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Why does price deviate from net asset value? The case of Singaporean infrastructure REITs

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ABSTRACT

This paper examines the determinants of the changes in premiums to Net Asset Value (NAV) in infrastructure REIT (infra-REIT) share prices in Singapore over the 2017–2021 period. Samples of 11 listed Singaporean REITs (S-REITs) are selected to create a balanced panel data for the analysis. Our finding shows that infrastructure S-REITs have generally been trading at premiums to their NAVs. The first part of the analysis shows that REIT premiums are positively related to REIT size (market cap) and percentage of institutional ownership. On the other hand, REIT premiums are negatively related to dividend yield. Volatility, volume, ROE and liquidity are found to be insignificant in explaining price and NAV divergence. The second part of the analysis finds that there is a higher proportion of uninformed (noise) traders when infrastructure S-REIT prices are diverging from their NAV. This finding supports the Noise theory which implies that there is some evidence that noise traders are present in the infrastructure S-REIT market and their actions might cause irrational departure of REIT prices from the underlying NAV.

1. Introduction

Given the similar investment characteristics between Real Estate (RE) and Infrastructure, it is not surprising that the boundaries between the two have been increasingly blurred. The overlap between them has clearly been observed in the Real Estate Investment Trust (REIT) market where companies increasingly manage assets that are customarily perceived as infrastructure, e.g., healthcare, logistics and telecommunication. With rising public deficits and increasing need for new infrastructure, governments have been exploring the use of REIT to attract private-sector funding. This results in the rise of 'infra-REIT' (Infra-REIT) in which characteristics might differ from traditional RE companies. Various academic studies have been done on the relationship between REIT prices and their underlying Net Asset Values (NAV) (Barkham & Ward, 1999; Clayton & MacKinnon, 2000; Brounen & Laak (2005); Morri & Baccarin, 2016; Lee, Sing, Tran, et al., 2013). If the market is efficient and rational, there should not be any divergence between the two as prices should always reflect the underlying NAV. This means that the value of the REIT as a company should closely reflect the value of the assets that it owns. However, such situations are hardly present – REITs are continuously traded at either discount or premium to their NAVs. This study therefore aims to understand the relationship between infra- REIT prices and NAV. The paper will be focusing specifically on the *Singaporean REIT market*. S-REIT is selected due to the breadth and the maturity of its infrastructure REIT market. The study will be split into two parts: *rational* and *sentiment* approach. Key variables such as REIT returns, firm-specific characteristics and the Noise/Information theory will be investigated as potential explanations for price and NAV divergence.

1.1. Defining infrastructure

Originating from French and first appearing in the English language in the nineteenth century, infrastructure initially refers to the construction work beneath or prior to unlaid tracks (Carse, 2016, p.27). The word was used to specifically describe transportation works such as roadbeds, tunnels, and bridges. The contested definition and its asset inclusion have evolved ever since. Synthesizing his research, Carse defines infrastructure as "a material assemblage built to support a higher-order project that is at once embedded in and constitutive of social

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Table 1
Infra-REIT Singapore as of December 2021 (REITAS, 2021b).

Sector	Name	Market Cap (SGD $bn)	Asset Value (SGD $bn)	Geography Focus	Year Listed
Industrial/ Logistics (I&L)	Mapletree Logistics Trust	7.9	11.5	Singapore, Australia, China, Hong Kong, India, Japan, Vietnam, Malaysia, S Korea	2005
	Mapletree Industrial Trust	6.7	8.6	Singapore, USA	2010
	AIMS APAC	0.9	2.2	Singapore, Australia	2007
	EC World	0.6	1.7	China	2016
	Sabana Industrial	0.5	0.9	Singapore	2010
	Daiwa House Logistics Trust[b]	0.5	0.9	Singapore, Australia	2021
	ARA LOGOS Logistics Trust[a]	1.2	1.8	Singapore, Australia	2010
	ESR[a]	1.7	3.2	Singapore	2006
Health	Parkway Life	2.5	2.1	Singapore, Malaysia, Japan	2007
	First REIT	0.4	0.9	Singapore, Indonesia, S Korea	2006
Data Centre (DC)	Keppel DC	4.9	3.3	Singapore, Australia, Europe, Malaysia	2014
	Digital Core[b]	1.8	2.3	USA	2021
Diversified	Ascendas[c]	11.6	16.3	Singapore, Australia, UK, USA	2002
	Frasers Logistics and Commercial Trust[d]	5.1	7.3	Singapore, Australia, Europe	2016
Total		**46.3**	**63.0**		

[a] ARA LOGOS was acquired by ESR in January 2022. The company changed their name to ESR-Logos and began trading in May 2022. Analysis will use this new company.
[b] Digital Core and Daiwa House Logistics will not be included in the analysis due to lack of available data
[c] Ascendas qualifying assets: 86% (I&L: 67%, DC: 19%). Remaining 14%: offices and retail
[d] Frasers REIT qualifying assets: 79% (I&L: 79%). The remaining 21%: offices.

relations" (Carse & Kneas, 2019). This definition establishes infrastructure as physical assets built for public purposes. The OECD proposes a broad definition as the "system of public works in a country, state or region, including roads, utility lines and public buildings" (OECD, 2002). Interestingly, the World Bank proposes a more restrictive selection of "essential" services in their definition (World bank, 2024). Both definitions are understandable given their position as public-governing bodies: infrastructure, accordingly, need to deliver public services.

On the other hand, private sectors have adopted a more flexible definition. In their classification standard, EDHECinfra, a leading provider of unlisted infrastructure market indices, creates a definition framework that is based on the investment characteristics of infrastructure as an asset class rather than the physical characteristics/ functional purposes of the assets themselves (EDHECInfra, 2018). Such characteristics include high sunk-cost, long-term investment, low-correlation with other asset classes and stable returns. This classification pushes the boundaries of infrastructure to include assets such as student accommodation, social housing, data centres, and goods port, resulting in overlap between infrastructure and RE.

In Singapore, there is no official definition of infrastructure. However, in 2021, the government approved an act titled "Significant Infrastructure Government Loan Act" that allows them to increase borrowing for infrastructure spending. Other than the inclusion of transport, energy and telecommunication, the official interpretation includes "any other purpose (which may include a supply chain or an interconnected network)" in which investment is "vital to support Singapore's economy" (Significant Infrastructure Government Loan Act, 2021). This interpretation opens possibilities on what constitutes as "nationally vital," and by extension, what can be considered as infrastructure. For this paper, the authors define infrastructure as physical assets that provide essential services to the public. The authors acknowledge the flexibility in defining "essential" the overlap between RE and infrastructure. As such, in addition to conventional sectors such as energy, water and treatment plants, assets such as logistics/ industrial warehouses and data centres should also be included under transport and telecommunications infrastructure respectively. Recent events such as Covid-19, digital communication transformation and Suez Canal blockage have confirmed the importance of such assets to ensure the stability of a country.

1.2. Net Asset Value and S-REIT

Net Asset Value (NAV) is the appraised value of all underlying assets owned by REITs adjusted for liabilities and other costs. REITs are said to be trading at premium if their share price is higher than the NAV/share. Conversely, REITs are trading at a discount if their price is lower than the NAV/share. While the two values may overlap, it is often the case that there is a divergence between REIT share price and NAV.

As of December 2021, there are 44 listed S-REITs with a total market cap of SGD $ 115 billion, making it one of the largest in Asia (REITAS, 2021a). REITs, in fact, have been dominating the Singapore IPO scene over the last few years (Tan, 2018). During its first few years of trading, the S-REIT landscape was dominated by traditional RE assets such as office, retail and hospitality properties (Sing, 2016). The scope of assets has expanded since. Under The Securities and Futures Act (2001), S-REITs are required to invest "primarily in real estate and real estate-related assets" (Securities and Futures Act, 2021). Any distribution shall be exempt from tax provided that 90% of the taxable income is distributed (Bothra, 2013). S-REITs are required to have >75% of the deposited funds to be invested in income- producing REs, with a maximum gearing of 35%.[1] Their investment scopes are restricted to "permissible investments" such as: RE in or outside Singapore; RE-related assets; debt securities and listed shares of non-property corporations; securities issued by a government, supranational agency or Singapore statutory board; cash and cash equivalents.

Based on the definition established earlier, there are currently 14 S-REITs that can broadly be considered as Infra- REITs (Table 1). The total market cap (S$46.3bn) makes up about 40% of the total S-REIT market cap (S$115bn). Specifically for diversified REITs, the author determines that companies can be considered as infra-REIT provided that greater than 75% of their underlying assets fall into the infrastructure qualification mentioned above. Based on this distinction, two diversified REITs, Ascendas and Frasers, can be said to fall into this category.

[1] This ratio has been increased recently in 2020 to 50% as part of efforts to sustain the industry from the impact of Covid-19.

1.3. Objectives and rationale

As REITs' underlying assets have expanded beyond retail and office to include traditionally perceived infrastructure sectors such as logistics, healthcare and telecommunications, existing research has mostly focused on REITs in general without the crucial distinction between the two. Increasingly seen as alternative mechanisms to attract private investment into infrastructure, understanding the relationship between infra-REIT price and NAV has become important for both investors and policy-makers due to the promising growth of the infrastructure sector to provide economic prosperity over a relatively long-term horizon. Moreover, existing studies on REIT price and NAV have mostly focused on the US or European REITs; limited papers have used Asian REITs as their focus. Given Asia's rapid progress as the next global economic growth centre, it should be of interest for investors to understand how the market works. S-REIT's market cap is currently the second largest in Asia after Japan. Using S-REIT as the primary subject of study should provide a good representation of the Asian REIT markets. As such, this paper aims to understand the relationship between infrastructure S-REIT price and their NAV, especially identifying factors that cause divergence between the two values.

The structure of this paper is as follows. Section 2 briefly reviews the literature on infrastructure REIT and the determinants of the divergence between share price and NAV. Section 3 provides an overview of the strategies and the data set used for the models used in the paper. Section 4 presents the hypotheses for the research, followed by results and highlights of the key findings in section 5. Section 6 offers concluding remarks.

2. Literature review

Despite being a relatively new concept, infrastructure REIT has gained numerous attentions as an alternative financing mechanism for infrastructure projects. In some jurisdictions, REITs' existing legal frameworks are even deliberately adjusted to include more infrastructure assets. In 2017, Belgium expanded its scope of REIT to include assets such as energy, water, waste management and social care (Marzuki & Newell, 2019). Under Private Letter Ruling 2019, US REIT expanded its eligible sectors to include energy transmission lines, PV modules, DCs and transmission towers (Keator, 2019). Conversely, rather than expanding existing REIT frameworks, some countries decided to establish an entirely new infrastructure-focused trust mechanism. In 2016, India established a tax-efficient structure called "Infrastructure Investment Trust" to promote private financing (Shah & Jain, 2022). Recently, in 2021, China launched a REIT structure that limits underlying investments to infrastructure assets (Fullick, 2021). Such developments indicate the global significance of infra-REIT in expanding existing financing mechanisms and encouraging greater private investment into infrastructure.

Various academic literature has indicated the strong benefits of infra-REITs. A study on the feasibility of Airport REIT in Canada highlighted its several advantages including lower overall risk and enhanced income streams for private investors (Messer, 2011). In addition, a 2011 study on infra-REITs in Turkey also showed how communities can benefit from improvement in public infrastructure through greater capital access (Erol & Ozuturk, 2011). The finding called for public-private joint ventures to set up localised REITs targeting regeneration projects; private sectors can provide technical support and in return, they will get tax-efficient returns. Hybrid public-private vehicle in the form of Urban Construction Investment Bond (UCIB) can be found in China and is increasingly becoming an asset class (Ye et al., 2022). Moreover, Jin and Xu (2021) went even further by suggesting a combination of REITs and PPP for projects in China. Accordingly, infra-REIT can reduce financing costs and democratise asset-ownership, thus promoting community oversight of infrastructure assets. In 2018, Preqin Global Infrastructure Reports noted that there was $150bn dry powder in the infrastructure sector, indicating investors' challenges in finding suitable commitments (Preqin, 2018). In one of their journals, Global Listed Infrastructure Organisation (GLIO) argued that Infra-REIT can serve as a part of a "stable, lower-volatility, yield- oriented investment portfolio allocation" for investors (Brooks & Hughes, 2018). Such allocation would reduce the amount of dry powder and allow more capital to be allocated to vital infrastructure.

2.1. Efficient market hypothesis

The discussion between REIT price deviations from NAV is based on the discourse on Efficient Market Hypothesis (EMH). Introduced by Fama, the EMH argues that prices reflect all available information (Fama, 1970). Accordingly, the financial market is efficient and stock prices always trade at fair values, making it virtually impossible to "beat the market." Contrary to EMH, Thaler argued that investors are irrational as humans. The Endowment Effect (Thaler, 1980) and Overreaction of Investors (De Bondt & Thaler, 1985), provided evidence that markets are inefficient, and studies should be cautious when assuming that investors are rational. Prices therefore do not reflect the accurate value of the underlying assets because sentiments and biases also interfere in price formation.

The debate between Fama and Thaler is an important cornerstone for this study. Adams and Venmore-Rowland (1990) stated that market valuation of property companies should reflect the value of underlying properties instead of its earnings/ dividends. If EMH is true, prices therefore should always reflect property companies' NAV. In other words, divergence between price and NAV should not exist if the market is efficient and all investors are rational. Even if overreaction (underreaction) occurs, Fama (1998) suggested that prices will revert to the NAV/ share. In reality however, REITs are constantly traded either at discount or premium to the NAVs. There are two broad categories in existing literature on Price to Net- Asset-Value (PNAV) divergence, namely *Rational Approach* and *Sentiment Approach*. The *Rational Approach* follows the assumption that EMH is valid, and the REIT market is efficient. Conversely, the *Sentiment Approach* assumes that the market is inefficient and irrational investors are present in the market.

2.2. The rational approach: returns and firm-specific characteristics

The *Rational Approach* assumes that the EMH is valid, and prices immediately reflect all available information (Morri & Baccarin, 2016). This approach is split into two: *Returns* and *Firm-Specific Characteristics*. The first part of the *Rational Approach* assumes that PNAV divergence is caused by individual REIT *returns*. Generally, it would be logical to expect that REITs with better returns would trade at lower discount/ higher premiums. Higher REITs performance was found to command lower price discounts to NAV in France, the UK and the Netherlands over the 2003-2014 period (Morri & Baccarin, 2016). Similarly, Kim and Wiley (2018) also indicated that premium is positively related to the profit level of REITs. However, there has been no consensus across literature on the nature of the relationships between premiums and performance. The earliest study on the topic was conducted by Malkiel (1977) on closed-end investment company shares that found no significant relationships between the two. A study on Australian REITs over 2008-2018 also indicated that historical stock returns did not have significant impacts on premiums (Erol & Tyvimaa, 2019). This is consistent with the earlier finding from Brounen & Laak (2005). In measuring REITs' financial performance, Morri, McAllister, Ward, et al. (2005) highlighted a negative relationship between ROE and discount as well as a positive correlation between dividend yield and discount. Erol and Tyvimaa (2019) also confirmed that ROE has a significant positive effect on REIT premiums. The positive relationship between dividend yield and discount is corroborated in a paper on the Italian REIT market (Morri & Benedetto, 2009). The second part of the *Rational Approach* assumes that PNAV divergence is caused by *firm-specific factors* such as

size, leverage, liquidity, volatility, etc. Firstly, firm size has a positive relation to REIT premiums (Barkham & Ward, 1999; Clayton & MacKinnon, 2000). Using market cap as a proxy for size, large companies (high market cap) tend to trade at premiums while smaller REITs trade at discount. As probable explanations, larger firms often have better access to capital and Economies of Scale. Analysis across the European REIT market also finds that larger REITs tend to trade at lower discounts (Brounen & Laak, 2005; Morri & Baccarin, 2016).

Existing literature disagrees on the impact of leverage. Anderson, Conner, and Liang (2001) found that leverage has negative relations on REIT premiums. This positive relationship between REIT discount and leverage has also been documented in several academic literature (Bond & Shilling, 2004; Brounen & Laak, 2005). Strong REITs with low leverage and long debt maturity tend to trade at premium to their NAV (Steiner, 2017). On the other hand, Clayton and MacKinnon (2000) showed evidence that leverage is positively related to REIT premiums. A more recent paper on France, Netherlands and UK REITs noted that there are slight differences in results in different geographical locations, e.g.: higher leverage results in higher discount for UK and France while the contrary happens in the Netherlands (Morri & Baccarin, 2016). The paper noted that the difference in results could be caused by investors having different perceptions on leverage across different geographies.

Volatility (Bond & Shilling, 2004; Clayton & MacKinnon, 2000) and liquidity (Clayton & MacKinnon, 2000; Brounen & Laak, 2005) have negative relations on REIT premiums. Higher volatility might indicate higher risk which results in lower share prices. Liquidity, however, is the true advantage of REITs. In theory, higher liquidity should command premiums. However, existing literature has indicated that liquidity has a negative relationship with premiums. Clayton and MacKinnon (2000) attributed this to the existence of 'noise' traders in the REIT market.

2.3. The sentiment approach: noise or information

In contrast to the *Rational Approach*, the *Sentiment Approach* assumes that there are inefficiencies in the REIT market. There are two opposing theories that make up the *Sentiment Approach*, namely the *noise* and *information* theories. The *noise* theory assumes that divergence occurs due to the sentiment of noise traders, while the latter attributes it to the sentiment of informed traders. The 'noise trader' approach was first introduced by Shiller (1989), De Long, Shleifer, Summers, et al. (1990) and Shleifer and Vishny (1990). The approach proposes the existence of uninformed or 'noise' traders who trade based on irrational sentiment instead of information. Divergence in share prices and NAVs is caused when noise investors are irrationally pessimistic (optimistic) about the market which causes prices to go below (above) the underlying value.

Discounts-to-NAV observed in closed-end funds could be attributed to the large proportion of individual/retail investors in ownership (Lee, Shleifer, Thaler, et al., 1991). The paper argued that prices are exposed to unpredictability because individual investors tend to trade more in emotions. Additionally, Grullon and Wang (2001) suggested that discounts can also be attributed to the informational asymmetry between institutional and individual investors. Institutional investors arguably have access to more comprehensive information and risk-analysis tools, resulting in differences in the perception of risks between individual and institutional investors.

According to the noise theory, REIT prices will deviate from NAV due to the presence of noise traders who trade on sentiments rather than careful analyses of fundamentals. Studies on 39 UK-listed property companies from 1993 to 1995 found that irrational sentiment is a major cause of discount to NAV (Barkham & Ward, 1999). Lin, Rahman, Yung, et al. (2008) found direct correlations between investor sentiments and REIT returns: higher returns when investors are optimistic and vice versa. Using Noise Trader Model, Mueller and Pfnuer (2013) confirmed the existence of noise traders in REIT pricing in a study of 111 EU REITs. The presence of noise traders whose behaviours are unpredictable creates additional risks to informed investors. This results in REIT prices diverging from the NAV, even in the absence of fundamental changes in the underlying properties.

Conversely, the information theory suggests that PNAV divergence occurs due to the sentiments/ future expectations of informed traders. Informed traders would buy/sell REIT shares to anticipate the future performance of the underlying RE market. As an example, a fall in REIT prices would forecast a future downturn in the property market and vice versa. In other words, REIT prices would foreshadow the value of the NAVs, e.g.: premium to NAV would narrow, but it will do so by NAV getting higher instead of price coming down. This theory implies that the securitised market (REIT) is more efficient than unsecuritised property market, resulting in price discovery happening in the REIT market (Aguilar, Boudry, Connolly, et al., 2017; Barkham & Geltner, 1995; Geltner, 2007).

Studying the difference in pricing efficiency across property sectors, Yavas and Yildirim (2009) found that price discovery takes place in the REIT market across all sectors including industrial, logistics and healthcare. Thus, information theory suggests that price changes reflect the future expectations of informed investors on the underlying property market. Using transaction cost as a proxy for liquidity, Clayton and MacKinnon (2000) found evidence of the existence of noise traders in the US REIT market. The finding was also consistent with the information theory, but only at different points in the cycle - there was an increased number of informed traders when REIT prices were getting closer to NAV. Despite its significance, the study is based on data from over 20 years ago and it is unclear if such conclusions are still observed today.

2.4. Research gaps

Limited studies have been done on the PNAV divergence in the S-REIT or Asian REIT market in general. Using listed Singaporean property company prices from 1985 to 1999 (15 years), Liow provided evidence that NAV is important in capturing price fluctuations and therefore should be used as part of company valuation (Liow, 2003). The study found some evidence that prices revert to the underlying NAV/share, but the mean reversion is slow. A more recent paper on 293 listed property stocks across six Asian markets (including Singapore) also supports this conclusion (Liow & Yeo, 2018). Despite acknowledging the existence of price departures from NAV, the two papers unfortunately did not provide explanations for this PNAV divergence.

The divergence in the S-REIT market could perhaps be understood by observing REITs in neighbouring Asian countries. A 2011 paper on the performance of 13 Malaysian REITs found extensive divergence between Malaysian REIT prices and their underlying NAV. The paper argued that some REITs trade at discount because of the poor sentiment of the companies, despite them having strong management in real-life (Ong, Teh, Chong, et al., 2011). However, these arguments were presented as the authors' subjective opinions on potential explanations for PNAV divergence as the author unfortunately did not provide sufficient qualitative/quantitative analysis to justify these propositions. Jiamchoatpatanakul (2019) conducted a study on Thai REITs and found that firm size, liquidity, leverage and sentiments to be significant factors affecting PNAV divergence. The significance of these factors was also confirmed in an earlier study that analysed performance of 5 Asian REIT markets, including Singapore (Mohamad & Zolkifli, 2014). A 2013 paper on S-REIT deviations provided us with a more systematic and quantitative analysis of the PNAV divergence (Lee et al., 2013). Using data from 23 S-REITs from 2005 to 2010, the study found the following firm- specific factors to be significant in explaining PNAV divergence: firm size, volatility, volume, percentage of institutional ownership, EBITDA and sectoral diversification. The study also showed evidence of "lagged behaviours of uninformed traders that irrationally drive-up REIT stock prices" - indicating the presence of noise traders.

3. Data and methodology

3.1. Data and specification

We collected financial data on S-REITs from Refinitiv Eikon. Balanced panel data from 11 infra-S-REITs from January 2017 to December 2021 are collected. The selection period provides an understanding of infra- S-REIT over the past 5 years, including its performance during the Covid-19 pandemic. Descriptive statistics are provided below in Table 2 and 3.

3.2. Model and specification

According to Clayton and MacKinnon (2000), the relationship between price and NAV is represented as:

$$\frac{P_{it} - NAV_{it}}{NAV_{it}} = \gamma_i + \epsilon_{it} \tag{1}$$

where Pit is the price of REIT *i* at time *t,* NAVit is the REIT's NAV per share, γi is the equilibrium premium linking REIT price to NAV and εi is the error term for short-run departure. As εi represents short-run dynamics, any departures should be short-lived and revert to zero in the long-run. Simplifying this, premium to NAV (PNAV) can be shown as:

$$\frac{\text{Last price}}{\text{NAV per share}} - 1 \tag{2}$$

where last price is the closing price at the end of the month. Positive (negative) results indicate a premium (discount) to NAV. PNAV = 0 indicates no differences between share price and NAV/share.

3.3. Rational: Firm-specific characteristics

With hypothesis that characteristics and return characteristics are priced, we proceed with a panel regression with LOGRTN, DIVYIELD and ROE with various REIT fundamentals as independent variables as the independent variables. The model should help understand the relationship between return, as well as fundamental characteristics, and PNAV. The equation is given as:

$$\begin{aligned} PNAV_{it} &= \beta_0 + \beta_1 LOGRTN_{it} + \beta_2 DIVYIELD_{it} + \beta_3 ROE_{it} \\ &+ \beta_4 MKTCAP_{it} + \beta_5 DEBTEQT_{it} + \beta_6 VOLTY_{it} \\ &+ \beta_7 INSTOWN_{it} + \beta_8 VOLUME_{it} + \beta_9 EBITDA_{it} + \beta_{10} LQDT_{it} + \epsilon_{it} + \nu_{it} \end{aligned} \tag{3}$$

$$\nu_{it} = c_i + d_t \tag{4}$$

where *εit* is the error term for REIT *i* at time *t* and *νi* is the heterogeneity, across time and across individual REIT.

$LOGRTN_{it}$ is the logged return in the investment of REIT i calculated by:

$$\text{LOGRTN}_{it} = ln\left(\frac{P_t}{P_{t-1}}\right) \tag{5}$$

where Pt is the close price of the REIT at time t and Pt-1 is the close price one period earlier.

DIVYIELD is the dividend yield of REIT *i* at time *t*, given as:

$$\text{DIVIDEND} = \frac{\text{Dividend per Share}}{\text{Monthly Close Price}} \cdot 100\% \tag{6}$$

ROE is the Return on Equity.

MKTCAPit is the REITs' market capitalisations - used as a proxy for firms' size.

$$\text{MKTCAP} = \text{current shares outstanding} \cdot \text{last monthly price} \tag{7}$$

DEBTEQTit is the debt-to-equity ratio of particular REITs (assumed to be constant for the year), as follows:

$$\text{DEBTEQT} = \frac{\text{Short term debt} + \text{Long term debt}}{\text{Total equity}} \cdot 100 \tag{8}$$

VOLTYit is the monthly volatility measured by calculating the standard deviation of change in close price for all trading days in the particular month, multiplied by the square root of number of trading days in the month.

INSTOWNit is the sum of institutional ownership as percentage of total ownership of REITs. Institutional ownership includes investment advisors, mutual funds, asset managers, insurance companies, etc. The data on INSTOWN are based on quarterly filings.

VOLUMEit is the total amount of shares traded throughout the month.

REGIONit is the geographical focus of the investments made by REITs. Dummy binary variables are used: 1 is given if the underlying assets are based in more than two countries and 0 if REIT invests in less than or equal to two countries. However, under the framework of some panel models, e.g., two-way fixed effect, the effect of region are mostly subsumed by more granular individual fixed effect, so we leave out this variable in the model.

EBITDAit is the Earnings Before Interest, Taxes, Depreciation and Amortisation. Monthly EBITDA is approximated by dividing the annual EBITDA by 12. The formula is given as:

$$\text{EBITDA} = \text{Operating Profit} + \text{Depreciation} + \text{Amortisation} \tag{9}$$

LQDTit is the liquidity of the REIT which will be calculated using transaction costs as a proxy. Values are obtained by finding the percentage of quoted spread, which is given as:

$$\text{LQDT} = \frac{|\text{Ask} - \text{Bid}|}{\text{Mid Price}} \tag{10}$$

The estimation is done with MLE estimation, and we consider the two-way fixed effect (TWFE) model and the random effect (RE) model under the panel model framework. We conduct Hausman test to see whether fixed model holds. If the null hypothesis is not rejected, the model enjoys the efficiency and consistency provided by random effect models. Otherwise, we use the consistent TWFE estimator. To cope with heterogeneity, we use cluster robust standard error in inference. We apply cluster robust standard error clustered by individual and time under TWFE model setting and individual cluster effect under random effect setting.

3.4. Sentiment: Noise or information

To distinguish between noise and information theories, Clayton and MacKinnon (2000) examine changes in bid-ask spreads as a proxy of transaction costs when PNAV divergence is narrowing and widening. Market-makers have to widen their spreads when there is a large proportion of informed traders to reduce their losses. If PNAV deviations are caused by the presence of informed traders, there would be an increase in spreads. Conversely, if deviations are caused by uninformed (noise) traders, one would expect a reduction in spreads. These opposing impacts of both theories on spreads will be used to estimate the composition of informed and uninformed traders, thus allowing us to distinguish the two theories.

T-tests are conducted on 3 variables: % change in LQDT (quoted spread), % change in VOLTY and % change in VOLUME. Each variable will be averaged across all infra-S-REITs for each month from Jan 2017 to Dec 2021. Each month will be classified as either PNAV widening or narrowing. Single-sample (hypothesized mean of zero) and two sample t-tests (hypothesized mean difference of zero) will be conducted to find which variables are significant. Simple linear regression will be conducted to test the relationship between LQDT (quoted spread) and noise/ information theories, as well as to control the VOLUME and the VOLTY. The equation is given as:

Table 2
Summary statistics - PNAV.

Name	Mean	Std Dev	Skewness	Kurtosis	Min	Max
AIMS APAC REIT	0.00509	0.07085	−0.79925	1.21041	−0.22963	0.16176
Ascendas REIT	0.29307	0.09783	0.51677	0.43952	0.10938	0.60012
EC World REIT	−0.16891	0.05305	−0.92530	2.06505	−0.37079	−0.07647
ESR-LOGOS REIT	0.08123	0.13012	−0.02625	−0.71664	−0.25235	0.35823
First REIT	0.04667	0.30830	0.99364	1.94004	−0.52525	1.04040
Frasers Logistics & Commercial Trust	0.14756	0.08308	−1.55185	5.32355	−0.21681	0.31868
Keppel DC REIT	0.65435	0.39027	0.64798	−0.82529	0.21973	1.50420
Mapletree Industrial Trust	0.52220	0.21438	0.35988	−0.94183	0.16275	1.01806
Mapletree Logistics Trust	0.33776	0.20095	0.28401	−1.13429	0.01141	0.75754
Parkway Life REIT	0.66289	0.21599	0.68914	−0.64242	0.38068	1.16456
Sabana Industrial REIT	−0.22878	0.07138	−0.07373	−0.12820	−0.42157	−0.06481

Table 3
Summary statistics - firm-specific factors.

Variables	Symbol	Count	Mean	Std. Dev	Min	Max
Premium to NAV	PNAV	660	0.2139	0.3538	−0.5253	1.5042
Liquidity	LQDT	660	0.0074	0.0041	0	0.0414
Market Cap (S$ million)	MKTCAP	660	2870	2900	189	13,000
Debt to Equity Ratio	DEBTEQT	660	0.6319	0.1385	0.4100	1.054
Monthly Volatility	VOLTY	660	0.0575	0.04528	0.1267	0.4105
Institutional Ownership	INSTOWN	660	0.5128	0.1156	0.1780	0.8315
Volume (in million)	VOLUME	660	101	116	0.1129	1230
Geographical Focus	REGION	660	0.5455	0.4983	0	1
EBITDA (S$ million)	EBITDA	660	16.0	14.1	3.0433	68.3
Log Return	LOGRTN	660	0.0035	0.0635	−0.5925	0.1804
Dividend Yield	DIVYIELD	660	0.0575	0.2067	0.2339	0.1872
Return on Equity	ROE	660	0.0628	0.1020	−0.534	0.254

$$\Delta LIQDT_{it} = \beta_0 + \beta_1 \Delta VOLTY_{it} + \beta_2 \Delta VOLUME_{it} + \beta_3 DIVG_{it} + \epsilon_{it} \quad (11)$$

where *εit* is the error term for REIT *i* at time *t*.0

DIVG is the monthly divergence of REIT prices and their NAVs. Dummy binary variables are used. 1 is given if the divergence is widening while 0 is given if the divergence is narrowing.

4. Research hypothesis

Overall, infra-S-REITs have been trading at premiums from 2017 to 2021 (see appendix 1). When sectoral differences are concerned, Data Centre and Healthcare were the two industries that traded at significant premiums and experienced major PNAV fluctuations compared to others (see appendix 2).[2] Below are the three hypotheses for the divergence trend observed in the infra-S-REIT market.

Hypothesis 1. Rational: PNAV and Returns

As part of the rational approach, we argue that the market is efficient and PNAV divergences are caused by REITs' returns. Panel regressions are run using PNAV as the dependent variable and log return, dividend yield and return on equity as the independent variables.

Hypothesis 2. Rational: Firm-specific Characteristics

In this hypothesis, we assume that the infra-S-REIT market is rational and PNAV divergence is caused by company-specific fundamentals, namely Market Cap, Debt to Equity Ratio, Volatility, Institutional Ownership, Volume, Geographical Focus and EBITDA. Panel regressions are run using PNAV as the dependent variable and firm-specific characteristics as the independent variables.

Hypothesis 3. Sentiment: Noise or Information

In contrast to the two previous hypotheses, this hypothesis assumes that the market is inefficient. We will test whether price deviations from NAV in the infra-S-REIT market can be attributed to the presence and actions of both informed and uniformed traders. The framework follows the method proposed by Clayton and MacKinnon (2000).

5. Results and discussion

Our analysis on hypotheses 1 indicates that REIT returns might not necessarily contribute to price deviations despite being significant in the regression results. On the other hand, our analysis on hypothesis 2 shows a stronger indication that firm-specific factors play an important role in explaining this price divergence. On Hypothesis 3, our finding shows evidence of the existence of noise traders that are responsible for pushing infra-S-REIT prices away from their underlying values. Overall, the study confirms the validity of hypotheses 2 and 3 whereby price and NAV divergence can be contributed to firm-specific factors and the presence of noise traders.

We first go through the Hausman test, with FE model and RE model using full model structure as presented in Equation (3). Results from Table 4.1 suggest that our model rejects the null hypothesis on a significant level of 1%. FE model is thus a reasonable choice for our research, and the estimate is consistent. Heterogeneity is still relevant in the inference. The results presented hereafter will thus use cluster robust standard error. We conduct unit root test (**Table 4.2**) for panel data for the variables in hypothesis 1 and 2 with order 1, 2 & 3 lags. The test result suggests stationary.

Based on Model 1 (Table 5.1), dividend yield is the solely stably significant variable amongst those that concern hypothesis 1 in explaining PNAV divergence under all settings, while return on equity is insignificant under full settings. Log return is mildly significant on a significant level of 10%. Model 1 also shows that REIT size is significant on a 5% significance level, and institutional ownership is significant on a 10% significance level. Both coefficients are positive.

It is important that we assume the full model, because failing to incorporate relevant variables will lead to missing variable biases and

[2] The result for the DC and healthcare sectors might not be representative of the industries as there are only limited companies in both sectors in comparison to Industrial & Logistics; 1 company for DC and 2 companies for healthcare.

Table 4.1
Hausman test.

	(1) FE	(2) RE
MKTCAP	0.135***	0.167***
	(12.95)	(12.81)
DEBTEQT	0.194*	−0.106
	(1.98)	(−1.45)
VOLTY	0.0211	0.447
	(0.08)	(1.76)
INSTOWN	0.782***	0.210**
	(7.31)	(2.72)
VOLUME	0.0561	0.0406
	(0.66)	(0.36)
EBITDA	−19.55***	−32.00***
	(−8.20)	(−12.87)
LIQDT	−5.126*	−16.57***
	(−2.58)	(−6.51)
LOGRTN	0.263*	0.0445
	(2.23)	(0.31)
DIVYIELD	−6.097***	−7.448***
	(−10.05)	(−13.32)
ROE	−0.262**	−0.153
	(−3.10)	(−1.51)
Constant	0.0118	0.735***
	(0.11)	(12.28)
Hausman_chi2		103.7
Hausman_p		3.27e-17

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4.2
Unit root test.

	DF Lag 1	DF Lag 2	DF Lag 3
PNAV	4.75037e-11	4.04885e-09	2.49668e-09
MKTCAP	0.0003247016	0.0030204536	0.0040906658
DEBTEQT	0.0004271072	0.0003641242	0.0003016997
VOLTY	2.23728e-30	1.41419e-19	1.15711e-15
INSTOWN	6.37274e-07	1.92740e-07	7.52420e-08
VOLUME	3.85657e-29	5.39957e-20	6.36197e-15
EBITDA	0.0093717451	0.0089055465	0.0083715098
LIQDT	2.59211e-28	5.06276e-18	2.26224e-14
LOGRTN	5.84901e-66	2.17604e-42	2.72862e-31
DIVYIELD	3.17732e-08	2.58366e-06	7.26851e-06
ROE	0.0000915157	0.0000686454	0.0000486375
chgLIQDT	5.30765e-74	6.98128e-54	1.89558e-30
chgVOLTY	4.02565e-70	1.17525e-48	4.31877e-35
chgVOLUME	8.16006e-75	5.42095e-51	6.65350e-40
DIVGdummy	1.60576e-51	1.65814e-37	7.03552e-28

Note: Reported *p*-values of panel unit root test for different variables under different lags.

inefficiencies. To see this, we build Model B (Table 5.2). We see size and dividend yield remain to significant, but the bias and efficiency issue gets to the estimation and inference of both variables. We see an R-squared of 80% albeit the absence of other variables, and it suggests that the two variables are key in cross-sectionally explaining the PNAV divergence.

We proceed by eliminating either insignificant return variables or firm characteristics to see whether some significant results were caused by misspecification. First, we see that size and dividend yield remain significant. Combined with mild improvement in R-squared, the repeated results reiterate the robustness of size and dividend yield cross-sectionally. Second, we find institutional ownership stably significant on a 10% significance level. Third, all other significance results are unstable. The model results suggest albeit varying in significance level, size, dividend yield and institutional ownership remain relevant. The results remain similar even if we use RE models, but vary in the significance of institutional ownership, probably due to the inconsistency and

Table 5.1
Hypothesis 2 - Panel regression results.

	Model 1	Model 2	Model 3	Model 4
MKTCAP	0.135**	0.0674*	0.0744**	0.141**
	(2.37)	(1.96)	(2.26)	(2.51)
DEBTEQT	0.194			0.374
	(0.58)			(1.49)
VOLTY	0.0211			0.180
	(0.05)			(0.64)
INSTOWN	0.782*		0.827*	0.770*
	(1.83)		(1.97)	(1.82)
VOLUME	0.0561			0.00985
	(0.49)			(0.09)
EBITDA	−19.55			−21.20*
	(−1.78)			(−1.84)
LIQDT	−5.126			−5.138
	(−1.47)			(−1.41)
LOGRTN	0.263*		0.211	0.234
	(2.02)		(1.12)	(1.81)
DIVYIELD	−6.097**	−8.002***	−7.607***	−6.135**
	(−2.94)	(−3.41)	(−3.47)	(−3.02)
ROE	−0.262		−0.452**	
	(−1.02)		(−2.67)	
Constant	0.0118	0.480**	0.0413	−0.105
	(0.03)	(2.47)	(0.16)	(−0.29)
Observations	660	660	660	660
R^2	0.893	0.862	0.879	0.891
Adjusted R^2	0.878	0.845	0.863	0.876

t statistics in parentheses
Two-way fixed effects, cluster robust by REITs and time.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5.2
Hypothesis 2 - Panel Regression Results – Model B.

	Model 1	Model 2	Model 3	Model 4
MKTCAP	0.167***	0.0608*	0.0653**	0.139**
	(2.71)	(1.90)	(2.21)	(2.44)
DEBTEQT	−0.106			0.231
	(−0.58)			(1.15)
VOLTY	0.447			0.0308
	(0.83)			(0.11)
INSTOWN	0.210		0.727*	0.570*
	(0.66)		(1.91)	(1.70)
VOLUME	0.0406			−0.0266
	(0.14)			(−0.25)
EBITDA	−32.00***			−23.09**
	(−2.96)			(−2.05)
LIQDT	−16.57			−5.851
	(−1.62)			(−1.40)
LOGRTN	0.0445		0.184*	0.0909
	(0.32)		(1.67)	(1.15)
DIVYIELD	−7.448**	−8.801***	−8.153***	−6.668***
	(−2.50)	(−4.05)	(−4.07)	(−3.59)
ROE	−0.153		−0.432***	
	(−0.50)		(−3.02)	
Constant	0.735***	0.545***	0.149	0.173
	(3.62)	(3.11)	(0.69)	(0.79)
LM	0	6962.9	7112.5	5623.7
p_LM	1	0	0	0

t statistics in parentheses
Random Effect, cluster robust by REITs.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

inefficiency of RE according to the Hausman test. However, size and dividend yield remain to be significant, with the same signs (see Table 5.2 for reference).

Table 6
Average Changes when PNAV Divergence is Narrowing & Widening.***

	Divergence Widening ($N = 24$)	Divergence Narrowing ($N = 35$)	Difference
Monthly %Change in LIQDT	−0.0477	0.0667**	0.1144**
	(1.4417)	(2.0732)	(2.4054)
Monthly %Change in VOLTY	−0.0522	0.1051**	0.1573**
	(1.0427)	(2.2653)	(2.2561)
Monthly %Change in VOLUME	−0.0579	0.0743*	0.1321**
	(1.3495)	(1.7516)	(2.1196)

Absolute values of t-stats are shown in parentheses.
*** indicates significant at 1% confidence level
** indicates significant at 5% confidence level
* indicates significant at 10% confidence level.

5.1. *Hypothesis 1 Rational: PNAV and Returns*

We discuss the implication of the results, starting from hypothesis 1. The finding is consistent with several literature that found no significant relationship between premiums and returns (Malkiel, 1977; Brounen & Laak, 2005; Erol & Tyvimaa, 2019). Some may argue that the explanatory power of the log return is subsumed by REIT firm characteristics, but Model 3 suggests that the absence of irrelevant firm characteristics does make significance re-surface for log return. The result on ROE, however, is rather unexpected. ROE is unstably significant, negatively related to REIT premiums. This is inconsistent with Morri et al. (2005) and Erol and Tyvimaa (2019). Nevertheless, the contribution of ROE to the improvement of R-squared are always small, adding to the unstable nature of this predictor. It appears that log return and ROE are not quite as relevant when it comes to explaining PNAV divergence for S-REITs.

Dividend yield is found to be significant in explaining PNAV divergence. This should be unsurprising given that stable and passive dividends are characteristics that investors often look at in REITs. As REITs are commonly used in long-term investment strategy, it is right for investors to be more concerned with the dividend yield, rather than daily/ monthly price volatility. Moreover, the coefficient on dividend yield is found to be negative, meaning that higher dividend yield results in lower premiums. This is consistent with Morri et al. (2005) and Morri and Benedetto (2009).

Theoretically, more investors will invest in REITs if they provide attractive dividends. However, the annual dividend payment for infra-S-REITs in fact has remained relatively constant throughout the 5-year study. A high dividend yield might therefore be attributed to a decline in share prices, which signal various issues within the company. As such, Morri et al. (2005) argues that a high dividend yield might be a result of other firm-specific factors that affect PNAV divergence, rather than being one of the factors that affect PNAV divergence. Hence, despite being significant in the regression results, we cannot necessarily conclude that dividend yield is a factor that affects PNAV divergence.

5.2. *Hypothesis 2 Rational: Firm-specific Characteristics*

As expected, REIT's size (MKTCAP) has positive coefficients which are consistent with Barkham and Ward (1999), Clayton and MacKinnon (2000) as well as Mohamad and Zolkifli (2014). Larger REITs indicate better Economies of Scale and stronger organisational capabilities. Consistent with Wang and Zhang (2009) and Lee et al. (2013), institutional ownership is positively related to PNAV on a significant level of 10%. One explanation is that institutional investors tend to hold REITs for long-term purposes. REIT shares with higher institutional ownership are less likely to react to noise traders that cause price fluctuations.

As mentioned in the literature review, the impact of leverage on PNAV can vary depending on investors' preferences. In this analysis, leverage is found to be insignificantly related to PNAV, albeit its positive estimates in all models. Despite the divided opinions of Morri and Baccarin (2016) or Bond and Shilling (2004) and Brounen & Laak (2005), markets of S-REITs do not seem to price a premium by leverage. Combined with the discussion above, revenue generating ability and signs reliability such as size and institutional ownership is of much more emphasis. The strict gearing limit prevents S-REITs from over-stretching, thereby reducing the exposure to refinancing risks during credit crunch similar to the 2008 crisis, making it a relatively safe investment. In comparison, there are no gearing limits for the US-REIT market where most of the academic literature is based upon (European Public Real Estate Association, 2016). In fact, some US-Infra-REITs have been trading at significantly high leverage, e.g.: American Tower D/E=820%, Crown Castle D/E=250%, Extra Space Storage D/E=193%.[3] As such, different investors might perceive the impact of higher gearing differently. Investors in S-REITs rely little on leverage since it provides limited information as to the management or operating quality of S-REITs.

Volatility, liquidity, volume and EBITDA are not as relevant in this market. Removing the insignificant ROE in Model 4 does not add to the significance of insignificant firm characteristics except for EBITDA. Comparing Model 3 and 4, where insignificant predictors are removed with different predictor categories, we see that ROE and EBITDA seem to take the place of each other. The model suggests that an accurate measure of profitability measure may contribute to the correct pricing of S-REITs. Again, significant variables in earlier models remain significant in Model 4. In conclusion, firm-specific factors are important to infra-S-REIT price and NAV divergence, namely firm's size, institutional ownership and potentially a profit characteristic like EBITDA.

5.3. *Hypothesis 3 Sentiment: Noise or Information*

Firstly, it is important to establish the relationship between transaction costs (spread) and the presence of informed/ uninformed traders. Market-makers face disadvantageous situations when they deal with informed traders who possess more information about the securities. If the proportion of informed traders is high, market-makers would have to widen their spreads to avoid losses. Conversely, lower spreads would be expected if there are lots of “noise” investors in the market. Such a relationship between (un)informed traders and spread has been well established in literature (Copeland & Galai, 1983; Glosten & Milgrom, 1985).

Informed traders, acting on sentiments/ expectations of future price movements, will buy (sell) REIT stock in advance of upswing (downswing) in the underlying RE market. This causes PNAV divergence to widen. As such, Clayton and MacKinnon (2000) proposed that information theory is valid if there is an increase in spread when PNAV is widening, meaning that the actions of informed traders are responsible for the increasing PNAV divergence. Conversely, noise theory is valid if there is a reduction in spread when PNAV is widening. Since noise and

[3] Data taken from Refinitiv Eikon based on D/E on December 2021

Table 7
Hypothesis 3 Regression results.***

	Model 1	Model 2	Model 3
Constant	0.0465	0.0451	0.0667**
	(1.52)	(1.48)	(2.20)
Monthly %change in VOLTY	0.290**	0.205**	–
	(2.44)	(2.36)	
Monthly %change in VOLUME	−0.139	–	–
	(1.05)		
DIVG	−0.0872*	−0.0822*	−0.114**
	(1.82)	(1.72)	(2.41)
R-squared	0.190	0.174	0.092
Adjusted R-Squared	0.146	0.145	0.076

Absolute values of t-stats are shown in parentheses.
*** indicates significant at 1% confidence level
** indicates significant at 5% confidence level
* indicates significant at 10% confidence level.

information theories have opposite impacts on transaction costs (spread), a cross-sectional sample of REIT spreads can help to distinguish between the two theories. Their relationship can be summarised below:

Each month from January 2017 to December 2021 is categorised as either a narrowing or widening PNAV divergence. If REITs trade at a premium (discount) in the current month and the value is greater than the premium (discount) of the previous month, the current month is classified as widening divergence. Conversely, if the current premium (discount) is smaller than those of the previous month, the current month is classified as a narrowing divergence. Additionally, months in which REITs switch from discount to premium (or vice versa) will be categorised as widening divergences.

This classification will allow the focus to be on whether prices are getting closer or further away from NAV instead of direction change. Single-sample t-tests with a hypothesized mean of zero are conducted on the monthly changes in LQDT (quoted spread), VOLTY and VOLUME when PNAV is widening and narrowing. Each variable was averaged across 11 S- REITs for each month from Jan2017 to Dec2021.

Table 6 presents the means across months for each variable.

Firstly, the results indicate that the %change in LQDT (quoted spread) is positive and significant when divergence is narrowing. On a single-sample t-test like this, the positive sign implies that the sample mean is greater than the hypothesized mean that is zero. This shows that when PNAV divergence narrows, there is a positive change in quoted spread, or, in other words, an increase in quoted spread. Conversely, the negative results for %change in LQDT show that there are reductions in quoted spreads when PNAV divergence widens.

Therefore, it can be implied that spreads may increase when PNAV divergences are narrowing because informed traders are capitalising on PNAV deviations, e.g.: taking profits when prices are higher than NAV or buying stocks when prices are at discount. This results in narrowing divergence as prices get closer to the underlying NAV. Put in another way, when PNAV divergence widens, there is a higher proportion of noise traders in the market. When PNAV divergence narrows, there is a higher proportion of informed traders.

The presence of noise traders causes widening divergence in PNAV and only through the presence of informed traders, prices come back closer to the underlying fundamentals and PNAV divergence narrows. Based on Table 6, this result supports the Noise theory but not the Information Theory. Hence, there is some evidence that noise traders are present in the infra-S-REIT market.

This finding should not be surprising after all. Based on the summary statistics Table 5, institutional investors only contribute 51% of ownership across the infra-S-REIT market, with retail investors making up the rest of them. As proposed by De Long et al. (1990), a large percentage of retail investors in asset ownership might result in noise traders' risk. There are several reasons why infra-S-REITs are popular among Singapore's retail investors. Firstly, investors might turn to REITs as they are increasingly unable to invest directly in the highly expensive Singapore's RE market. Secondly, S-REITs have become more accessible than ever. By the end of 2021, the average share price among the 11 Infra S-REITs was SGD$1.83. With SGX's minimum lot size of 100 shares, it only takes SGD$183 (US$130) for investors to get access to a stable portion of REITs' income. Lastly, S-REITs have proven to be resilient, maintaining the dividend payments despite the fall in unit prices during Covid-19 (Hoo, 2021).

Moreover, it is important to note that the Covid-19 pandemic has also brought a significant influx of retail investors in Singapore, thereby potentially increasing the percentage of noise traders in the market (Palma, 2021). Technology and Healthcare were the two major industries that attracted retail investors as they saw profit gains from share price increase (Braithwaite, 2020). It is therefore possible to argue that retail investors might have caused further price deviations from fundamentals due to herd-behaviour and sentiment-driven responses. In fact, high noise trading during Covid-19 was found to be the case in the US (Pagano, Sedunov, Velthuis, et al., 2021) and the Indian market (Talwar, Talwar, Kaur, et al., 2021).

Table 6 also indicates that the %change in volatility and volume are positive and significant when divergence is narrowing. Before making stronger conclusions on the noise/ information theory, Clayton and MacKinnon (2000) suggested that inventory costs should be taken into account for the analysis. Inventory costs arise because market- makers must hold some securities. Market-makers will have to increase their spreads as compensation when there is an increase in risk brought by higher volatility or lower volume (Stoll, 1978). Thus, changes in volatility and volume can affect spreads and therefore must be controlled for.

To further investigate the relationship between spreads and PNAV divergence, a simple linear regression is conducted with the average monthly %change in quoted spreads (LQDT) as the dependent variable and the average monthly %change in volatility, volume and divergence as the independent variables. A binary dummy variable will be used for divergence; DIVG = 1 when the divergence is widening and DIVG = 0 when the divergence is narrowing. As expected from the inventory cost risk to market-makers, the results from Model 1 (Table 7) show that the coefficients for volatility and volume are positive and negative respectively. More importantly, Table 7 shows that the coefficients of the divergence are negative and significant throughout the 3 models. This

means that even after controlling volatility and volume, the quoted spread (LQDT) of infra-S-REITs still increases when the divergence is narrowing. This means that there is a higher proportion of informed traders when PNAV divergence narrows. The finding here supports the Noise theory but fails to support the Information theory. Overall, the results above find some evidence of the existence of noise traders that cause widening PNAV divergence. This is consistent with Lee et al. (2013) that also found evidence of the existence of noise traders in the S-REIT market.

6. Conclusions

Theoretically, if the market is efficient and integrated, we should expect REIT prices to closely follow the value of the underlying assets. However, such situations hardly exist as prices often diverge away from the NAV. This study therefore focuses on the departures of REIT prices in the context of Singapore Infra-REIT market by empirically testing two key explanations for PNAV divergence: *Rationality* or *Sentimentality*. The *Rationality* approach suggests that the market is efficient, and divergence is caused by differences in individual firms' fundamentals. Conversely, the *Sentimentality* approach argues that the uninformed (noise) trade irrationally in the market causing prices to diverge even in the absence of changes in the underlying values. The study is done using a balanced panel of monthly data of 11 infra-S-REITs from January 2017 to December 2021.

Our finding on the *Rationality approach* did not find conclusive evidence on the relationship between REIT returns and PNAV divergence despite the significant results. However, our finding shows that firm-specific factors are important in explaining the price and NAV divergence in the infra-S-REIT market. PNAV premiums are positively related to infra-REIT size (market cap), leverage and percentage of institutional ownership, and potentially with profitability characteristics like EBITDA. Higher market capitalisation is likely associated with strong corporate governance and perceived value of growth opportunities. This implies that the actions of REIT managers in the property market play a key role in the performance of infra-S-REIT companies as good governance practices can enhance companies' values. Companies with higher institutional ownership are also traded at premiums as they are less likely to react to noise traders that cause price fluctuations. Conversely, PNAV premiums are negatively related to EBITDA.

Our finding on the *Sentiment Approach* found evidence of the presence of noise traders in the infra-S-REIT market. We have observed that noise traders cause widening divergence in PNAV and only through the presence of informed traders, prices come back closer to the underlying fundamentals and PNAV divergence narrows. This implies that the actions of noise traders contribute to the price and NAV divergence in the infra-S-REIT market. Investors in the infra-S-REIT market should therefore be conscious of sentiment-driven uninformed traders that might cause irrational price behaviours and volatility.

It can also be concluded that infra-REITs have been successful as a financing vehicle for infrastructure assets. For investors, infra-REITs have shown great resilience by maintaining stable dividends even during the early phase of Covid-19 economic downturn. For the society in general, additional funding can now be allocated to more essential infrastructure development. The high interest among institutional and retail investors alike, as well as the overall premium that the market commands further support the case for tapping into the capital market through infra-REITs as an alternative infrastructure financing mechanism. Given the rising public budget deficits and the increasing need for new infrastructure globally, governments across the world perhaps can learn to emulate the success of infra-S-REITs to finance their respective infrastructure projects. Policy makers can either expand the existing definition of REIT to include more infrastructure assets or create an entirely new Infrastructure Trusts. Ownership of certain assets can be partially released to the private sector to fund the building and management of costly yet essential infrastructure. Given the popularity of REITs, similar investment vehicle with infrastructure as the underlying assets would attract huge interests among the private sector, thus allowing more dry powder to be allocated to provision of infrastructure assets that would greatly benefit the society.

These findings on PNAV divergence on the infra-S-REIT market also present a few interesting arguments in the use of infra-REIT as an alternative financing mechanism for infrastructure projects. Firstly, the high level of premiums of infra-REITs shown in this study indicates that this mechanism has been popular among investors. It can therefore be implied that infra-REIT has been successful in attracting capital and allocating it to the development of infrastructure assets. Secondly, this presents a case for greater involvement of private sector in the infrastructure market. Coupled with strict regulations to ensure quality of service provision, privatisation of certain assets can help to fund the building and management of costly yet essential infrastructure. Thirdly, the existence of noise traders in the market can also imply that infra-REITs are popular among individual investors. This presents an opportunity for the government to encourage greater involvement of local communities in the asset ownership by enacting relevant regulations, e.g.: a minimum percentage of infra-REIT must be owned by local trusts/ communities. This ensures that communities can benefit from the tax-efficient returns and the specialised technical support of the private sectors while simultaneously having greater oversight of the infrastructure assets.

If successful, stronger adoption of infra-REITs can potentially bring great benefits to investors, governments, and societies altogether. For investors, infra-REITs have shown great resilience and defensive properties by maintaining stable dividends even during the early phase of Covid-19 economic downturn. For the governments, creation of such mechanisms would encourage greater participation of the private sector in the infrastructure market which is increasingly important in the context of rising public budget deficits. For the society in general, greater capital access would reduce financing costs and more dry powder can be allocated to provision of infrastructure assets that are critical to the functioning of the society.

To expand the work further, a comparison study can be conducted between infrastructure-backed S-REITs and RE-backed S-REITs to understand the similarities/ differences between the two. If such comparisons are conducted in the context of economic downturns, e.g.: Covid-19 period, the study would provide interesting evidence on whether infrastructure really offers stronger defensive benefits that are often marketed to investors. Additionally, comparison studies can be conducted for infra-REITs across different geographies, e.g.: US vs UK vs Singapore. This study would allow us to test if similar factors will contribute to PNAV divergence and if investors across different countries would respond similarly.

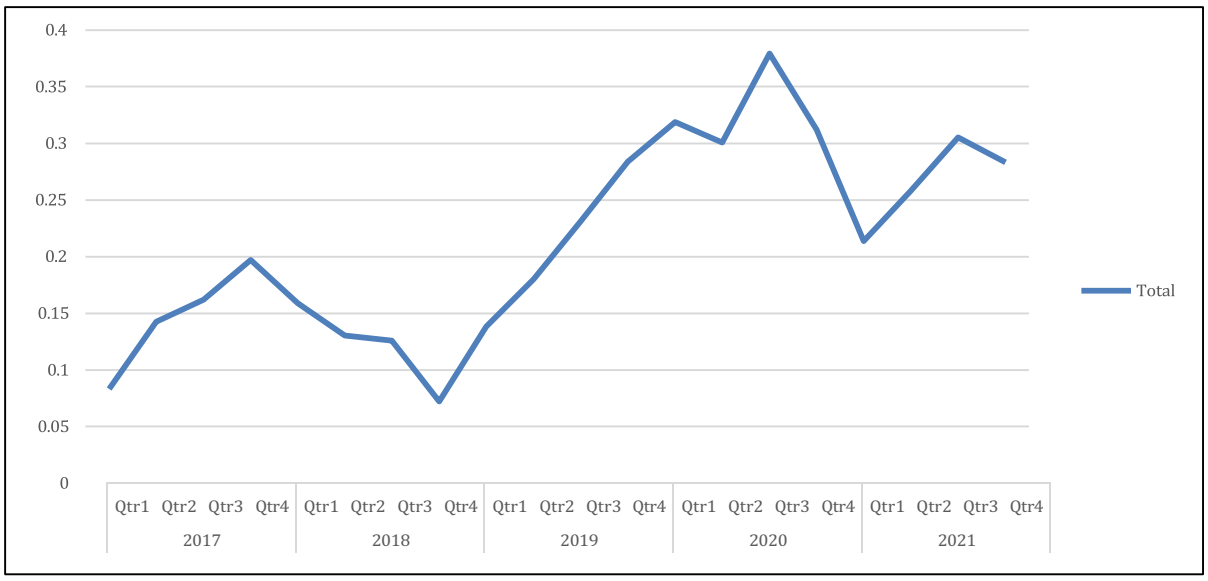
Statements and declarations

The Authors did not receive support from any organisation for the submitted work.

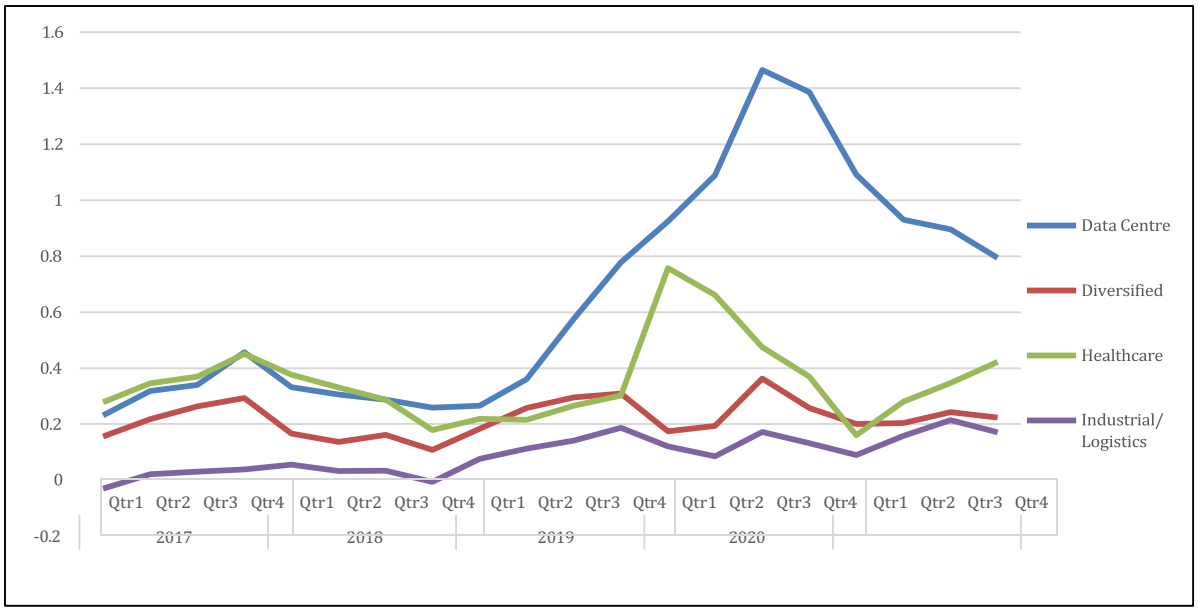
Data availability

I have attached the data and shared the link to original data, as well as, uploaded the STATA code.

Appendix A



Appendix 1. PNAV (overall).



Appendix 2. PNAV (by industries).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.irfa.2024.103172.

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