investments and thereby decreases direct and securitized real estate prices (retail sector model), as expected. The estimated reactions of REIT returns to shocks in the risk premium differ from those reported by Ewing and Payne (2005), according to which the reaction is positive. While the results by Ewing and Payne suggest flight-to-safety (from risky bonds to REITs; it is, of course, highly questionable whether REITs are safe), our results suggest that an increase in the risk perceived by investors lowers REIT prices via an increase in the discount factor.

The impulse responses suggest that in many cases it takes a while before real estate prices fully absorb new information regarding unexpected changes in the fundamentals. This may generate predictability in real estate returns in both REIT and direct markets. Of particular interest are whether the reaction to shocks is notably slower in the private market than in the public market, and whether and how quickly the REIT and direct markets react to shocks in each other. The findings are in line with the results of the Granger causality analysis. In particular, TBI returns appear to react slowly to innovations in REIT returns. In other words, the information that is revealed by unexpected movements in REIT prices is only sluggishly absorbed by direct real estate prices. This is particularly pronounced regarding the office and apartment sectors, but is clearly visible also in the retail and industrial sectors.

In the industrial sector, and to a lesser extent in the retail sector, there is also evidence of a sluggish REIT price reaction to a direct market shock. This indicates that there might be some arbitrage opportunities (predictability) in the REIT market through a sluggish response of the REIT market to shocks in the direct market returns. Since the publicly available data can be used to identify the shocks in the direct market only with a notable lag, only well informed investors could take advantage of these opportunities.

Furthermore, the impulse responses suggest that in many cases direct market prices react more sluggishly to shocks in the fundamentals than REIT prices. Regarding a sentiment shock, this seems to be the case in all the sectors. Indeed, it appears that the direct market does not react to sentiment shocks at all simultaneously, although the eventual impact of a sentiment shocks is substantial. In the retail sector, the REIT response to a risk premium shock is also substantially faster than that of direct real estate. In contrast, REITs do not appear to adjust more slowly to any of the shocks in the fundamentals except for a *GDP* shock in the industrial sector.

In sum, the sluggish response of direct real estate returns to shocks both in the fundamentals and in the REIT market causes the perceived lead-lag relationship between public and private real estate returns in the office, retail, and apartment sectors. Clear lead-lag relations cannot be observed in the industrial sector, however.

To gain more insight regarding the economic significance of various shocks for the public and private real estate performance, we report variance decompositions computed based on the multiple variable models in Table 8. The variance decompositions show the proportion of the movements in a series that are due to its own shocks versus the share due to shocks in the other variables in the model. The decompositions converge close to the eventual long-horizon values within 20 quarters.

Table 8. Variance decompositions for the TBI and REIT total return indices (retail, apartment, and industrial sectors) and returns (office sector)

OFFICE												
	Decomposition for TBI returns						Decomposition for REIT returns					
Step	Δ*TBI*	Δ*REIT*	Δ*GDP*	Δ*SE*	Δ*IR*	Δ*S*	Δ*TBI*	Δ*REIT*	Δ*GDP*	Δ*SE*	Δ*IR*	Δ*S*
1	.69	.10	.12	.01	.04	.03	.00	.73	.01	.13	.02	.11
2	.49	.25	.13	.08	.04	.03	.01	.65	.02	.20	.02	.10
5	.44	.23	.17	.10	.03	.03	.02	.63	.03	.19	.02	.10
10	.44	.23	.17	.10	.03	.03	.02	.63	.03	.19	.02	.10
20	.44	.23	.17	.10	.03	.03	.02	.63	.03	.19	.02	.10
RETAIL												
	Decomposition for TBI returns						Decomposition for REIT returns					
Step	Δ*TBI*	Δ*REIT*	Δ*GDP*	Δ*SE*	Δ*INF*	Δ*D*	Δ*TBI*	Δ*REIT*	Δ*GDP*	Δ*SE*	Δ*INF*	Δ*S*
1	.63	.15	.09	.12	.00	.00	.00	.85	.02	.08	.00	.04
2	.51	.28	.13	.08	.00	.01	.00	.73	.02	.17	.00	.07
5	.30	.44	.18	.05	.00	.04	.00	.61	.06	.24	.00	.09
10	.15	.51	.17	.10	.00	.07	.00	.58	.07	.24	.00	.10
20	.07	.54	.14	.16	.00	.09	.00	.57	.09	.24	.00	.10
APARTMENT												
	Decomposition for TBI returns						Decomposition for REIT returns					
Step	Δ*TBI*	Δ*REIT*	Δ*GDP*	Δ*SE*	Δ*IR*		Δ*TBI*	Δ*REIT*	Δ*GDP*	Δ*SE*	Δ*IR*	
1	.85	.13	.01	.00	.01		.00	.73	.00	.16	.11	
2	.61	.26	.01	.02	.11		.00	.60	.00	.17	.21	
5	.32	.38	.03	.08	.20		.01	.53	.04	.18	.25	
10	.13	.45	.05	.13	.23		.01	.51	.05	.18	.25	
20	.04	.48	.06	.17	.25		.00	.50	.06	.19	.25	

	INDUSTRIAL									
	Decomposition for TBI returns					Decomposition for REIT returns				
Step	ΔTBI	$\Delta REIT$	ΔGDP	ΔSE	ΔINF	ΔTBI	$\Delta REIT$	ΔGDP	ΔSE	ΔINF
1	.74	.09	.15	.01	.02	.00	.88	.03	.08	.02
2	.58	.14	.23	.01	.05	.04	.74	.03	.16	.03
5	.42	.24	.24	.01	.08	.09	.61	.10	.14	.04
10	.34	.31	.23	.03	.09	.15	.53	.14	.11	.06
20	.30	.36	.22	.04	.09	.20	.47	.17	.08	.07

The forecast error variance decompositions shown in the table are computed from the multiple variable VECM/VAR models. *SE* stands for the economic sentiment, *IR* for the short-term interest rate, *S* for the term spread of interest rates, *INF* for the inflation rate, and *D* for the default risk premium.

In Table 8, our main focus is on the importance of real estate related shocks. In line with the Granger causality and impulse response analyses, the table shows that REIT shocks are important for TBI performance in all the sectors, but only in the industrial sector TBI shocks have a notable influence on the evolution of the REIT index. In the extreme case, retail REIT shocks account for 54% of the TBI total return index variance at the five-year (20-quarter) horizon, while the corresponding impact of TBI shocks on REIT performance equals zero. The main implications are robust with respect to the ordering of the real estate markets. Again, an exception is the industrial sector, where the alternative ordering (i.e., TBI before REITs) would indicate that the direct market shocks are a more important determinant of real estate return volatility – regarding both direct real estate and REITs – than the REIT market. Since the office sector decompositions are based on a VAR model instead of a VECM, they are not directly comparable with those of the other sectors. While the decompositions in the office sector are for real estate returns, they are for the return indices in the other sectors.

Regarding the impact of the fundamentals, the main difference between REIT and direct real estate performance is the role of current economic growth (*GDP*) vs. that of expected future economic growth (economic sentiment). The forward-looking growth component is generally much more important for REITs than for direct real estate, whereas *GDP* shocks are more important with respect to direct real estate performance, at least in the relatively short horizon. In the apartment sector, sentiment shocks dominate regarding direct market performance as well, though. Moreover, the industrial sector REIT performance is driven more by *GDP* that by sentiment.

Robustness checks

In this section, we conduct two kinds of robustness checks for the real estate market dynamics. First, we investigate whether the results are robust to different escrow lag assumptions, after which we use the TBI 'demand' indices to test whether the lead-lag relations found in the baseline models could be explained by the time-varying liquidity of direct real estate.

The results which were discussed in the previous section are based on the most likely figure concerning the escrow lag, i.e., a 90-day lag. We test here the validity of our results to various alternative escrow lags. The Granger causality test results assuming various escrow periods are summarized in Tables 9-12. The tables also report the figures when no lag is considered in order to gauge the bias that may occur if the escrow lag is not accounted for. Again, the main focus is on the pairwise models, while the test statistics from the multiple variable models reveal some additional information.

Table 9. Granger causality test results for office sector assuming different escrow periods

Explanatory variable	Dependent variable: No escrow lag		Escrow lag = 45 days		Escrow lag = 90 days		Escrow lag = 135 days		Escrow lag = 180 days	
	ΔTBI	$\Delta REIT$	ΔTBI	$\Delta REIT$	ΔTBI	$\Delta REIT$	ΔTBI	$\Delta REIT$	ΔTBI	$\Delta REIT$
Pairwise model										
ΔOff_TBI	12.9*	0.6	19.4*	0.3	5.2*	0.5	7.6*	2.4	3.9*	4.4*
ΔOff_REIT	12.8*	12.9*	30.5*	6.7*	5.9*	3.0*	9.1*	0.9	2.9*	9.2*
Multiple variable model										
ΔOff_TBI	2.1*	0.9	2.2*	1.5	0.4	1.2	0.9	1.0	0.6	1.6
ΔOff_REIT	6.8*	2.2*	6.5*	1.6*	5.2*	2.6*	5.0*	1.6*	2.1*	2.7*

The table shows the F-values in the pairwise tests and the t-values (in absolute terms) from the multiple variable model.* denotes statistical significance at the 10% level. The null hypothesis in the tests is that 0f no Granger causality between the variables.ΔOff_TBI and ΔOff_REIT stand for direct and securitized office sector returns, respectively. The pairwise models include two lags and the multiple variable models one lag. To fulfill the assumption of normally distributed residuals, some models also contain one or more dummy variables that take the value one in a single period and are zero otherwise. The multiple variable models include the following fundamentals: ΔGDP, ΔSE, ΔIR and ΔS.

Table 10. Granger causality test results for retail sector assuming different escrow periods

Explanatory variable	Dependent variable: No escrow lag		Escrow lag = 45 days		Escrow lag = 90 days		Escrow lag = 135 days		Escrow lag = 180 days	
	ΔTBI	$\Delta REIT$	ΔTBI	$\Delta REIT$	ΔTBI	$\Delta REIT$	ΔTBI	$\Delta REIT$	ΔTBI	$\Delta REIT$
Pairwise model										
ΔRet_TBI	2.1*	0.7	1.4	2.3*	0.8	1.4	0.7	1.5	1.0	0.9
ΔRet_REIT	0.7	4.0*	0.5	0.8	2.0*	3.2*	1.4	1.9*	1.8*	2.3*
eqe	3.6*	1.0	5.3*	0.6	2.9*	0.9	3.5*	0.3	1.8*	1.6
Multiple variable model										
ΔRet_TBI	1.6	0.6	1.7*	1.0	1.1	0.5	0.9	0.9	0.6	1.1
ΔRet_REIT	1.1	1.2	1.4	0.2	0.9	1.3	0.7	0.3	1.5	0.6
eqe	3.7*	0.5	3.6*	0.4	2.2*	0.1	2.6*	0.6	1.2	1.0

The table shows the t-values (in absolute terms) in the Granger causality tests.* denotes statistical significance at the 10% level. The null hypothesis in the t-test is that of no Granger causality between the variables.ΔRet_TBI and ΔRet_REIT stand for direct and securitized retail sector returns, respectively, while *eqe* is the deviation from the cointegrating relationship. The models include one lag. To fulfill the assumption of normally distributed residuals, some models also contain one or more dummy variables that take the value one in a single period and are zero otherwise. The multiple variable models include the following fundamentals: ΔGDP, ΔINF, ΔSE and ΔD.

Table 11. Granger causality test results for apartment sector assuming different escrow periods

Explanatory variable	No escrow lag ΔTBI	No escrow lag $\Delta REIT$	Escrow lag = 45 days ΔTBI	Escrow lag = 45 days $\Delta REIT$	Escrow lag = 90 days ΔTBI	Escrow lag = 90 days $\Delta REIT$	Escrow lag = 135 days ΔTBI	Escrow lag = 135 days $\Delta REIT$	Escrow lag = 180 days ΔTBI	Escrow lag = 180 days $\Delta REIT$
Pairwise model										
ΔApt_TBI	1.4	1.1	0.9	1.5	0.9	1.3	1.0	0.3	1.6	0.4
ΔApt_REIT	2.3*	1.5	1.4	0.0	0.7	2.1*	1.4	0.3	3.6*	1.7*
eqe	3.4*	1.0	3.3*	0.7	2.5*	1.2	3.2*	1.0	1.1	1.4
Multiple variable model										
ΔApt_TBI	1.1	0.9	1.1	0.4	0.9	1.1	1.5	1.9*	1.1	1.7*
ΔApt_REIT	2.8*	2.5*	1.7*	1.0	2.1*	2.1*	1.4	0.3	2.8*	3.1*
eqe	3.5*	0.7	3.8*	0.2	2.1*	1.3	2.8*	0.4	2.7*	2.7*

(Dependent variable in column headers.)

The table shows the t-values (in absolute terms) in the tests.* denotes statistical significance at the 10% level. The null hypothesis in the t-test is that of no Granger causality between the variables.ΔApt_TBI and ΔApt_REIT stand for direct and securitized apartment returns, respectively, while *eqe* is the deviation from the cointegrating relationship. The models include one lag. To fulfill the assumption of normally distributed residuals, some models also contain one or more dummy variables that take the value one in a single period and are zero otherwise. The multiple variable models include the following fundamentals: ΔGDP, ΔSE and ΔIR.

Table 12. Granger causality test results for industrial sector assuming different escrow periods

Explanatory variable	No escrow lag ΔTBI	No escrow lag $\Delta REIT$	Escrow lag = 45 days ΔTBI	Escrow lag = 45 days $\Delta REIT$	Escrow lag = 90 days ΔTBI	Escrow lag = 90 days $\Delta REIT$	Escrow lag = 135 days ΔTBI	Escrow lag = 135 days $\Delta REIT$	Escrow lag = 180 days ΔTBI	Escrow lag = 180 days $\Delta REIT$
Pairwise model										
ΔInd_TBI	2.4*	2.7*	2.1*	2.5*	0.1	0.9	0.1	2.4*	0.2	3.0*
ΔInd_REIT	4.6*	3.7*	2.9*	3.4*	0.4	1.7*	0.4	1.5	2.1*	4.2*
eqe	3.3*	1.1	3.8*	0.6	1.9*	2.5*	2.3*	2.7*	1.0	4.4*
Multiple variable model										
ΔInd_TBI	1.5	2.4*	1.0	1.6	0.5	1.3	0.3	2.3*	0.5	3.5*
ΔInd_REIT	3.8*	2.9*	2.5*	2.5*	0.5	1.1	0.4	0.9	2.2*	3.0*
eqe	2.7*	0.8	3.0*	0.6	1.8*	2.0*	2.1*	2.3*	0.8	3.8*

(Dependent variable in column headers.)

The table shows the t-values (in absolute terms) in the tests.* denotes statistical significance at the 10% level.The null hypothesis in the t-test is that of no Granger causality between the variables.ΔInd_TBI and ΔInd_REIT stand for direct and securitized industrial sector returns, respectively, while *eqe* is the deviation from the cointegrating relationship. The models include one lag. To fulfill the assumption of normally distributed residuals, some models also contain one or more dummy variables that take the value one in a single period and are zero otherwise. The multiple variable models include the following fundamentals: ΔGDP, ΔSE and ΔINF.

According to the Granger causality test results, the escrow lag would have to *exceed* 45 days in the industrial sector, 90 days for apartments, 135 days for offices, and 180 days in the retail sector so not to observe a lead-lag relationship between REIT and direct real estate returns. Given that (1) the escrow period can be some 180 days *at maximum*, (2) in many cases the transaction price is renegotiated during the due diligence process, and (3) the U.K. experience suggests that the typical escrow periods are one quarter or less, this is unlikely with the exception of the industrial sector. Thus, the robustness checks strongly support the hypothesis that REIT returns lead direct real estate returns in the office and retail sectors. Moreover, in the apartment sector the escrow lag is likely to be shorter than90 days so that our results are also confirmed for that sector. In the industrial sector models assuming no lag or a 45-day escrow lag, the leading role of REITs with respect to TBI is due to the fact that only TBI adjusts towards the cointegrating relation. Moreover, in REIT equations the significant parameter on lagged TBI returns is negative. Hence, it would be hard to interpret these statistically significant parameter estimates as evidence of a sensible lead-lag relation between TBI and REITs even if TBI returns were not predictable by past REIT returns or a long-term deviation. The impulse responses from models assuming different escrow lags are in line with the Granger causality implications.

In theory, the perceived sluggish adjustment of direct real estate prices may be caused by asymmetries in buyers' and sellers' responses to shocks in the fundamentals. In particular, in search theoretical models where buyers are assumed to respond prior to sellers, sales volume is expected to respond prior to prices to changes in the fundamentals (Berkovec and Goodman, 1996; Hort, 2000; Fisher et al., 2003). That is, if buyers react more rapidly than sellers, changes in the demand for an asset are expected to lead returns on the asset (for empirical evidence of such dynamics in the private real estate market, see Berkovec and Goodman, 1996; Oikarinen, 2012). Clearly, given the notable informational asymmetries in the direct real estate market, asymmetries in buyers' and sellers' responses are more likely in the direct real estate market than in the REIT market where liquid assets are traded in a centralized market place. Therefore, the observed lead-lag relationship between REIT and direct real estate returns may be due to the slow adjustment of the supply side in the direct real estate market.

To gain further insight into the lead-lag relations, we investigate the dynamics of the sector level demand indices developed by Fisher et al. (2003 and 2007). The demand indices are based on the same properties as the TBI indices and track the movements in buyers' reservation prices. In other words, the demand indices show the development of the 'constant-liquidity value' of private real estate. Similar to our baseline models, we use the one quarter lagged demand indices in the analysis below. Table 13 present descriptive statistics regarding the constant-liquidity indices. In order to have comparable series to the TBI total return indices, we add a rental income return component to the constant-liquidity price changes based on the TBI rental income component.

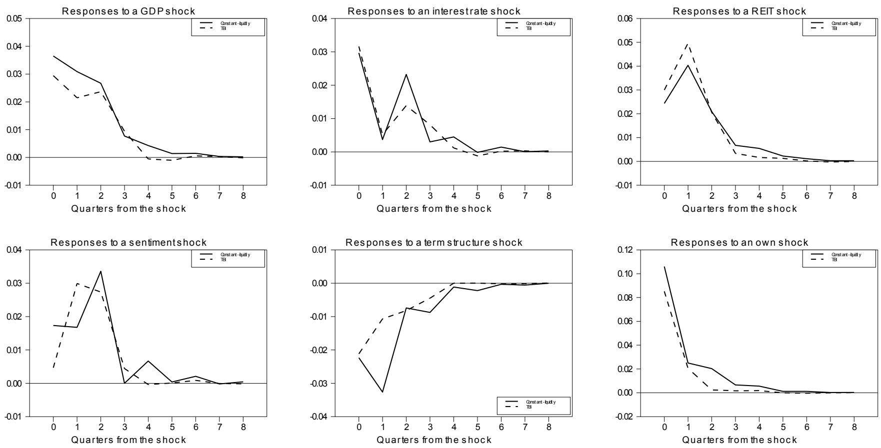
Table 13. Descriptive statistics of the levered sector level constant-liquidity total return index movements over 1994Q1-2010Q4

Sector	Mean (annualised %)	Standard deviation (annualised %)	Jarque-Bera test for normality (p-value)	Ljung-box test for auto-correlation (p-value, 4 lags)
Office	2.8	27.9	.00	.00
Retail	4.4	29.0	.00	.20
Apartment	9.5	25.1	.19	.13
Industrial	1.4	46.7	.00	.44

In line with the vast empirical evidence showing time-varying liquidity in the direct real estate market, the volatility of constant-liquidity returns is notably greater than that of the TBI returns. This is in accordance with the claim that in the direct real estate market demand is more volatile than prices. Expectedly, the constant-liquidity indices appear to be stationary in differences just like the TBI indices – after all there should not be any differences in the order of integration between the constant-liquidity and conventional TBI indices. Nevertheless, the cointegration tests reveal some differences, as the long-run parameters on REITs are somewhat different in the retail and apartment sector models and cointegration cannot be found at all in the industrial sector.

If movements in the constant-liquidity indices led TBI returns and did not lag REIT returns, an observed lead-lag relationship between REIT and TBI returns would be due to the slow reaction of the seller reservation prices in the direct market rather than a sluggish response of private market demand to shocks. However, the results do not support the hypothesis that the TBI returns lag REIT returns due to the slow response of sellers: The dynamics of the demand indices appear to be highly similar to those of TBI (see Figure 6 for the office sector case; the constant-liquidity reaction does not notably differ from the baseline reactions in the retail or apartment sectors, either). In particular, REIT returns lead changes in the constant-liquidity returns in office, retail and apartment sectors (Table 14), and the impulse responses show evidence of a more rapid reaction of demand than of price changes in only a few cases.

Figure 6. Reactions of baseline TBI returns and constant-liquidity TBI returns to shocks in the fundamentals, office sector



The Figure shows the generalized impulse response functions of private real estate returns to shocks that are of one standard error in magnitude. 'TBI' refers to impulse responses computed from the baseline model, while 'Constant-liquidity' refers to the constant-liquidity TBI model.

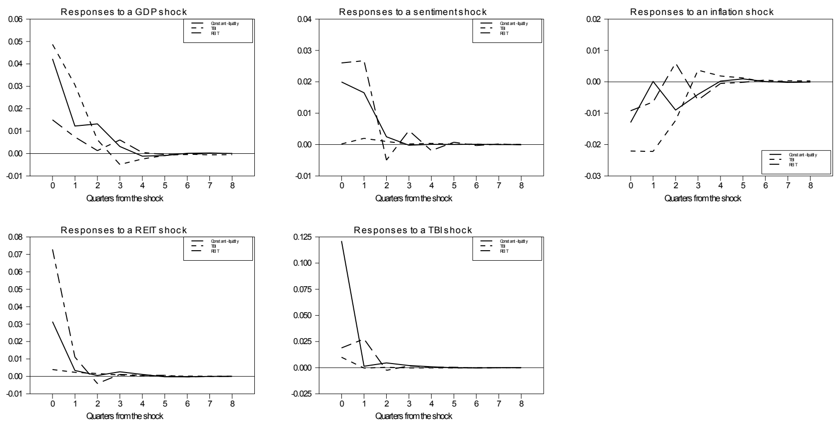
Table 14. Granger causality test results using TBI demand indices and assuming a 90-day escrow period

Explanatory variable	Office		Retail		Apartments		Industrial	
	Dependent variable							
	$\Delta TBId$	$\Delta REIT$	$\Delta TBId$	$\Delta REIT$	$\Delta TBId$	$\Delta REIT$	$\Delta TBId$	$\Delta REIT$
Pairwise model								
$\Delta TBId$	3.5*	1.0	0.3	1.5	1.5	6.5*	6.8*	4.6*
$\Delta REIT$	7.7*	12.4*	3.7*	4.5*	1.2	0.0	3.9*	1.4
eqe			0.7	0.1	3.9*	0.0		
Multiple variable model								
$\Delta TBId$	0.6	0.2	0.4	0.7	1.1	3.4*	0.4	3.1*
$\Delta REIT$	3.3*	1.9	2.1*	0.4	0.4	1.0	0.3	0.5
eqe			1.7*	0.1	4.1*	0.2		

The table shows the t-values, and the F-test values in the case of office sector pairwise model, in absolute terms in the Granger causality tests.* denotes statistical significance at the 10% level. The null hypothesis in the tests is that of no Granger causality between the variables. $\Delta TBId$ stands for direct demand index returns and $\Delta REIT$ for securitized returns in the given sector. *eqe* is the deviation from the cointegrating relationship. The models include one lag. An exception is the office sector pairwise model, which has two lags. To fulfill the assumption of normally distributed residuals, the models also contain one or more dummy variables that take the value one in a single period and are zero otherwise.

There are some differences between the constant-liquidity results and the findings from the baseline models, however. In particular, in the industrial sector the constant-liquidity direct real estate returns appear to lead REIT returns both based on Granger causality tests and impulse responses (see Figure 7). In the apartment sector, in turn, the lead-lag relation is statistically significant only through the long-term relation, while in the baseline model lagged REIT return Granger causes TBI also directly.

Figure 7. Reactions of baseline TBI returns, constant-liquidity TBI returns and REIT returns to shocks in the fundamentals, industrial sector



The Figure shows the generalized impulse response functions of private and public (REIT) real estate returns to shocks that are of one standard error in magnitude. ‘TBI’ refers to impulse responses computed from the baseline model, while ‘Constant-liquidity’ refers to the constant-liquidity TBI model. The REIT responses are those from the constant-liquidity TBI model.

The implications of variance decompositions are largely the same regardless of whether the constant-liquidity TBI or the baseline TBI indices are applied. However, the role of REIT shocks as a driving factor of private market performance is somewhat smaller, and the role of own TBI shocks is somewhat greater, when constant-liquidity indices are used instead of the conventional TBI return indices. This suggests that demand changes in the direct market are somewhat more independent than the observed TBI performance with respect to REIT shocks.

Concluding remarks

Due to the greater liquidity, larger number of market participants, smaller transaction costs, and the existence of a public market place in the securitized market, it is generally thought that the prices of securitized real estate investments react faster than the price of direct real estate to shocks in the fundamentals and thus that public real estate returns lead those of private real estate. Previous empirical evidence supports this hypothesis. However, since the reported lead-lag relations are generally based on data that do not correct for a number of complications present in the real estate market return data, the empirical evidence is not conclusive. In particular, no study so far has considered the impact of escrow lags on the reported lead-lag relations between the securitized and direct real estate markets.

This study appears to be the first one on the theme that uses transaction-based direct real estate data and caters for the property-type, leverage, and escrow period complications in the real estate return data. Thus, this study aims to provide a clearer picture of the dynamic relations between public and private real estate returns. In particular, the aim is to investigate whether the observed leading role of REIT returns with respect to private real estate returns could be an artifact of the problematic data or whether the lead-lag relation remains even after taking account of the data complications. In addition to examining the lead-lag relations between the securitized and direct real estate markets, our analysis provides a contribution to a better understanding of the behavior of both markets, also shedding light on issues such as price discovery.

We use sector level REIT (NAREIT) and direct real estate (TBI) total return data for the period 1994-2010 to study the reaction patterns of public and private real estate returns to economic shocks and to examine the lead-lag relations between the public and private real estate markets. To make REIT and TBI data more comparable, we add leverage to direct real estate returns. Furthermore, we ‘lag’ the direct market data to take the escrow lags into account, and add economic fundamentals in the analysis to cater for the influence of fundamentals on the real estate market dynamics.

We find tight long-term relations in terms of cointegration in three (office, retail, and apartments) out of the four sectors (the exception is industrial) included in the analysis. Based on vector error-correction and vector autoregressive models, our findings show that REIT returns lead private real estate returns even after catering for the property type, leverage, and a 90-day escrow lag. Regarding these sectors, the results suggest that the lead-lag relation between public and private real estate returns is not an artifact of complicated data but a true phenomenon. An exception is the industrial sector, where such lead-lag relation is not observed after catering for the escrow lag. Generally, REIT returns remain significant in the equation for TBI returns even after the inclusion of fundamentals in the models. This emphasizes the predictive power of REIT returns with respect to direct real estate returns.

The estimated impulse responses suggest that direct real estate prices adjust more slowly than REIT prices especially to shocks in the economic sentiment. Moreover, TBI returns appear to react to unexpected changes in REIT returns with a clear lag, i.e., the information that is revealed by movements in REIT prices is only sluggishly absorbed by direct real estate prices. Therefore, the direct market appears to be less informationally efficient than the REIT market, in general (for a discussion, see Barkham and Geltner, 1995, pp. 39-42). Nevertheless, our analysis shows that there are predictable components in REIT returns as well.

We also investigate whether the demand for direct real estate reacts more rapidly to shocks than prices do. It can be argued that if demand changes were to lead TBI returns and did not lag REIT returns, the observed lead-lag relationship between REIT and TBI returns would be due to the sluggish adjustment of sellers' reservation prices. However, our results suggest that the perceived lead-lag relations between the securitized and direct real estate returns cannot be explained by a slower reaction of sellers' reservation prices than of the demand side in the direct market.

Our results suggest some notable differences between the sectors regarding the return dynamics. Consequently, it would seem appropriate to use sector level data when evaluating the return and price dynamics in the REIT and direct real estate markets and when attempting to forecast prices for these markets. The aggregate data may mask valuable sector specific information.

In addition, our findings have portfolio implications. In the industrial sector, and to a lesser extent in the retail sector, there is evidence of a sluggish REIT price reaction to a direct market shock. This indicates that there might be some arbitrage opportunities (predictability) in the REIT market. Since the publicly available data can be used to identify the shocks in the direct market only with a notable lag, only well informed investors could take advantage of these opportunities. Furthermore, the reported positive lead-lag relations indicate that over the longer horizon the co-movement between REIT returns and direct real estate returns is notably stronger than suggested by the contemporaneous quarterly correlation coefficients. Indeed, as the observed TBI index returns are likely to include a recording lag due to the escrow period, even the short-term linkages between REIT and direct real estate returns are greater than suggested by the correlation coefficients between REIT and TBI index returns.

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Notes

[1] We are grateful to an anonymous reviewer for his/her input on this issue.

[2] For a general discussion concerning the price discovery mechanism between the markets, see Geltner et al. (2003).

[3] The construction of 'shadow portfolios', as in Pavlov and Wachter (2011), cannot be applied here as appropriate data are not available for our time period of analysis.

[4] The table shows the unit root test results for the non-lagged TBI indices, as those include one more observation than the 90-day lagged indices. The greater number of observations yields more reliable test statistics while the leading or lagging of the indices does not affect the order of integration of a variable.

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