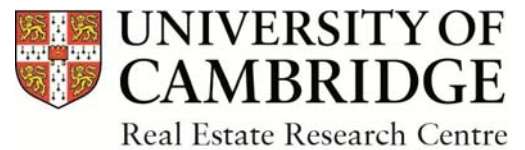


Department of Land Economy

Environment, Law & Economics



Working Paper Series

No. 2017-05

Title: A Behavioral Interpretation of the NAV Discount Puzzle in Listed Real Estate Companies

Authors: Sally Monson^a, Helen XH Bao^b, Colin Lizieri^c

Affiliation: University of Cambridge^{a, b & c}

Contact corresponding author: Helen Bao, hxb20@cam.ac.uk

A Behavioral Interpretation of the NAV Discount Puzzle in Listed Real Estate Companies

Sally Monson, Helen X. H. Bao¹ and Colin Lizieri

Department of Land Economy, University of Cambridge, CB39EP, Cambridge, UK

Executive Summary:

The NAV discount is a long standing puzzle in the listed real estate context. In this paper we extend the existing literature's rational and noise trader explanations by exploring the influence of specific irrational behaviors. Based on behavioral biases identified in the stock and real estate markets, we hypothesize the existence of a relationship between lagged NAV growth and the NAV discount. The findings provide initial evidence of trend-chasing behavior between the dual real estate markets. The results have broader implications for the perception of the relationship between public and private real estate markets.

RERC Working Papers Series (Version: Dec 2016)

¹ Corresponding author (hxb20@cam.ac.uk).

A Behavioral Interpretation of the NAV Discount Puzzle in Listed Real Estate Companies

1. Introduction

The net asset value (NAV) discount is not just an academic puzzle. Persistent differences between public and private market valuations influence decisions to privatise listed real estate companies. Understanding the NAV discount puzzle is also crucial for investment strategies attempting to time the market. Yet, despite the importance of the topic, existing research is unable to fully account for the NAV discount puzzle. In this paper, we propose an extension of existing ‘irrational’ explanations, using insights from behavioral theory.

Recently, behavioral approaches have become increasingly popular in a variety of research disciplines. However, the potential contribution of such an approach to the NAV discount puzzle in listed real estate companies remains unexplored. The peculiarities of real estate are widely acknowledged to affect the efficiency of the market and its susceptibility to irrational behavior. The unique market necessitates industry-specific training and specialised skills, reflected in the increasing number of dedicated real estate MBA programmes. Within this context, a behavioral perspective emerges as a natural extension to existing explanations for the NAV discount puzzle. Existing literature identifies a trend-chasing tendency among investors, and it is suggested that similar behavior could provide an explanation for the NAV discount if public market real estate investors are found to overreact to trends in the private market.

The real estate market presents a challenging setting in which to conduct research. Not only is the market subject to a wide range of confounding macroeconomic influences, but the availability of econometric techniques is also constrained by data limitations. Nevertheless, it is in this context that we attempt to investigate specifically the relationship between past NAV growth and the NAV discount and whether, contrary to widespread belief, there is evidence to suggest that the public market can lag behind the private market. In addition to highlighting the value of incorporating behavioral ideas into explanations for the NAV discount, our results also point to the need to review the traditional understanding of the relationship between the private and public markets.

The remainder of this paper sets out the investigation and discusses the results in more detail. Section 2 introduces the existing literature on the NAV discount debate. Section 3 considers the relevance of the behavioral perspective and justifies the selection of specific behavioral explanations as the hypotheses to be tested. The econometric methods adopted and the data employed are discussed in Section 4, followed by the presentation and discussion of results in Section 5. Section 6 concludes.

2. Literature Review

Attempts to explain the NAV discount in both financial asset and real estate markets can be organised into two schools of thought; the 'rational' approach and the 'noise trader' approach.

2.1 Rational Explanations (Generation I)

The rational approach attempts to explain the NAV discount by reference to the different characteristics of direct and indirect investment (Malkiel 1995; Cherkes et al. 2009). According to traditional discounted cash flow methodology, the different prices recorded in the public and private market reflect differences in the level and risk of cash flows investors expect to receive. For instance, greater liquidity in the public market over the private market, and the consequent reduction in liquidity risk premium, is hypothesised to increase the value of indirect investment (Benveniste et al. 2001; Cheung et al. 2015). This approach also argues that firm-level differences can influence the NAV discount. For example, high management fees may be interpreted as a principal-agent problem, leading firms with high management fees to have larger discounts (Capozza and Korean 1995; Lenkey 2015).

Barkham and Ward (1999) investigate a comprehensive set of rational hypotheses for listed property discounts. Their hypotheses include the effect on the NAV discount from management expenses, leverage, inside ownership, outstanding tax burden, size, and firm reputation. The hypotheses are tested in a cross-sectional regression for UK property companies, with a control variable to reflect different market conditions at each reporting date. They find strong evidence that the NAV discount becomes more negative with increasing tax liability. The result is explained on the basis that taxes represent the state's claim on the firm's assets, diminishing the value retrievable by investors. They also find support for the hypothesis that increased leverage is associated with more negative NAV discounts, which is explained in terms of increased equity risk. In an extension of their model, they include the market NAV discount and report an increase in R^2 from 15% to 30%. Similar results are found in other research (Clayton and MacKinnon 2001; Morri et al. 2005).

Despite the clear intuition and evidence for specific rational hypotheses, there are several flaws with the approach. Particular criticism has focused on the methodology employed in the tests and the narrow emphasis on individual hypotheses. According to Rehkugler et al. (2012) "although they are able to test this factor's influence on the NAV spread, these studies fail to explain its relative strength and the complex interrelationship with other factors". The lack of stability in the results generated by alternative specifications supports the view that conclusions from incomplete models are likely to be misleading (Morri et al. 2005).

The methodological issues are compounded by the inconclusive explanations that can be invoked to account for the findings. For several variables, there is no clear direction that the rational hypothesis should take. Depending on the researcher's perspective, it is possible to argue that it is 'rational' for a particular characteristic to either increase or decrease the NAV discount. For instance, on the one hand, management expenses can be

viewed as a proxy for managerial ability (smaller, less negative, NAV discount); on the other hand, expenses can be viewed as additional fee associated with indirect investment and potentially a source of agency costs (larger, more negative, NAV discount). Similarly, Brounen and Laak (2005) and Clayton and MacKinnon (2001) identify a negative relationship between firm size and the NAV discount, attributing the finding to greater access to capital and investment opportunities. However, Barkham and Ward (1999) and Bond and Shilling (2003) find evidence of the opposite relationship, arguing instead that this represents greater liquidity costs arising from the distortion in market supply on asset liquidation. Interpretations risk being chosen ex-post to fit findings.

A further problem for the rational approach arises from the identification of a significant market NAV discount variable. Morri et al. (2005) highlight that while firm-level NAV deviations are explained by market NAV deviation, there is no explanation for the cause of the common NAV deviation.

2.2 Noise Trader Explanations (Generation II)

The rational approach has been challenged by an alternative perspective, emphasising the role of sentiment. This is based on a closed-end fund application of the noise trader model from De Long et al. (1990). The model assumes two types of traders exist: rational and noise traders. Other critical assumptions include: (1) noise trader sentiment is unpredictable; (2) rational investors have relatively short time horizons; (3) noise trader sentiment is systematic. The model predicts that prices diverge from fundamental values, with NAV discounts reflecting additional noise trader risk.

Investigations employing a variety of methodologies have generated support for the role of sentiment in asset pricing and the NAV discount. The early literature identified high correlations between returns on closed-end funds and small-cap stocks. Based on the assumption that individual investors dominate the small-cap stock market, it is argued that the sentiment of individual investors is driving the performance of both investments (Lee et al. 1991). Later real estate research has directly incorporated a proxy for investor sentiment into the NAV discount model. Barkham and Ward (1999) employ the CBI industrial confidence index and the MMI inflation expectations. Their findings support a role for sentiment, recording significant coefficients on the sentiment variables and increased explanatory power in their model ($R^2 = 33\%$). Rehkugler et al. (2012) provide further evidence for the 'noise trader' hypothesis, achieving an R^2 of 76% with the inclusion of a sentiment variable in their model.

While mainstream economics in general has moved away from the restrictive assumptions of rationality, the noise trader explanation has been criticised on the basis of its treatment of irrationality. In Lee et al. (1991), individual investors are assumed to generate the noisy fluctuations that lead to NAV discounts. However, this has been challenged by a number of other studies. Chen et al. (1993) provide an initial critique, identifying instability in the relationship between the closed-end fund discount and ownership structure, and concluding that the findings of Lee et al. (1991) cannot be generalised.

Elton et al. (1998) also dispute the idea that the existence of discounts can be attributed to additional risk from noise traders. The authors compare the return generating process

across portfolios of closed-end funds and portfolios consisting of large, institutionally-held industrial firms. They find that the influence of a proxy for sentiment is not significantly different across the portfolio categories. To the extent that institutional investors do not engage in noise trading, the results suggest that sentiment is not behind the price behavior of closed-end funds. The authors extend the analysis to explain the closed-end fund discount as a result of influences unrelated to sentiment. They use the different characteristics of the closed-end fund stock and the underlying assets as explanatory variables, and find that the size, value investment style, and greater sensitivity to bonds means that investors face greater risk in closed-end funds and discount accordingly. Finally, Elton et al. (1998) consider evidence from closed-end bond funds. Despite being subject to less sentiment influence than stocks, the discounts on bond funds are found to present similar magnitudes of systematic risk, suggesting that sentiment is not relevant in accounting for returns.

In addition to the evidence against the noise trader hypothesis in general, its application to the real estate market appears to be especially vulnerable to criticism. The peculiarities of real estate, particularly in relation to the operational burdens, means that it is common to outsource real estate expertise, even for institutional investors. Institutional ownership of US equity REITs increased from 14.14% in 1990 to 75.19% in 2011 (An et al. 2015). Thus, it is not clear whether the players in the market can be expected to show the purported irrationality.

From surveying the literature, it is apparent that neither the rational nor noise trader approaches are infallible, nor are they capable of fully accounting for the puzzling existence of the NAV discount. This gap in the literature provides the scope to introduce a 'Generation III' explanation, which can supplement the existing approaches. Given the tendency for more recent explanations to incorporate irrational behavior, the contribution made by this paper towards Generation III involves investigating the details of irrational behaviors and the impact on the NAV discount. It is hoped that by adopting a nuanced perspective of market participants' behaviors, the Generation III approach will be able to account for the market-wide NAV discount movements that currently remain unexplained.

3. A Behavioral Interpretation of the NAV Discount Puzzle (Generation III)

The noise trader approach represents an initial application of behavioral ideas in explanations for the NAV discount puzzle. However, while the approach relaxes the assumption of perfect rationality, it is limited to considering a crude measure of sentiment, dominated by economy-wide, as opposed to market specific, conditions. The use of a broad business confidence index (e.g., Barkham and Ward 1999) risks conflating the sentiment of business leaders and real estate investors (Wameryd 2001). On the other hand, to the extent that business confidence is relevant to real estate investors in terms of representing the expected demand for space, it is arguably erroneous to regard the variable as representing a proxy for irrational behavior.

Contrasting with the reliance on a single catch-all sentiment measure, the behavioral literature outside the NAV discount debate emphasises not only the tendency to be affected by sentiment, but also why this occurs and how this impacts behavior (Tversky

and Kahneman 1974). A variety of specific biases and heuristics have been identified, including, inter alia, loss aversion, availability bias, optimism bias, anchoring bias, conservatism and representativeness. A disaggregate approach, focusing on specific biases, has the potential to provide a better understanding of the mechanisms behind the NAV discount. The specific Generation III hypotheses are formed by considering the characteristics of the real estate market from a behavioral perspective and drawing on the relevant formal theories from the stock market behavioral literature.

The tendency of the real estate market to undergo cyclical episodes of boom and bust behavior is well-known and the topic of real estate cycles is widely researched. Explanations have generally focused on a combination of construction lags, real options, and game theory. The uncertainties, time delays and strategic interactions implied by these approaches reflect the complexity of decision-making in the real estate context and the demands placed on investor cognition may lead to the adoption of effort-saving heuristics and biases (Geltner et al. 2013). In addition, the specialised skills necessary to understand the real estate market may lead to further divergences from rationality for non-specialist equity traders investing in the public real estate market (Geltner et al. 2013).

In this already convoluted context, the rise of Big Data has generated yet more information for investors to absorb. It follows that research into the concept of salience has become particularly relevant (Andreassen 1990; Brown and Matysiak 2000; Jandl 2015). A range of factors have been considered to affect the salience of information, including inter alia, timing, presentation, and availability of alternatives (Andreassen 1990; Bordalo et al. 2015). A compelling result for the real estate context concerns the effect of perceived trends (Andreassen and Kraus 1990). Evidence of the association between salience and trends already exists in a variety of real estate settings. For example, Case and Shiller (1988) conduct a survey of home buyer expectations across US cities and identify a relationship between past housing market conditions and the expectations of survey participants. Cities which have experienced rapid house price increases in the past are found to be associated with higher expectations of future house price rises than is expected elsewhere. Evidence from the real estate development industry indicates that even professionals in the real estate market may be enticed by trends and exhibit habit persistence (Antwi and Henneberry 1995).

In a further extension, it is suggested that trends accompanied by an explanation for the trend are more prone to generate anti-regressive behavior (Wameryd 2001). In particular, there is evidence to support the media's role in influencing the market via the dissemination of explanations and beliefs regarding investment performance (Tetlock 2007). Given the fundamental importance of the property market to the economy, and the media attention it attracts, this appears to raise the possibility of trend following behavior in the real estate market.

The nature of the real estate industry may provide a further mechanism for a perceived trend to influence investor behavior. In the UK, the real estate industry is relatively small, with widespread opportunities for social interaction to affect behavior (DeCoster and Strange 2012). It is plausible that the belief a trend will continue, or at least belief that

others will believe this, may trigger herd behavior. After all, according to Maital et al. (1986), “there is nothing more disastrous than a ‘rational’ investment strategy in an irrational market”.

Thus, based on the understanding of the cognitive demands on investors and the broader socio-economic context of the real estate market, trend-chasing behavior provides the focus for the behavioral extension of the NAV discount explanation. Extensive analysis already conducted for similar behavior in the stock market is used to formalise the hypotheses.

According to the weak form of the Efficient Market Hypothesis, past performance should not be able to predict future performance. However, investment strategies based on historical performance and fundamental data have identified profitable opportunities in the market. De Bondt and Thaler (1985) document the returns from a contrarian investing strategy. Stocks in the top and bottom decile of preceding three-year performance are used to form ‘winner’ and ‘loser’ portfolios respectively, and subsequent results reveal substantial positive returns from the ‘loser’ strategy. The authors suggest this indicates market overreaction to past trends and a subsequent reversal. Jegadeesh and Titman (1993) further explore the short-term momentum effect by constructing portfolios based on stocks’ past six-month performance. They find that the ‘winner’ portfolio outperforms the ‘loser’ portfolio over the next six-months. In a related strand of research, Lakonishok et al. (1994) advocate a value strategy based on extrapolation of fundamentals. They hypothesise that investors expect stocks with low earning growth rates in the past to continue to have low growth in the future. When this expectation is not realised, an adjustment process takes place in the pricing of the stock, generating abnormal returns. They find the annual return on a value portfolio is approximately 10-11% greater relative to a glamour portfolio.

In contrast to the above research identifying overreaction/momentum/trend-chasing, there is evidence to suggest that the market exhibits underreaction to isolated corporate events (Bernard and Thomas 1990; Ikenberry and Ramnath 2002; Kadiyala and Rau 2004). Several traits identified in psychological studies also support the existence of underreaction. For instance, anchoring bias refers to the tendency for agents to adjust their beliefs only marginally from expectations in the prior period. Chen et al. (1993) find evidence for anchoring in the incorporation of information into stock market analyst forecasts, with forecasts adjusting slowly despite the provision of new information. Underreaction may also be explained on the basis of local representativeness, referring to the tendency for unexperienced participants to predict a series that appears more random than would actually be expected from chance alone (Kahneman and Tversky 1972).

Theoretical contributions have sought to accommodate the empirical findings which suggest the co-existence of over and underreaction. Daniel et al. (1998) provide an explanation based upon investor overconfidence and biased self-attribution. Short term momentum is driven primarily from overreaction to short term information (the result of overconfidence) and trends (the result of self-attribution bias). Barberis et al. (1998) offer an alternative explanation based upon representativeness (trend following) and

conservatism (mean-reversion). In the model, investors are uncertain which ‘regime’ – trend or mean-reversion – is in operation at any point in time, and players’ beliefs regarding the prevailing regime are influenced by past experience. To the extent that the investor considers that the mean reverting regime applies, they underreact to information. Alternatively, belief in the trending regime means that they overact to information (Shefrin 2013).

Further nuances have been identified in relation to the symmetry of responses to positive and negative trends. Easterwood and Nutt (1999) find evidence of generalised optimism, which is a tendency for overreaction to be greater when responding to good news. In the context of trend extrapolation, generalised optimism suggests that past rising trends may trigger greater overreaction than past falling trends. Additional research has also considered the nature of the information itself. Daniel and Titman (2006) argue that linking over extrapolation to overconfidence implies an emphasis on ‘soft’ information as opposed to fundamental information.

Based on these findings from the stock market context, it remains to be investigated whether analogous under and overreaction behavior can provide the missing piece in the explanations for the NAV discount puzzle. The hypotheses in this paper aim to test this possibility.

Focusing on the public market response to fundamental information from the private market, we hypothesise a relationship between NAV growth and NAV discount, whereby trend following behavior in relation to past NAV growth influences the current NAV discount. It is noted that while NAV growth could be regarded as a fundamental accounting measure, thus falling foul of the tangible/intangible distinction raised by Daniel and Titman (2006), the imprecise nature of NAV estimates distinguishes the variable from other fundamentals. Consequently, there is arguably a greater opportunity for investor interpretation and biases to be introduced. Our hypotheses are as follows:

Hypothesis I: Market underreaction to isolated NAV changes. This will lead to movement in the NAV discount in the opposite direction to the growth in NAV. Positive (negative) past NAV growth will not generate sufficiently positive (negative) changes in share price and will lead to more (less) negative NAV discounts.

Hypothesis II: Market overreaction to runs of high NAV growth. This will lead to movement in the NAV discount in the same direction as growth in NAV. Runs of past NAV growth will generate excessively positive changes in share price and will lead to less negative NAV discounts.

The under and overreaction hypotheses demonstrate the extension from the general ideas of Generation I and II, towards the more focused approach proposed for Generation III. The formulation, specifically based on what is known about particular behaviors in the real estate context, is hoped to be able to provide the additional detail necessary to accommodate the unexplained variation in the NAV discount. The hypothesis also implies an alternative direction of causality between the public and private real estate markets to the traditional public-to-private assumption. Support for the hypotheses

could potentially have broader implications for conceptualising the relationship between the public and private market.

4. Data and methods

The framework adopted is based on the market NAV discount model developed by Clayton and MacKinnon (2002), which expresses the NAV discount as a linear function of three variables: present value of growth opportunities, liquidity, and sentiment.

$$NAV\ Discount = c + \beta_1(growth\ opportunities) + \beta_2(liquidity) + \beta_3(sentiment) + e_t, \quad (1)$$

The growth opportunities and liquidity variables represent the rational explanations for the NAV discount at the market level (Generation I). The variables reflect that according to the rational approach, cash flows from public real estate can be distinguished from private real estate on the basis of shares being freely tradable (i.e. liquidity variable) and the potential value added by the skills and market power of listed real estate companies (i.e. growth opportunities variable). The sentiment variable represents the noise trader hypothesis (Generation II). Additional variables can be added to control for macroeconomic influences.

In the estimation of the model, Clayton and MacKinnon (2002) adopt a market-wide approach in order to avoid the issues with the early firm-level investigations. The infrequency of appraisals is the primary limitation of the firm-level approach. Capozza and Korean (2009) attempt to overcome this constraint by using a weighted capitalisation rate to capitalise property income. However, their weightings are determined according to average property value in the metropolitan area for each asset, which fails to take into account property idiosyncrasies and results in a loss of precision. The use of a market-wide NAV index provides an alternative method to mitigate the infrequency of appraisals as it incorporates a wider distribution of appraisal dates from all firms in the market.

An additional advantage of adopting a market-wide perspective is the reduction in appraiser error. While, for example, the RICS Red Book provides guidance for UK valuers, the guide is largely procedural and there remains scope for errors in appraisal inputs (Barkham and Ward 1999). A market-level approach enables a reduction in unsystematic error, in addition to reducing systematic error from individual appraiser's biases of valuing too high/low (Geltner 1993; Liow 1996). It is also possible to justify the market-level perspective from the finding that the NAV discount is a market-wide phenomenon and the market discount is a significant explanatory factor in firm-level estimations (Morri et al. 2005).

Despite the benefits of a market-wide approach, there is a notable absence of market-level investigations into the NAV discount for the UK market despite its size and significance in the global listed real estate universe. In order to redress this research deficiency, this paper's behavioral extension of the Clayton and MacKinnon (2002) framework is conducted using UK data.

The analysis begins by replicating the specification of Clayton and MacKinnon (2002) with UK data for the period January 2003 – September 2015. The FTSE EPRA/NAREIT UK Index provides the monthly NAV discount data for the UK listed market. Other variables are defined for the UK context using analogous proxies to the original US orientated estimation. Growth opportunities in the public market are approximated using the logarithm of the market value of equity issuances by constituents of the EPRA index. The liquidity variable is derived from private market transaction volume data collected by HMRC. Further variables control for the interest rate, GDP growth and FTSE return. The definitions, sources and descriptive statistics are found in Table 1, alongside a division of the variables into Generation I and II categories.

Next, variables representing the Generation III approach are introduced. To investigate *Hypothesis I*, we include a lagged NAV growth variable. The lagged EPRA index return controls for reactions to past public market performance. To test *Hypothesis II*, we define a dummy variable to reflect the presence of a series of above average NAV growth (ABOVE). We generate interaction terms between the dummy variable and NAV growth to test for evidence of overreaction to growth information following a run of high growth.

A vector autoregression model (VAR) is used as the econometric technique to test the hypotheses. An unrestricted one-period lagged VAR model is estimated, with NAV growth and NAV discount represented as endogenous variables. The approach provides the appropriate framework for accommodating statistical complexity and feedback effects, without the informational demands of a long-term structural model (Li et al. 2009).

Before estimating the econometric model, some initial investigations provides general evidence in support of the hypotheses. Figure 1 shows the evolution of the NAV discount and NAV growth series for the period under investigation. The close movements of the two series in the time series plot is indicative of a relationship between the variables. An initial pairwise Granger causality test identifies bi-directional causality between the series. ADF tests identify both the NAV discount and NAV growth series as $I(0)$, leading to the rejection of co-integration between the variables. Following ADF tests on other variables, a Hodrick Prescott(HP) filter (with $\lambda = 14400$) is used to remove the cyclical trends of non-stationary series in preparation for the VAR analysis.

Figure 1. NAV discount and NAV growth (2002 - 2015)

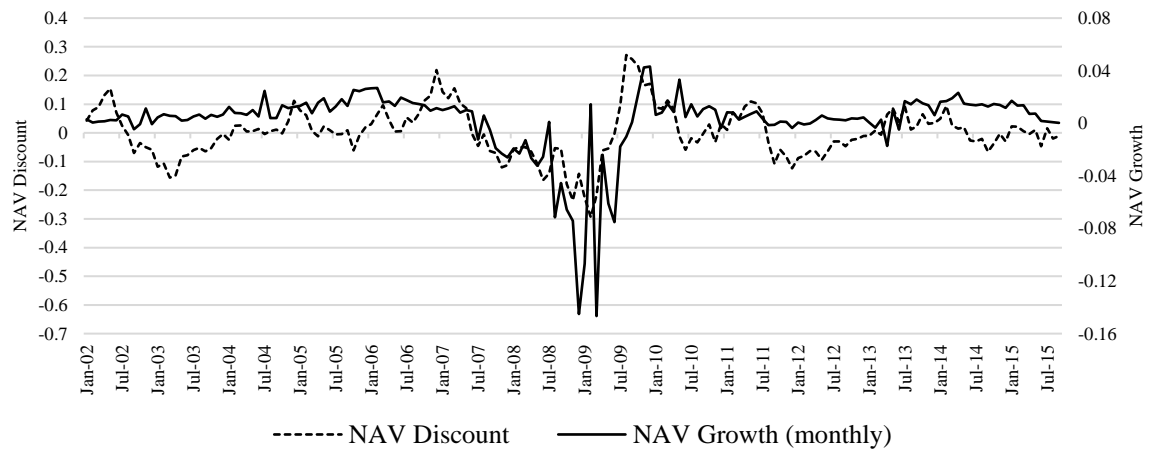


Table 1. Variable definitions

	Variable/Proxy	Var. Name	Definitions	Data Sources	Mean	SD	Min	Max
Dependent	NAV discount	NAVD	Percentage difference between NAV and stock market index valuation (Share price / NAV per share) – 1 (monthly)	FTSE EPRA/NAREIT UK	-0.127	0.133	-0.510	0.116
Generation I	Monthly equity offering	EQ	Monthly GBP worth of real estate equity offerings (monthly) (ln transformation)	SNL	0.326	1.539	-4.811	5.279
	Change in annual transaction index	TRANS	Index of annual number of non-residential property transactions (monthly) (Jan 2002 = 1) (differenced)	HMRC	-0.002	0.015	-0.040	0.040
Generation II	Business Confidence	BUS CONF	Index of business confidence (long term average = 1) (monthly)	OECD	1.002	0.013	0.960	1.020
Generation III	Monthly NAV growth	NAVG	Monthly percentage change in NAV (monthly)	FTSE EPRA/NAREIT UK	0.001	0.027	-0.147	0.043
	Monthly FTSE/NAREIT return	REIT	Monthly return on FTSE/NAREIT UK index (monthly)	FTSE EPRA/NAREIT UK	0.009	0.064	-0.271	0.187
	Run of above average NAV growth	ABOVE	= 1 if two immediately prior months record above average NAV growth, and 0 otherwise	FTSE EPRA/NAREIT UK	0.6732	0.4706	0	1
Controls	Interest rate	INT	Close of business redemption yields on 10 year gilts (monthly) (HP filter de-trended)	Bank of England	0.000	0.004	-0.009	0.008
	Annual GDP growth	GDP	Annual percentage change in GDP (monthly) (October 2015 prices) (HP filter de-trended)	Office of National Statistics	0.000	0.014	-0.049	0.024
	Monthly FTSE return	FTSE	Monthly return on FTSE 100 index (monthly)	SNL	0.003	0.039	-0.140	0.083

5. Empirical findings

This section reports the main results from the estimation of the model (see Table 2). Subsequent model refinements are also presented, which incorporate the contributions of more recent behavioral literature.

Model 0: Clayton and MacKinnon Approach

Model 0 replicates the specification of Clayton and MacKinnon (2002), using an AR(1) model to allow for serial correlation in the NAV discount. The model specification is as follow.

$$NAVD_t = \beta_0 + \beta_1 NAVD_{t-1} + \beta_2 EQ_t + \beta_3 TRANS_t + \beta_4 BUSCONF_t + \beta_5 INT_t + \beta_6 FTSE_t + \beta_7 GDP_t + \varepsilon_t$$

None of the variables representing Generation I explanations (i.e., EQ and TRANS) are found to be significant. The business confidence variable (i.e., the Generation II variable) is found to be weakly significant at the 10% level. These results serve to highlight the inadequacies of the existing explanations within Generation I and II.

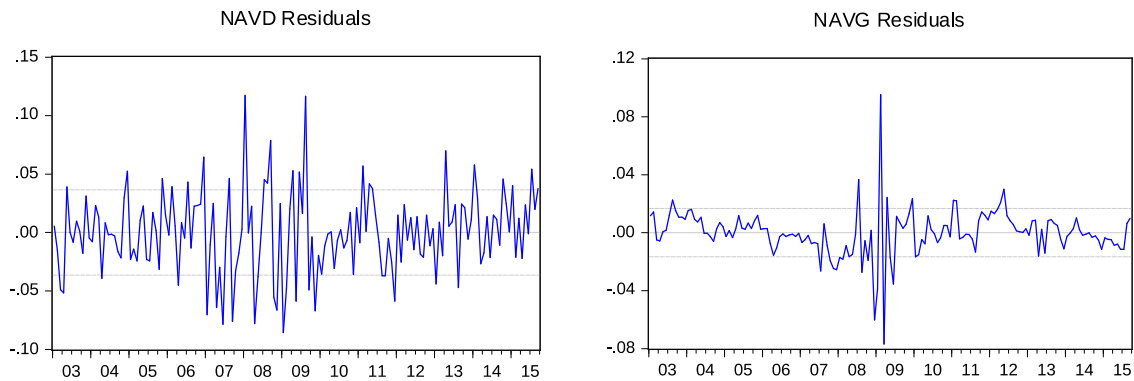
Model I: Basic VAR Model

Model I represents the initial VAR model specification, which extends the variables used by Clayton and MacKinnon (2002) to include lagged NAV growth and the reaction to series of above average NAV growth, in a form that reflects the potential feedback relationships between the public and private markets.

$$\begin{aligned} \begin{bmatrix} NAVD_t \\ NAVG_t \end{bmatrix} = & \begin{bmatrix} c_D \\ c_G \end{bmatrix} + \begin{bmatrix} A_{D,D} & A_{D,C} \\ A_{C,D} & A_{C,C} \end{bmatrix} \begin{bmatrix} NAVD_{t-1} \\ NAVG_{t-1} \end{bmatrix} + \begin{bmatrix} \beta_{D,1} \\ \beta_{C,1} \end{bmatrix} [ABOVE] + \begin{bmatrix} \beta_{D,2} \\ \beta_{C,2} \end{bmatrix} [ABOVE * NAVG_{t-1}] \\ & + \begin{bmatrix} \beta_{D,3} \\ \beta_{C,3} \end{bmatrix} [EQ] + \begin{bmatrix} \beta_{D,4} \\ \beta_{C,4} \end{bmatrix} [TRANS] + \begin{bmatrix} \beta_{D,5} \\ \beta_{C,5} \end{bmatrix} [BUSCONF] + \begin{bmatrix} \beta_{D,6} \\ \beta_{C,6} \end{bmatrix} [INT] \\ & + \begin{bmatrix} \beta_{D,7} \\ \beta_{C,7} \end{bmatrix} [FTSE] + \begin{bmatrix} \beta_{D,8} \\ \beta_{C,8} \end{bmatrix} [GDP] + \begin{bmatrix} \beta_{D,9} \\ \beta_{C,9} \end{bmatrix} [REIT_{t-1}] + \begin{bmatrix} e_{D,t} \\ e_{C,t} \end{bmatrix} \end{aligned}$$

The results are as hypothesised. The lagged NAV growth variable which tests *Hypothesis I*, and the interaction variables representing *Hypothesis II*, both show the hypothesised sign. However, neither term is significant. In addition, despite a high R^2 , residual representations reveal a poor fit of the model during the middle portion of the sample period, seemingly coinciding with the global financial crisis (see Figure 2).

Figure 2 NAVD and NAVG residuals from Model I



Model II: VAR with Structural Break

Based on a visual inspection of the data (Figure 1) and residuals (Figure 2), a dummy variable is defined between January 2007-April 2009 (BREAK). The structural break dummy is incorporated into the estimation of *Model II* using interaction terms to allow for different responses to NAV growth and trends in NAV growth during this period. The information criterion tests for lag length are shown in Table 2. LM tests report no autocorrelation issues.

Table 2. VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	618.13	NA	1.49e-06	-7.74	-7.23	-7.53
1	744.11	227.25	3.03e-07	-9.33	-8.74*	-9.09*
2	746.44	4.15	3.10e-07	-9.31	-8.64	-9.04
3	753.02	11.53	3.00e-07*	-9.35*	-8.59	-9.04
4	754.80	3.07	3.09e-07	-9.32	-8.49	-8.98
5	756.15	2.28	3.20e-07	-9.28	-8.37	-8.91
6	762.06	9.89*	3.13e-07	-9.31	-8.32	-8.91
7	763.59	2.53	3.24e-07	-9.28	-8.21	-8.84
8	766.29	4.38	3.30e-07	-9.26	-8.11	-8.79

The negative coefficient for the lagged NAV growth variable in the estimation of *Model II* indicates underreaction; the model predicts a larger NAV discount (i.e. more negative) following an increase in NAV, which is interpreted as reflecting an increased divergence between the public and private valuations due to a subdued response in the stock market valuation. In contrast, the interaction term, which represents the response to NAV growth information following a series of above average growth, displays a positive coefficient. This implies that the model predicts overreaction to information following a perceived pattern in earlier growth. These findings provide support for *Hypothesis I* and *Hypothesis II* respectively.

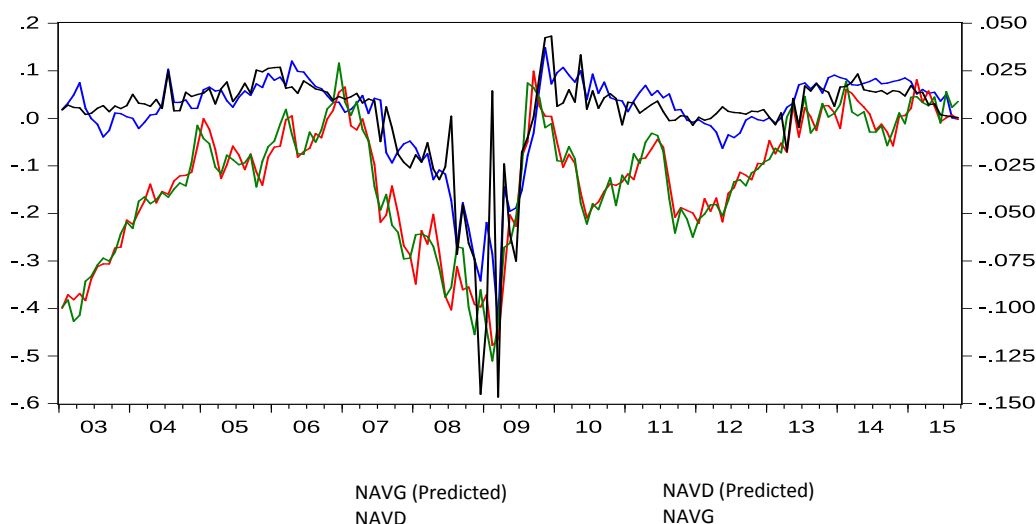
The structural break dummy variable which, unsurprisingly, is found to span the period of the financial crisis, adds another dimension to the findings. The interaction term, which

represents the effect of past NAV growth during the crisis, displays a positive coefficient. As above, the positive coefficient is interpreted as indicating overreaction to growth information during this period. An additional variable tests for consistency in the reaction to above average growth patterns during the crisis. The significant negative coefficient recorded for the relevant interaction variable is in contrast to the results for ordinary conditions outside the crisis. The result suggests a prediction that the response to positive trends is influenced by conditions during the crisis, such that the public market displays a significantly limited response to positive trends in growth in this period, and NAV discounts widen substantially.

In addition to the main findings regarding the hypotheses under investigation, the model specification generates a number of other results that are consistent with existing literature. As expected, in the NAV discount equation, the lagged dependent variable is highly significant, representing serial correlation in the series. The model also predicts that the business confidence variable (i.e., BUSCONF) exhibits a positive relationship with the NAV discount, which is interpreted as reflecting the greater sensitivity of the public market to market sentiment. For instance, an increase in market sentiment is predicted to lead to a greater increase in the public market valuation, resulting in a narrowing of the discount between public and private market valuations. This suggests a role for economy-wide sentiment beyond the irrational behaviors implied by the hypotheses. It also indicates the importance of providing a specification with an adequate disaggregation of behavioral variables to enable pure effects of general sentiment and specific biases to be isolated.

Dynamic forecasting is used to confirm the efficacy of the model. The model is estimated using observations between January 2003 - January 2014, followed by forecasting which extends to September 2015. A graphical representation of the model prediction and forecasting is shown in Figure 2. It is apparent that the complicated profile of the NAV discount over time is captured by the model both in and out of sample. The mean absolute error (MAE) of the NAVG model is 0.10 and MAE of the NAVD model is 0.79. VAR Granger causality tests indicate the rejection of the null hypothesis of no Granger causality in both cases and suggests bi-directional causality.

Figure 2. VAR Model Dynamic Forecasting



— NAVG (ns.wf1") — NAVD (ns.wf1")
— NAVD — NAVG

Model III: Asymmetric Response to NAV Growth Trends

Model II focuses on testing overreaction to series of above average NAV growth. However, close examination of the literature reveals mixed results as to whether overreaction should be more pronounced to negative or positive information.

Easterwood and Nutt (1999)'s generalised optimism concept provides the initial impetus for the focus on series of above average growth information. They contend that investors have a tendency to show greater sensitivity to positive information and are less likely to acknowledge negative information. More recently, it has been suggested that overreaction on the up-side may be a rational response (Gu and Xue 2007). Clatworthy et al. (2012) find evidence for asymmetry in the loss functions of stock market analysts and suggest that the lower costs of making positive errors results in more analysts generating optimistic forecasts. To the extent that the optimistic analyst forecasts influence the behavior of investors, an up-side bias in analyst forecasts may also lead to overreaction to positive news in the market, consistent with the findings of *Model II*.

However, stressful situations often trigger coping strategies and 'primitive methods of expression', providing scope for heuristics and myopic behavior during downturns. More recent explanations for overreaction to negative news emphasise the role of reference points. This argument begins by assuming individuals are naturally optimistic, holding a positive reference point. It follows that when negative news arrives, as its distance is further from the reference point than positive news of the same magnitude, it appears worse and attracts an extreme response (Soroka 2006). Aversion to loss provides a further explanation, which is supported by the consumption dynamics observed in the macro economy.

Ahmed et al. (2000) attempt to replicate the conclusions of Easterwood and Nutt (1999) and identify significant instability in the results, casting doubt on the original research. Overreaction to negative news also seems to be a feature of other national stock markets (Ahmed and Skerratt 2010). The peculiar characteristics of property companies relative to the rest of the stock market might provide further support for a prediction that overreaction would be more extreme to negative information. The high debt capacity and REIT pay out regulations, which result in a low free cash flow, are among the factors that lead public real estate companies, on average, to be highly levered (Yang et al. 2012). The reduced liquidity, increased likelihood of default, and possibility of fire sales, suggest high gearing may increase investor aversion to negative information.

Model III shows the results of an extension to account for an asymmetric response to good and bad news. The extension is made by including an additional dummy variable to enable a comparison between responses to series of high or low NAV growth information. Mimicking the approach taken to represent positive trends, the dummy variable is defined to represent periods in which the two prior periods show below average growth (BELOW).

Consistent with *Model II*, the results reveal overreaction to series of above average NAV growth. The coefficient displays a similar magnitude to the findings of *Model II* and remains significant at the 10% level. The coefficient for the interaction term representing a series of below average NAV growth also takes on a positive sign, suggesting overreaction. However, the coefficient of this term is insignificant. It follows that the results appear to support the original model specification, which focused on investigating overreaction to series of above average growth information. However, the insignificant finding for the term representing overreaction to series of below average growth information may be a peculiarity of the time period under investigation. There is a significant correlation between the BELOW and BREAK variables, which suggests that one variable may be redundant. *Model II* identified significant overreaction to NAV growth information during the crisis period, which may also be capturing the effects of overreaction to series of below average growth. Further research using a longer time series is needed in order to identify whether there is a distinct overreaction response to below average growth, beyond the crisis effect.

Model IV: Contradictory Information and Cognitive Dissonance

A further possible nuance in the relationship is related to the concept of cognitive dissonance (Festinger 1962). Antoniou et al. (2013) suggest that the severity of behavioral biases is related to the broader economic sentiment. They argue that a combination of contradictory information has the effect of muting behavioral biases; if information is received contrary to the sentiment held at the time, it will receive less attention and underreaction is more likely to be observed.

Model IV attempts to extend the analysis to incorporate the effect of cognitive dissonance. Two additional dummy variables are defined to reflect categories of investor sentiment. Investors are categorised as pessimistic (PESS) when the business confidence index value is in the lower quartile of the series and optimistic (OPT) when business confidence is recorded in the upper quartile. The investor sentiment categories are interacted with the opposing trend variable for NAV growth information; the pessimistic variable is interacted with the above average run of NAV growth and the optimistic variable is interacted with the below average run of NAV growth.

The findings from the estimation of the model are consistent with the expectations from the theory. The explanation of Antoniou et al. (2013) suggests that underreaction is expected to be most pronounced during optimistic conditions due to limited arbitrage activity as a result of increased costs of short selling. The results confirm significant underreaction when an optimistic investor climate is coupled with negative information in the form of successive below average NAV growth. The response under the alternative cognitive dissonance arrangement is insignificant.

The results of the model iterations thus appear to provide broad support for the adoption of specific behavioral biases in NAV discount models. The Generation III hypotheses, predicting underreaction to isolated information (*Hypothesis I*) and overreaction to positive growth patterns (*Hypothesis II*), are both supported and the conclusions are robust to alternative specifications. Some initial nuances have been explored, but there

remain many areas for further research, particularly if the results are to succeed in stimulating a re-evaluation of long standing views of the market.

Table 2. VAR Model Results

	Model 0	Model I		Model II		Model III		Model IV	
	NAVD	NAVD	NAVG	NAVD	NAVG	NAVD	NAVG	NAVD	NAVG
NAVD(-1)	0.9153***	0.8995***	0.0575***	0.9083***	0.0306**	0.9253***	0.0352**	0.9486***	0.03108**
NAVG(-1)		-0.1207	-0.0550	-0.9058***	0.1513	-1.1152	0.0281	-1.3161*	0.0463
ABOVE		-0.0104	0.02046***	-0.0085	0.0080**	-0.0082	0.0097**	-0.0112	0.0109***
ABOVE*NAVG(-1)		0.6343	-0.4453**	1.3796**	-0.5154**	1.7001*	-0.3761	1.8731*	-0.6332
BREAK				-0.0024	-0.0425***	0.0029	-0.0417***	-0.0033	-0.0388***
BREAK*NAVG(-1)				0.8344**	-0.5364***	0.5720	-0.5438	0.7408	-0.5919*
BREAK*ABOVE*NAVG(-1)				-4.4571**	3.5760***	-4.8134**	3.4691***	-4.4286**	3.4247***
EQ	-0.0009	-0.0010	0.0074***	-0.0018	0.0069***	-0.0044*	0.0064***	-0.0072*	0.0067***
TRANS	0.2092	0.1715	-0.0907	0.0787	-0.1939	0.1963	-0.1634*	0.3130	-0.1960*
BUSCONF	0.7473*	1.10177**	-0.0315	1.2889***	0.0882	1.0218**	0.0124	1.3013*	0.3649
INT	-1.3804*	-1.4856*	-0.3623	-1.3206*	0.2828	-1.2757*	0.3248	-0.9470	0.2540
FTSE	0.7149***	0.7318***	0.0079	0.7096***	0.0157	0.6378***	-0.0044	0.6647***	-0.0080
GDP	-0.9106***	-0.9610***	0.9055***	-0.9031***	1.0275***	-0.9863***	0.9984***	-1.2010***	0.9283***
REIT(-1)		0.0574	-0.00067	0.0353	-0.0222	-0.0052	-0.0340*	-0.0177	-0.0342*
BELOW						0.0012	0.0038	-0.0042	0.0042
BELOW*NAVG(-1)						0.29880	0.2090	0.5746	0.0670
BREAK*BELOW*NAVG(-1)						0.6637	0.0654	0.4801	0.2032
OPT								-0.0042	-0.0043
PESS								0.0171	-0.0006
OPT*BELOW*NAVG(-1)								-2.3763**	0.4711
PESS*ABOVE*NAVG(-1)								-0.0067	0.4651*
C	-0.7588*	-1.1145**	0.0277	-1.3000***	-0.0836	-1.0284**	-0.0081	-1.3035*	-0.3611
N	153	153	153	153	153	153	153	153	153
Adj. R-squared	0.9275	0.9270	0.6073	0.9319	0.7107	0.9344	0.7123	0.9355	0.7145

***1% significance level, **5% significance level, *10% significance level

6. Discussions and conclusions

Through the adoption of an explicit behavioral approach to the NAV discount model, this dissertation contributes to the explanations for the NAV discount puzzle. Evidence is found for biased public real estate market reactions to fundamental information in the private real estate market. In line with existing literature, the evidence suggests a combination of underreaction to isolated information and overreaction to series of good news.

In addition to its contribution to the NAV discount literature, the findings of this paper have broader implications. The bursting of the property market bubble during the financial crisis is a dramatic illustration of the impact of real estate investor behavior on the wider economy. It follows that how to dissolve bubbles in the future is of grave concern to policy makers. This paper highlights the significant challenges faced by those designing policy for such a complex market. It is often suggested that improving information available to investors would reduce the tendency for prices to diverge from fundamentals (Graff and Young 1997). However, the discussion in this paper highlights that such a strategy may be misguided if an overwhelming volume of information serves to promote heuristics that contribute to market distortions. The findings suggest that biases tie together the public and private market and that the feedback effects from each market may perpetuate cyclical tendencies.

However, while history has shown the bubble-like behavior of real estate markets and momentum trading is an intuitive aspect of such bubbles, the suggestion of causality from NAV growth to NAV discount is likely to be controversial. Martin Allen, ex-Head of Pan-European Real Estate Research at Deutsche Bank, has commented on the challenges of changing the long-standing viewpoint of many in the industry:

“I would caution that while I am convinced of the above I have found it practically impossible to convince anyone in the industry that this is the case. Most people cling to the quasi-superstitious view that the stock market can somehow divine the future in a mysterious way and anticipate future growth.”

It is widely believed that the public market is relatively more efficient than the private market in terms of incorporation of information. Existing literature on the price/information transmission mechanism has largely emphasised the process from public to private markets (see, for example, Gyourko and Keim 1992; Yavas and Yildirim 2011). The perspective is reflected in the development of so-called ‘pure property’ indices, which attempt to use the valuation of REIT shares to uncover real time valuation of the underlying property (Geltner 2015).

Nonetheless, it does not necessarily follow that the effect of the public market on the private market must operate to the exclusion of a relationship in the opposite direction. The possibility of a two-way interaction between the public and private real estate market is supported by recent research which adopts a broader perspective than the traditional account of information transmission in the NAV discount context. Building on the increasing attention being paid to behavioral explanations in general, the emphasis has turned to understanding the role of different types of investor (Freybote and

Seagraves 2016). The findings from this strand of research reveal a complex web of relationships among participants and markets. Both general investors (e.g. institutions) and real estate focused investors (e.g. REITs) invest in the public and private market, presenting the opportunity for spill overs between the markets, not only of fundamental information, but also sentiment (Das et al. 2015; Freybote and Seagraves 2016). Institutional investors are found to mimic the sentiment and behavior of REITs, and determine REIT investments decisions on the basis of REIT sentiment in the private market (Freybote and Seagraves 2016). According to this logic, after the release of a series of 'good' NAV figures, if it is interpreted as positive REIT sentiment by institutional investors, this may drive REIT investments by institutions. Consistent with the findings of this paper, this mechanism appears to suggest overreaction in the public market to the initial perceived trend in the private market.

There is much scope for more detailed research of the market and its nuances. For instance, there has been some indication that the public real estate market might be considered in terms of liquidity classes, in order to improve understanding of movements of capital among REITs in accordance with the 'flight to liquidity theory' (Das et al. 2015). Sectors of the US market (i.e. apartment, retail, office) have also been considered to display different public/private market behaviors, but this is yet to be considered for the UK (Hoesli et al. 2015). Such work may be followed by research investigating whether the results can be replicated in overseas markets, where cultural factors may mitigate or exaggerate the existence of certain biases. While research in this area is still emerging, the fundamental insight is the emphasis that investors do not operate in isolation, but rather are part of the broader real estate system, engaging with the other sides of the market and market participants. The impossibility of isolating one market from another seems to present the opportunity for the transmission of information and sentiment to operate in all manner of directions.

Thus, unlike Allen, we accept the possibility of a "quasi-superstitious view" whereby public markets influence the private market. However, we argue that the view that the public market leads the private market should not eclipse the potential for a causal relationship in the other direction. We hope that this more balanced view will be more palatable to those concerned.

References

- Ahmed A. and L. Skerratt, How markets react to earnings announcements in the absence of analysts and institutions: evidence from the Saudi market, *International Journal of Monetary Economics and Finance*, 2010, 3:4, 338-358.
- Ahmed A. S., X. Zhang and G. J. Lobo, Do analysts under-react to bad news and over-react to good news? Available at SSRN 253889 2000.
- An H., Q. Wu and Z. Wu, REIT crash risk and institutional investors, *The Journal of Real Estate Finance and Economics*, 2015, 1-32.
- Andreassen P. B., Judgmental extrapolation and market overreaction: On the use and disuse of news, *Journal of Behavioral Decision Making*, 1990, 3:3, 153-174.
- Andreassen P. B. and S. J. Kraus, Judgmental extrapolation and the salience of change, *Journal of Forecasting*, 1990, 9:4, 347-372.
- Antoniou C., J. A. Doukas and A. Subrahmanyam, Cognitive dissonance, sentiment, and momentum, *Journal of Financial and Quantative Analysis*, 2013, 48:1, 245-275.
- Antwi A. and J. Henneberry, Developers, non-linearity and asymmetry in the development cycle, *Journal of Property Research*, 1995, 12:3, 217-239.
- Barberis N., A. Shleifer and R. Vishny, A model of investor sentiment, *Journal of Financial Economics*, 1998, 49:3, 307-343.
- Barkham R. J. and C. W. R. Ward, Investor sentiment and noise traders: Discount to net asset value in listed property companies in the U.K., *Journal of Real Estate Research*, 1999, 18:2, 291.
- Benveniste L., D. R. Capozza and P. J. Seguin, The value of liquidity, *Real Estate Economics*, 2001, 29:4, 633-660.
- Bernard Victor L, Thomas Jacob K. Evidence that stock prices do not fully reflect the implications of current earnings for future earnings. *Journal of Accounting and Economics*, 1990, 13:4, 305-340.
- Bond S. and J. Shilling, An evaluation of property company discounts in Europe. working paper, EPRA, University of Cambridge, Cambridge, 2003.
- Bordalo P., N. Gennaioli and A. Shleifer, Competition for attention, *The Review of Economic Studies*, 2015, 83:2, 481-513.
- Brounen D. and M. Laak, Understanding the discount: Evidence from European property shares, *Journal of Real Estate Portfolio Management*, 2005, 11:3, 241-251.
- Brown G. R. and G. A. Matysiak, *Real estate investment : a capital market approach*, Harlow, Grande-Bretagne: Financial Times Prentice Hall, 2000.
- Capozza Dennis, Korean Sohan. Property type, size and REIT value. *Journal of Real Estate Research*, 1995, 10:4,: 363-379.
- Case K. E and R. J. Shiller, The behavior of home buyers in boom and post-boom markets, *New England Economic Review*, 1988:Nov, 29-46.
- Chen N., R. Kan and M. H. Miller, Are the discounts on closed-end funds a sentiment index? *The Journal of Finance*, 1993, 48:2, 795-800.
- Cherkes M., J. Sagi and R. Stanton, A liquidity-based theory of closed-end funds, *Review of Financial Studies*, 2009, 22:1, 257-297.
- Cheung W. M., R. Chung and S. Fung, The effects of stock liquidity on firm value and corporate governance: Endogeneity and the REIT experiment, *Journal of Corporate Finance*, 2015, 35: 211-231.
- Clatworthy M. A., D. A. Peel and P. F. Pope, Are analysts' loss functions asymmetric? *Journal of Forecasting*, 2012, 31:8, 736-756.
- Clayton J. and G. MacKinnon, Explaining departures from NAV in REIT pricing: noise or information? Working paper, University of Cincinnati, Cincinnati, OH, USA. 2000.
- Clayton J. and G. MacKinnon, Departures from NAV in REIT pricing: The private real estate cycle, the value of liquidity and investor sentiment. Real Estate Research Institute, Working Paper 2002.

- Daniel K., D. Hirshleifer and A. Subrahmanyam, Investor psychology and security market under- and overreactions, *The Journal of Finance*, 1998, 53:6, 1839-1885.
- Daniel K. and S. Titman, Market reactions to tangible and intangible information, *The Journal of Finance*, 2006, 61:4, 1605-1643.
- Das P. K., J. Freyboote and G. Marcato, An investigation into sentiment-induced institutional trading behavior and asset pricing in the REIT market, *The Journal of Real Estate Finance and Economics*, 2015, 51:2, 160-189.
- De Bondt W. F. M. and R. Thaler, Does the stock market overreact, *The Journal of Finance*, 1985, 40:3, 793-805.
- De Long J. B., A. Shleifer, L. H. Summers and R. J. Waldmann, Noise trader risk in financial markets, *Journal of political Economy*, 1990, 703-738.
- DeCoster G. P. and W. C. Strange, Developers, herding, and overbuilding, *The Journal of Real Estate Finance and Economics*, 2012, 44:1-2, 7-35.
- Easterwood J. C. and S. R. Nutt, Inefficiency in analysts' earnings forecasts: Systematic misreaction or systematic optimism? *The Journal of Finance*, 1999, 54:5, 1777-1797.
- Elton E. J., M. J. Gruber and J. A. Busse, Do investors care about sentiment? *The Journal of Business*, 1998, 71:4, 477-500.
- Festinger L., *A theory of cognitive dissonance*, Vol. 2: Stanford university press, 1962.
- Freybote J. and P. A. Seagraves Philip A. Heterogeneous investor sentiment and institutional real estate investments, *Real Estate Economics* 2016 (forthcoming).
- Geltner D., Estimating market values for appraised values without assuming an efficient market, *Journal of Real Estate Research*, 1993, 8:3, 325-345.
- Geltner D., Real estate price indices and price dynamics: An overview from an investments perspective, *Annual Review of Financial Economics*, 2015, 7:1, 615-633.
- Geltner D., G. Norman, J. Clayton and P. Eichholtz, *Commercial real estate analysis and investments*. Mason, Ohio: Thompson South-Western, 2013.
- Graff R. A. and M. S. Young, Serial persistence in equity REIT returns, *Journal of Real Estate Research*, 1997, 14:3, 183-214.
- Gu Z. and J. Xue, Do analysts overreact to extreme good news in earnings? *Review of Quantitative Finance and Accounting*, 2007, 29:4, 415-431.
- Gyourko J. and D. B. Keim, What does the stock market tell us about real estate returns? *Real Estate Economics*, 1992, 20:3, 457-485.
- Hoesli M., E. Oikarinen and C. Serrano, Do public real estate returns really lead private returns? *The Journal of Portfolio Management*, 2015, 41:6, 105-117.
- Ikenberry D. L. and S. Ramnath, Underreaction to self-selected news events: The case of stock splits, *Review of Financial Studies*, 2002, 15:2, 489-526.
- Jandl J., Information processing and stock market volatility-evidence from real estate investment trusts. Paper presented at the Twenty-first Americas Conference on Information Systems, Puerto Rico, 2015.
- Jegadeesh N. and S. Titman, Returns to buying winners and selling losers: Implications for stock market efficiency, *The Journal of Finance*, 1993, 48:1, 65-91.
- Kadiyala P. and P. R. Rau, investor reaction to corporate event announcements: Underreaction or overreaction? *The Journal of Business*, 2004, 77:2, 357-386.
- Kahneman D. and A. Tversky, Subjective probability: A judgment of representativeness. *Cognitive psychology*, 1972, 3:3, 430-454.
- Lakonishok J., A. Shleifer and R. W. Vishny, Contrarian investment, extrapolation, and risk, *The Journal of Finance*, 1994, 49:5, 1541-1578.
- Lee C., A. Shleifer and R. Thaler, Investor sentiment and the closed-end fund puzzle, *The Journal of Finance*, 1991, 46:1, 75-109.
- Lenkey S. L., The closed-end fund puzzle: Management fees and private information, *Journal of Financial Intermediation*, 2015, 24:1, 112-129.
- Li J., R. M. Mooradian and S. X. Yang, The information content of the NCREIF index, *Journal of Real Estate Research*, 2009, 31:1, 93-116.

- Liow K. H., Property companies' share price discounts and property market returns: The Singapore evidence, *Journal of Property Finance*, 1996, 7:4, 64-77.
- Maital S., R. Filer and J. Simon, What do people bring to the stock market (besides money)? The economic psychology of stock market behavior, *Handbook of behavioral Economics*, 1986: 272-307.
- Malkiel B. G., The structure of closed-end fund discounts revisited, *Journal of Portfolio Management*, 1995, 21:4, 32-38.
- Morri G., P. McAllister Patrick and C. Ward, Explaining deviations from NAV in UK property companies: rationality and sentimentality, working paper, presented at 12th ERES Annual Meeting, Dublin 2005.
- Rehkgugler H., F. Schindler and R. Zajonz, The net asset value and stock prices of European real estate companies, *Real Estate Finance*, 2012, 48(S1), 53-77.
- Shefrin H., Asset pricing and behavioral finance. in *Portfolio theory and management*. Edited by H. Kent Baker and Greg Filbeck. New York: Oxford University Press, 2013.
- Soroka S. N., Good news and bad news: Asymmetric responses to economic information, *Journal of Politics*, 2006, 68:2, 372-385.
- Tetlock P. C., Giving content to investor sentiment: The role of media in the stock market, *The Journal of Finance*, 2007, 62:3, 1139-1168.
- Tversky A. and D. Kahneman, Judgment under uncertainty - heuristics and biases, *Science*, 1974, 185:4157, 1124-1131.
- Wameryd K., *Stock-market psychology: How people value and trade stocks*. Northampton. USA: MA, 2001.
- Yang J., Y. Zhou and W. K. Leung, Asymmetric correlation and volatility dynamics among stock, bond, and securitized real estate markets, *The Journal of Real Estate Finance and Economics*, 2012, 45:2, 491-521.
- Yavas A. and Y. Yildirim, Price discovery in real estate markets: A dynamic analysis, *The Journal of Real Estate Finance and Economics*, 2011, 42:1, 1-29.

Acknowledgement:

We thank Martin Allen for his presentation at the Real Estate Investment and Finance Seminar (Michaelmas Term 2015), Department of Land Economy, University of Cambridge. His ideas and insights shared during this seminar have provided the basis for the subsequent research undertaken in this paper. We are also grateful for Eva Steiner's advice during the initial stages of the project.