On the Return Dynamics and Diversification Benefits of Property Sector REITs in the Japanese Market

RAZAK, MUHAMMAD,ZAIM

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Muhammad Zaim Razak

Department of Economics and Finance

Durham University Business School

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Supervisors
Professor Damian S. Damianov
Professor Muhammed-Shahid Ebrahim

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Abstract

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MUHAMMAD ZAIM RAZAK

This thesis consists of three empirical chapters. First, we examine the long-run linkages and short-term dynamics between Japan REITs, direct real estate and stocks. Our estimation using a vector error correction model shows the long-run cointegration relation between REITs and direct real estate, where stocks can be excluded from the long-run relation. We present the short-run bidirectional causality between REITs and direct real estate and the causal relation between REITs and stocks. The cointegration relation implies that Japanese REITs have a comparative advantage in terms of liquidity providing the same diversification benefit as a real estate asset.

Second, we develop a new methodology for deriving the variance-covariance matrix between the cumulative returns of assets over different time horizons from a vector error correction model, a framework that accounts for their long-run relationship and short-run dynamics. Our estimation results show the term structure of volatility for each asset increase with the increase in time horizon. Further, we find that J-REITs and direct real estate assets are positively correlated. Their correlation increases with the time horizon and converges to unity in the limit. We use the estimated variance-covariance matrix into a buy-and-hold portfolio. We find that the portfolio weight of Japanese REITs is reduced with the increase in time horizon. Our result suggests the substitutability of REITs as real estate is horizon-dependent, consistent with the high level of correlation between REITs and direct real estate.

Third, we examine the dynamic role of Japanese REITs in a mixed-asset portfolio. Using a DCC-GJRGARCH model, we derive forecast estimates of time-varying volatility of REITs and correlations with other assets returns. Using the estimates, we construct dynamics out-of-sample portfolios between these three assets on a daily basis. Our results show the diversification benefits of incorporating REITs over a benchmark portfolio consisting of stocks and bonds. We analyse the economic benefit of including REITs in improving the investor's utility over the average transaction cost. Our results affirm that Japanese REITs are portfolio diversifiers for active portfolio management.

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Declaration

I, Muhammad Zaim Razak can confirm that the work written in this thesis is my own. For information taken from other resources, a proper citation has been quoted in the thesis. The work in this thesis is based on research carried out at the Department of Economics and Finance, Durham University Business School. No part of this thesis has been submitted elsewhere for any other degree or qualification.

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Dedication

This thesis is especially dedicated to my family, their encouragements, love and joy which they have provided me all these years

To,

Farhanah, my wife

&

my 3 children,

Numan, Sofeah and Idris

CHAPTER 1

Overview of the Study

1.1 Motivations

Over the decades, Real Estate Investment Trusts (REITs) have provided access to property investment to a large group of both individual and institutional investors. The securitisation of real estate assets in REITs allows for liquid property investment, like holding a fractional share in common stocks. The REITs shareholders are the indirect owners of a portfolio of real estate properties and receive income streams through rentals in dividend form. Their listing in the stock market offers investors liquidity, low transaction costs and transparency in their direct real estate portfolio in various property sectors and different geographic locations (Feng, Pattanapanchai, Price, & Sirmans, 2019).

The properties held by REITs can be either focused on a specific property sector or diversified properties. The classification stems from the heterogeneity of each property: two properties can be similar but not identical, (i.e. no two office buildings are truly alike (Ibbotson & Siegel, 1984). In this context, each property sector attracts different kinds of tenants who demand a property that suits their needs (Giambona, Harding & Sirmans, 2008). Also, each property sector may vary in terms of the tenancy period (Van Nieuwerburgh, 2019), vacancy, and capitalisation rate (Plazzi, Torous, & Valkanov, 2011). Therefore, these attributes reflect each property sector REIT has a distinct line of business (Ertugrul & Giambona, 2011; Yavas & Yildirim, 2011).

Related to this, investors prefer REITs to focus on a specific property sector rather than diversify in many property sectors (Ro & Ziobrowski, 2011, 2012). From their standpoint, property sector REITs reduce the cost of searching and monitoring as well as reduce their dispersion of belief on the properties hold by a REITs (Capozza & Seguin, 1999; H. Chen, Downs, & Patterson, 2012). Property sector REITs contribute to greater operating efficiency at both property- and REIT firm-level (Feng et al., 2019). In addition, property sector REITs improve their pricing efficiency at the index level, given the similarity in the underlying real estate fundamentals (Pavlov, Steiner, & Wachter, 2018).

Investment in direct real estate asset is cumbersome, given their illiquidity and managing the associated operating cost and revenue of portfolio of direct properties (Ambrose, Highfield, & Linneman, 2005; Hardin, Hill, & Hopper, 2009). For a typical investor that seek liquidity, direct real estate is not an option. But instead, the investor invests in other financial assets like common stocks and bonds. On the other hand, REITs provide exposure to real estate assets with a various types of property sector to choose. Hence, the investor can include REITs their portoflio, by assessing their expected returns and variance-covariance matrix with other financial assets.

Following the successful path in developed REITs markets like the US, Canada and Australia, Japan is a pioneer in the Asian REITs market. The initial step was the development of a fundamental regulatory framework in November 2000. The first two Japan REITs were listed in 2001, with a primary focus on office property REITs. As of the year 2019, Japan REITs have expanded into various property sectors, including residential, retail, hotel, and logistics property sectors. There are 66 listed REITs in Japan’s stock markets, with a market capitalisation of 14900 billion yen or (149 billion USD). Although these developments are recent, Japan established itself as the second-largest REITs market in the world in terms of market capitalisation, after the United States.

Existing literature on Japan’s REITs is primarily focused on corporate finance aspects, for instance, the assessment of investors’ reactions to corporate decisions to expand REITs' underlying real estate portfolio (Ooi, Ong, & Neo, 2011). Studies in property acquisition are not confined to measuring abnormal returns, but rather look into investors’ perceptions of ways to finance property acquisition either by seasoned equity issuance (Ong et al., 2011) or the use of leverage (Tang et al., 2016). In addition, existing literature also examines the gains from the issuance of shares of Japanese REITs in the stock market (Kutsuna, Dimovski & Brooks, 2008; Ooi, Mori & Wong, 2019) as well as mergers and acquisition amongst the Japanese REITs (Goujie & Michayluk, 2015). The above literature shows that financial market players have positively perceived Japanese REITs as an asset class. This acceptance reflects the investment in liquid real estate assets with access to the efficient allocation of capital into investment in underlying direct real estate properties (Q. Li, Ling, Mori & Ong, 2020). REITs offer professional real estate asset portfolio management the capacity to generate revenues and control expenses (Beracha, Feng, & Hardin, 2019).

On the other hand, several other studies examine the role of Japan's REITs in a mixed-asset portfolio, assessing historical performance and using correlation coefficients between asset returns. It is found that Japan REITs have a high level of return, are positively correlated with stocks, but negatively correlated with the bonds. Including the Japanese REITs in a traditional mean variance portfolio framework improves the performance of a portfolio of stock and bonds (Newell & Peng, 2012). Quite recently, the assessment of Japanese REITs' return and risk characteristics has been undertaken on their specific property classes. Each type of REIT is shown to provide a diversification benefit to a portfolio of financial assets (Cho, 2017; C.-Y. Lin, Lee & Newell, 2019).

While large number of studies have focused on the Japanese REITs, much less effort has been made on examining the linkages between the Japanese REITs and stocks as well as direct real estate assets. For an investor, these linkages can provide an important intuition on the return characteristics of REITs. Related to this, REITs serve a dual purpose. Holding fractional shares in REITs is akin to an investment in a direct real estate asset. On the other hand, the holding of REITs may be no different from investment in common stocks, where REITs do not provide a diversification benefit offered by the direct real estate market. Many studies use a cointegration framework to examine whether REITs are similar to direct real estate or stocks. Indeed, such analyses have been performed in many international markets, (see for e.g., Hoesli & Oikarinen, 2012; Oikarinen, Hoesli, & Serrano, 2011; Yong & Pham, 2015; Yunus, Hansz, & Kennedy, 2012).

Against this background, the first empirical chapter of this thesis aims to examine whether the property sector REITs in the Japanese market to behave like direct real estate or stocks. We explore whether there is a long-run cointegration relation between each property sector REITs, direct real estate, and stocks. Related to this, we examine whether the notion of substitutability by Glascock, Prombutr, Zhang, & Zhou (2017) holds for each property sector REITs in the Japanese market. In addition to that, we examine the short-run linkages between the property sector REITs, direct real estate and stocks. In our study, we test whether REITs return lead direct real estate return or vice versa. By doing so, we can examine whether Japanese REITs is an informationally efficient asset. Also, we test whether REITs return is predictable by stocks. Last but not least, to examine whether the REITs are sensitive to shocks exerted to other asset, direct real estate or stocks, we buttress our analysis in this chapter by performing forecast error variance decomposition and impulse response function analyses.

While the long run cointegration relation literature suggests REITs to be a substitute to direct real estate, little is known on how this relationship affects the asset allocation between REITs, direct real estate and stocks for investors with different time horizons. To date, the asset allocation literature have been heavily reliant on Campbell & Viceira (2005a) long-run asset allocation model. They derive an estimate of a variance-covariance matrix based on the short-run predictability structure between past and contemporaneous asset returns. This model does not take into account that assets are bound by a long-term relationship which may exist between REITs and direct real estate. Therefore, in the second empirical chapter, we extend the analysis of long-run relation and short-term dynamics between the REITs, direct real estate and stocks into the aspect of a portfolio choice problem. In particular, we modify the Campbell & Viceira (2005a) model by adding the long-run cointegration relation between REITs and direct real estate. By this way, we derive the variance-covariance matrix for investment in short- and long-term horizons. Related to this, we then examine the term structure of risk and correlation structure between REITs and other assets, that include stocks and direct real estate. Further, we use the estimated variance-covariance matrix to construct an optimal buy-and-hold portfolio for investments with different time horizons.

In the third empirical chapter, to get a sense of a daily investment horizon, we exclude direct real estate assets and instead use the property sector REITs, stocks and bonds returns. We adopt a framework that accounts for short- and long-run persistence in shocks to examine how the volatility structure of REITs in each property sector as well as the dynamics of their correlation with stocks and bonds. In doing so, we use the forecasted variance-covariance matrix to examine how the dynamics of the volatility and correlation impacts optimal portfolios in the Japanese market. With regards to property sector REITs, we examine whether this asset provides diversification benefits to investors. That is, we use the estimated variance-covariance matrix to construct an optimal portfolio with a daily portfolio rebalancing. We construct an optimal portfolio with and without property sector REITs and compare the performance between the two sets of portfolios.

The contributions that this study makes to the existing literature are as follows. First,we examine the return characteristics of the Japanese REITs in relation to direct real estate and stocks. A past study by Su, Huang, & Pai (2010) has examined the linkages of the Japanese REITs with other financial assets. In view of this, their study does not explain whether the Japanese REITs exhibits return dynamics similar to real estate asset or stocks. Such analyses exist for the US and other markets, but not for Japanese REITs which are relatively new.

Our analysis offers several insights to an investor in terms of understanding the return characteristics of the Japanese REITs. In particular, we show that there is a long-run cointegration relation between the Japanese REITs and direct real estate, while stocks can be excluded from the long-run relation. Secondly, we find that Japanese REITs lead stocks in the short-run causal relation. Nevertheless, there is bidirectional causality between REITs and direct real estate returns. Lastly, we find that the cointegration between REITs and direct real estate implies the sensitivity of direct real estate to shocks from REITs is greater than the sensitivity of REITs to shocks from direct real estate. Hence, in the first empirical chapter, our study sheds light on the linkages between REITs and direct real estate, whereby the Japanese REITs serve as a substitute to investment in a direct real estate asset.

Secondly, we extend the model of Campbell & Viceira (2005a) by accounting for the cointegration relation between REITs and direct real estate into the portfolio choice problem. In comparison with a series of past studies like Delfim & Hoesli (2019), Fugazza, Guidolin, & Nicodano (2015) and Mackinnon & Al Zaman (2009) which have applied the above model, our model provides a better estimate of variance-covariance matrix for investment in a different time horizon. In particular, we show that the correlation between the two cointegrated assets is close to one for a long-run horizon. Also, we demonstrate that REITs are less volatile asset in the long run compared to stocks. As will be discussed in Chapter 3, REITs participate in the error-correction mechanism due to their cointegration relation with direct real estate. Thus, our derivation of the variance-covariance model based on the modified model makes a novel contribution to the asset allocation literature.

Third, we contribute to the literature by using the cointegration relation between REITs and direct real estate and applying it to investments with different time horizons. To be specific, our exercise on the optimal buy-and-hold portfolio using the estimated variance-covariance matrix shows REITs to gain higher average allocation in a mixed-asset portfolio for short- and medium-term horizon. For that reason, our extended model offers a practical guideline for an institutional investor with a buy-and-hold portfolio involving REITS, direct real estate and stocks, by not negating the cointegration relation between the real estate assets.

Fourth, our study extends the past studies of Liow et al., (2009) and Liow (2012) by analysing the volatility and correlation dynamics of Japanese REITs and other financial assets by accounting for REITs in a specific property sector. Our results show that each property sector REITs can be distinguished since it exhibits distinct volatility and correlation structure with stocks and bonds. Accordingly, our findings recommend a time-varying dynamic allocation of property sector REITs with other financial assets to examine the diversification benefit of property-sector REITs in a mixed-asset portfolio.

Finally, we contribute to the growing literature on assessing the diversification benefit of the Japanese property sector REITs in a mixed-asset portfolio. Our study follows an alternative approach. To be specific, instead of applying unconditional estimates in the estimation of the variance-covariance matrix as in Cho (2017) and Y. C. Lin et al. (2019), our study account for the dynamics in the forecast estimates of variance-covariance matrix between each property sector's REITs, stocks and bonds. For that reason, our study also differs from the two past studies, where we use daily data. We examine the diversification benefit for each property sector REITs in a dynamic portfolio allocation, with a daily portfolio rebalancing. Our evaluation shows a portfolio with property sector REITs performs better than a portfolio consisting of stocks and bonds. All in all, our analysis gain insights on employing the dynamics in the variance-covariance matrix to highlight the diversification benefit of property sector REITs in the Japanese market for investment on a daily horizon.

1.2 Background Information on Japanese REITs

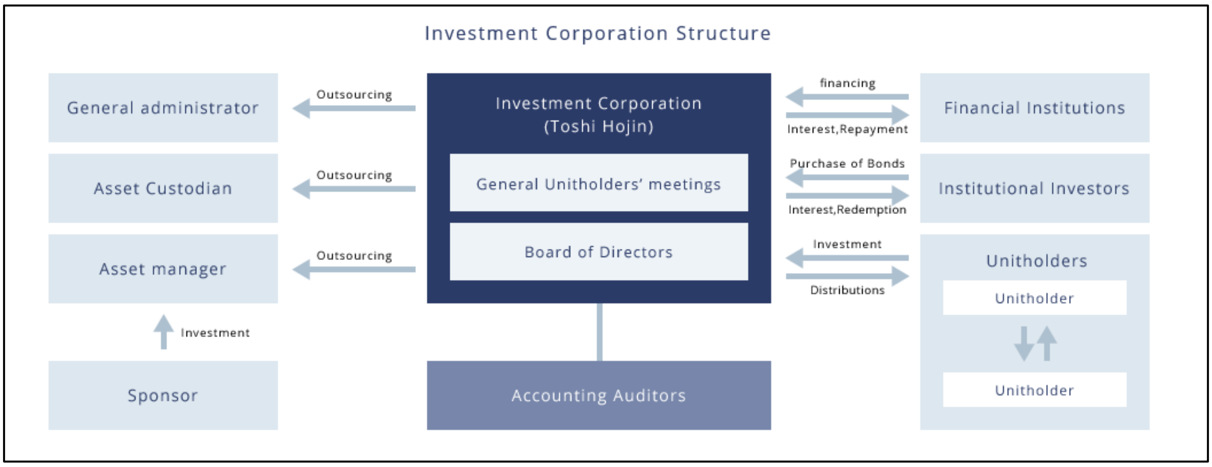
1.2.1 Japanese REITs' Legal Framework

The Japanese Real Estate Investment Trust was introduced with the enactment of the Investment Trust and Investment Corporation Law Corporation Act in November 2000. The legislation stipulates the formation of Japanese REITs as an investment corporation, where the corporation needs to be registered with the Financial Services Agency and subjected to the reporting and inspection requirements of the FSA, Securities and Exchange Surveillance Commission and the local finance bureau (EPRA, 2016). Japanese REITs adopt externally managed REITs. The established corporation is a dormant type whereby Japan's REITs need to outsource their main business activity, particularly to manage their underlying real estate assets. Japanese REITs also need to outsource the asset custodian and general administrative tasks.

As can be seen in Figure 1.1, the manager originates from the sponsor, from the listed property companies (Onishi & Sugihiro, 2015). They perform the duty of real estate fund manager, which involves property acquisitions or disposals (Iwakura & Ueno, 2016). In the year 2013, the ITL regulation was amended and required any decision made by the managers to be subject to prior consent from the investment corporation, i.e. REIT shareholders (Iwakura & Ueno, 2016). According to EPRA (2016), the real estate managers are governed by the Financial Instruments and Exchange Law (FIEL), which served as the regulation that oversees Japanese REITs' asset management companies. Under this regulation, the asset management company must first be registered as an investment manager. The company needs to obtain a Building Lots and Building Transactions Agent Licence and a Discretionary Transaction Agent Licence from the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Then, the company has to register as an investment manager with the Financial Services Agency. In addition, the real estate management company must have paid-in capital of at least 50 million yen and sufficient experienced personnel (EPRA, 2016). To ensure transparency, Japanese REITs abide by the Tokyo Stock Exchange regulation on disclosing information of the real estate asset management companies that manage the real estate portfolio held by the Japanese REITs (Onishi & Sugihiro, 2015).

Figure 1.1

A Typical Investment Corporation Structure by a J-REIT[1]



Source: The Association of Real Estate Securitization, Japan

Under the ITL, a Japanese REIT corporation can be established with paid-in capital of at least 100 million yen. The issuance of J-REIT shares needs to be a closed-end fund. During the initial listing, there must be at least 4000 shares. The ten largest J-REIT shareholders should hold not more than 75%, and the number of shareholders (apart from the ten largest shareholders) should be more than 1000. The J-REIT must invest more than 70% of its total assets in real estate which includes 1) direct real estate properties, 2) leasehold rights in direct properties, 3) surface rights, 4) easement, and 5) trust beneficiary interest. Japanese REITs are not allowed to undertake property development activity. The total asset value needs to be at least 5 billion yen (EPRA, 2016).

[1] See https://j-reit.jp/en/about/

In 2013, an additional amendment to the ITL act on Japanese REITs allowed the repurchase of investment units, either by private solicitation or market acquisition. The amendment is consistent with the changing dynamics of REITs prices that reflect both the value of underlying assets and changes in financial and capital markets. The board of directors of Japanese REITs needs to control the activities of share repurchases in terms of the number of investment units and the holding period of the acquired shares. Japanese REITs are now permitted to engage in rights offering. The amendment allows shareholders to subscribe to investment units at a fixed exercise price. This enables Japanese REITs to acquire capital and mitigate the dilution loss of shareholders' wealth caused by the issuance of additional shares in the market. Lastly, it lifts the restriction for J-REITs to acquire direct ownership of real estate in foreign countries. The new regulation permits Japan REITs to invest in real estate assets through an investment vehicle. Japanese REITs now can acquire shares in foreign entities that engage in real estate asset acquisition and they can recoup the income from this foreign investment (EPRA, 2016; Onishi & Sugihiro, 2015).

Japanese REITs are allowed to borrow to finance their real estate investment, with no leverage restriction (APREA, 2014). On average, the loan to value ratio adopted by Japanese REITs stood at 55% to 60% (Sumitomo Mitsui Trust Research Institute, 2016). The allowance is consistent with the obligation to distribute 90% of the income back to shareholders. Japanese REITs are allowed to borrow from securities companies, banks, insurance companies and pension funds (Khoi Pham, 2013). Over a fiscal year, Japanese REITs are subjected to corporate tax on 10% of their retained earnings, at 35%. Similar treatment applies to the capital gains made by Japanese REITs. Other taxes imposed on Japanese REITs include the tax on acquisition and disposal of their real estate assets, as well as a consumption tax on leasing properties for commercial use. Meanwhile, at shareholder level, their receipts from dividend and capital gains are taxable at a progressive tax rate (EPRA, 2016).

Table 1.1

Differences between Japan and U.S REITs Regulatory Structure

	Japan	United States U.S
Minimum capital	100 million yen	Not required
Management style	External	Internal and External
Leverage provision	No	No
Real estate asset	More than 70%	More than 75%
Real estate development	No	Yes
Dividend policy	90% of the rental income	90% of the rental income
Tax on REITs entity	Retained earnings & capital gains at 35%	Retained earnings & capital gains at 21%
Tax on shareholders	Dividend income & capital gains at a progressive tax rate	Dividend income & capital gains at 37% and 23.8%

Note. This table shows the differences between the Japanese and US REITs regulatory structures. Source: Authors compilation from (EPRA, 2016, 2019) and (Ghosh & Petrova, 2021).

The discussion on the Japanese REITs' legal requirements throws light on several similarities with the US REITs market. These include, among others, the aspect of leverage restriction and the requirement to distribute 90% of their rental income back to the shareholders (PwC, 2017). Regulation in the US market also stipulates several other requirements for REITs similar to those for Japanese REITs, although slightly different in manner. In particular, US REITs must invest at least 75% of their total assets in real estate. The corporate tax of 21% is imposed on retained earnings and capital gains. The shareholders of US REITs are also taxed on their dividend income and capital gain distribution at rates of 37% and 23.8%, respectively (EPRA, 2019).

On the other hand, one notable difference between Japanese and US REITs is that the latter are permitted to develop real estate in order to expand their portfolio of properties (EPRA, 2016).

Also, US REITs allow both internal and external management structures, although only 13% of the US REITs are externally managed (EY, 2017). According to Ghosh & Petrova (2021), the differences between the management styles of Japanese and US REITs induce a greater score for the US in the REITs Regulation Index than in Japan. The differences between the Japanese and the US REITs regulatory structure motivates us to build upon the knowledge on the return characteristics and diversification benefits for property sector REITs in the Japanese market. We document the similarities and differences between the Japanese and US REITs in the Table 1.1.

1.2.2 The Emergence of Japan REITs

Similar to other financial assets, Japanese REITs have been affected by the global financial crisis in 2008 (Miyakoshi, Shimada & Li, 2016). While by 2007 market capitalisation had reached 6.8 trillion yen, a year later it plunged to 2.66 trillion yen with the onset of the global financial crisis. From then onwards, market capitalisation has gradually increased, and despite the Japan earthquake catastrophe in 2011, it reached a level of about 3 trillion yen in that year (ARES, 2020c). Japan's REITs also steadily grew in number and market capitalisation, such that in 2019 there were 66 listed REITs with market capitalisation worth 14 900 billion yen or (149 billion USD). In the world market, Japan's REITs came in just behind the US in terms of market capitalisation (see Table 1.1). The market capitalisation and number of listed REITs exceed other developed REITs markets, like Australia and Canada, established in the years 1985 and 1994 respectively (EPRA, 2019). Japan's REITs show the ability to provide a stable stream of income to investors. In Figure 1.2, we can see Japanese REITs report dividend yields above 3%, with the highest yields in 2017 and 2018, when they reached more than 4%, and the lowest at 3.02% in 2014. The dividend yield of Japan's REITs is higher than the average dividend yield of stocks which ranges between 1.5 and 2.2% between 2013 and 2019. Japanese REITs attract various types of investors. The investors comprise mutual funds (42.5%), foreign investors (25.4%), domestic individual investors (11.8%), and business corporations and city regional investors which account for about 8 and 5.4% respectively of shares in Japan's REITs. The first two REITs, Japan Real Estate Investment and Nippon Building Fund were listed on the Tokyo Stock Exchange in September 2001. Since then, the number of listed Japanese REITs has grown substantially from two in 2001 to 66 as at December 2019. They provide a vehicle to invest in liquid real estate assets[2]. Based on Figure 1.3, as at August 2018, J-REITs manage to attract various group of investors, especially institutional investors i.e. mutual funds, foreign investors and domestic individual investor[3].

Table 1.2

Size of REITs in Leading Markets

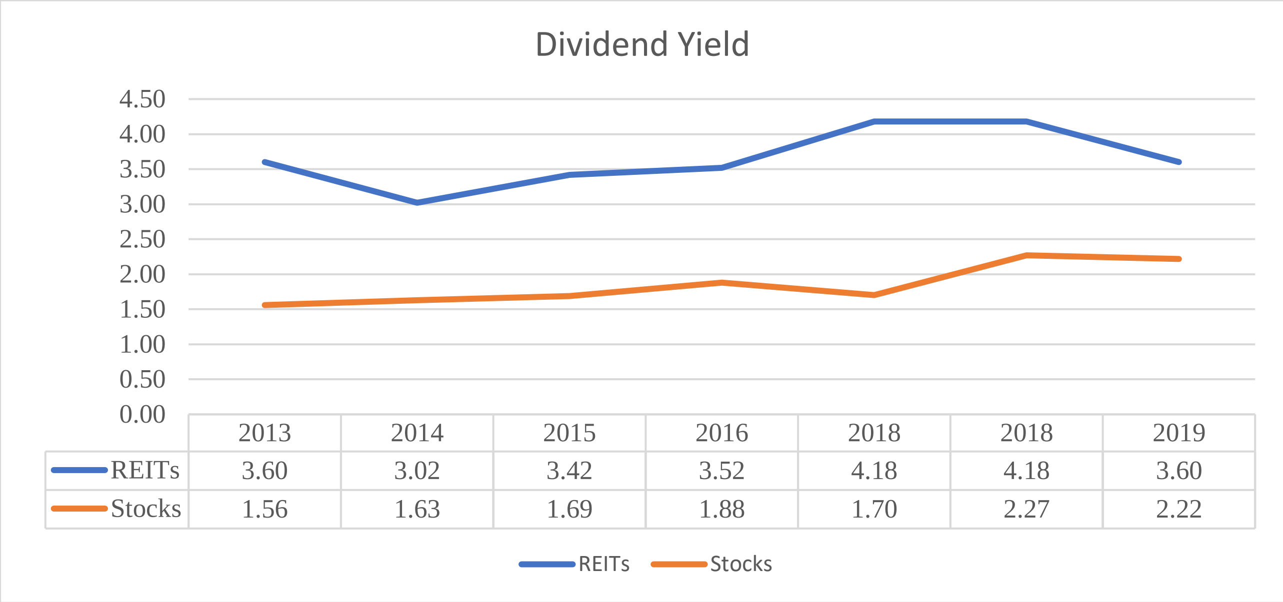
Countries	Year of Inception	Number of REITs	Market Cap USD Billion	Market Cap JP Yen Billion
United States	1960	192	1 256	130 550
Japan	2001	66	143	14 900
Australia	1985	44	104	10 800
United Kingdom	2007	55	77	8032
France	2003	30	61	6401
Canada	1994	46	64	6674

Notes. This table shows the market capitalisation of leading REITs markets in the world as at December 2010. Source: EPRA, 2019.

[2] In general, there are two types of REITs. Equity REITs invest directly and hold physical real estate properties, while mortgage REITs invest in mortgages, either providing loans or purchasing commercial mortgage-backed securities (Hansz et al., 2017). To the best of our knowledge, Japanese REITs only consist of the former type (equity REITs) and not mortgage REITs.
[3] The figures are excerpts from REIT Investor Survey August 2018 (Tokyo Stock Exchange, 2018).

Figure 1.2

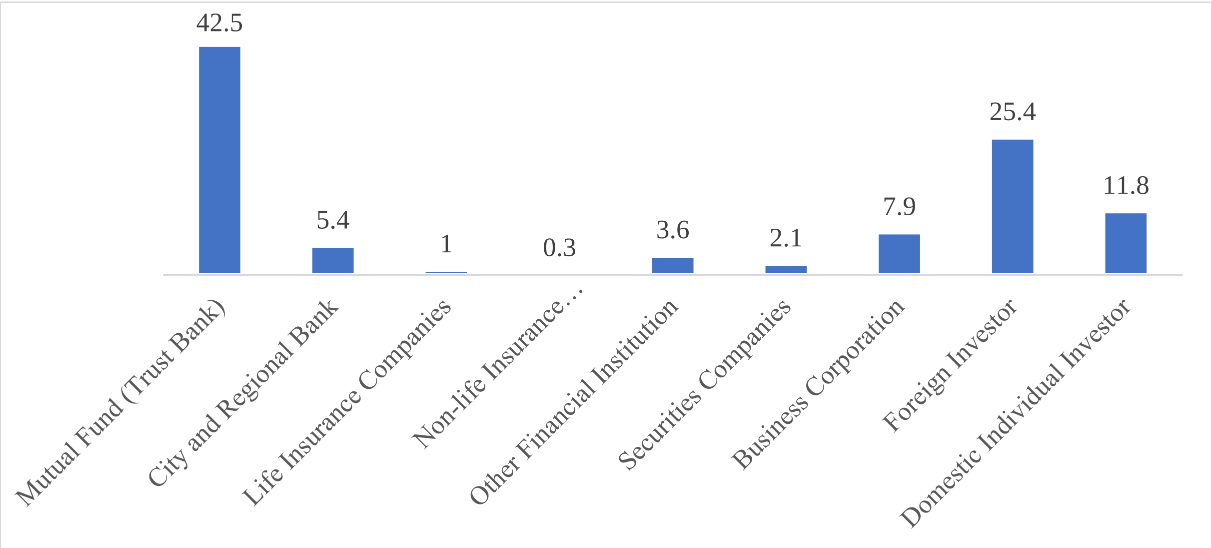
Dividend Yield Japanese REITs versus Stocks



Notes. This figure compares dividend yield between Japanese REITs and Japanese stocks from 2013 to 2019. Source: ARES, 2020b.

Figure 1.3

Japan's REITs Investment by Different Types of Investor



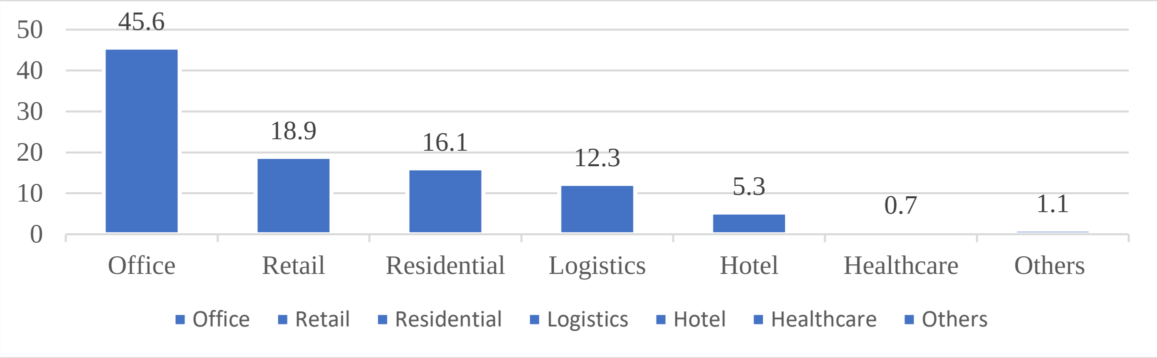
Notes. This figure shows the various type of investors in Japanese REITs. Source: Tokyo Stock Exchange, 2018.

Japanese REITs invest in various property sectors. Figure 1.4 shows that the largest investment is in the office sector (45.6%), followed by retail (18.9%) residential (16.1%), logistics (12.3%) and hotel (5.3%) (ARES, 2016). Since their inception, underlying assets have performed well. In 2019, there were a total of 3,672 real estate properties worth 17.3 trillion yen or 196.3 billion USD owned by listed Japanese REITs. The properties held by Japanese REITs are mostly located in Tokyo, with other cities include Nagoya, Osaka and Fukuoka (Nomura Research Institute, 2018). Table 1.2 reports the estimated market values for the underlying real estate properties in between 2013 and 2019. We can see the tremendous increase in the number and estimated market values of the properties over the sector. Accordingly, we observe that office properties increase about 55.5%, and their value increases to 84.4%. The number of residential properties increases by 30% with an increase in market value of about 77.4%. There is a 69% increase in retail properties with a market value increase of 66%. The number of hotel properties and their market values rise by more than 300%. Logistics properties and their market values also increase by more than 200%. Similarly, the occupancy rate (by tenants) never falls below 95% within this period. This would yield promising rent on the properties, given an average rent of 9900 yen per tsubo[4]. In particular, the average rent on REITs' office properties is 18,400 yen (177.13 USD), residential 11,100 (106.9 USD), retail 5,800 (55.83 USD) and hotels worth 9,700 yen (93.4 USD) (ARES, 2020a).

[4] Per tsubo is equivalent to per 3.3 square metres.

Figure 1.4

REITs Real Estate Investment According to Specific Property Sector



Notes. This figure shows the composition of underlying real estate properties invested by Japanese REITs. Source: ARES, 2016.

Table 1.3

The Estimated Market Value for Underlying Properties Hold by Japanese REITs

Sector	Number of Properties (2013)	Estimated Market Value (in bn yen) (bn USD) (2013) (USD)	Number of Properties (2019)	Estimated Market Value (in bn yen) (bn USD)(2019)
Office	620	4,845 (46.6)	964	8,936 (86.2)
Residential	1224	1,829 (17.6)	1696	3,245 (31.2)
Retail	228	1,861 (17.9)	385	3,102 (29.8)
Hotel	54	287 (2.76)	258	1,613 (15.5)
Logistics	110	779 (7.5)	369	3,493 (33.6)

Notes. The table shows the estimated market value for underlying properties held by Japanese REITs between 2013 and 2019. Source: ARES, 2020a[5].

[5] See https://index.ares.or.jp/en/ajpi/

1.3 Organisation of the Thesis

The rest of the thesis is structured as follows. In Chapter 2, The Long-Run Linkages and Short-run Dynamics between Japanese REITs, Direct Real Estate and Stocks**,** we examine whether REITs in each property sector of Japan are like their peers in direct properties or are similar to common stocks. Chapter 3: Investment Horizon and Correlation: Evidence from Japanese REITs proposes a portfolio choice framework that accounts for short-run dynamics between asset returns and cointegration between REITs and direct real estate in a time horizon correlation and covariance matrix. We incorporate the estimated covariance matrix into a buy-and-hold optimal portfolio involving each property sector REITs and direct real estate plus stocks. Chapter 4: The Dynamic Role of Japanese REITs in a Mixed-Asset Portfolio examines the time-varying volatility and correlation dynamics between REITs, stocks and bonds. We test the portfolio implications by accounting for the dynamics in an optimal daily portfolio with admissible portfolio rebalancing. We begin each chapter with an introduction to the specific research issue. We review the extensive past literature on the issue of the chapter. Subsequently, in each chapter, we describe the research methodology and data used, present the empirical findings and discussions, and note concluding observations. Lastly, in Chapter 5, we offer an overall summary of the three empirical chapters and provide suggestions for future research.

CHAPTER 2

On the Long-Run Linkages and Short-term Dynamics in Japanese REITs, Direct Real Estate and Stocks

2.1 Introduction

Since their inception in the new millennium, Japanese REITs have grown substantially both in terms of market capitalisation and underlying real estate assets in various property sectors. The return characteristics of Japanese REITs have gained the attention of a wide array of academics and practitioners, both local and international. As a result, we now have a better understanding of their historical performance (Newell & Peng, 2012) and forecasting their future returns owing to their unique regulatory structure (Ghosh & Petrova, 2021) as well as assessing the systematic risk of the Japanese REITs in relation to the local stocks market (Brounen & De Koning, 2012).

In addition to that, for an investor, one important question is to examine whether Japanese REITs are akin to be like direct real estate or stocks. Consistent with the notion of substitutability by Glascock et al. (2017), it can be argued that Japanese REITs is a substitute to direct real estate asset. That is, holding fractional shares in Japanese REITs is similar to a direct investment in real estate. On the other hand, Japanese REITs are no different from common stocks, whereby an investor needs to allocate a portion of their wealth to direct property investment.

In this chapter, we study the dynamics of Japanese REITs returns with direct real estate and stocks, between April 2004 and December 2019. Our sample selection is accordance with the availability of the data on direct real estate index and gradual development of property sector

REITs[6]. Thus, we select the sample within this period as to establish a level playing field among the REITs in each property sector. We use the REITs total return indices, in the composite and specific property sectors. These include office, retail, residential and hotel properties. We use the Tokyo Price Index (TOPIX) total return index as the proxy for common stocks. With regard to the direct real estate market, our study uses the Association of Real Estate Securitization (ARES) Japan Property Index. These indices are appraisal-based indices where their construction replicates the National Council of Real Estate Investment Fiduciaries (NCREIF) in the US market. These indices track changes in income and the appraisal value for each individual property held by institutional investors.

We estimate a vector error correction model (VECM) which considers the long run relationship between Japanese REITs, direct real estate and stocks, as well as their short-run causal relation. Also, we use the VECM to examine the sensitivity of REITs to hypothetical shocks to direct real estate and stocks through variance decomposition and impulse response function analyses. Taken together, our study in this chapter seeks to examine the following research questions:

- Do Japanese REITs behave like direct real estate or stocks?
- Do Japanese REITs predict direct real estate and stocks returns?
- Are Japanese REITs sensitive to shocks from other assets?

An added contribution of our study is examining the linkages between the Japanese REITs, direct real estate and stock. Although great attention has been paid to the relationship between REITs, direct real estate and stocks in the US, European and Australian market, what has not been studied properly is examining the linkages between the three assets in the Japanese market. One closely related past study with ours is the study by Su et al. (2010), but they have

[6] The early development of Japanese REITs in 2001 primarily focused on office properties. Other property sectors - retail, residential and hotel REITs emerged in 2003, 2004 and 2006 respectively. In exception to Hotel sector, where our sample selection is in between June 2006 to December 2019.

investigated the linkages of the Japanese REITs with stocks and bonds. Thus, to the best of our knowledge, our study is the first to examine the linkages between the Japanese REITs together with stocks and direct real estate markets. In this context, we test for cointegration relation between REITs, direct real estate and stocks and estimate the VECM by accounting for the specific property sector. By doing this, our analysis offers a number of new insights, particularly to understand the return characteristics of the Japanese REITs that are:

First, our Johansen test shows one cointegrating relationship between property sector REITs, direct real estate and stocks. Subsequently, we manage to establish a pairwise long-run relation between the Japanese REITs and direct real estate, as stocks can be excluded from the relation. Then, in our estimation of the VECM, we normalise a long-run cointegrating equation with respect to direct real estate, with a cointegrating coefficient β. By this way, we find that the an increase in the price of direct real estate is lower than the increase in the price of REITs. Also, we observe the cointegrating coefficient β to vary for each property sector, where the findings reflect the heterogeneity in different types of underlying real estate assets.

Second, by using the VECM, our analysis provides an understanding on the short-run causal relation between Japanese REITs, direct real estate and stocks. Our results show the prevailing causal relation between the lagged REITs and stocks. The findings suggest the leading role of Japanese REITs that can predict the return on stocks. On the other hand, as evidenced by the speed of adjustment parameter for REITs and direct real estate, our results indicate a causal relation between REITs and direct real estate as well as a causal relation between direct real estate and REITs. Given that Japanese REITs are relatively new, the finding on causal relation suggests the lack of informational efficiency of Japanese REITs as their returns are predictable by direct real returns.

Third, our analysis on the variance decomposition and impulse response function does not contradict the evidence of the long-run relation between REITs and direct real estate. That is, we indicate both assets are sensitive to shocks exerted either to REITs or direct real estate. But rather, we show that direct real estate is more sensitive to hypothetical shocks exerted to REITs, then the sensitivity of REITs to shocks exerted to direct real estate. Meanwhile, the causality between REITs and stocks infer that the latter is also sensitive to shocks exerted to REITs.

Taken together, our analysis on the Japanese REITs conform with the evidence of cointegration between REITs and direct real estate conducted on other international markets both in general (Morawski, Rehkugler, & Fuss, 2008; Oikarinen et al., 2011; Sebastian & Schatz, 2009; Yong & Pham, 2015; Yunus et al., 2012) and in specific property sectors (Boudry et al., 2012; Hoesli & Oikarinen, 2012, 2016). In relation to the analysis on the Japanese market, our results demonstrate that, despite being relatively new, Japanese REITs can stand together along with their peers in the REITs international market. That is to say that an investor can also construe Japanese REITs to be a substitute for investment in the direct real estate asset. Accordingly, since Japanese REITs is a liquid asset with low transaction costs, Japanese REITs can be used by an investor that seeks exposure to real estate asset in a wide array of property sectors.

2.2 Literature Review

2.2.1 Are REITs Real Estate?

The question as to whether REITs can generate the same performance with respect to expected returns and diversification as their direct real estate counterparts or stocks has received substantial attention both in earlier and more recent literature. A strand of literature explores the sensitivity beta of REITs within the stock market. Ambrose, Lee and Peek (2007) examine the short-run implications of listing REITs in the S&P 500 index. They indicate the return beta for both indexed and non-indexed REITs increases in relation to common stocks. The increase in beta is rather unexpected but arises due to non-fundamental effects, like sentiment and reduction in market frictions from investors in these two markets. Hoesli and Camilo (2007) decompose the REITs beta into correlation and standard deviation of REITs and stock returns. They find that the correlation between these two assets decreases while the standard deviation of stocks increases. As a result, their study presents evidence of decreasing beta of REITs, in both the medium and long term. Alcock and Steiner (2018) assess the relationship between firm-level REITs and stock market returns using both systematic beta and joint negative return clusters in the two markets. They argue that REITs firm fundamental characteristics reflect the sensitivity of a REIT's systematic risk, where leverage is the source of joint negative return clusters between REITs and stock markets.

Several studies examine common features of REITs, direct real estate and (or) stocks. Seck (1996) develops a concept of asset substitutability where asset value is determined by the same elements of relevant information. He finds that securitised real estate and direct real estate assets are not substitutable. In particular, securitised real estate asset prices follow a random walk, while appraisal-based assets do not. Ling and Naranjo (1999) introduce the concept of integrated assets based on whether the risk premia of the assets can be attributed to the same systematic risk factors, and find that REITs are integrated with the stock market, with the level of integration increasing during the 1990s.

Studies by Clayton and Mackinnon (2001, 2003) develop a multi-factor regression modelling that tests the sensitivity of REITs return to stock and bond returns and direct real estate returns. They report that REITs returns are bound to be linked with common stocks until after 1993, where their returns are closely followed by direct real estate returns. M. L. Lee, Lee and Chiang, (2008) examine the sensitivity of REITs' returns by classifying them into small-cap and large-cap REITS. Their factor model suggests small-cap REITs have exposure to both stock market and direct real estate assets Large-cap REITs returns are closely related to direct real estate returns.

Mühlhofer (2013) developed a factor model to examine REITs returns and direct real estate returns. In particular, the direct returns are decomposed into income and appreciation returns. The study finds that REITs returns reflect the income from rents but cannot capture the growth in the value of the underlying direct real estate assets. He suggests REITs are a partial substitute for direct real estate assets. Ang, Nabar and Wals (2013) investigate the common factor of REITs in the short and long run. In the short run, REITs have an exposure to stock market factors. In the long run, the exposure reduces as REITs share a common factor with direct real estate assets.

Hansz, Zhang and Zhou (2017) classify REITs as equity and mortgage REITs. By using a VAR framework, the study suggests the two types of REIT are distinct as different sets of macroeconomic fundamentals determine the returns on these two assets. The results indicate that the two assets are deemed to be non-substitutable. Kroencke, Schindler and Steininger (2018) examine the underlying fundamentals between REITs, stocks and direct real estate returns. By applying principal component analysis, they dissect the risk premium for each asset.

They find that two-thirds of the risk premium of REITs is explained by direct real estate risk rather than stock market risk. Their findings suggest REITs are more related to their underlying properties rather than stocks.

2.2.2 The Differences Between Return and Risk Characteristics of REITs and Direct Real Estate

A couple of studies examine the return and risk characteristics of REITs and direct real estate market. The study by Riddiough, Moriarty and Yeatman (2005) evaluates a historical annual return and risk for both assets in the US market between 1980 and 1998. Their findings indicate that, on average, REITs report higher and more volatile returns than direct real estate assets. Pagliari, Scherer and Monopoli (2005) use annual data over a longer period, from 1980 to 2001. The study compares and tests the hypothesis of return and risk similarities between REITs and direct real estate assets. They add leverage and de-smooth the direct real estate indices. Their findings are similar to Riddiough et al. (2005), but the returns and risk differences are not statistically significant. REITs reckon to be more liquid and provide more returns and risk than direct real estate. It turns out that investors value REITs as corporations, in which factors like management quality and managerial decisions are considered as well as underlying real estate fundamentals. The required return on REITs is higher as they undertake a bigger scale of investment and property holdings than the direct real estate assets. This exacerbates their volatility and hence investors require a higher level of return than investment in direct properties.

2.2.3 Predictability and Lead-Lag Structure Between REITs and Direct Real Estate Assets

The differences in liquidity and playing field between these two assets call for researchers to examine the information flow between REITs and direct real estate. An early study by Giliberto (1990) considers a regression of direct real estate returns with lagged REITs returns. He finds a significant relationship where lagged REITs would explain direct real estate returns. J. Li, Mooradian and Yang (2009) observe the significance of ARCH effects between REITs and direct real estate. They present evidence of information transmission from REITs to direct real estate returns. In the UK market, Stefek and Suryanarayanan (2012) examine the linkages between lagged REITs and direct real estate returns, where lagged REITs returns significantly impact direct real estate returns. Meanwhile, Oikarinen, Hoesli and Serrano (2011) apply the Granger causality test to examine the lead-lag structure between these two assets. Their study in the US market indicates REITs lead direct real estate returns. Another study by Yunus et al., (2012) reports similar findings in the context of European and Australian real estate markets, with no feedback effects from the direct real estate market.

Several studies examine the lead-lag linkages by classifying real estate according to specific property sectors. Studies by Hoesli and Oikarinen (2012) and Hoesli, Oikarinen and Serrano, (2015) explore the causality between these two assets and accentuate the robustness of a lead structure by REITs, at least in the US market. For instance, apartment REITs Granger cause apartment direct real estate. In similar settings, however, there is an absence of unilateral causality between these two assets in the UK market, as there is a feedback effect from their direct properties. Several contemporaneous studies confirm the role of REITs as a transformation information channel to the direct real estate market, both in general (all property) and in specific property sectors (Ling & Naranjo, 2015; Ling, Naranjo, & Scheick, 2018). As a result, REITs contain information to predict future direct real estate returns.

2.2.4 The Linkages of REITs, Direct Real Estate and Stocks

From a different perspective, a substantial number of studies examine the linkages of REITs either with direct real estate and/or stocks in long-run relation in a vector error correction model framework. In the early stage, Eng (1995) reports the absence of cointegration between listed real estate and direct real estate in Singapore due to the absence of a suitable proxy for tracking direct real estate performance. The latter studies suggest the use of an index that captures the performance of investment-grade properties, such as the NCREIF appraisal-based indices of direct real estate owned by institutional investors (Hoesli & Oikarinen, 2016; Morawski et al., 2008; Sebastian & Schatz, 2009; Yunus et al., 2012) or transaction-based direct real estate indices in US markets (Boudry, Coulson, Kallberg & Liu, 2012; Hoesli & Oikarinen, 2012).

Oikarinen et al. (2011) examine a pairwise cointegration between REITs and direct real estate and REITs and stocks in the US market. They use quarterly data for FTSE NAREIT as a proxy for REITs, S&P 500 as a stock market proxy and transaction-based NCREIF-TBI and appraisal-based NCREIF direct real estate indices. They examine the presence of cointegration between the first pair, REITs and direct real estate, either with NCREIF or NCREIF-TBI, and the absence of cointegration between REITs and stocks. Yunus et al. (2012) study and report cointegration between REITs and direct real estate in several developing real estate markets: the United Kingdom, Netherlands, and Australia.

Some other studies explore the cointegration between REITs, direct real estate and stocks by controlling for a specific property class. Boudry et al. (2012) expand the financial assets by including both large and small or mid-cap indices as well as bonds. They present the two cointegrating relations where the first is between REITs and direct real estate in the composite and specific property sector, while the second cointegrating relation is amongst financial assets. Hoesli and Oikarinen (2012) examine the cointegration between REITs, direct real estate and stocks for the US and UK market. They examine the cointegrating relation between REITs, direct real estate, and stocks. Further exclusion tests indicate stocks can be excluded from the long-run relationship. For instance, they report the pairwise cointegration between REITs and direct real estate, like retail and office property in the US and the UK.

Additional statistical filters are also being incorporated whilst attempting to test the robustness of the long-run linkages between REITs and direct real estate. The studies by Hoesli and Oikarinen (2012) and Hoesli and Oikarinen (2016) determine the long-run relationship between REITs and direct real estate either by adding the leverage on the direct real estate or by deleveraging the REITs indices, respectively, also de-smoothing the appraisal-based direct real estate indices. The cointegration between REITs and direct real estate is robust neither to de-smoothing (Hoesli & Oikarinen, 2016; Yong & Pham, 2015) nor de-smoothing the direct real estate indices. The findings highlight that the appraisal smoothing issue does not affect the cointegration relation in the long run (Oikarinen et al., 2011; Yunus et al., 2012)[7].

The examination of Japanese REITs is closely related to financial assets. Su, Huang and Pai, (2010) consider the linkages between REITs with low-risk and high-risk regimes in the stock market. They conjecture that investors should allocate more REITs in the context of a low-risk regime. In a high-risk regime, they suggest investors keep REITs in their portfolio as a source of income. However, our study in this chapter explores the portfolio choice problem of Japan REITs by examining their fundamental characteristics in terms of long-run linkages and short-term dynamics. That is we examine the linkages of Japan REITs with direct real estate and stocks using the vector error correction model.

[7] The appraisal-based direct real estate index carries the issue of appraisal smoothing. The issue arises as appraisals of direct real estate are not conducted frequently. Consequently, appraisers rely on past values to estimate the current market value of direct real estate assets. This reduces the volatility of index return series and contributes to positive autocorrelation in the index return series (Geltner, 1993a).

2.3 Methodology

2.3.1 Model Specification

We estimate a vector error correction model (VECM) to study the long-run cointegrating relationship between REITs, direct real estate and stocks. In particular, suppose that y_t consists of 3-dimensional, N=3 vectors of indices, that are REITs, direct real estate and stocks, denoted as $DRE_t, REIT_t, Stock_t$ respectively. Thus, we express the VECM equation as

$$\Delta y_t = \mu + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \alpha C + \alpha\beta' y_{t-1} + d\_i x_t + \epsilon_t \qquad (2.1)$$

where, $\Delta y_t = [\Delta\,\mathrm{DRE}_t, \Delta\mathrm{REIT}_t, \Delta\,\mathrm{STOCK}_t]$[8] [9]. The parameter μ is a three – dimensional (3 x 1) vector of drift terms in the differenced equation, and. The parameter Γ_j is a 3 x 3 matrix of autoregressive terms for the lagged differences at lag *j,* with *p* as the maximum lag to be included in equation (2.1)[10]. In what follows, αC is a 3x *r* vector of intercepts in cointegration relation, $\alpha\beta'$ or Π is a 3 x3 long-run impact matrix, where α is the vector of the speed of adjustment parameter (in 3 x *r* matrix) and β' is the long-run cointegrating vector (in *r* x 3 matrix). The r's in α and β' matrices are the number of cointegrating relations between these three assets[11] [12]. Meanwhile, x_t is a (3 x *1*) vector of an exogenous dummy variable. That is,

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[8] We represent the 3-D vectors of indices accordingly to specific REITs and direct real estate sectors. Hence, there are five different models to be estimated. We estimate the VECM as in equation (2.1) by using STATA application.

[9] The availability of REITs and direct real estate data determines the period of investigation. Therefore, the stock market variable is entered just as the total number of observations and study period for the REITs and direct real estate indices.

[10] Example at lag of j=1, the $\Gamma_j = \begin{bmatrix} a_{DD,1} & a_{DR,1} & a_{DS,1} \\ a_{RD,1} & a_{RR,1} & a_{RS,1} \\ a_{SD,1} & a_{SR,1} & a_{SS,1} \end{bmatrix}$, whereby the subscripts of D, R, S correspond to the DRE,REIT and Stock respectively.

[11] We provide more information about r in the subsection 2.3.3.

[12] Our model specification to estimate the VECM is similar to the past studies for the case of US, UK and Australian real estate (Hoesli & Oikarinen, 2012; Yunus et al., 2012) in order to establish a fair comparison for the analysis to be conducted in the Japanese market.

x_t equals to 1 for the sample period correspond to Global Financial Crisis Period, in between August 2007 to March 2003, and 0 for other observation periods. Lastly, ϵ_t is the 3-dimensional (3 x 1) vector of normally distributed white noise error terms with zero mean and constant variance.

2.3.2 Empirical Estimation

To estimate equation (2.1), we apply Johansen's (1988) and Johansen and Juselius' (1990) test of cointegration. This method is preferable rather than Engle and Granger's (1987) method since there are possibilities to have more than one long-run cointegrating relationship between the indices. For our studies, this can occur as we have *N*=3, 3-dimensional vector of indices. Johansen proposes two maximum likelihood test statistics, which are useful to determine the number of cointegrating relations or rank, *r* of matrix Π in equation (2.1). First is the trace test statistic, which is formulated as:

$$\lambda_{trace(r)} = -T \sum_{i=r+1}^{n} \ln(1-\lambda_i) \tag{2.2}$$

where *T* is the number of observations, λ_i are the estimated eigenvalues of Π. This trace statistic tests for the null hypothesis of no more than *r* cointegrating relations. As a result, a large value of this statistic implies that the null hypothesis of no more than *r* cointegrating relations be rejected. Second is the maximum eigenvalue test of the number of cointegrating relations, which is formulated

$$\lambda_{\max(r,r+1)} = -T \ln(\, 1-\lambda_{r+1}) \tag{2.3}$$

where T is the number of observations and λ_{r+1} is the estimated $r+1^{\text{th}}$ estimated eigenvalues of Π. The maximum eigenvalues test for the maximum number of r cointegrating relations against the $r+1$ cointegrating relations. Consequently, these two statistics are continuous iterative processes until the null hypothesis of r number of cointegrating relations fails to be rejected.

Since our model consists of three assets, there are three possible cases of r which are: rank of Π equal to zero, then there is no linear combination of y_t that is stationary; or Π can be a full rank, $r=N$ where $N=3$ that causes the vector process to be stationary. This extreme contradicts the non-stationary data generating process of all the indices. In the middle, there exists at most $r \leq N-1$ number of cointegrating vectors which indicate that there is (are) r linear combination(s) of y_t that is stationary and cointegrated. As a result, only if there is more than one or at most $r \leq N-1$ number of cointegrating vectors, then the Π matrix in equation (2.1) can be further estimated to obtain the vectors of α and β' by the maximum likelihood estimation method. The vectors of α represent the speed of adjustment parameters and β' represent long-run cointegrating coefficients. Since we have $N=3$ series, the possible number of rank, $r=1$ number of cointegrating vectors, or at most $r=2$. If cointegration is absent, when r=0, the VECM equation will be reduced as a VAR in a first difference.

2.3.3 Weak Exogeneity and Long-Run Exclusion Tests

The estimated parameters of the speed of adjustment, α and long-run cointegrating coefficients β' vectors can be restricted in two different ways. Firstly, a weak exogeneity test in which the coefficient of α for an individual variable can be restricted to be zero (Hunter, 1992). We hypothesise, $H_0\ \alpha = 0$. As a result, if the restriction is valid, then we indicate the variable will not be deviated (adjusted) from (to) the long-run cointegrating equilibrium. Secondly, an exclusion test, whereby an individual variable is allowed to be excluded in the long-run cointegrating relation (Hunter, 1992; Juselius, 1995), such that the coefficients in vector β can be restricted to zero. In particular, we hypothesise that $H_0\,\beta = 0$. We conduct this test by restricting the β coefficient to correspond to an individual series equal to zero. These two tests follow a Chi-square test statistic. We assume that, the restriction of coefficients either in α or β' vectors are valid if the p-value for the restriction test is greater than 0.10.

2.4 Data

In this study, we employ the total return indices for direct real estate, REITs and stocks. We use monthly data from April 2004 (2004m4) to December 2019 (2019m12). We select the sample within this period as to establish a level playing field among the REITs in each property sector. Our observations include the global financial crisis period between July 2007 (2007m7) and March 2009 (2009m3) (Hoesli & Oikarinen, 2016; M. C. Huang, Wu, Liu, & Wu, 2016) . We use the data from Datastream to study the performance of Japanese REITs. The classification of Japanese REITs in Datastream is based on the constituents of their portfolios which fall in the following four categories: office, retail, hotel, and residential sectors. For each sector, the constituents of each REITs are weighted by a market capitalisation method[13]. We use the Tokyo Stock Exchange (TOPIX) total return index as the proxy for common stocks and TOPIX small as the proxy for small-cap stocks in the Japanese market.[14]

With regards to direct real estate, a few caveats should be considered prior to describing the direct real estate indices used in this study. The direct real estate asset market is segmented from the financial market. There is a heterogeneity in the characteristics of each individual property, where two properties may be similar but not identical, (i.e. no two office buildings are truly alike (Ibbotson & Siegel, 1984). There is no central marketplace for a property to

[13] Source (Thomson Reuters Datastream, 2012).

[14] Total return indices exhibit the theoretical growth in the value of the share price over a specified period and dividends which are assumed to be re-invested to purchase additional units of shares, at the closing price applicable on the ex-dividend date. This is in contrast to the price index which only accounts for the theoretical growth in the value of the share price over a specified period of time. Source: Datastream.

change hands, where a typical transaction takes place privately between an interested buyer and a willing seller. The issue of illiquidity of direct real estate assets arises, as trading of an asset is infrequent. In addition, there is also the issue of the marketing period (i.e. the time upon the price is agreed and the transfer of the ownership of real estate asset) (Ibbotson & Siegel, 1984; Z. Lin & Liu, 2008; Z. Lin & Vandell, 2007).

The inherent attributes of the direct real estate market make constructing an index capable of keeping track of the performance of direct real estate assets complex. Geltner (2015) provides a comprehensive analysis of the methodology to construct direct real estate indices, each carrying advantages and disadvantages. The first type is an appraisal-based direct real estate index, which is based on the appraisal of each property owned by institutional investors. Each property in the index is appraised and equally weighted. The index measures the appraisal-based change in value for each property within a period.

There are two issues associated with an appraisal-based index. First, it suffers from temporal lag bias, whereby the appraisal of each property may occur in different periods but they are then averaged together to produce an index value for a specific time period (Geltner, 1993b). Secondly, appraisers typically use the past value to estimate the current market value of the property, or they use the past value of a transacted property which is comparable to estimate the value of the property (Geltner, 1989). These two issues cause the appraisal smoothing in direct real estate indices, where their volatility is lower than the volatility of the true unobserved property price. Also, there is an autocorrelation in direct real estate return distributions, as the appraiser relies on the past value in estimating the current market price of a property.

The other method of constructing direct indices is based on the transaction price for individual assets. However, the construction of this index also has several underlying issues, as discussed earlier, relating to the heterogeneity and illiquidity in direct real estate assets. The illiquidity causes scarcity of observed transacted property prices, which consequently may not fully represent the type of property. To address the issue of heterogeneity, the construction of the price index uses the hedonic method. This method regresses the price against the underlying attributes of individual property (held constant) and observes the price changes using a time dummy variable. Meanwhile, the repeat-sales method tries to overcome the scarcity issue by observing the data on properties that sell more than once. Within the same property type, both hedonic and repeat sales methods track price change over time using the time dummy variable (Geltner, 2015).

The inception of REITs in the Japanese market promotes transparency in evaluating the performance of underlying direct real estate assets, which previously was not publicly disclosed. The Association of Real Estate Securitization (ARES) in Japan engages with Japanese real estate management companies to share the data on the direct real estate properties held by Japanese REITs and unlisted property funds. This allows ARES to develop the ARES Japan Property Index. The calculation of the index replicates the well-established National Council of Real Estate Investment Fiduciaries (NCREIF) in the US market. The index is derived from weighted average income (net operating income) and capital (changes in appraisal values) for each individual property that constitutes the index. ARES has stipulated several characteristics for a property to be included in the basket of real estate assets. Among others, the property must be income-producing through rentals. The property must be owned by institutional investors such as listed REITs and unlisted property funds. The investment return is also reported on a non-leveraged basis. Lastly, each individual property must be appraised by an external valuer twice a year.

Meanwhile, the Ministry of Land Infrastructure, Transport and Tourism (MLIT) released a transaction-based index, the Japan Commercial Property Price Index (JCPPI), as an experimental series in 2016 (MLIT, 2017) . The transaction-based index is constructed using the hedonic method with a time dummy variable. The construction of the JCPPI index also faces the issue of sparse transactions in direct real estate property in the Japanese market (Diewert & Shimizu, 2015; Shimizu, Diewert, Nishimura, & Watanabe, 2015). However, an alternative approach to overcome the issue such as the transaction-based index in the US market is yet to be adopted for the Japan direct real estate index[15]. Moreover, the JCPPI index only captures the changes in price over a period. Meanwhile, the AJPI is a total return index that accounts for both changes in price and income of the properties constituting the index. Taken together, the issue in the JCPPI and the commonality of the AJPI index and the NCREIF appraisal-based index prompts us to use the latter as the proxy to track the performance of direct real estate assets in the Japanese market.

Whilst the AJPI indices suffer from the issue of appraisal smoothing, *we* attempt to correct the direct real estate indices by using the de-smoothing technique following the formula defined by Geltner (1993):

$$DRE_t^* = \alpha DRE_t^U + (1-\alpha)DRE_{t-1}^* \tag{2.4}$$

where, DRE_t^* is the observed unleveraged direct real estate value from the data at a time, t, DRE_t^U is the current market value (unleveraged) of the property at time t, and DRE_{t-1}^* is the unleveraged direct real estate value at time t-1 and α is the appraiser's confidence parameter. The above equation can be re-expressed in terms of the returns (or the log of the first differences). Following Geltner (1993) the observed returns, based on the data $r_{DRE,t}^*$, are assumed to follow an AR(1) process whereby the above equation can be re-expressed as,

$$r_{DRE,t}^* = \alpha r_{DRE,t}^U + (1-\alpha) r_{DRE,t-1}^* \tag{2.5}$$

[15] According to (Geltner, 2011) , the construction of transaction-based in the US attempts to solve the issue of sparse transaction data, by using a non hedonic-based model back in the year 2010. In particular, an appraisal-based index is converted to a transaction-based index, by multiplying the appraisal-based index with the ratio of the relative price difference between the transaction price and the recent prior appraised valuation of the sold properties each time period.

Therefore, to obtain an estimate for $\alpha,$ we employ the AR (1) model on $r^*_{DRE,t}$. Hence, we are able to recover the current market value of the property DRE^U_t as implied by the reported index return from the data $r^*_{DRE,t}$ by using the estimated α. Thus DRE^U_t can be computed as

$$DRE^U_t = \frac{DRE^*_t - (1-\alpha)DRE^*_{t-1}}{\alpha} \tag{2.6}$$

Based on our observation, our estimated α varies from the individual property sector. Therefore, we assign the estimated α accordingly, where α= 0.71 for composite direct real estate and $\alpha = \{0.68, 0.77, 0.79, 0.57\}$ for retail, offices, hotel and residential property sectors.

The direct real estate total return indices are also reported monthly on an unleveraged basis. To account for leverage, we adopt the Barclays Japan Asia-Pacific BAA Corporate Bond redemption yield, which is a proxy for the cost of debt, denoted by $\mathrm{k_{dt}}$. Following Hoesli and Oikarinen (2012), the levered direct real estate indices are obtained by using the formula:

$$DRE_t = (DRE^U_t - k_{dt} \times LTV)/(1 - LTV) \tag{2.7}$$

where $\mathrm{DRE_t}$ is the levered direct real estate index at time t, DRE^U_t is the unleveraged direct real estate index, $\mathrm{k_{dt}}$ is the cost of debt in time t, and LTV is the loan-to-value ratio of Japanese REITs (both composite and sectors), which we set at 55% for the study period (Sumitomo Mitsui Trust Research Institute, 2016).[16]

We express all indices in real terms by deflating the nominal index values. We deflate the index value by using the monthly consumer price index (CPI). We take natural logarithms of the REITs, direct real estate, and stock market indices for the analysis. We assume returns to be

[16] The survey conducted by Sumitomo Mitsui Trust Research Institute in 2016, indicates that Japanese REITs real estate managers report LTV ratios of more than 50% and less than 60%. Hence, we set the LTV for this study at the 55% level.

continuously compounding by differencing the time series. A summary of the variables used for each property sector is provided in Table 2.1.

Table 2.1

Data Sources and Variables

Variable	Abbreviation	Source	Period
Direct Real Estate			
Overall	DRE	AJPI Composite and Sectorial Direct Real Estate Indices	2002:m6-2019:m12
			2004:m4-2019:m12
Retail	Retail_DRE		2003:m6-2019:m12
Office	Office_DRE		2001:m12-2019:m12
Hotel	Hotel_DRE		2006:m6-2019:m12
Residential	Res_DRE		2004m3: 2019m12
REITs			
Overall	REIT	Datastream Japan REITs	2002:m6-2019:m12
Retail	Retail_REIT	Datastream Japan Retail REITs	2003:m6-2019:m12
Office	Office_REIT	Datastream Japan Office REITs	2001:m12-2019:m12
Hotel	Hotel_REIT	Datastream Japan Hotel REITs	2006:m6-2019:m12
Residential	Res_REIT	Datastream Japan Residential REITs	2004m3: 2019m12
Common Stocks			
Overall stock market	Stock	Tokyo Price Index (TOPIX)	2001:m12-2019:m12
Small-cap Stock	SmStock	TOPIX small	2001:m12-2019:m12

Notes. This table reports a summary of the collected dataset**.** Data for all assets is collected from Datastream except for the direct real estate indices, taken from AJPI database. We analyse the period from April 2004 (2004m4) to December 2019 (2019m12) for all sectors except for the hotel sector, for which observations begin in June 2006 (2006m6).

Descriptive statistics are reported in Table 2.2, whereby continuously compounded returns are obtained by taking the difference in logs. In general, REITs have a higher mean than direct real estate indices. However, the direct real estate indices are less volatile than the REITs indices. The standard deviation of the direct real estate indices ranges from 0.0033 to 0.0052, while the standard deviation of the Japanese REITs indices ranges from 0.0425 to 0.0647. The stock market index has lower volatility compared to REITs. As proposed by Bonato (2011), we compute a measurement of skewness and kurtosis for the return series that robust to any extreme observation in data generating processes[17]. We observed that return series are not positively or negatively skewed and kurtosis for each asset return fluctuates around 3.00.

[17] Bonato (2011) proposes a quantile-based measurement of skewness and kurtosis that robust to extreme observation in data generating processes. In particular, we use Bowley coefficient of skewness by Hinkley (1975) given by the formula $SK = \frac{Q_{1-\alpha}+Q_{\alpha}-2Q_{\alpha}}{Q_{1-\alpha}-Q_{\alpha}}$ with $\alpha = 0.25$. On the other hand, we use Crow & Siddiqui (1967) measure of kurtosis given by the formula $KR = \frac{Q_{1-\alpha}-Q_{\alpha}}{Q_{1-\beta}-Q_{\beta}}$ with $\alpha = 0.025$ and $\beta = 0.25$ respectively

Table 2.2

Descriptive Statistics

Variables	Mean	Std Dev	Min	Max	Skewness	Kurtosis
ΔStock	0.0048	0.0519	-0.1337	0.1380	-0.1132	3.1655
ΔSmStock	0.0077	0.0547	-0.1588	0.1496	0.0452	3.2358
Δ REIT	0.0101	0.0461	-0.1078	0.1357	-0.0812	3.3369
ΔRetail_REIT	0.0101	0.0475	-0.1164	0.1274	-0.0122	3.1312
ΔOffice_REIT	0.0115	0.0439	-0.1094	0.1335	-0.1229	3.4287
ΔHotel_REIT	0.0072	0.0647	-0.1673	0.1779	0.0030	3.1332
ΔResidential_REIT	0.0064	0.0425	-0.1050	0.1131	-0.0224	3.2371
ΔDRE	0.0046	0.0043	-0.0065	0.0159	0.0023	3.1108
ΔRetail_DRE	0.0051	0.0033	-0.0044	0.0140	-0.0171	3.4000
ΔOffice_DRE	0.0045	0.0048	-0.0063	0.0183	-0.0738	3.0383
ΔHotel_DRE	0.0052	0.0058	-0.0080	0.0180	0.1116	3.1360
ΔResidential_DRE	0.0037	0.0043	-0.0053	0.0130	-0.0391	3.2247

Notes. This table reports the descriptive statistic for all indices. The indices are inflation-adjusted using the monthly CPI. The direct real estate index is a levered and de-smoothed index by construction. We report the statistics for all series (REITs, direct real estate and stocks) by taking the differences in logs.

2.5 Empirical Results

2.5.1 Unit root test

An initial step before estimating the vector error correction model as in equation (2.1) is to examine whether the indices used in this study exhibit unit root. The unit root reflects the nature of the non-stationary or random walk process for all series, with non-constant mean and variance (Hendry & Juselius, 2000; StataCorp, 2009). The test is conducted with a null hypothesis, that is, an index is non-stationary. This study chooses to apply two unit root tests where the first one is the Philips and Perron (1988) unit root test. Secondly, we use Dickey-Fuller Generalised Least Squares (DF-GLS) unit root test, developed by Elliott, Rothernberg, and Stock (1996). The unit root tests on the level for all indices indicate that all series are non-stationary and exhibit a unit root. So, the null hypothesis is failed to be rejected. Consequently, we follow Hendry and Juselius' (2000) recommendation by taking transformation for all series through the difference in logs. The transformation shows that at the first difference the hypothesis of non-stationarity for all indices is rejected. As we can see from Table 2.3, both unit root tests indicate the indices for all REITs, direct real estate and stock market are only stationary after taking the difference in logs, at least with 5% significance level. In short, the stationarity of all series after taking the first difference indicates they are integrated at the order one, I (1). Thus, our prerequisite tests fulfil the condition that all series (direct real estate, REITs and stocks) are non-stationary and integrated at I (1). Hence, we can incorporate the series for estimating the vector error correction model, as formulated in equation (2.1).

Table 2.3

Unit Root Tests

Variable	Philips and Perron Level	Philips and Perron First difference	DF-GLS Level (Lags)	DF-GLS First difference (Lags)
Stock	-1.169	-13.146*	-0.4900 (1)	-8.1880 * (1)
REIT	-1.345	-14.109*	0.3760 (1)	-8.4520*(1)
Retail_REIT	-1.586	-13.800*	-0.0600 (1)	- 8.0920* (1)
Office_REIT	-1.462	-14.630*	0.4190 (1)	-2.0880* (6)
Hotel_REIT	-0.432	-11.775*	-0.0560 (1)	-8.8560*(1)
Residential_REIT	-1.1270	-9.9070*	-1.0240 (1)	-2.9830* (2)
DRE^{L}	-0.652	-5.7480*	-2.0880 (4)	-4.2130* (1)
Retail_DRE^{L}	-0.958	-5.7720*	-2.5000 (5)	- 3.4800† (2)
Office_DRE^{L}	-1.155	-4.7760*	-3.1800 (1)	-3.8230* (1)
Hotel_DRE^{L}	1.364	-3.7600*	-1.1760 (1)	-3.1620* (1)
Residential_DRE^{L}	-0.1620	-4.4520*	-0.9340 (1)	-3.3500† (1)

Notes. This table shows the Phillips and Perron and Dickey-Fuller GLS (DF-GLS) unit root test for all series; REITs, stock market and direct real estate indices. 'L' denotes an additional linear time trend component for both unit root tests. The Phillips and Perron test's critical values at 1% and 5% significance level are -4.010 and -3.440 when a trend component is included and -3.480 and -2.880 when the trend component is excluded in the test. The critical values for DF-GLS at 1% and 5% significance level are -3.490 and -2.950 when a trend component is included. Otherwise, for 1% and 5% significance levels, the critical level is -2.590 and -1.950 when a trend component is excluded in the test. 5 and 1 indicate significance levels of 5% and 1%, respectively. Significance level

2.5.2 Cointegration Test and VECM Estimation

We estimate the vector error correction model, as in equation (2.1) in a multivariate system by incorporating REITs, direct real estate and the stock market as a 3-dimensional vector of indices. We set five different models that include the composite and specific property sectors: retail, office, hotel and residential. We seek to determine the optimal lag length in equation (2.1) using Hannan Quinn Information Criteria (HQIC), where j=2 is the optimal lag length.

We estimate the Johansen test of a number of cointegrating relations. We present the Johansen test for determining the number of cointegrating relations in Table 2.4. Both trace test and maximum eigenvalue test indicate one long-run cointegrating relationship between REITs, direct real estate and stock market for composite and specific property sector REITs in the Japanese market at a 5% significance level. But we indicate that the long-run relation between residential REITs, direct real estate, and stocks is absent as there is no cointegration between these three assets since r =0. The residential sector is reduced to VAR in a first difference model[18].

[18] We choose to apply Case 3 for the Johansen test of cointegration and subsequent estimation in VECM.

Table 2.4

Johansen Cointegration Test

Null	Trace test	Critical values CV 5%	Maximum eigenvalues	Critical values 5 % CV
Composite (all-property)				
r ≤ 0	52.5421	29.6800	39.5474	20.9700
r ≤1	**12.9946†**	**15.4100**	**12.6260†**	**14.0700**
r ≤2	0.3686	3.7600	0.3686	6.6500
Retail				
r ≤ 0	46.1294	34.9100	36.1917	22.0000
r ≤1	**9.9377†**	**19.9600**	**9.0842†**	**15.6700**
r ≤2	0.8535	3.7600	0.853500	6.6500
Office				
r ≤ 0	57.7003	34.9100	44.2239	22.0000
r ≤1	**15.3898†**	**19.9600**	**14.6470†**	**15.6700**
r ≤2	0.7428	3.7600	0.7428	6.6500
Hotel				
r ≤ 0	37.9972	34.9100	28.6307	22.0000
r ≤1	**9.3665†**	**19.9600**	**9.1627†**	**15.6700**
r ≤2	0.2038	3.76	0.2038	6.6500
Residential				
r ≤ 0	**28.8835†**	**34.9100**	**18.7382†**	**34.9100**
r ≤1	10.1453	19.9600	8.6522	19.9600
r ≤2	1.4931	3.7600	1.4931	6.6500

Notes. This table shows the Johansen test for cointegration between REITs, direct real estate and stocks both in the composite and individual property sector. We apply two tests for cointegration that are trace test and maximum eigenvalues statistic. The null hypothesis is there is no more than r number of cointegrating relations. † indicates the significance at 5% level.

We estimate the vector error correction model with one cointegrating relation. We perform the two tests for parameters in long-run cointegrating relation: weak exogeneity and long-run exclusion tests. We present the p-values associated with the two estimation tests, corresponding to each asset in Table 2.5. At the 5% level, the p-values for the exclusion of stocks are greater than 0.05. Therefore, we fail to reject the null that the β_S is not significantly different from zero. Hence, the stocks can be excluded from the long-run relation. As a result, we can establish a pairwise long-run relation between REITs and direct real estate. Meanwhile, in the weak exogeneity test, for the case for direct real estate, we can reject the null that α_D is not significantly different from zero. The finding on each property sector reflects that direct real estate can adjust from the long-run equilibrium. For the case of REITs, we also fail to reject the null $\alpha_R = 0$, at 10% significant level for each of the property sectors. The findings imply REITs and direct real estate are not weakly exogenous, where these two assets are participating in an error correction mechanism. We can infer that both real estate assets may deviate and readjust themselves in the long-run equilibrium. In addition, the failure to reject the null α_S is rather to be expected. Since the stocks variable is absent in the long-run relation, it should not be allowed to participate and deviate or adjust from the long-run equilibrium.

Table 2.5

Exclusion and Weak Exogeneity Test

	H_0			
Sectors	$\alpha_D = 0$	$\alpha_R = 0$	$\alpha_s = 0$	$\beta_S = 0$
All	0.0000	0.0757	0.6519	0.6500
Retail	0.0000	0.0987	0.1333	0.1920
Office	0.0000	0.0619	0.3413	0.4940
Hotel	0.0000	0.0158	0.1913	0.6610

Notes. The table shows the p-values for weakly exogenous and exclusion tests, where the significance has been set at 5% and 10% levels. These two tests are following the Chi-Square test statistic. The tests are not conducted for residential as there is no cointegration between the assets in this particular property sector.

We present the long-run cointegration equation based on the vector error correction model in Table 2.6. We normalise the long-run cointegration with respect to direct real estate, where we set the beta of DRE equal to one. Consistent with Hunter and Ali (2014), we claim our normalisation to direct real estate is necessary since it is neither weakly exogenous nor excluded in the long-run relation, unlike the case of REITs and stocks.

The long-run cointegrating equation estimation can be translated into a regression equation (Bhattacharya & Banerjee, 2003). Accordingly, each property sector REITs has an individual estimates of β beta coefficients. For instance, a point increase in the REITs index will increase the DRE index by 0.7586 units, and a point increase in the retail REITs index will increase the retail DRE index by 0.7452 units. A point increase in the office REITs index will increase the office DRE index by 0.5835 units. Similarly, in the hotel sector, a point increase in the hotel REITs index will increase the hotel DRE index by a 0.5302 unit.

Since β is less than one, the translation of the long-run cointegrating equation in a classic linear regression indicates that the increase in the price of direct real estate is somehow lower than the increase in the price of REITs. The higher level of increase in the REITs price relative to direct real estate is rather to be expected, as the latter is reported on an unleveraged basis. Differences in the rate of increase across the property sector are consistent with the heterogeneity in different types of underlying real estate asset. The differences also reflect that each type of property attracts different types of investor and each type of investor has a different perspective on the future growth of a property sector (Van Nieuwerburgh, 2019).

We also report the speed of adjustment parameter, α for REITs and direct real estate. In terms of magnitude, our results across the property sector show that the speed of adjustment of REITs ranges between 7% and 12%. The speed of adjustment of direct real estate for each sector is between 0.79% and 1.4%. REITs have a greater speed of adjustment than direct real estate. The exhibits reflect that whilst both assets adjust themselves in long-run equilibrium relation, REITs react faster than direct real estate, the shorter and smaller the temporary deviations from the long-term equilibrium (Hoesli & Oikarinen, 2016). The parameters of the exogenous time dummy variable correspond to Global Financial Crisis period in between August 2007 to March 2009 are negative and significant. The findings suggest that financial crisis negatively impact the returns of direct real estate and REITs for each property sector as well as the returns of stocks.

The findings on the speed of adjustment of REITs and direct real estate in the Japanese market indicate that each asset can deviate from the long-run equilibrium relation, and therefore each asset needs to be adjusted accordingly. Comparing the speed of adjustment between REITs and direct real estate, the former is greater than the latter. The difference in the magnitude reflects that the deviation of REITs from the cointegrating relation is somehow shorter than direct real estate, or alternatively, that the deviation of direct real estate in the short-run is longer-lasting than REITs (Hoesli & Oikarinen, 2016) . The deviation sheds light on the dynamics of each asset responding to recent changes in market information. The absorption of recent changes is then reflected in the price of REITs and direct real estate. However, we conjecture that deviation of each asset will disappear in accordance with the adjustment, allowing the cointegrating relation to persist in the long-run.

Table 2.6

Vector Error Correction Model Results for Composite and Individual Property Sector REITs

Composite REITs (k=2)					
Long-run relations	***DRE*** **= 3.4234 + 0.7586 *REIT***				
	$\boldsymbol{\alpha_D}$	$\boldsymbol{\alpha_R}$	***d_DRE***	***d_REIT***	***d_Stock***
	-0.0113*	0.0902†	-0.0025*	-0.0681*	-0.0455*
Retail (k=2)					
Long-run relations	***RETAIL*****_DRE = 3.0370+ 0.7452 *RETAIL*****_REIT**				
	$\boldsymbol{\alpha_D}$	$\boldsymbol{\alpha_R}$	***d_DRE***	***d_REIT***	***d_Stock***
	-0.0102*	0.0727‡	-0.0032*	-0.0807*	-0.0455*
Office (k=2)					
Long-run relations	***OFFICE*****_DRE= 2.9424 + 0.5835 *OFFICE*****_REIT**				
	$\boldsymbol{\alpha_D}$	$\boldsymbol{\alpha_R}$	***d_DRE***	***d_REIT***	***d_Stock***
	-0.0139*	0.0704 ‡	-0.0016†	-0.0701*	-0.0455*
Hotel (k=2)					
Long-run relations	***HOTEL*****_DRE = 3.7805+ 0.5302 *HOTEL*****_REIT**				
	$\boldsymbol{\alpha_D}$	$\boldsymbol{\alpha_R}$	***d_DRE***	***d_REIT***	***d_Stock***
	-0.0079*	0.1204†	-0.0024*	-0.0721*	-0.0455*
Residential (k=1)					
			d_DRE	***d_REIT***	***d_Stock***
			-0.0026*	-0.0788*	-0.0455

Notes. This table shows the estimation of long-run cointegration equation in the Vector Error Correction Model as in equation (2.1). The k indicates the lag length incorporated to estimate the VECM as in equation (2.1). α is the speed of adjustment parameter, d_i represent the coefficients for exogenous time dummy variable, x_t correspond to Global Financial Crisis periods, where i denotes the individual asset return, that are DRE, REITs and stocks. That is, we assign the value of x_t equals to 1 for the sample period in between July 2007 until March 2009 and 0 for other observation periods. Also note that, there is no long-run relation for Residential sector, but we include the estimates of exogenous dummy variable. *, † and ‡ denote the significance at 1%, 5% and 10% levels.

With regards to the residential sector, our findings also indicate the absence of cointegration between the residential REITs, direct real estate and stock. The absence of cointegration is not that peculiar to the residential property sector, where similar findings have been documented in the US Apartments market (Hoesli & Oikarinen, 2012, 2016). Often, residential properties are often used by households for consumption and not for income generation (Dietz & Haurin, 2003; Sinai & Souleles, 2005). Meanwhile, other commercial real estate are tenant-occupied and income are generated from rentals. For business, owning a commercial properties is capital intensive, and often renting is a cost efficient option (Barkham & Park, 2011; Brounen & Eichholtz, 2005). The above arguments highlights the differences between residential and other property sector, where it supports our findings that no cointegration relation can be established between residential REITs, residential DRE and stocks.

Our analysis in the vector error correction model framework provides an understanding of the return characteristics of Japanese REITs, in general and in specific property sectors, where Japanese REITs are akin to real estate, rather than stocks. Therefore, our study expands the literature on the return characteristics of the Japanese REITs . In addition, the findings on Japanese REITs overlap and conform with the evidence of cointegration between REITs and direct real estate conducted on other markets both in general (Morawski et al., 2008; Oikarinen et al., 2011; Sebastian & Schatz, 2009; Yong & Pham, 2015; Yunus et al., 2012) and in specific property sectors (Boudry et al., 2012; Hoesli & Oikarinen, 2012, 2016). Our study on Japanese REITs supports the notion of the cointegration and the implied substitutability of REITs as a real estate asset (Glascock et al., 2017). The investor could make a small gain by including both REITs and direct real estate in a portfolio. As a result, the holding of fractional shares in Japanese REITs is similar to investment in direct real estate. The investment in REITs has a comparative advantage in terms of liquidity and lower transaction costs. Japanese REITs in various property sectors provide access to a larger pool of investors (such as retail investors) in income-producing commercial real estate assets, which might previously have been limited to institutional investors.

2.5.3 Granger Causality Test

Our estimations using the VECM also account for short-run relations between assets inclusive of the differenced set of the VECM equation. In this section, we investigate the causal relationship between one asset and another using the Granger causality test. Consistent with Yunus et al. (2012), our test on the short-run causal relationship between all assets is based on the vector error correction model (VECM):

$$\Delta y_t = \mu + \Gamma_i y_{t-i} + \Gamma_i y_{t-p} + \alpha C + \alpha ECT_{t-1} + \varepsilon_t \quad (2.8)$$

where Δy_t=(Δj_$\mathrm{DRE}_t, \Delta j$_$\mathrm{REIT}_t, \Delta S\mathrm{TOCK}_t)$. According to Granger (1988), there are two sources of causation. The first source is through the lagged values of independent variables, as measured by the non-zero coefficients of Γ_i; or alternatively through the coefficients of the speed of adjustment parameter, α. The latter source of causality is associated with an error correction mechanism, whereby the dependent variables adjust to deviations from the long-run cointegrating relationship in the period of $t-1$. To illustrate, suppose that we set direct real estate $\Delta\mathrm{DRE}_t$ as the dependent variable. The equation can be rewritten as:

$$\Delta\mathrm{DRE}_t = \mu + \sum_{t=1}^{p} \Gamma_i \Delta\mathrm{REIT}_{t-i} + \sum_{t=1}^{p} \Gamma_i \Delta\mathrm{DRE}_{t-i} + \sum_{t=1}^{p} \Gamma_i \Delta\mathrm{STOCK}_{t-i} + \alpha C + \alpha\, ECT_{t-1} + \varepsilon_t \quad (2.9)$$

where $ECT_{t-1} = \mathrm{DRE}_{t-1} - \mathrm{DRE}^{*}_{t-1}$. We can say that REITs Granger direct real estate if

- The coefficients of the lagged $\Delta\mathrm{REIT}_{t-i}$ are jointly significant as measured by the F-statistic, or

- The coefficient of α is significant, as calculated by the t-statistic (Yunus et al., 2012).

We conduct the test for REITs in composite and individual property sectors either with the stock market or the respective direct real estate indices. We present the findings on the Granger causality test in Table 2.7. In the Table 2.7, we report the p-value of the relation between the lagged and contemporaneous variable as well as the speed of adjustment parameter of REITs and direct real estate.

We observe the significant relation between lagged REITs and stocks, but no significant relation between lagged stocks and REITs. The results show that REITs can Granger cause stocks, whilst stocks are not able to Granger cause REITs. The findings on the leading role of Japanese REITs contradict the evidence of causality in an early study by Clayton & Mackinnon (2003) for the US market. Nevertheless, the leading role of Japanese REITs is not unusual with the evidence of leading role of real estate market found in Asian countries, like Singapore and Taiwan (T. C. Lin & Lin, 2011). With regards to the Japan, the country had experienced with real estate price bubble in the 1980s, since investors held the assets for speculative purposes (Stone & Ziemba, 1993). In the year 1990, the central bank increased their interest rates as a mean to control speculative behaviour in the property market. However, It turned out this action led to collapse in the stocks and real estate prices, and Japan was in a long-term recession until the year 2000 (Kanaya & Woo, 2000). Meanwhile, the securitisation of real estate assets in the form of REITs began in the Japanese market in the year 2001. From there onwards, it could be the case that investors have learnt the history, and thus be cautious on information on the real estate market that also can be useful to stocks. In fact, there were two economic events in the Japanese market showed the leading of REITs followed by the stocks market [19]. Given

[19] In year 2007, it is found that REIT index peaked out two months before a separate high in Nikkei 225 share. While in the year 2013, it is found that a peak in REITs arrived about two months before a mini-collapse in the broader equities market in May. See https://www.reuters.com/article/markets-japan-reit-idUKL3N0ZQ2DO20150712

these circumstances, our result on causality suggests that Japanese REITs can predict the return on stocks.

With regards to the relation between REITs and direct real estate, we observe a significant relation between lagged DRE and REITs. In addition, we observe that the speed of adjustment parameter for REITs in each property sector and direct real estate are significant, where REITs have a greater speed than direct real estate. The greater speed of adjustment for the Japanese REITs is not unusual with the evidence found in the studies conducted in the UK real estate market (Hoesli & Oikarinen, 2012). The findings reflect that REITs are a more liquid asset, and they incorporate new real estate information more rapidly than direct real estate. Accordingly, REITs also serve as a channel to transmit real estate information to predict direct real estate returns (Ling & Naranjo, 2015). Nonetheless, our findings in the Japanese market emphasise that the causal relation is not only from REITs to direct real estate. Rather, direct real estate also Granger causes REITs. The evidence of a feedback effect indicates the presence of bi-directional causality between REITs and direct real estate.

The findings on predictability of REITs by direct real estate returns in the Japanese market resemble those of US REITs prior to the modern REIT era in the 1990s (Oikarinen et al., 2011) and the predictability of UK REITs (Hoesli & Oikarinen, 2012, 2016). The reason may be that US REITs prior to the 1990s and UK REITs established in the mid-2000s were immature and less informationally efficient (Hoesli & Oikarinen, 2012, 2016). We conjecture that the predictability of the Japanese REITs occurs because there is a lack of direct participation amongst sophisticated institutional investors, like pension funds (public and private sector) in the Japanese REITs. Instead, the investment in the Japanese REITs by pension funds takes place through trust bank channels[20]. Also, there is a wide array of investors, although in small proportions. These include banks, insurance companies, foreign and local investors[21]. These group of small investors may not be capable to bear the cost of collecting information on an asset return and their performance (J. Chen, 2007) Thus, there is information asymmetry amongst the small market players in the Japanese REITs. (J. Chen & Kawaguchi, 2018). Accordingly, the lack of direct participation of institutional investors and presence of several groups of small investors contributes to the lack of informational efficiency of Japanese REITs, since their returns are also predictable by direct real returns.

Taken together, the causal relation between REITs, direct real estate and stocks in the Japanese market gives us two different narratives. On one hand, the causal relation between REITs and direct real estate indicates that the lack of Japanese REITs to be an informationally efficient asset, as direct real estate can also predict the return of REITs. On the other hand, the causal relation between REITs and stocks suggests Japanese REITs contain useful information to predict the returns on stocks.

[20] Trust banks in the Japanese market function as an intermediary which provide an access to portfolio of assets, including REITs. Typically, trust banks are akin to mutual funds. Nomura Research Institute (2020), presents the portfolio of assets owned by private and public pension funds, whereby, the trust bank accounts for about one-third of asset under management managed by the Japanese private and public pension funds.

[21] As presented in figure 1.3 (on page 24), there are different types of investors in Japanese REITs. This includes, City and Regional Bank (5.4%), Life Insurance Companies (1%), Non-life Insurance Companies (0.3%), Other financial institutions (3.6%), Securities Companies (2.1%), Business Corporation (7.9%), Foreign Investor (25.4%) and Domestic Individual Investor (11.8%).

Table 2.7

Granger Causality Test

Composite	Independent variables			
Dependent Variables	Δ*REIT*	ΔDRE	ΔSTOCK	Adjustment speed, α
Δ*REIT*	-	0.024†	0.7660	0.0348†
ΔDRE	0.5420	-	0.5130	0.0000*
ΔSTOCK	0.0140†	0.6000	-	0.1602
Retail	Independent variables			
Dependent Variables	Δ*RETIAL*_REIT	Δ*RETAIL*_DRE	ΔSTOCK	Adjustment speed, α
Δ*RETIAL*_REIT	-	0.0270†	0.7860	0.0790‡
Δ*RETAIL*_DRE	0.7510	-	0.3960	0.0000*
ΔSTOCK	0.0200†	0.9730	-	0.2280
Office	Independent variables			
Dependent Variables	Δ*OFFICE*_REIT	Δ*OFFICE*_DRE	ΔSTOCK	Adjustment speed, α
Δ*OFFICE*_REIT	-	0.0470†	0.9700	0.0708‡
Δ*OFFICE*_DRE	0.5100	-	0.3110	0.0000***
ΔSTOCK	0.1160	0.9860	-	0.4290
Hotel	Independent variables			
Dependent variables	Δ*HOTEL*_REIT	Δ*HOTEL*_DRE	ΔSTOCK	Adjustment speed, α
Δ*HOTEL*_REIT	-	0.0030*	0.3810	0.0183†
Δ*HOTEL*_DRE	0.3070	-	0.3020	0.0000*
ΔSTOCK	0.0000*	0.1920	-	0.1610
Residential	Independent variables			
Dependent variables	Δ*RESIDENTIAL*_REIT	Δ*RESIDENTIAL*_DRE	ΔSTOCK	Adjustment speed, α
Δ*RESIDENTIAL*_REIT	-	0.3150	0.5210	
Δ*RESIDENTIAL*_DRE	0.0020*	-	0.0580‡	
ΔSTOCK	0.1390	0.5360	-	

Notes. The table reports the p-values for the Granger causality test. The null hypothesis is no Granger causality between one series and another. First, is the p-values associated with lagged values of independent variables, measured by the F-statistic. Second is the p-values associated with the speed of adjustment parameter, α, determined by the t-statistic. *, †, and ‡ denotes significance at 1%, 5%, and 10% level.

2.5.4 Forecast Error Variance Decomposition

The estimation of the VECM allows us to examine the sensitivity of each asset return (REITs, direct real estate and stocks) attributable to the shocks exerted to one of the assets. First, we adopt variance decomposition analysis. The variance decomposition discloses the proportions of forecast error variance in each index owing to a shock in the other asset and within the individual asset. We present the forecast error variance decomposition results in the table 2.8. The forecast error variance of each asset is decomposed into contributions from exogenous shocks to the three assets. The columns represent the source of the exogenous shocks which originate in the DRE, REITs and stock. The decomposition is presented in the rows whereby the sum of shares of the variance across each row equals one.

We observe that shocks to REITs can explain their forecast error variance. For instance, shocks to hotel REITs can explain about 65.2% of their forecast error variance decomposition. In other types of REITs, we find that their forecast variance can be explained by their own shocks, for instance, 75.3% in retail REITs, 96.6% in residential and 81% in composite REITs. Shocks to REITs can also account for variance decomposition for their respective peers in direct real estate assets. We establish that shocks to REITs can explain 63% of the forecast error variance decomposition in DRE. In other cases, we observe office REITs can explain 74.7% of the forecast error variance decomposition of office DRE. The forecast error variance decomposition for retail and hotel DRE is about 49% and 44% respectively explained by retail and hotel REITs. An exception is the residential case, where shocks to residential REITs can explain only 3.75% of the forecast error variance decomposition of residential DRE.

The shocks to DRE can also explain the variance decomposition of REITs but with a lower percentage. For instance, the variance decomposition for each type of REIT can be determined by 18.2% from DRE, 24.7% from shocks to retail DRE, 13.2% from shocks to office DRE, 35.7% from shocks to hotel DRE, and also 3.2% from shocks to residential DRE respectively.

The shocks received by DRE can also explain their variance decomposition. Shocks to retail DRE and office DRE contribute 51% and 56% to their variance decomposition, respectively. The shocks to composite DRE can explain 25% of their variance decomposition. Our result in office DRE shows that 37% of their variance decomposition due to internal shocks. However, in the residential sector, the shocks to their DRE account for the highest proportion of the variance decomposition, which is close to 95%.

In the case of stocks, our findings across property sectors show that the shocks to their market account for more than 60% of their variance decomposition, whereas shocks to REITs in the composite, retail and office REITs give proportions of 24%, 31.5% and 21.5% respectively to the variance decomposition of stocks. However, we find that shocks to DRE account for a relatively low proportion of the variance decomposition for stocks, that is, less than the 10% level. In addition, the findings on a relatively low proportion of stocks to the variance decomposition in REITs suggest shocks to stocks do not have a significant impact on REITs.

All in all, our results show that despite the varying proportions of forecast error variance decomposition in each type of asset, the results are not inconsistent with the estimation in the long-run relation between REITs, direct real estate and stocks. In particular, the cointegration between REITs and direct real estate reflects their tight association with the exclusion of stocks in the long run. The ability of shocks to REITs to explain the variance decomposition of stocks is parallel with the causal relation between REITs and stocks. However, the absence of cointegration in the residential sector accentuates the lack of each asset's contribution towards variance decomposition amongst the asset returns. Instead, their variance decomposition is explained by the shocks received from the individual market.

Table 2.8

Variance Decomposition

Composite REITs		Shock to	
Variance decomposition of	*REIT*	DRE	STOCK
REIT	0.8097	0.1802	0.0001
DRE	0.6285	0.3714	0.0001
STOCK	0.2364	0.0335	0.7301
Retail REITs		Shock to	
Variance decomposition of	*RETAIL*_REIT	*RETAIL*_DRE	STOCK
*RETAIL*_REIT	0. 7528	0. 2469	0.0003
*RETAIL*_DRE	0. 4903	0. 5088	0.0009
STOCK	0.3149	0.0631	0.6220
Office		Shock to	
Variance decomposition of	*OFFICE*_REIT	*OFFICE*_DRE	STOCK
*OFFICE*_REIT	0.8677	0.1322	0.0001
*OFFICE*_DRE	0.7473	0.2523	0.0004
STOCK	0.2151	0.0133	0.7716
Hotel		Shock to	
Variance decomposition of	*HOTEL*_REIT	*HOTEL*_DRE	STOCK
*HOTEL*_REIT	0.6518	0.3476	0.0006
*HOTEL*_DRE	0.4393	0.5605	0.0002
STOCK	0.01363	0.0329	0.8308
Residential		Shock to	
Variance decomposition of	*RESIDENTIAL*_REIT	*RESIDENTIAL*_DRE	STOCK
*RESIDENTIAL*_REIT	0.9659	0.0320	0.0022
*RESIDENTIAL*_DRE	0.0375	0.9457	0.0168
STOCK	0.0155	0.2382	0.7462

Notes. This table reports forecast error variance decomposition for each asset return, at the time horizon of 48-months. Each row presents the forecast error variance decomposition of an asset return. The columns represent the source of the exogenous shocks which originate in the DRE, REITs and stock. For each row, the sum of the proportions for the forecast error variance decomposition of an asset equals 100%.

2.5.5 Impulse Response Function

We further analyse an asset's dynamics in response to the shocks received to one asset by applying impulse response function analysis. The impulse response function shows the magnitude of an asset’s response to one standard deviation of shocks both on the asset itself and on another asset. The findings of this function can be illustrated with a diagram where the horizontal axis is the period from which shocks occur. The vertical axis measures the speed at which an asset responds to shocks occurring from another market. In our study, we derive the impulse response function for REITs, direct real estate, and stocks, both in composite and specific property sectors, for a period of up to 48 months.

We present the impulse response function for the composite and for each property sector in Figure 2.1. In each figure, the first variable is the response variable, and the second variable is the impulse, or the origin of the shock variable. We observe first the IRF for each asset due to an impulse in the DRE market. We find DRE responds positively to the shocks from their market. There is an increase in the magnitude of the response of REITs, to the impulse from DRE, but it reduces as the horizon expands. Stocks respond positively to shocks from DRE, and this continues to increase at a low rate. Based on the second row, we can see that DRE reacts positively to the shocks received by DRE, and the magnitude increases over several months.

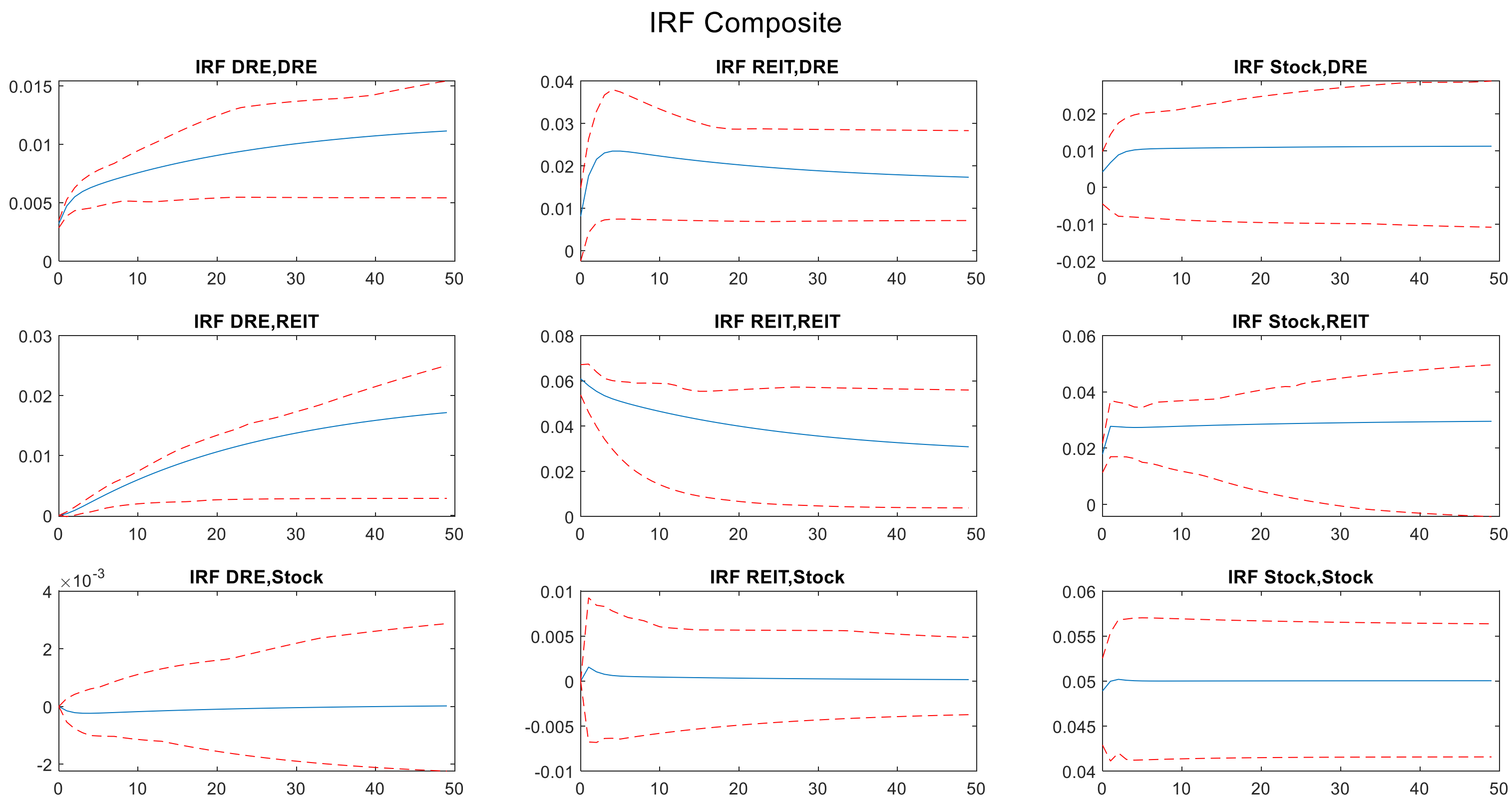
REITs respond negatively to shocks received from their assets, where we observe the declining pattern in their IRF curve. Stocks also react positively to the impulse in REITs, albeit at a higher magnitude than in the case of DRE. In the third row, we observe DRE responds negatively to the impulse on stocks, in the initial months, before continuing to rise and increase in subsequent months, albeit at a low magnitude. REITs react positively to shocks to stocks in the early months, but then show a negative reaction in magnitude.

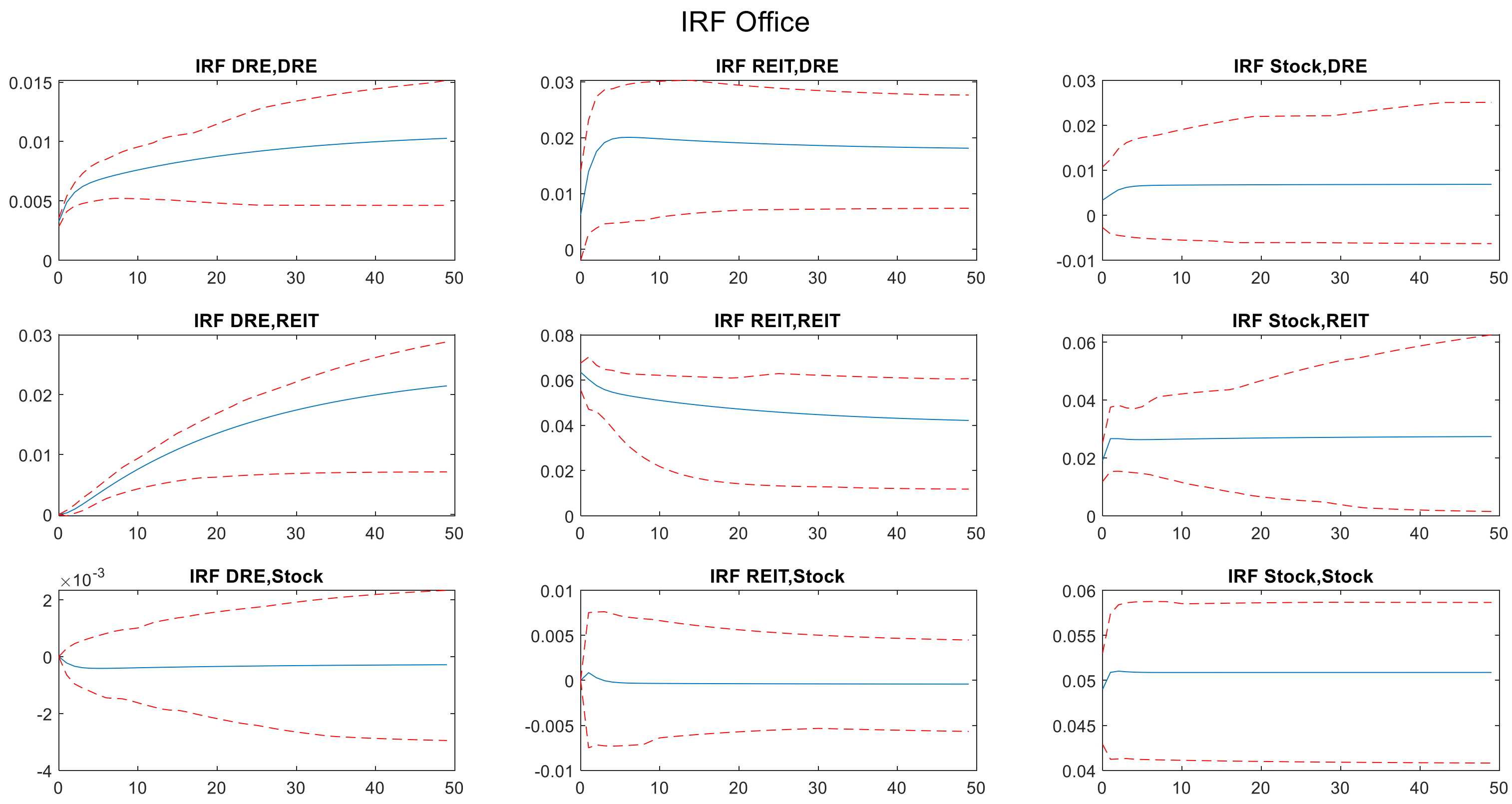
Stocks react positively to the impulse within their own. The magnitude increases in the initial months and stabilises in the remaining months. In the residential market, we observe that all assets react to the shocks received from their own and other assets. However, the responses die out quickly after several months. The findings on the residential sector are peculiar to their own market as the relationship between these assets is derived from the VAR in the first differences.

Our findings using the impulse response function are consistent with the long-run and short-run causal relationship between the assets in our VECM estimation. The cointegration established between REITs and DRE shows both assets are sensitive to shocks to one of their peers. However, we observe a difference in magnitude. Our results show that REITs respond positively to shocks received by direct real estate, although the magnitude is gradually reduced with the increase in the horizon. However, when DRE reacts positively to the shocks received by REITs, the magnitude continues to increase in subsequent months. Meanwhile, the findings on the causal relationship between REITs and stocks is consistent with the leading role of REITs. The results reflect a slow response of the lagged asset market to shocks from the lead market (Glascock et al., 2017).

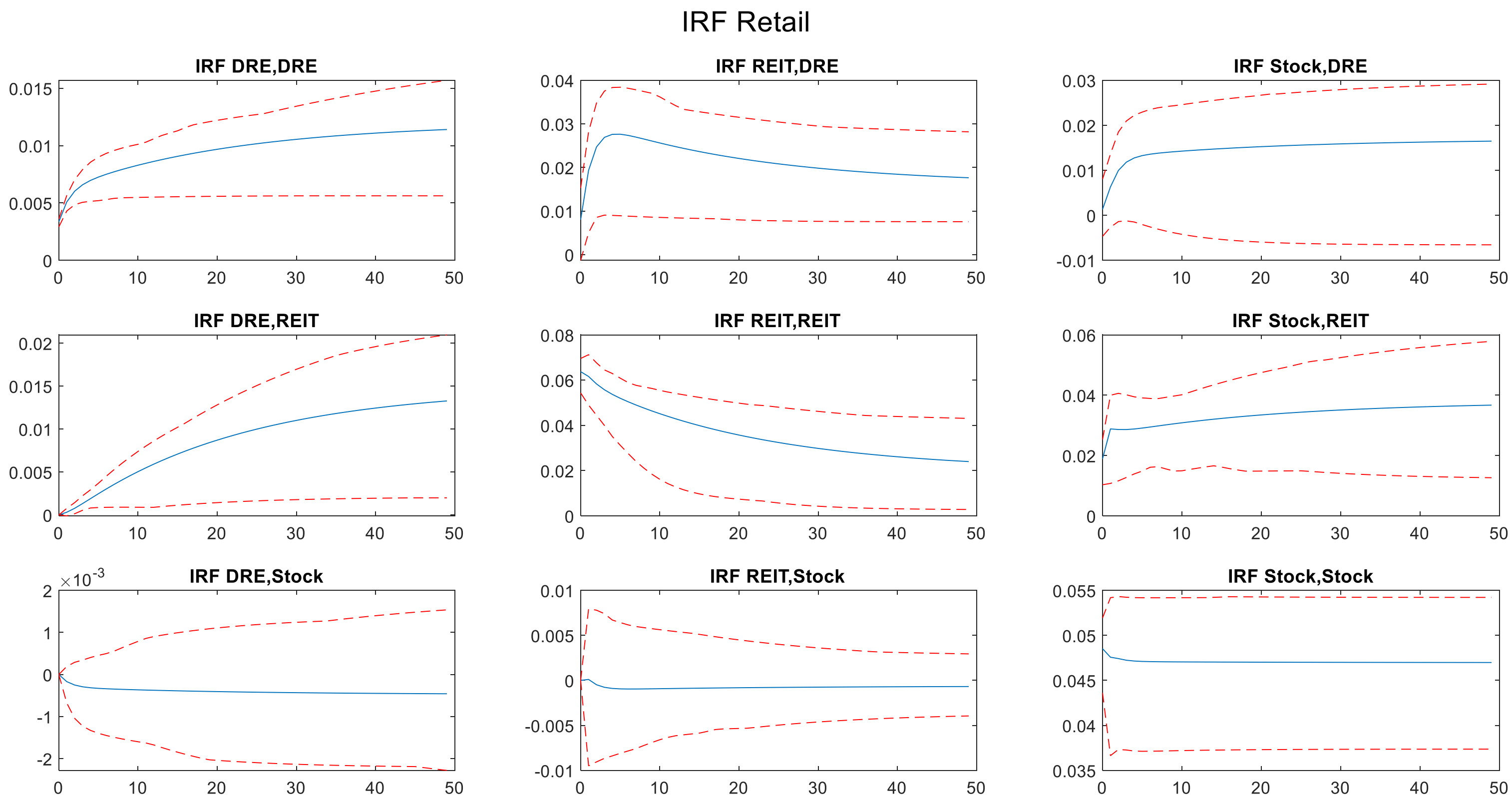
Figure 2.1

Impulse Response Function

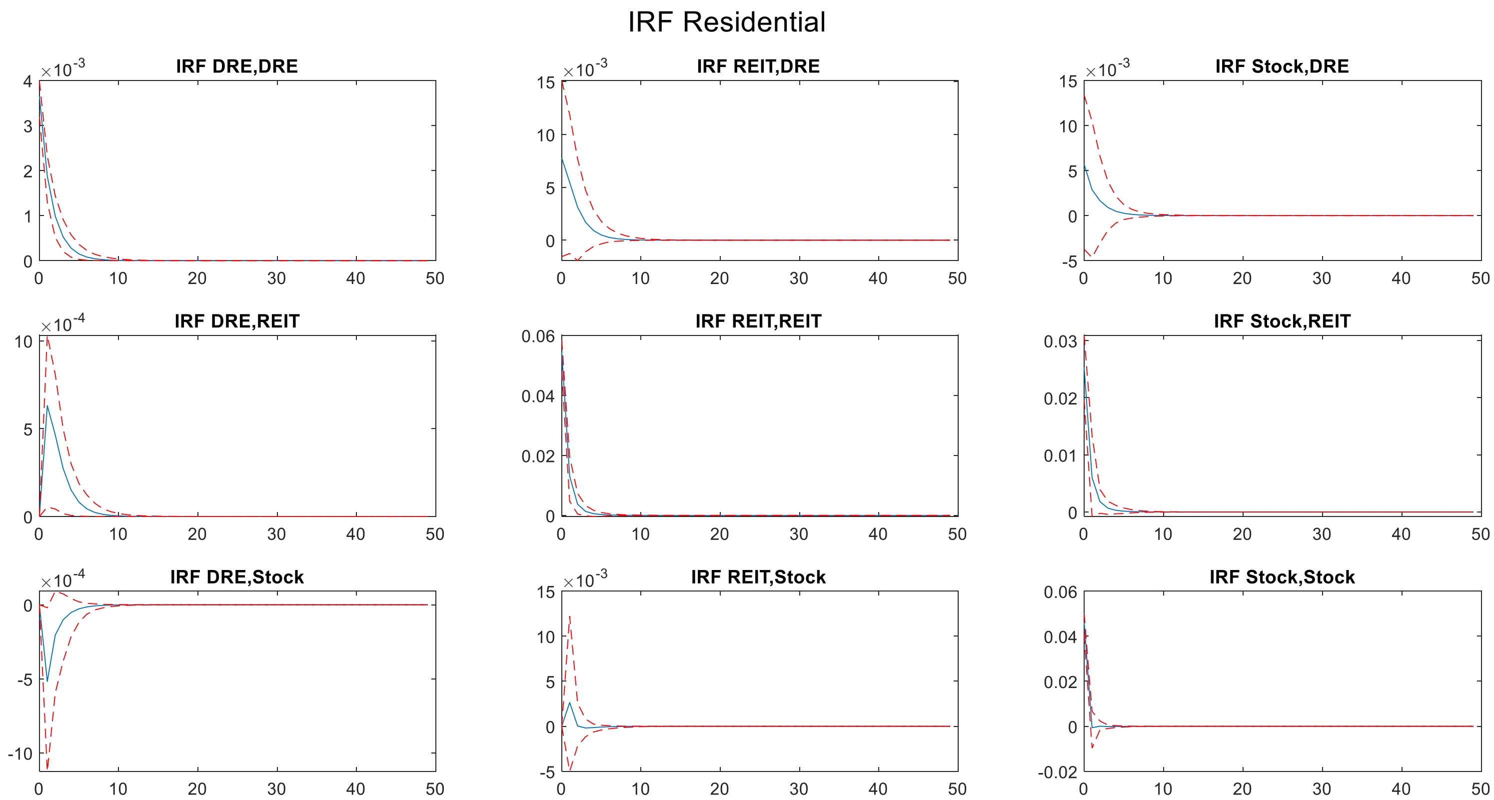




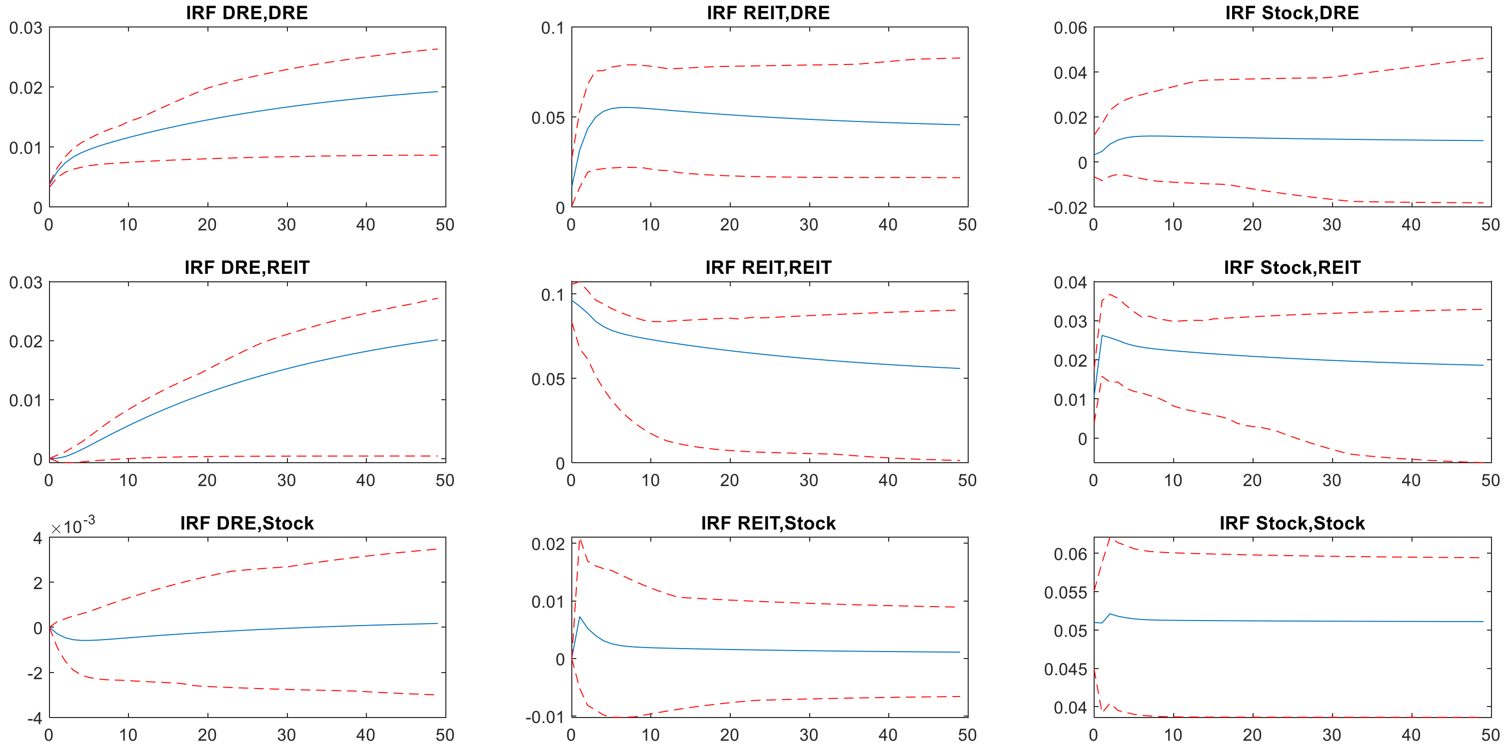
IRF Office
IRF DRE,DRE
IRF REIT,DRE
IRF Stock,DRE
IRF DRE,REIT
IRF REIT,REIT
IRF Stock,REIT
IRF DRE,Stock
IRF REIT,Stock
IRF Stock,Stock



IRF Retail
IRF DRE,DRE
IRF REIT,DRE
IRF Stock,DRE
IRF DRE,REIT
IRF REIT,REIT
IRF Stock,REIT
IRF DRE,Stock
IRF REIT,Stock
IRF Stock,Stock


IRF Residential
IRF DRE,DRE
IRF REIT,DRE
IRF Stock,DRE
IRF DRE,REIT
IRF REIT,REIT
IRF Stock,REIT
IRF DRE,Stock
IRF REIT,Stock
IRF Stock,Stock

IRF Hotel



Notes. These figures represent the impulse response function for the time horizon up to 48 months. We consider the impulse and response functions between REITs, direct real estate and the stock market. We represent these figures for composite, retail and residential property sectors. Each figure is labelled accordingly in the form of IRF, where the first variable is the response variable, and the second variable is the impulse, the origin of the shocks variable response variable and impulse (shock) variable (separated by comma). The red dash line is the 95% confidence bands. The x-axis of the time horizon is on a monthly frequency.

2.5.6 Robustness Check

As a robustness check on the tight long-run relationship of REITs with direct real estate, we re-estimate the VECM as in equation (2) by replacing the TOPIX index as the proxy for an overall stock market variable with a small-cap stock index. The exercise is consistent with Boudry et al. (2012), where REITs can also be akin to small-cap stocks. Therefore, we replace the TOPIX with the TOPIX small as the proxy for the small-cap stocks. We conduct the estimation in composite and individual property sectors, namely retail, office, and hotel real estate[22].

We present the findings from the robustness check in Tables 2.9 and 2.10. Our empirical estimation indicates one cointegrating relation between REITs, direct real estate and small-cap stocks in the long-run in the Japanese market. As with stocks, the small-cap stocks can also be excluded from the long-run cointegrating relationship. Small-cap stocks are also weakly exogenous, as they do not participate in long-run adjustment processes. The inclusion of small-cap stocks does not alter the error correction mechanism between REITs and direct real estate. Notwithstanding, the exogenous dummy variable correspond to Global Financial Crisis periods is significant, which negatively impact the return on the small-cap stocks. All in all, we can say that small-cap stocks do not negate the earlier findings on pairwise cointegration between REITs and direct real estate in the long-run.

[22] As before, the index for the small-cap stocks will be entered with the same period and total number of observations, as determined by the availability of REITs and direct real estate data.

Table 2.9

Johansen Cointegration Test with Small-Cap Stocks

Null	Trace test	Critical values	Maximum eigenvalues	Critical values
All				
r ≤ 0	48.0471	29.6800	39.7752	20.9700
r ≤1	**8.2720†**	**15.4100**	**7.9846†**	**14.0700**
r ≤2	0.2874	3.7600	0.2874	6.6500
Retail				
r ≤ 0	39.8907	34.9100	32.2764	22.0000
r ≤1	**7.6142†**	**19.9600**	**7.1306†**	**15.6700**
r ≤2	0.4837	3.7600	0.4837	6.6500
Office				
r ≤ 0	57.3345	34.9100	44. 9573	22.0000
r ≤1	**12.3771†**	**19.9600**	**11.4042†**	**15.6700**
r ≤2	0.9729	3.7600	0.9729	6.6500
Hotel				
r ≤ 0	34.3739	34.9100	26.1313	22.0000
r ≤1	**8.2426†**	**19.9600**	**8.1745†**	**15.6700**
r ≤2	0.0681	3.7600	0.0681	6.6500
Residential				
r ≤ 0	**22.1128†**	**34.9100**	**11.8897†**	**34.9100**
r ≤1	10. 2231	19.9600	9.0293	19.9600
r ≤2	1.1938	3.7600	1.1938	6.6500

Notes. This table shows the Johansen test for cointegration between REITs, direct real estate and stocks both in composite and individual property sectors. We apply two tests for cointegration, namely the trace test and maximum eigenvalues statistic. The null hypothesis is there are no more than r number of cointegrating relations. † indicates the significance at a 5% level.

Table 2.10

Vector Error Correction Model Results with Small-Cap Stocks

Composite REITs (k=2)			
Long-run relations	***DRE* = 3.2135 + 0.6317 *REIT***		
	DRE	***REIT***	**SmSTOCK**
P-value in weak exogeneity test	0.000	0.0341	0.4745
Speed of adjustment parameter	-0.0118	0.0889	P-value in exclusion for SmSTOCK 0.129
Retail (k=2)			
Long-run relations	***RETAIL*_DRE= 3.0553+ 0.6107*RETAIL*_ REIT**		
	***RETAIL*_DRE**	***RETAIL*_REIT**	**SmSTOCK**
P-value in weak exogeneity test	0.000	0.0194	0.9465
Speed of adjustment parameter	-0.0099	0.0964	P-value in the exclusion test for SmSTOCK 0.947
Office (k=2)			
Long-run relations	***OFFICE*_DRE= 3.14541 + 0.6409 *OFFICE*_REIT**		
	***OFFICE*_DRE**	***OFFICE*_REIT**	**SmSTOCK**
P-value in weak exogeneity test	0.000	0.0624	0.9002
Speed of adjustment parameter	-0.0139	0.07954	P-value in the exclusion test for SmSTOCK 0.128
Hotel (k=2)			
Long-run relations	***HOTEL*_DREIT = 3.552+ 0.4897 *HOTEL*_REIT**		
	***HOTEL*_DRE**	***HOTEL*_REIT**	**SmSTOCK**
P-value in weak exogeneity test	0.000	0.014	0.4931
Speed of adjustment parameter	-0.0081	0.1065	P-value in the exclusion test for SmSTOCK 0.631
d_SmStk	-0.0487*		

Notes. This table shows the estimation of long-run cointegration equation in the vector error correction model as in equation (2.1) by replacing the stocks variable with a small cap stock. The k indicates the lag length incorporated to estimate the VECM as in equation (2.1). *d_SmStk* represent the exogenous time dummy variable correspond to Global Financial Crisis periods, That is, we assign the value of 1 for the sample period in between July 2007 until March 2009 and 0 for other observation periods. *, † and ‡ denote the significance at 1%, 5% and 10% levels.

2.6 Conclusion

REITs are a hybrid asset sharing some characteristics of the underlying physical real estate assets they derive income from and some features of equity to which they bear similarity in terms of business organisation and trading marketplace. Their presence in the Japanese market has important implications as an additional avenue for investment in real estate assets, especially for stock market investors. This chapter examines the long-run linkages and short-term dynamics between REITs, direct real estate, and stocks in the Japanese market by adopting the vector error correction model. We examine the individual characteristics of REITs and direct real estate using the error correction mechanism and excluding stocks from the long-run relationship. We supplement our analysis in VECM through analysis of causal relations, variance decomposition and impulse response function analysis.

By considering specific property sectors, we find evidence of a single cointegrating relation between REITs, direct real estate and stocks. We find that REITs and direct real estate are pairwise cointegrated as stocks can be excluded from the long-run relationship. Our findings further show that REITs and direct real estate participate in an error-correction mechanism where REITs are faster than direct assets in adjusting in a long-run equilibrium relation. However, there is a lack of information efficiency gain by REITs in terms of feedback from the direct markets as evidenced in the Granger causality test. Also, it appears that REITs and direct real estate are interrelated as the two assets react with the shocks in either of the two markets, where direct real estate is more vulnerable to shocks in the REITs market.

Our estimation of the vector error correction model conforms to indications of long-run linkages between REITs and direct real estate found in developed real estate markets like the US and European and Australian markets. Thus, REITs can be a substitute for the direct real estate market and typically provide the same diversification benefit for the stock market investor. Now, the question of practical importance is to use the VECM model for deriving the correlations between asset returns over investment in different time horizons. We will explore and discuss this issue in the subsequent chapter.

CHAPTER 3

Investment Horizons and Correlations. Evidence from Japanese REITs

3.1 Introduction

The transition of real estate as an asset class from 'Main Street' to 'Wall Street' and its transformation from a lumpy, illiquid asset to a highly liquid security traded on a stock exchange represents a general long-term trend in Japan and in other global real estate markets. In view of this, the allocation of a property in a portfolio of real estate assets held by an equity REIT takes into account individual property attributes: capitalisation rates, property size, and vacancy rates (Plazzi et al., 2011)[23].

In particular, Ghysels, Plazzi, Valkanov, & Torous (2013) argue that the vacancy rate is negatively related to the income of a property, where a high level of vacancy reduces rental income and contributes to the poor performance of the REITs (Hoesli & Reka, 2015). In terms of capitalisation rate, Beracha, Downs, & MacKinnon (2017) indicate that a higher capitalisation rate predicts a higher level of real estate returns. Plazzi et al., (2011) suggest that the optimal portfolio weights are tilted to real estate with a high capitalisation rate. Lastly, Pai & Geltner (2007) show that large property may earn a return premium. Large REITs acquire and hold large properties and vice versa since large REITs can efficiently generate revenue and control their costs (Highfield, Shen, & Springer, 2021), and can also secure debt to finance a property at a lower rate than small REITs (Cvijanović, Milcheva, & van de Minne, 2021). For REITs, accounting for these attributes is vital, as subsequent returns may be detrimental to the performance of the individual property in their portfolio of real estate assets (Hoesli & Johner, 2021; Plazzi, Torous, & Valkanov, 2010).

[23] The construction of portfolio of real estate asset for REITs manager is different from the conventional Markowitz portfolio theory. In particular, the Markowitz theory accounts for estimation of expected return and variance-covariance matrix of two or multiple number of assets in a portfolio. The theory is applicable to solve for asset allocation problem involving REITs and other financial assets (like stocks and bonds) as well as direct real estate asset.

Recent studies shed some light on the participation of institutional investors in REITs (Ling, Wang, & Zhou, 2021; Milcheva, Yildirim, & Zhu, 2021). Against this background, an important issue for institutional investors is how to allocate REITs and other investable assets, such as direct real estate and stocks, in a buy-and-hold portfolio for different time horizons. Past studies have heavily relied on the Vector Autoregressive of lag 1 VAR(1) model to derive an estimate of a variance-covariance matrix to solve the asset allocation puzzle between direct real estate, REITs, and stocks (Campbell & Viceira, 2005a). To date, the application of this model in the past has suggested that REITs are moderately correlated with direct real estate in the long run (Delfim & Hoesli, 2019; Mackinnon & Al Zaman, 2009; Pagliari, 2017). With regards to the term structure of volatility, prior studies that use this model have indicated REITs to be more volatile than stocks (Delfim & Hoesli, 2019; Fugazza et al., 2015). Because of that, the allocation to REITs has considerably reduced with the increase in an investment horizon.

On the other hand, we argue that the application of VAR(1) to model variance-covariance matrix involving REITs and direct real estate is not consistent with the compelling evidence of cointegration between these two assets in the long run, that construes REITs as real estate rather than stocks. Therefore, we suggest that the asset allocation framework needs to account for the cointegration relation between the two real estate assets rather than be limited to short-run autoregressive relations.

By using the data of Japan's REITs, direct real estate and stocks from April 2004 to December 2019, we estimate the vector error correction model involving the three assets in one cointegrating relation and excluding stocks from the long-run equilibrium relation. We use the VECM to model a portfolio choice framework for investment in different time horizons. In particular, we modify the Campbell and Viceira asset allocation model by adding the long-run cointegration component between REITs and direct real estate. We then use the revised framework to derive the variance-covariance matrix between asset returns over different time horizons, from 1-month up to 20-year periods. Our estimated variance-covariance matrix generates the term structure of risk for each asset return as well as the correlation structure between REITs and direct real estate and REITs and stocks pairs, and direct real estate and stocks. Lastly, we further use the estimated variance-covariance matrix implied by the VECM into a mean-variance portfolio optimisation in a buy-and-hold portfolio setting in short-, medium- and long-term horizons. This chapter seeks to address the following questions:

i. What is the implication of the cointegration relation between REITs and direct real estate for correlations and variance-covariance structures between DRE, REITs and stocks?

ii. What is the optimal allocation of DRE, REITs and stocks over different time horizons?

Our studies extend the earlier literature in several ways. To the best of our knowledge, our study is the first that accounts for the cointegration relation between REITs and direct real estate to derive an estimate of a variance-covariance matrix in a different time horizon. In this context, we derive the term structure of volatility and correlation between REITs, direct real estate and stocks implied from the VECM model. Our analysis in this chapter suggests that the estimation of volatility and correlation based on the VECM provides a better estimate of volatility and correlation, than in the VAR model.

To be specific, our volatility structure, as implied by the VECM, indicates that the term structure of risk for REITs asset returns is lower than that implied based on the estimates in the VAR model. The differences reveal the distinction between these two econometric models, where the latter model omits the cointegration relation between REITs and direct real estate. The cointegration relation sheds some light on the error correction mechanism between REITs and direct real estate. This mechanism corrects for deviation in the short-run disequilibrium in the long-run relation between the two assets. We conjecture that as REITs correct and adjust faster, this causes REITs to be a less volatile asset in the long run.

In addition to that, we accentuate the ability of VECM to express the correlation between asset returns at different time horizons. To be specific, across the property sectors, our results on the term structure of correlation portray REITs and direct real estate as positively correlated, and their correlation is close to 1 at a time horizon of 20 years. Also, we find that the correlation between REITs and stocks, and direct real estate and stocks, are also positively correlated, albeit with a lower correlation than between REITs and direct real estate. The cointegration relation implies the correlation between REITs and direct real estate returns increases with the increase in the time horizon. Thus, our findings on correlation implied by the VECM indicates the limitation of the VAR model, which understates the correlation between REITs and direct real estate.

Secondly, our study contributes to bridging the gap in the literature that underline the cointegration relation between REITs and direct real estate and the literature on asset allocation problem for investment in a different time horizon. In particular, we use the variance-covariance matrix implied by the VECM to form an optimal portfolio allocation involving direct real estate, REITs and stocks, for a time horizon up to 20 years. Our results indicate the allocation of REITs and stocks for 1-year investment horizon. For a medium-term horizon of 4 to 8 years, we observe a mixed-asset portfolio of REITs, direct real estate and stocks, while in the long run, an investment can be channelled solely to direct real estate. We find that REITs generally gain a higher allocation in a mixed-asset portfolio for short- and medium-term horizon, when we use the variance-covariance matrix as implied from the VECM, compared to the VAR. Our analysis offers practical guidelines for institutional investors with a buy-and-hold portfolio involving REITS, direct real estate and stocks, by considering the cointegration relation between the real estate assets derived from the VECM model.

3.2 Literature Review

3.2.1 Optimal Portfolio of Real Estate in Conventional Portfolio Theory

It is widely known that traditional portfolio theory applies unconditional estimates of moments of return and risk to construct an optimal portfolio of mixed assets. Hoesli, Lekander, and Witkiewicz (2004) perform an optimal portfolio exercise involving direct real estate, stocks and bonds for various countries between 1987 and 2001. Their study reports the correlation between direct assets and bonds ranges between -0.5 to 0.2, and direct assets and stocks ranges between -0.2 to 0.4 They report that estimates of an optimal portfolio involving 5% to 15% allocation of direct assets helps to reduce portfolio risk by about 5% to 10% level. Lee and Stevenson, (2005) examine the role of REITs in a mixed-asset portfolio with a long-run investment horizon. They roll their sample data to compute the covariance and correlation estimates for 5-, 10- 15- and 20- year periods. They report an increase in average allocation of REITs from 9.5% in a 5-year horizon up to 16% in a 20-year investment horizon. A study by Mueller and Mueller, (2003) reports the unconditional correlation of direct real estate and REITs of 0.20 in the US market. In their 25-year investment horizon portfolio, they report a 33% allocation to REITs and 36% allocation to direct real estate assets. Their findings reflect a diversification benefit through investment in these two assets as the correlation is low despite REITs being riskier than illiquid real estate assets.

3.2.2 Underlying Characteristics of Direct Real Estate Investment

Nevertheless, investment in direct real estate has its own complexity, compared to other financial assets. It is widely known that investment in direct real estate incurs a high level of transaction costs. For instance, Collet, Lizieri and Ward, (2003) suggest a round-trip transaction cost of 7% to 8% in trading direct assets. They conjecture that the assessment of profitability from acquiring and investing in real estate needs to account for such transaction costs. They suggest the determination of a holding period on the property for the cost to be covered, arguing that different properties have different holding periods, where larger buildings typically have a greater holding period than small buildings. In comparison with financial assets, the expectation would be that holding periods for direct properties would be much greater than for stocks and bonds. In relation to optimal portfolio application, therefore, the use of unconditional correlation and covariance estimates without accounting for transaction costs and holding periods involving real estate will lead to a lethal portfolio diversification.

Investment in direct real estate also leads to the issue of illiquidity, where immediate sale execution may not be possible. This gives rise to a marketing period, before the actual transaction takes place (Z. Lin & Liu, 2008; Z. Lin & Vandell, 2007). The application of modern portfolio theory may be inadequate to capture illiquidity as a key characteristic of direct real estate investment. Cheng, Lin and Liu, 2010 suggest the term structure risk of direct real estate needs to account for illiquidity risk and should be horizon dependent. Cheng, Lin, and Liu (2013) test the portfolio implications by incorporating the real estate risks. They suggest a marketing period of 4 to 12 months and a holding period of between 2 and 6 years, consistent with Collet et al. (2003). They suggest an optimal allocation of direct real estate of between 3 and 8%. In a subsequent study, Cheng et al. (2017) test their model by varying transaction costs and targeting a portfolio return of 10.5% per annum. They identify a holding period between 4 and 6 years and an 18% allocation to direct real estate assets.

In contrast, Bond, Hwang, Lin and Vandell (2007) develop a model that takes into account the marketing period risk in a portfolio context. They conjecture that the risk will be diversified away as the unsystematic (i.e. marketing period risk) in individual properties diminishes. Anglin and Gao, (2011) suggest the inclusion of liquid assets together with illiquid direct real estate so as to mitigate the marketing period risk. A subsequent analysis by Rehring (2012) presents evidence that the risk is negligible in a portfolio context, given the inclusion of direct real estate with other assets in a mixed-asset portfolio. Rather, consistent with holding period literature on direct assets, these studies confirm that estimation is horizon dependent in the term structure of risk for each asset within a portfolio, where the risk will be negligible as the holding period of direct assets increases.

3.2.3 Mean Variance Long-Horizon Portfolio with Real Estate Assets

A substantial number of studies adopt the Campbell and Viceira (2005a) framework. The framework appreciates the autoregressive processes between past and contemporaneous asset returns, as well as the correlation between past shocks to a variable and the unexpected return component of an asset. It raises the notion of predictability, where positive autocorrelation reflects a mean-aversion in the term structure of risk and negative autocorrelation exacerbates a mean-reversion in the term structure of risk. As a result, this framework modifies the conventional portfolio theory by inducing horizon effects in expectation of risk and return for each asset; either in the short- or long-run.

Other studies include Fugazza et al. (2007) on the optimal portfolio allocation of REITs, stocks and bonds for European markets. They find that REITs and stocks have a higher degree of predictability as compared to bonds. In what follows, a mean-reversion effect occurs where these two risky assets are more attractive as their term structure of risk is lower in the long-run than in the short-run. The attractiveness of these two assets can be seen in the increase in the optimal portfolio allocation from 9% to 30% for a 1-year horizon to 44% and 33% for a 10-year horizon, respectively. As bonds are a riskier asset, in the long-run they become a less attractive investment with a lower allocation in the portfolio, where the allocation diminishes from 60% to 20% in a 10-year horizon. In similar framework, Fugazza et al. (2009) assess the diversification benefits of REITs in a mixed-asset portfolio with stocks and bonds. The allocation to REITs increases to 30% with a similar decrease in allocation to stocks, for an investment horizon of up to 60-months or 5-years. As a result, the inclusion of REITs improves the portfolio Sharpe ratio. The improvement is consistent with the decrease in the term structure of risk of REITs since they are a less volatile asset as compared to stocks.

Mackinnon and Al Zaman, (2009) incorporate REITs and direct real estate and consider their predictability structure with other assets, stocks, and bonds. They examine a decreasing term structure of risks for all asset returns. In their mean-variance portfolio, they suggest the allocation to direct real estate assets increases as the investment horizon lengthens, where the allocation of direct real estate is higher than REITs. For instance, at a 10-year horizon, the portfolio consists of 20% direct real estate and only 4% REITs. This is consistent with the lower risk level of direct real estate than REITs, despite the correlation between these two assets becoming higher at 0.60 level in the long run.

Hoevenaars et al. (2008) suggest an optimal portfolio of assets with liabilities including REITs as an additional asset, apart from stocks, bonds and treasury bills. The study reports the mean-averting term structure of risk for REITs, which is higher than stocks. The correlation between these two assets is 0.65, on average. This inclusion of liabilities fails to capture REITs as a diversifiable asset, as it accounts for only 1% of allocation for investment horizons of 5- to 25-years. Fugazza et al. (2015) compare the out-of-sample portfolio performance between equally weighted and optimal portfolios within a VAR framework for the case of European markets. They report a mean-averting pattern in the term structure of risk in REITs and bonds. The volatility of stock reduces as the time horizon increases. By using a power utility function, the effect can be seen in the allocation to REITs in investment horizons from 1-month to 60-months. As the aversion level increases, the allocation to REITs gradually reduces as the time horizon increases from 24-month to 60-months. Nevertheless, the predictability framework of VAR in optimal buy-and-hold portfolios outperforms the equal-weighted portfolio in terms of higher mean return, as the investment horizon is greater than 12 months.

Rehring (2012) incorporates transaction costs and marketing period risk as additional factors in the framework. The investment in direct real estate increases to a peak of 87%, as the horizon extends from 9 years to 20 years. The allocation to stocks gradually reduces whilst the allocation for bonds fluctuates around 1% to 13%. Accounting for transaction costs causes the allocation to DRE is unfeasible in the short-run, as the high transaction costs need to be amortised over a long-horizon period. He shows the relative importance of predictability, transaction costs and marketing period risk. He shows that the absence of predictability will lead to a substantial reduction in real estate allocation for the medium- and long-term horizon. Also, the effect of negating transaction cost is severe since it will lead to an over allocation of direct real estate in the short-term investment horizon, whilst considering marketing period risk appears to make no significant difference to the optimal portfolio.

In another perspective, Pagliari (2017) incorporates a long-term portfolio allocation of real estate with investors' level of risk aversion. He accounts for the presence of predictability between current and past asset returns on the estimation of a time-horizon covariance matrix. The study examines the increased correlation between REITs and direct real estate in the long run, where either REITs or direct real estate can be included but should not exceed the 15% level. Their findings classify investment in real estate based on risk preference, in particular, REITs for a risk taker and direct counterparts for risk-averse investors. This is consistent with the premise on the use of leverage; particularly in REITs. Amédée-Manesme, Barthélémy, Bertrand and Prigent, (2019) develop a continuous time portfolio optimisation model by taking into account the mean reversion in the term structure of risk for direct real estate assets. In a utility-based model, they test their model against the Rehring (2012) dataset. By assuming a low level of risk aversion, this study reports a similar result on the 80% allocation to direct real estate for a 20-year horizon.

Delfim and Hoesli (2019) expand the menu of real estate assets, by including REITs, direct real estate, and real estate funds in the US market. In contrast to earlier studies, they report a mean-aversion in the term structure of risk for stocks and direct real estate. In a similar fashion, the correlation between these two assets is higher in the long run than in the short run. The portfolio allocation of stock gradually reduces whilst direct real estate increases to 20%. In competing real estate assets, they emphasise that REITs are a partial substitute to direct real estate under a short-term investment horizon of fewer than two years. Nevertheless, they suggest real estate funds are a better substitute for long-term investment as the correlation between the funds and direct assets is up to 80%.

Guidolin, Pedio and Petrova, (2020) investigate the degree of predictability and its exploitability in REITs and DRE markets, in a standard VAR model and VAR with a Markov switch framework. By using the latter framework, they present a time-varying predictability structure to forecast the returns on these two assets. The estimation of an optimal portfolio in mean-variance utility indicates a 75% allocation for REITs and direct real estate for a five-year investment horizon. More importantly, their suggested alternative VAR specification implies portfolio diversification of DRE and REITs with other financial assets, particularly for the improvement of portfolio performance and utility for investors with an intermediate level of risk aversion, over a standard VAR model.

3.2.4 Portfolio Allocation Model Based on VECM Framework

The presence of cointegration between REITs and DRE in various markets underlines the limitation of VAR(1) in the Campbell and Viceira model, to address the long-run comovement between these two real estate assets. Thus, a question of practical importance concerns the suitability of incorporating cointegration into long-horizon portfolio allocation. However, portfolio application based on a cointegration framework is relatively scarce. Phengpis and Swanson (2011) test the cointegration between several stock markets. Using monthly data, they form an equal-weighted portfolio by incorporating excludable assets from the long-term cointegrating relation. They contend that the use cointegration, by incorporating excludable assets, will further improve portfolio performance as the investment horizon expands up to a seven-year holding period. Gallo and Zhang (2010) form a cointegration test of real estate stocks amongst 14 countries from different regions. They identify five countries which are non-cointegrated and nine countries which are cointegrated. They report that the average correlation of cointegrated countries is higher than that of non-cointegrated countries. They show the optimal portfolio of real estate stocks between cointegrated and non-cointegrated countries where the former underperforms the latter portfolio with a higher level of risk. Haran et al. (2013) present evidence of cointegration between REITs and DRE in the UK, Australian and Swedish markets. They apply unconditional correlation coefficients to examine the optimal portfolio between the two assets plus stocks and bonds. Their findings on mean-variance frontiers indicate REITs will be favoured in a high-risk spectrum whilst DRE will be favoured in a low-risk spectrum. A similar attempt by Glascock et al. (2017) forms a value-weighted portfolio of stocks including REITs and listed property companies. They argue that there are limited diversification benefits between these two liquid real estate assets as they are cointegrated, though not perfect substitutes.

From the above literature, it appears that a cointegration-based portfolio implied from the vector error correction model still follows traditional portfolio theory on the correlation and covariance structure between asset returns. Also, previous studies are yet to address the optimal portfolio allocation exercise with different holding periods, implied by cointegration. The choice to estimate a covariance matrix involving real estate is necessary so as to avoid it being a harmful portfolio diversifier (Platanakis, Sakkas, & Sutcliffe, 2019). In short, the close linkages between REITs and direct real estate prompts us to expand the VECM model which is not limited to cointegration analysis. Rather, we seek to emphasise the application of the VECM model to address the covariance and correlation structure between REITs, direct real estate and stocks and the implications for an optimal portfolio over different time horizons, particularly in the context of the Japanese market.

3.3 Methodology

3.3.1 Campbell and Viceira (2005) Long-Horizon Asset Allocation Model

The Campbell and Viceira (2005) long-horizon asset allocation model assumes that returns follow a VAR (1) process. The equation of VAR(1) processes can be represented as

$$z_t = \theta_0 + \theta_1 z_{t-1} + v_t \tag{3.1}$$

where z_t is 3x1 vector of asset returns, θ_0 is a vector of constant terms and θ_1 is the 3x3 vector of autoregressive coefficients of past asset returns. v_t is a vector of error terms assumed to iid with zero mean and covariance matrix such that $v_t \sim N(0, \Sigma_v)$.

Since the VAR(1) processes induce the return predictability, between past and contemporaneous asset returns, it contributes towards the conditional covariance structure in the asset returns. In particular, the term structure of risk for each asset return is detrimental to the unexpected component for each asset return, captured in the covariance matrix of the error term Σ_v. Nevertheless, although the model is horizon-dependent in terms of the structure of risk, it assumes the variance and covariance of the error term do not vary over time (Campbell & Viceira, 2005b). Therefore, for each time horizon, k, with a data frequency f, the conditional covariance matrix imputed from VAR (1) can be defined as:

$$\frac{f}{k} Var_t(z_{t+1} + \cdots + z_{t+k}) \tag{3.2}$$

$$= \frac{f}{k}\left(\sum_v + (I + \theta_1) \sum_v (I + \theta_1)' + (I + \theta_1 + \theta_1\theta_1) \sum_v (I + \theta_1 + \theta_1\theta_1)' + (I + \theta_1 + \ldots + \theta_1^{k-1}) \sum_v (I + \theta_1 + \ldots + \theta_1^{k-1})'\right)$$

with I as an identity matrix. The elements in the diagonal matrix are the variance for each asset return and off-diagonal elements are the covariance between the asset returns.

3.3.2 Vector Error Correction Model

Nevertheless, the assumption of asset returns following the VAR(1) processes does not take into account of the cointegration relation between assets, that are REITs and direct real estate. Hence, consistent with the findings of the Johansen cointegration test in Chapter 2, subsection 2.5.2, we establish the vector error correction model with one co-integrating relationship (r=1) and one autoregressive lag, $(p-1)=1$, where p=2[24]. Also, we allow for intercept terms in differenced series and cointegrated relation. We then restate VECM in a matrix form as

$$\begin{bmatrix} \Delta DRE_t \\ \Delta REIT_t \\ \Delta Stock_t \end{bmatrix} = \begin{bmatrix} \mu_D \\ \mu_R \\ \mu_S \end{bmatrix} + \begin{bmatrix} a_{DD} & a_{DR} & a_{DS} \\ a_{RD} & a_{RR} & a_{RS} \\ a_{SD} & a_{SR} & a_{SS} \end{bmatrix} \begin{bmatrix} \Delta DRE_{t-1} \\ \Delta REIT_{t-1} \\ \Delta Stock_{t-1} \end{bmatrix} + \begin{bmatrix} \alpha_D \\ \alpha_R \\ \alpha_S \end{bmatrix} e_{t-1} + \begin{bmatrix} \alpha_D \\ \alpha_R \\ \alpha_S \end{bmatrix} C + \begin{bmatrix} u_t \\ v_t \\ w_t \end{bmatrix} \quad (3.3)$$

In this representation, the second term accounts for the short-run dynamics of the assets in the differenced term. The third term captures the long-run equilibrium cointegration relationship, where α_i are the speed of adjustment coefficient and e_{t-1} is the long-run cointegration relation. The last term represents the vector of error terms. Also, the equation (3.3) will be reduced to VAR with a lag 1 if the vector for speed of adjustment parameter equals to zero.

Adjusting for the constant term, we have the VECM model as

$$\begin{bmatrix} \Delta DRE_t \\ \Delta REIT_t \\ \Delta Stock_t \end{bmatrix} = \begin{bmatrix} \mu_D & \alpha_D C \\ \mu_R + & \alpha_R C \\ \mu_S & \alpha_S C \end{bmatrix} + \begin{bmatrix} a_{DD} & a_{DR} & a_{DS} \\ a_{RD} & a_{RR} & a_{RS} \\ a_{SD} & a_{SR} & a_{SS} \end{bmatrix} \begin{bmatrix} \Delta DRE_{t-1} \\ \Delta REIT_{t-1} \\ \Delta Stock_{t-1} \end{bmatrix} + \begin{bmatrix} \alpha_D \\ \alpha_R \\ \alpha_S \end{bmatrix} e_{t-1} + \begin{bmatrix} u_t \\ v_t \\ w_t \end{bmatrix} \quad (3.4)$$

Where $e_t = DRE_t - b_R REIT_t - b_S Stock_t$ and $e_{t-1} = DRE_{t-1} - b_R REIT_{t-1} - b_S Stock_{t-1}$.

Combining the two above two equations, we obtain

$$e_t - \Delta DRE_t + b_R \Delta REIT_t + b_S \Delta Stock_t = e_{t-1} \quad (3.5)$$

[24] We assume the lag of 2, p=2 in the underlying VAR processes. Therefore, we have the VECM baseline model with a lag of 1.

by fitting the VECM. Adding equation (3.5) to the other three equations presented in (3.4), we obtain the following system of equations:

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -1 & b_R & b_S & 1 \end{bmatrix} \begin{bmatrix} \Delta DRE_t \\ \Delta REIT_t \\ \Delta Stock_t \\ e_t \end{bmatrix} \tag{3.6}$$

$$= \begin{bmatrix} \mu_D & \alpha_D C \\ \mu_R + \alpha_R C \\ \mu_S & \alpha_S C \end{bmatrix} + \begin{bmatrix} a_{DD} & a_{DR} & a_{DS} & \alpha_D \\ a_{RD} & a_{RR} & a_{RS} & \alpha_R \\ a_{SD} & a_{SR} & a_{SS} & \alpha_S \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \Delta DRE_{t-1} \\ \Delta REIT_{t-1} \\ \Delta Stock_{t-1} \\ e_{t-1} \end{bmatrix} + \begin{bmatrix} u_t \\ v_t \\ w_t \\ 0 \end{bmatrix}$$

We assume φ_t as is iid with zero mean and covariance matrix such that $\varphi_t \sim N(0, \Sigma_v)$.The variance-covariance matrix of error terms, is given by

$$\Sigma_v \coloneqq Cov\left(\begin{bmatrix} u_t \\ v_t \\ w_t \end{bmatrix}\right) = \begin{bmatrix} \sigma_{uu}^2 & \sigma_{uv}^2 & \sigma_{uw}^2 \\ \sigma_{uv}^2 & \sigma_{vv}^2 & \sigma_{wv}^2 \\ \sigma_{uw}^2 & \sigma_{wv}^2 & \sigma_{ww}^2 \end{bmatrix}$$

To simplify our model specification, a shorthand representation of the above system in the equation (3.6) is given by:

$$\mathrm{BX_t} = \pi + \mathrm{DX_{t-1}} + \varphi_\mathrm{t} \tag{3.7}$$

where $\mathrm{X_t} = (\Delta\mathrm{DRE_t}, \Delta\mathrm{REIT_t}, \Delta\mathrm{Stock_t}, \mathrm{e_t})'$. Pre-multiplying equation (3.7) with B^{-1} we obtain

$$\mathrm{X_t} = \mathrm{B}^{-1}(\pi + \mathrm{DX_{t-1}} + \varphi_\mathrm{t}) \tag{3.8}$$

3.3.3 Derivation of Expected K-Period Term Structure of Risk and Correlation Implied from VECM

To estimate the k-period moments of the covariance matrix, we modify the Campbell and Viceira (2005a) framework to accommodate our VECM framework. In particular, our term structure of risk captures the unpredictable components for each asset return determined by error terms φ_t and the disequilibrium of cointegrated assets in the long-run relation, particularly in e_{t-1}. Consistent with Campbell and Viceira (2005b), we assume that variance and covariance of the error term may not vary over time, that is, $\varphi_t \sim N(0, \Sigma_v)$. Assume that the vector x_t is the vector of asset return for each asset. Thus, we define the expression of k-period covariance matrix of the vector x_t, as follows:

$$Var_t(x_{t+1} + \cdots + x_{t+k}) = Var_t[(I + \theta_1 + \cdots + \theta_1^{k-1})v_{t+1} + \ldots(\mathrm{I}+\theta_1+\ldots+\theta_1^{k-2})v_{t+2}+\ldots+(I + \theta_1)v_{t+k-1} + v_{t+k}\ ] \tag{3.9}$$

$$Var_t(x_{t+1} + \cdots + x_{t+k}) = \textstyle\sum_v + (I + \theta_1)\sum_v(I + \theta_1)' + (I + \theta_1 + \theta_1\theta_1)\sum_v(I + \theta_1 + \theta_1\theta_1)' + (I + \theta_1+\ldots+\theta_1^{k-1})\sum_v(I + \theta_1+\ldots+\theta_1^{k-1})' \tag{3.10}$$

where $\sum_v$ is the estimated covariance matrix of the residuals (or error terms). The diagonal in the matrix $\sum_v$ captures the variance for the residuals for each asset return and covariance of the residuals implied from VECM. I is the 4x4 identity matrix and $\theta_1 = \mathrm{B}^{-1}(\mathrm{D})$, where B is a matrix inclusive of long-run cointegrating coefficients and D is a matrix composed of autoregressive terms and coefficients of speed of adjustment parameter α_i, for each asset involved in the VECM system of equations.

The estimated covariance matrix for each time horizon, k, allows us to obtain the variance of each asset return. In particular, at a horizon, k, and data frequency, f (f=12), the variance of each asset return can be determined as:

$$\frac{12}{k} Var\left(\sum_i^k x_{t+i}\right) = \tag{3.11}$$

$$\frac{12}{k}\begin{bmatrix} var_t\left(D_{t+k}^{(k)}\right) & Cov_t\left(D_{t+k}^{(k)}, R_{t+k}^{(k)}\right) & Cov_t\left(D_{t+k}^{(k)}, S_{t+k}^{(k)}\right) \\ Cov_t\left(D_{t+k}^{(k)}, R_{t+k}^{(k)}\right) & var_t\left(R_{t+k}^{(k)}\right) & Cov_t\left(R_{t+k}^{(k)}, S_{t+k}^{(k)}\right) \\ Cov_t\left(D_{t+k}^{(k)}, S_{t+k}^{(k)}\right) & Cov_t\left(R_{t+k}^{(k)}, S_{t+k}^{(k)}\right) & var_t\left(S_{t+k}^{(k)}\right) \end{bmatrix}$$

Also, by using the equation (3.11), we can determine the correlation between asset returns. For instance, at any time horizon k, we can set the correlation between REITs and stocks as

$$Corr\left(R_{t+k}^{(k)}, S_{t+k}^{(k)}\right) = \frac{Cov_t\left(R_{t+k}^{(k)}, S_{t+k}^{(k)}\right)}{\sqrt{var_t\left(R_{t+k}^{(k)}\right) var_t\left(S_{t+k}^{(k)}\right)}} \tag{3.12}$$

We suggest two sources that affect the term structure of volatility for returns on each type of asset over multi-period horizons. First, consistent with Campbell and Viceira (2005a), concerns the autocorrelation of asset returns. To be specific, the positive autocorrelation stems from a positive correlation between error terms ρ_{ij}; which reflects that past shocks to an asset will also cause the volatility of another asset to increase, compounded by the positive autoregressive terms between the past return on an asset and the current return on the other asset a_{ij}. The combined effects of these two terms $a_{ij}\rho_{ij} > 0$ contributes to the positive autocorrelation for an asset return, which causes the term structure of risk to increase with the increase in time horizon.

Alternatively, the negative correlation between error terms ρ_{ij}; which reflects past shocks to an asset, will also cause the volatility of another asset to decrease, compounded with the positive autoregressive terms between the past return of an asset and the current return for the other asset a_{ij}. Hence, the negative autocorrelation, $a_{ij}\rho_{ij} < 0$ implies that asset volatility exhibits a mean reversion, whereby as the time horizon increases, the volatility of an asset reduces.

The VECM framework also captures the deviation of the cointegrated asset from the long-run equilibrium relation, e_{t-1}. We argue that the disequilibrium from the long-run relation is the additional factor that contributes to the term structure of volatility for each asset's returns. Of particular interest are the cointegrated assets, which involve the speed of adjustment parameters. The parameters in the error-correction process reflect an asset's responsiveness to deviation from the long-run equilibrium. In particular, the high speed of adjustment reduces the volatility of an asset. A low speed of adjustment causes an asset's volatility to increase with the increase in the time horizon.

3.3.4 Derivation of Expected K-Period Moments of Expected Return

We use the unconditional mean to derive the k-period of expected returns for each asset[25]. So, for each time period, k, and unconditional mean return for each asset $\bar{x}^{26}$, we defined the expected log return for each asset as

$$E\left(x_{t+k}^{(k)}\right) = \frac{k}{12}\bar{x}, k[1,240] \tag{3.13}$$

[25] Instead of forecasting returns by means of VECM or VAR, we choose to apply this method to estimate the k-period expected return for each asset to form a level playing field for the long-horizon optimal portfolio for the VECM and VAR(1) process. The application has been extensively used to examine the optimal portfolio under average market conditions (Mackinnon & Al Zaman, 2009). Guidolin, Pedio, and Petrova (2020) use a similar approach to examine the optimal portfolio with difference covariance matrix estimation but with a same estimation procedure to estimate the expected return for each asset.

[26] We estimate the unconditional mean return for each asset, $\bar{x}$ from our available dataset.

Our expected return for each asset also accounts for transaction costs. Following Rehring, (2012), we assume transaction costs for liquid assets, stocks and REITs, of 1%. The cost comprises a brokerage fee of 0.8% and bid-ask spread of 0.2%. For direct real estate, where we assume that transaction cost would be 8%, the cost can be broken down into 4% for the brokerage fees and 4% as transfer tax (Rehring, 2012). Given the illiquidity of direct real estate, we follow Amihud and Mendelson (1986) where the transaction costs of each asset need to be amortised over the holding period. In particular, we define the annualised transaction cost as $\times \frac{12}{k}$.

3.3.5 Optimal Portfolio Allocation of REITs, Direct Real Estate and Stock Derived from VECM Model

We test the estimated covariance and correlation derived from the vector error correction model into the optimal buy-and-hold portfolio. For a particular time horizon, we follow the method of Campbell and Viceira (2005a) to determine the optimal weights of REITs, direct real estate and stocks to be included in a portfolio[27]. The objective function of the mean-variance portfolio can be defined as

$$\min \frac{1}{2}\frac{12}{k}\left(Var_t\left(r_{p,t+k}^{(k)}\right)\right) \tag{3.14}$$

Subject to

$$\frac{12}{k}\left(E_t(r_{p,k}) + \frac{1}{2}Var_t\left(r_{p,t+k}^{(k)}\right)\right) = \mu_{p,k} \tag{3.15}$$

[27] Typically, the inclusion of a risk-free asset (like a 3-month treasury bill) will be rolled over for a long-term investment horizon. The practice causes the risk free asset to be susceptible to reinvestment (or real interest rate) risk (Campbell & Viceira, 2005b; Rehring, 2012). Alternatively, another example of risk-free asset like nominal government bond can also be highly risky in real terms, since inflation risk can be relatively high in the long-run (Campbell & Viceira, 2005a). In view of this, we have decided not to include risk free asset in the contruction of optimal portfolio for investment in a different time horizon.

The variance of portfolio return can be defined as

$$Var_t\left(r_{p,t+k}^{(k)}\right) = w_t' Var\left(\textstyle\sum_i^k x_{t+i}\right) w_t \tag{3.16}$$

where w_t is the (3 x 1) vector of the assets weights and $Var\left(\sum_i^k x_{t+i}\right)$ is the estimated variance-covariance matrix for each asset, as implied from the estimated VECM. The log of the expected portfolio return can be defined as

$$\frac{12}{k}\left(E_t(r_{p,t+k}) + \frac{1}{2}Var_t\left(r_{p,t+k}^{(t)}\right)\right) = \frac{12}{k}\left(w_t'\left((E_t(x_{t+k} - c) + \frac{1}{2}\sigma_r^2(k)\right)\right) \tag{3.17}$$

Consistent with Rehring (2012), we also apply Jensen's inequality adjustment. The expected log return has to be adjusted by one-half the return variance for each asset to obtain the log expected return for portfolio optimisation. We obtain the $\sigma_r^2(k)$ from the diagonal matrix in the variance-covariance matrix of $Var\left(\sum_i^k x_{t+i}\right)$.

3.4 Data

In this chapter, we employ the total return indices for direct real estate, REITs and Stocks. We use a monthly data from April 2004 (2004m4) to December 2019 (2019m12). We select the sample within this period as to establish a level playing field among the REITs in each property sector. Our observations include the global financial crisis period between July 2007 (2007m7) and March 2009 (2009m3) (Hoesli & Oikarinen, 2016; M. C. Huang, Wu, Liu, & Wu, 2016) We use the data from Datastream to study the performance of Japanese REITs. The classification of Japanese REITs in Datastream is based on the constituents of their portfolios which fall in the following four categories: office, retail, hotel, and residential sectors. For each sector, the constituents of each REITs are weighted by a market capitalisation method[28]. We

[28] Source (Thomson Reuters Datastream, 2012).

use the Tokyo Stock Exchange (TOPIX) total return index as the proxy for common stocks. As a measure of direct real estate returns, we use the ARES Japan Property Indices (AJPI) and represent total return appraisal-based indices, produced by the Association for Real Estate Securitisation (ARES) in Japan.

The direct real estate total return indices are also reported monthly on an unleveraged basis. To account for leverage, we adopt the Barclays Japan Asia-Pacific BAA Corporate Bond redemption yield, which is a proxy for the cost of debt, denoted by $\mathrm{k_{dt}}$. Following Hoesli and Oikarinen (2012), the levered direct real estate indices are obtained by using the formula:

$$DRE_t = (DRE_t^U - k_{dt} \times LTV)/(1 - LTV) \tag{3.18}$$

where $\mathrm{DRE_t}$ is the levered direct real estate index at time t, DRE_t^U is the unleveraged direct real estate index, $\mathrm{k_{dt}}$ is the cost of debt in time t, and LTV is the loan-to-value ratio of Japanese REITs (both composite and sectors), which we set at 55% for the study period (Sumitomo Mitsui Trust Research Institute, 2016).[29]

We express all indices in real terms by deflating the nominal index values. We deflate the index value by using the monthly consumer price index (CPI). We take natural logarithms of the REITs, direct real estate, and stock market indices for the analysis. We assume returns to be continuously compounding by differencing the time series. For empirical estimation, we control the real estate by classifying it accordingly into the individual property sector. For example, we have the VECM empirical estimation for retail DRE, retail REITs and stocks in our system of equations.

We present the correlation matrix for the index return series in the following Table 3.1. The results show that each type of REIT has a low and positive correlation with its pair in direct

[29] The survey conducted by Sumitomo Mitsui Trust Research Institute in 2016, indicates that Japanese REITs real estate managers report LTV ratios of more than 50% and less than 60%. Hence, we set the LTV for this study at the 55% level.

real estate assets. The correlation between REIT and DRE is 0.1415, residential REITs and residential DRE (0.1977), retail REITs and retail DRE (0.1097), office REITs and office DRE (0.0563), and hotel REITs and hotel DRE (0.1286). The correlation between REITs and stocks is higher than the correlation between REITs and direct real estate. The correlation between REITs and stocks is 0.3393, residential REITs and stocks (0.5189), retail REITs and stocks (0.3576), office REITs and stocks (0.3707) and hotel REITs and stocks (0.1685).

Table 3.1

Correlation Matrix of REITs with Direct Real Estate and Stocks

	ΔREIT	Δ*RESIDENTIAL*_REIT	Δ*RETAIL*_REIT	Δ*OFFICE*_REIT	Δ*HOTEL*_REIT
Δ*DRE*	0.0920	0.1123	0.0279	0.0938	0.0835
Δ*RESIDENTIAL*_DRE	0.1415	0.1977	0.0877	0.1336	0.1774
Δ*RETAIL*_DRE	0.1622	0.2224	0.1097	0.1580	0.1780
Δ*OFFICE*_DRE	0.0566	0.7780	-0.0143	0.0563	0.0218
Δ*HOTEL*_DRE	0.1087	0.1769	0.0556	0.1109	0.1286
ΔSTOCK	0.3393	0.5189	0.3576	0.3707	0.1685

Notes. This table reports the correlation between the variables used in the chapter. We present the correlation by treating all variables in their form of difference in logs, denoted by "Δ" notation.

3.5 Empirical Results

3.5.1 The VECM Regression Estimates

We present the estimated coefficient derived from the vector error correction model. Consistently, we follow the representation of VECM as in equation (3.6) for tabulating the estimated coefficients. Panel A corresponds to estimated coefficients for each equation of ΔDRE_t , Panel B for $\Delta REIT_t$and Panel C for $\Delta Stock_t$[30].

Table 3.2 presents the VECM results for the composite and the three property sectors. The cointegrating vectors [1 β_R β_S] are normalised with respect to the direct real estate indices. Column (13) reports the β_R, while column (20) presents the cointegrating coefficient for stocks, β_S. Although there is one cointegrating relation between REITs, direct real estate and stocks, we can see that the beta coefficients of stocks, β_S are insignificant. The beta coefficient of REITs, β_R varies across property sectors. The REITs, in general, have the highest beta while the beta of hotel REITs is the lowest. For example the β_R shows that a unit increase in the retail direct real estate index is associated with an increase in the retail REITs index by 0.7545 units (see, e.g. Bhattacharya & Banerjee, 2003).

Columns (2) (8) and (15) present the speed of adjustment for direct real estate, REITs and stocks, respectively. We observe that the α_D, for each property sector is negative and significant. For the REITs, the speed of adjustment coefficient is positive and significant at least at the 10% significance level. The speed of adjustment coefficients α_S are insignificant for all sectors. The autoregressive coefficients are significant for the a_{DD}, a_{RD}, and a_{SR}; whereby their magnitudes are higher than those of the a_{DR}, a_{DS} and a_{RS} . The significance of a_{DD} reflect the return of direct real estate is predictable by their own lagged return. The

[30] We use MATLAB to estimate the VECM model and subsequent empirical estimation. We also estimate a VAR model in our empirical estimation.

significance of a_{RD} reflect the predictability of REITs return by direct real estate return. Whilst the significance of a_{SR} indicates the lagged of REITs return can predict the return of stocks. The significance of both a_{RD} and a_{SR} suggest the presence of positive autocorrelation and momentum in the asset returns. However, the significance and sign of the autoregressive terms reported in the VECM are similar to the estimated autoregressive AR terms reported in the VAR(1) model, as reported in the table 3.2 Panel B.

We present the volatility and correlation of residuals of DRE, REITs and stocks in Table 3.3. We observe the positive correlation between DRE and REITs residuals ρ_{uv} where it ranges between 0.1 and 0.13. The correlation of REITs and stocks residuals ρ_{vw} ranges between 0.2 and 0.37, while the correlation between DRE and stocks residuals ρ_{uw} ranges from 0.02 to 0.081. The standard deviation of the DRE residuals σ_{uu} is the lowest compared to other assets, where it fluctuates around 0.03%, while the σ_{uu} of hotel DRE residuals is the highest. The standard deviation of the REITs residuals σ_{vv} fluctuates around 0.06%, except for the hotel REITs. The standard deviation of stocks residuals σ_{ww} fluctuates around 0.05% level.

Table 3.2

Estimated Regression Parameters

Panel A	***Vector Error Correction Model*** ΔDRE					
	(1)	(2)	(3)	(4)	(5)	(5)
Sector	μ_D	α_D	a_{DD}	a_{DR}	a_{DS}	$\alpha_D C$
All	0.0403* (0.0067)	-0.0113* (0.0000)	0.4667 * (0.0605)	0.0024 (0.0038)	-0.0029 (0.0044)	-0.0387
Retail	0.0370* (0.0072)	-0.0102* (0.0002)	0.4813* (0.0622)	0.0014 (0.0039)	-0.0036 (0.0049)	-0.0309
Office	0.0431* (0.0065)	-0.0139* (0.0002)	0.4935* (0.0508)	0.0028 (0.0038)	-0.0049 (0.0045)	-0.0408
Hotel	0.0308 (0.0071)	-0.0079* (0.0002)	0.6186* (0.0062)	0.0031 (0.0029)	-0.0057 (0.0054)	-0.0298

	ΔREIT						
	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Sector	μ_R	α_R	a_{RD}	a_{RR}	a_{RS}	$\alpha_R C$	β_R
All	0.2755† (0.1303)	0.0902† (0.0301)	0.2655† (0.1166)	0.0069 (0.0735)	0.0255 (0.0848)	0.3087	-0.7585* (0.0835)
Retail	0.2435‡ (0.1407)	0.0727‡ (0.0017)	0.2693‡ (0.1214)	0.0400 (0.0764)	0.0208 (0.0936)	0.2207	-0.7452* (0.0835)
Office	0.2182‡ (0.1286)	0.0704‡ (0.0044)	0.2126* (0.1140)	0.0054 (0.0742)	0.0139 (0.0886)	0.2071	-0.6139* (0.0362)
Hotel	-0.4556† (0.1885)	0.1204† (0.0019)	0.4947* (0.1642)	0.0226 (0.0791)	0.0128 (0.0144)	0.4551	-0.5302* (0.0639)

	ΔStock						
	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Sector	μ_S	α_S	a_{SD}	a_{SR}	a_{SS}	$\alpha_S C$	β_S
All	0.1571 (0.1100)	-0.0051 (0.0036)	0.5226 (0.9848)	0.1398† (0.0620)	0.0111 (0.0716)	-0.1554	0.1137 (0.1089)
Retail	-0.2649 (0.117)	-0.0087 (0.0328)	0.2056 (0.9654)	0.1368† (0.0607)	0.0499 (0.0743)	-0.2656	0.2110 (0.1089)
Office	0.1239 (0.1061)	-0.0042 (0.0036)	0.6296 (0.9404)	0.09617 (0.0611)	0.0267 (0.0731)	-0.1203	0.0598 (0.1159)
Hotel	0.1936 (0.1001)	-0.0079 (0.0243)	0.1555 (0.8721)	0.1507* (0.0420)	0.0223 (0.0766)	-0.1948	0.1157 (0.471)

Panel B	***Vector Autoregressive VAR(1) Model*** ΔDRE			
	(1)	(2)	(3)	(4)
Sector	μ_D	a_{DD}	a_{DR}	a_{DS}
All	0.0013* (0.0003)	0.6886* (0.0506)	0.0015 (0.0041)	-0.0004 (0.0047)
Retail	0.0015* (0.0003)	0.6589* (0.0543)	0.0017 (0.0041)	-0.0004 (0.0050)
Office	0.0010* (0.0003)	0.7542* (0.0457)	0.0014 (0.0041)	-0.0010 (0.049)
Hotel	0.0012* (0.0004)	0.7898* (0.0495)	0.0015 (0.0031)	-0.0027 (0.057)
Residential	0.0018* (0.0004)	0.5452 (0.0622)	0.0015* (0.0005)	-0.0075 (0.0057)

	ΔREIT			
	(5)	(6)	(7)	(8)
Sector	μ_R	a_{RD}	a_{RR}	a_{RS}
All	0.0027	0.1075†	0.0213	0.0069
	(0.0059)	(0.0450)	(0.0730)	(0.0852)
Retail	0.0004	0.1473†	0.0188	0.0476
	(0.0064)	(0.0827)	(0.0758)	(0.0929)
Office	0.0049	0.7462†	0.0280	0.0075
	(0.0056)	(0.2834)	(0.0735)	(0.0883)
Hotel	-0.0044	0.2748†	0.0035	0.0787
	(0.0107)	(0.1265)	(0.0798)	(0.1451)
Residential	-0.0033	0.1493	0.1943†	0.0925
	(0.0059)	(0.1011)	(0.0589)	(0.0935)

	ΔStock			
	(9)	(10)	(11)	(12)
Sector	μ_S	a_{SD}	a_{SR}	a_{SS}
All	0.0007	0.3677	0.1552†	0.0207
	(0.0049)	(0.7658)	(0.0613)	(0.0715)
Retail	-0.0017	0.1266	0.1597*	0.0206
	(0.0051)	(0.8028)	(0.0606)	(0.0743)
Office	0.0020	0.1265	0.1082‡	0.0374
	(0.0046)	(0.6760)	(0.0604)	(0.0725)
Hotel	0.0003	0.0417	0.1611*	0.0029
	(0.0056)	(0.6681)	(0.0421)	(0.0766)
Residential	-0.0015	0.1212	0.1019	0.0143
	(0.0055)	(0.9489)	(0.0806)	(0.0877)

Notes**.** The table in Panel A reports the estimates of the vector error correction model as in equation (3.6) with individual equations of ΔDRE_t, $\Delta REIT_t$, and $\Delta Stock_t$. Meanwhile, for the purpose of comparison, table in panel B reports the estimates of the vector autoregressive model also with individual equations of ΔDRE_t, $\Delta REIT_t$, and $\Delta Stock_t$ as in equation (3.1). Figures in parentheses are standard error and *, † and ‡ denote the significance at 1%, 5% and 10% levels. The parameter μ_i represents the intercept term in the differenced equation, and $\alpha_i C$ denotes the intercept in the cointegrated relation equation. The a_{ij} denotes the autoregressive terms in differenced equations and α_i denotes the speed of the adjustment parameter. The β_i denotes the long-run cointegrating parameter. The subscript $_i$ and $_j$ are the individual assets, where $_D$ notes direct real estate, REITs, $_R$ and stocks, $_S$.

Table 3.3

Standard Deviation and Correlation of Residuals

Sector	σ_{uu}	ρ_{uv}	ρ_{uw}	σ_{vv}	ρ_{vu}	ρ_{vw}	σ_{ww}	ρ_{wu}	ρ_{wv}
Panel A									
All	0.0032	0.1316	0.0809	0.0615	0.1316	0.3492	0.0522	0.0809	0.3492
Retail	0.0034	0.1248	0.0253	0.0642	0.1248	0.3625	0.0521	0.0252	0.3625
Office	0.0033	0.0965	0.0637	0.0637	0.0965	0.3663	0.0527	0.0637	0.3663
Hotel	0.0037	0.1135	0.0604	0.0968	0.1135	0.2098	0.0521	0.0604	0.2098
Panel B									
	σ_{uu}	ρ_{uv}	ρ_{uw}	σ_{vv}	ρ_{vu}	ρ_{vw}	σ_{ww}	ρ_{wu}	ρ_{wv}
All	0.0034	0.0653	0.0987	0.0622	0.0653	0.3348	0.0522	0.0986	0.3348
Retail	0.0035	0.0679	0.0542	0.0651	0.0679	0.3384	0.0520	0.0542	0.3384
Office	0.0036	0.0444	0.0972	0.0641	0.0444	0.3509	0.0526	0.0972	0.3509
Hotel	0.0039	0.0647	0.0959	0.0988	0.0647	0.4883	0.0521	0.0959	0.4883
Residential	0.0037	0.1414	0.1074	0.0549	0.1414	0.3771	0.0529	0.1074	0.3771

Notes**.** This table (Panel A) reports the standard deviation and correlation of residuals from estimates of the vector error correction model. While Panel B reports the standard deviation and correlation of residuals from estimates of the vector autoregressive model. For each asset, *u* refers to residuals of direct real estate, *v* residuals of REITs and *w* residuals of stocks, respectively.

3.5.2 Term Structure of Risk

In this subsection, we illustrate the term structure of volatility for each return under different time horizons. We derive the volatility of each asset return from variance-covariance implied from the VECM framework. In particular, we exclude stocks from the long-run relation. This implies that the asset does not participate in long-run disequilibrium (or deviation from a long-run equilibrium). We account for the exclusion of stocks in the long-run cointegrating relation, by setting the β_S to zero. We also assume stocks to be weakly exogenous. Thus, by setting the α_S to zero, stocks do not participate in the error-correction mechanism. As a result, the interaction of stocks amongst other assets is limited to short-run autoregressive relations.

We present the term structure of volatility for each asset return in Figure 3.1. We present the term structure of volatility based on VECM in the left column. For the purposes of comparison, we also present the term structure of volatility for each asset return implied from VAR(1) estimates, as in the second column in Figure 3.1.

The first column in Figure 3.1 shows that the term structure of DRE is the lowest over the time horizon. For each of the property sectors, we observe the term structure of REITs is lower than stocks except for the hotel REITs. The term structure of stocks increases steadily from short-term to long-term horizons of 20 years. In the second column, the term structure of risk for each asset's returns as implied from VAR over different time horizons also indicates DRE is the lowest, while REITs are more volatile than stocks. The similarities between the term structures of volatility implied from both models show that each asset exhibits a mean-aversion pattern. The results reflect that volatility in each asset is higher in the long-run than in the short-run period. Following Campbell and Viceira (2005a), the increase in the long-run volatility implied from our VECM model as well as the VAR model is consistent with the positive autocorrelation in the return on each asset. In particular, the positive autocorrelation stems from the positive correlation between error terms ρ_{ij}; which reflects that past shocks to an asset will cause volatility in the other asset also to increase, as well as the positive autoregressive terms between past return on an asset and current return on the other asset a_{ij}. The combined effects of these two terms $a_{ij}\rho_{ij} > 0$ contribute to the positive autocorrelation for an asset return. Hence, the volatility of an asset will increase with the increase in time horizon.

Our illustration on the volatility structure can be supported by the above argument. For instance, we report the positive correlation between the residuals of REITs and stocks, as well as the positive autoregressive coefficients of a_{SR}. The product of these two terms, $a_{SR}\rho_{SR}$ represents the magnitude of positive autocorrelation in the stock returns. In the same manner, we also report the positive correlation between the residuals of DRE and stocks, and the positive autoregressive coefficient of the lagged DRE and stocks a_{SD}. These effects cause the mean aversion pattern in the term structure of volatility in stocks. The observations across each property sector show that the volatility structure of stocks is similar, either implied from the VECM or the VAR. The similarity is rather to be expected as stocks participate in short-run autoregressive relations with other assets.

In REITs, the increase in their term structure of risk in VAR, is consistent with the high degree of persistence in positive autoregressive relations between lagged DRE and REITs a_{RD} in each of the property sectors and positive correlation between the residuals of REITs and DRE ρ_{RD}. The low degree of persistence in the positive autoregressive coefficient of lagged stocks and REITs a_{RS} and the positive correlation between the residuals of REITs and stocks also demonstrate mean-aversion in the term structure of risk for the REITs in each property sector. For DRE, we observe an increase in volatility implied from VAR at a lower rate. The observation is consistent with a positive correlation between residuals of DRE and stocks and a negative autoregressive coefficient of the lagged stocks and DRE, a_{DS}. Nevertheless, the low degree of persistence in the lagged REITs and DRE, and a positive correlation between the residuals of REITs and DRE causes the term structure of risk for DRE to increase at a lower rate.

The evidence of a mean-aversion pattern in the term structure of risk is similar to the that shown in recent studies such as Pagliari (2017) and Fugazza et al.(2015) of the US market. Following Delfim & Hoesli (2019), one of the possible reasons for the similarity is that our estimation in the Japanese market uses recent observation data, including the global financial crisis period. In addition, our illustrated term structure of risk indicates the presence of momentum in the returns of REITs and stocks in the Japanese market, which suggests the return structure is positively autocorrelated (Lewellen, 2002). The momentum in asset returns reflects a high level of volatility (Chui, Titman, & Wei, 2003; Hung & Glascock, 2008; Zhang, 2006) which is in accordance with the increase in the future information uncertainty prevailing in both REITs and stock markets. As a result, the long-run volatility of an asset will be higher than the volatility in the short-run (Cochrane, 2011; Engle, 2009; Pástor & Stambaugh, 2012).

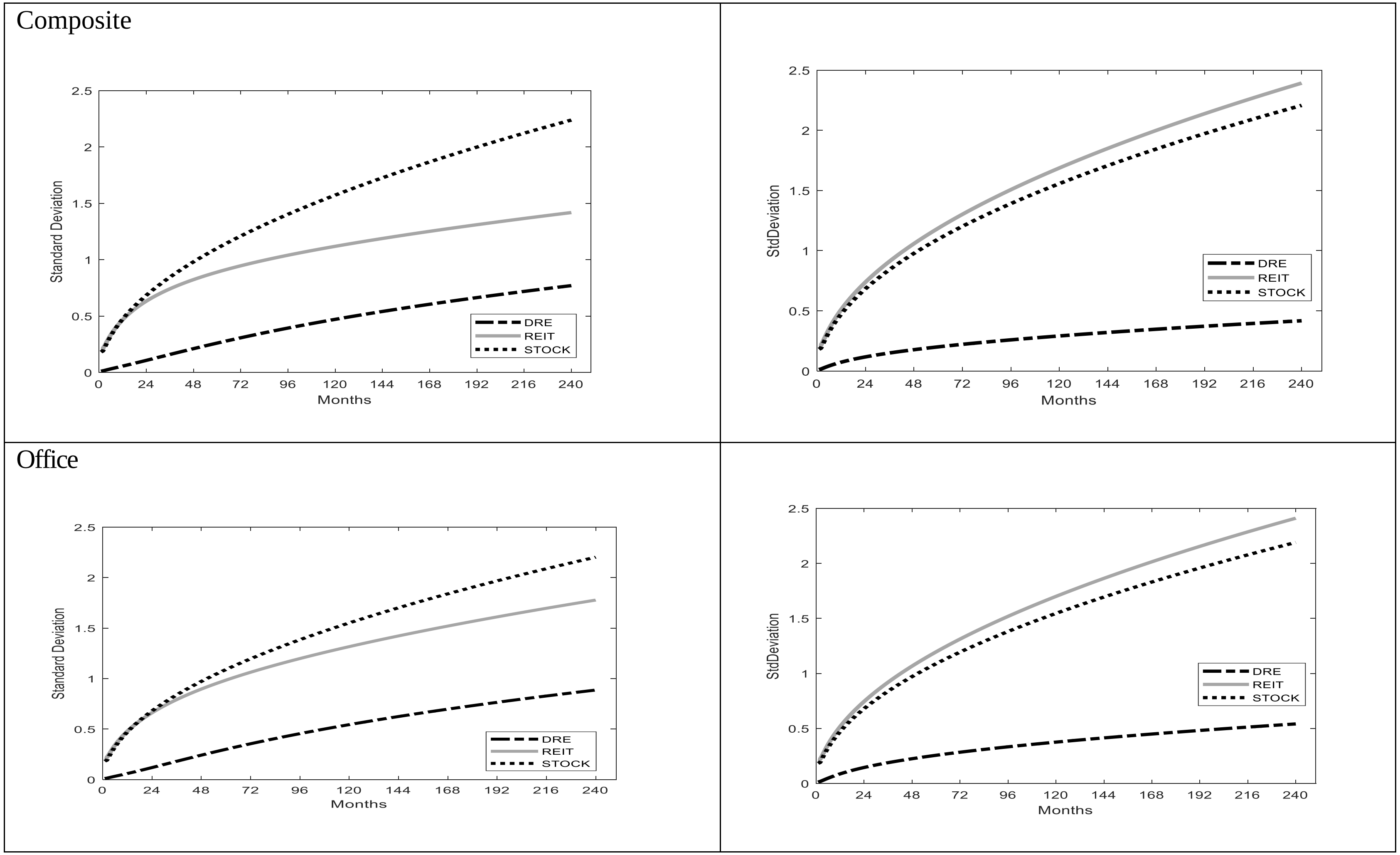
However, there is one notable difference between the term structure of volatility implied from VECM versus the VAR model estimation, in particular, regarding the term structure of risk for REITs and direct real estate asset implied from the two models. We observe that, based on the VECM model estimates, in the long-run the term structure of REITs is lower than that implied from the VAR model. Also, the increase in the term structure of risk for direct real estate in the long run is slightly higher when implied from the VECM than the VAR.

Our results on the term structure of risk for real estate assets highlight the differences between the VAR and VECM in the theoretical aspect of the volatility modelling. To be specific, the term structure of risk implied from the VECM accounts for both autoregressive relation in asset returns as well as the cointegration relation between REITs and direct real estate in the long-run. In what follows, the cointegration relation caters for short-run deviation from the long-run equilibrium, as evidenced in the speed of adjustment parameters. The deviation accentuates both asset REITs and direct real estate participates in the error correction mechanism. The mechanism corrects for the deviation in the short-run in order for cointegration relation to persist in the long run. The deviation occurs since both assets receive information pertaining to the real estate market. Their responses to this information then trigger the changes in both prices of REITs and direct real estate assets.

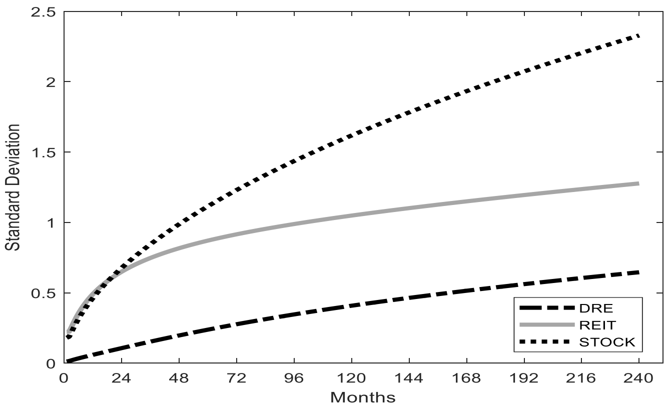
Based on the speed of adjustment parameter, REITs have a higher speed response than direct real estate. We suggest that the higher speed of adjustment reflects a rapid response to deviation in the disequilibrium, which simultaneously helps to correct REITs prices. The longer deviation in the short-run disequilibrium suggests a sluggish response to real estate information that will then price in the direct real estate assets. The above arguments clear up our results on the differences in the term structure of risk for both REITs and direct real estate, as implied from the VECM and the VAR models. Consistent with Amihud (2002), the reduction in the volatility of REITs in the long run, as indicated by the VECM occurs as REITs are a liquid asset, whereas direct real estate is a less liquid asset, and their slow response translates into a slight increase in their volatility structure in the long run. All in all, in comparison to the term structure of REITs return implied by the VAR processes, the error correction mechanism in the VECM manages to alleviate the excess volatility in the REITs return over the long run.

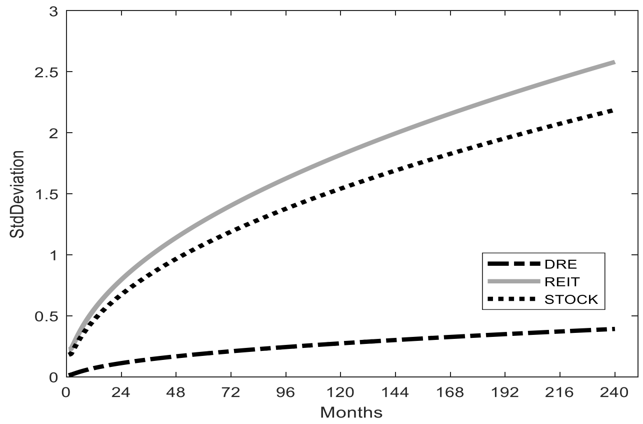
Figure 3.1

Term Structure of Risk implied in VECM versus VAR (1) estimates

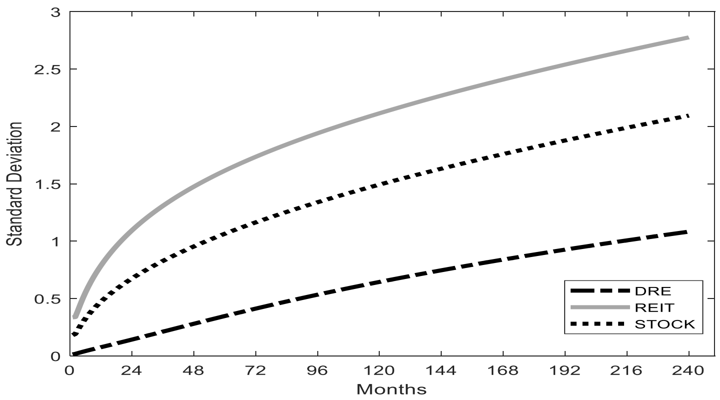


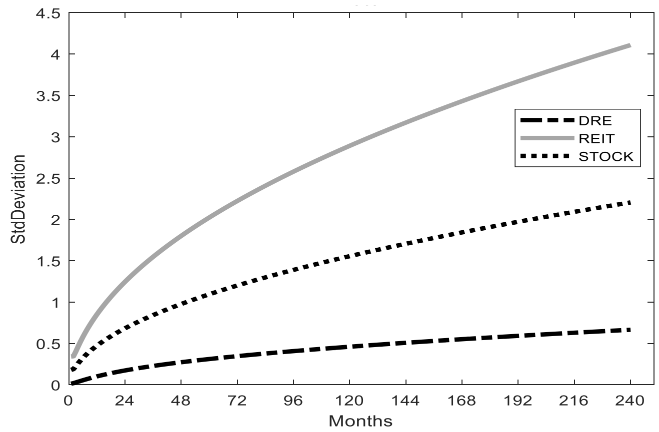
Retail



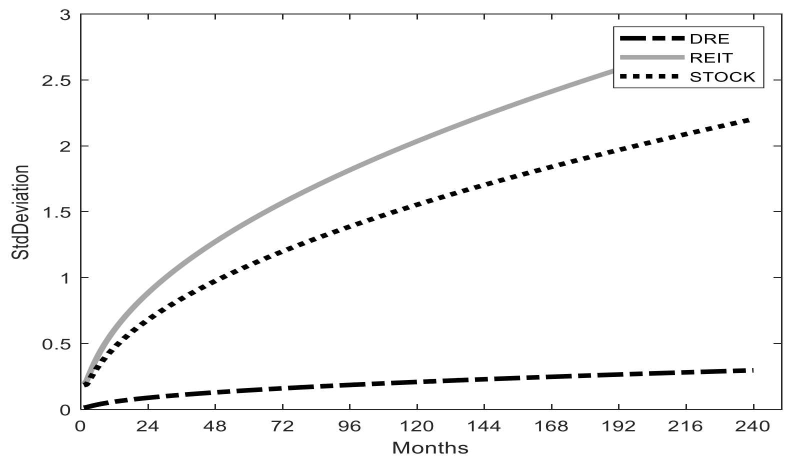


Hotel





Residential



Notes. These figures show the term structure of risk implied from VECM (in the left panel) and VAR (1) (in the right panel) for REITs and direct real estate in composite and specific property sectors. The exception is the residential sector where we derived the term structure of risk implied by VAR (1).

3.5.3 Term Structure of Correlations

We present the term structure of correlations between asset returns for different time horizons. We extract the correlation of asset returns based on the estimated variance-covariance matrix implied from the VECM framework. Of particular interest are the correlation pairs between REITs and DRE, REITs and stocks, and DRE and stocks. By taking into account specific property sectors, we present the term structure of correlations between asset returns in Figure 3.2.

For each sector, we present the correlation from time horizon, k of 1 month until k is equal to 240 months or 20 years. In the left column in Figure 3.2, we present the correlations derived from the VECM framework. We observe the correlation pair between REITs and DRE increases gradually in the short and medium-term. In the long run, the correlation between REITs and DRE increases and may exceed 0.9. A similar result is shown when we observe the correlation between REITs and DRE in other property sectors. Based on the first figure in the left column, we show the term structure of correlation between stocks and REITs is flat and fluctuates around 0.5. The correlation between DRE and stock returns is lower than the REITs and stocks pair, where the correlation increases from 0.1 to 0.4, for k less than 50 months. The correlation between DRE and stocks increases from 0.4 to 05, where k is between 50 months and 240 months.

Similar findings emerge from the correlation between office REITs and stocks, and between office DRE and stocks. The term structure of correlation between retail REITs and stocks is also flat at the 0.55 level. The correlation between retail DRE and stocks initially increases as the time horizon, k, becomes longer. But as k reaches more than 50 months, there is a small increase in the correlation, slightly higher than the retail REITs and stock correlation. The correlation between retail REITs and stocks and retail DRE and stocks is similar at k=144 months or when the time horizon is equal to 12 years. The correlation between hotel REITs and stocks increases from 0.2 to 0.5 between k=1 to k=12 months, before gradually decreasing to around 0.4 in the long-term horizon. When k is less than 48 months, or 4 years, the correlation between hotel DRE and stocks gradually increases from 0.05, before stabilising at 0.3. All in all, the term structure of correlation between stocks and REITs is higher than the term structure of correlation between stocks and DRE. The finding is somewhat expected as REITs and stocks are liquid and trading in the same platform.

We illustrate the term structure of correlation derived from VAR in the right column in Figure 3.2. We find the highest correlation is between REITs and stocks. The term structure of correlation between REITs and stocks is flat, where they remain at the 0.5 level. The correlation between residential REITs and stocks is slightly higher, as the correlation between these two assets stays above 0.6. For each property sector, we find that the correlation between real estate returns, REITs and DRE is lower than the term structure of correlation between REITs and stocks. For a k period less than 24 months, the correlation between REITs and DRE increases, before it becomes flat in the medium- and long-term horizons. In composite cases, the correlation between these two assets is found to be 0.25. The correlation between office REITs and DRE is 0.25, while for hotel REITs and DRE the correlation is about 0.35. The correlation between residential REITs and DRE is the highest amongst other property sectors, where the correlation is above 0.4. The correlation between DRE assets and stocks is the lowest, for each of the property sectors, with the exception of the retail sector, where we can see the correlation between retail REITs and DRE and retail DRE and stocks overlaps in the medium and long run.

Our findings for Japan on the ranking of the pairwise correlations reveal relative differences with earlier studies of the US market. For example, the US market shows an historical correlation between REITs and stocks that is higher than the correlation between REITs and direct real estate in the short-run, where T is less than 12 months (Boudry et al., 2012;

Morawski et al., 2008). In addition, our estimated correlation between REITs and DRE is also higher than the findings implied from VAR in the US market. For instance, studies by Mackinnon and Al Zaman (2009) and Pagliari (2017) report the correlation between REITs and direct real estate to be not more than 0.6. A recent study by Delfim and Hoesli (2019) also presents similar results in which the correlation between REITs and direct real estate remains at the 0.5 level.

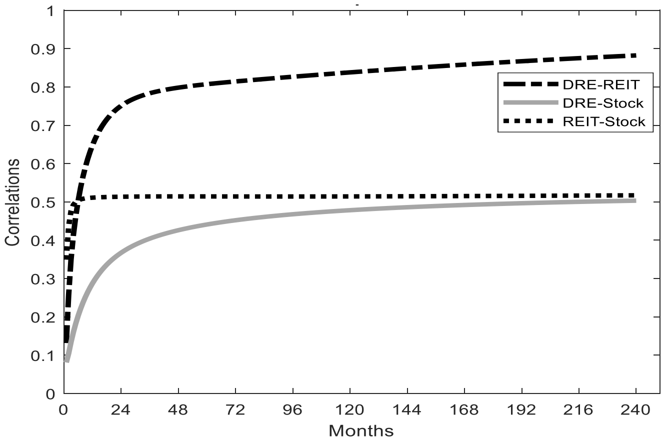
A vital observation concerns the differences in the correlation pairs between REITs and direct real estate, implied from VECM versus VAR estimation. In VECM, we observe the increase in the term structure of correlation between REITs and DRE with the increase in the time horizon. We suggest that the increase in correlation between these two assets is consistent with their cointegration in the long run. Our results shed light on the ability of the VECM to express the correlation between asset returns at different time horizons. This includes the correlation between the cointegrated assets and between non-cointegrated assets. Our findings accentuate the limitations of the VAR (1) process for examining the interaction between asset returns. Despite accounting for the autoregressive function and predictability between lagged and contemporaneous asset returns, the VAR(1) process masks the cointegration structure between variables. This feature causes the correlation between cointegrated assets to be underestimated, in both the short- and long-term horizon.

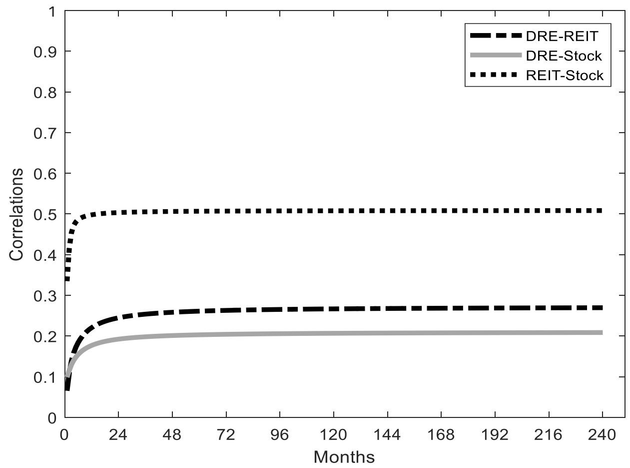
Whilst competing literature in cointegration studies suggests that REITs can be substitutes for DRE as real estate assets, our estimated correlation derived from VECM has important implications regarding whether the substitutability between these two assets holds, for investors with different holding periods. Our next subsection examines the implications of covariance structure derived from VECM for a mean-variance optimal portfolio involving REITs, stocks and direct real estate assets for investors with short- and long-term investment horizons.

Figure 3.2

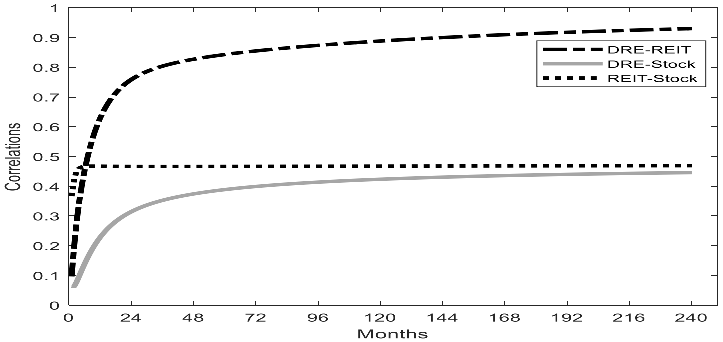
Term Structure of Correlation

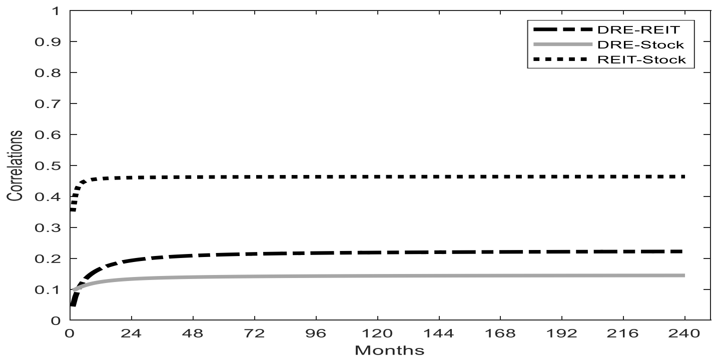
Composite



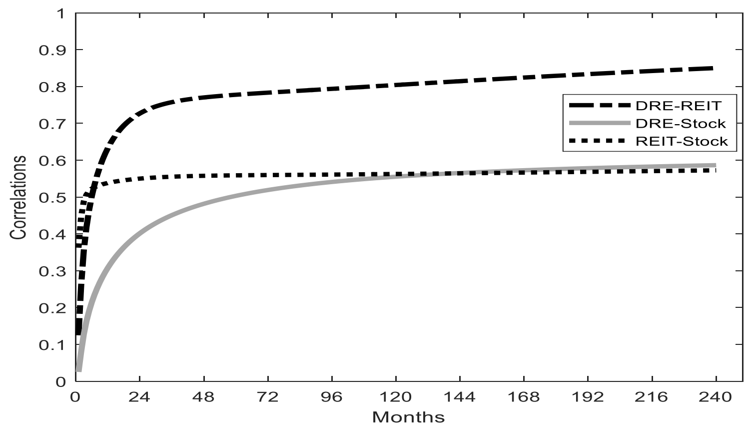


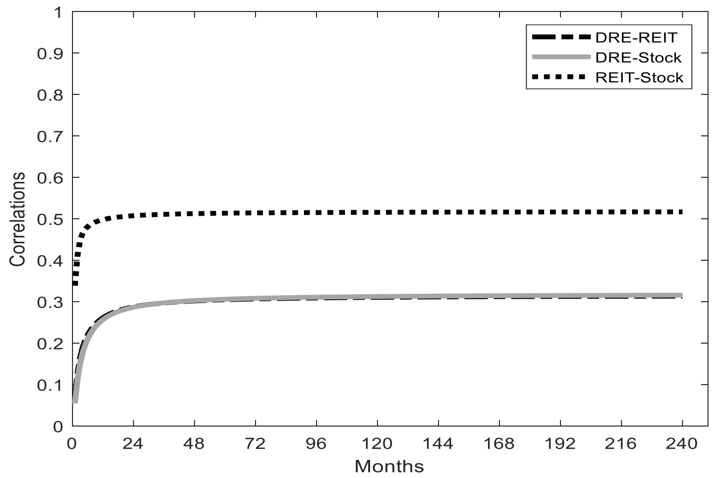
Office



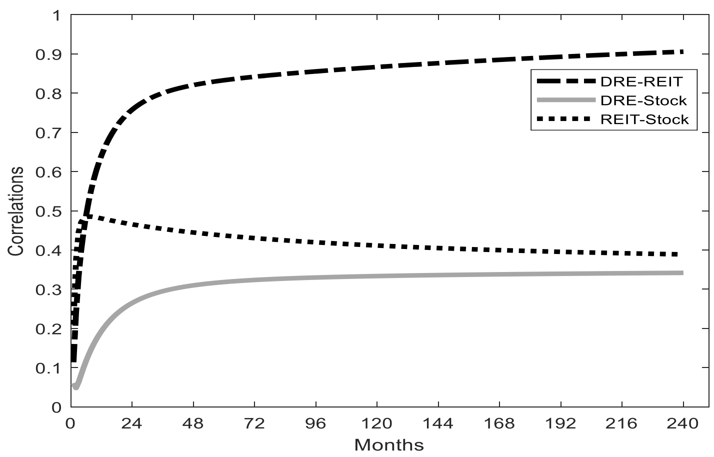


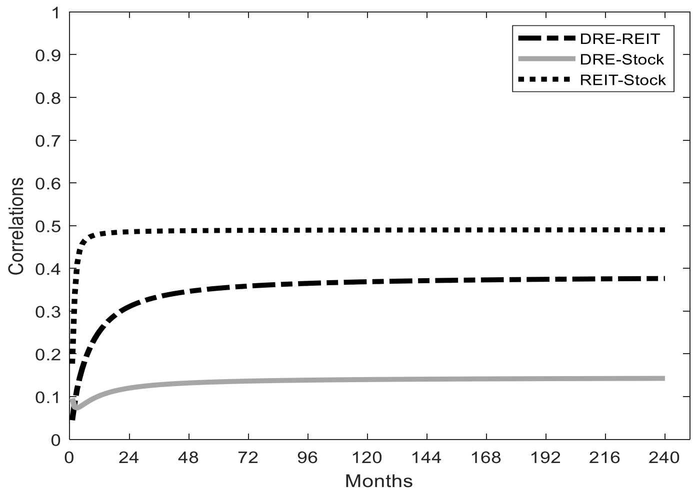
Retail



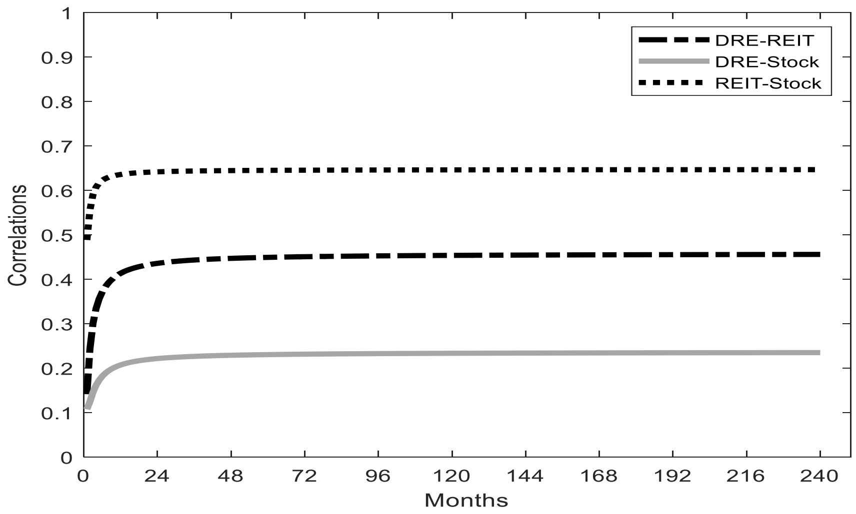


Hotel





Residential



Notes. These figures show the term structure of correlation implied from VECM (in the left panel) and VAR (1) (in the right panel) for REITs and direct real estate in composite and specific property sectors for investment horizons between 1 and 240 months (or 20 years). The exception is the residential sector where we derived the term structure of risk implied by VAR (1).

3.5.4 Mean-variance Optimal Portfolio

The correlation between REITs and DRE raises an important issue as to whether the diversification potential of REITs varies according to the investment time horizon. In this subsection, we perform an exercise of optimal buy-and-hold portfolio allocation for direct real estate DRE, REITs and stocks for investment horizons from one month to 20 years (or 240 months). We use the estimated variance-covariance matrix implied from VECM corresponding to the holding period. We use the unconditional expected return, net of transaction costs. The expected return is readjusted for each asset by adding one-half of the variance of each asset. We assume a rate of portfolio return per period of $\frac{k}{12} * r = \mu_{p,k}$, where $k = [1{,}240]$ months and $r = 0.005 \; or \; 0.5\%$.

We also present the curve to show the optimal portfolio for investment horizons from 1-month to 20 years (240 months). In the composite case, at k equal to 24 months, we examine the 17.5% allocation to direct real estate, 65% to REITs and 18% to stocks. For k of in-between 24 and 60 months, the allocation of REITs gradually reduces to 30%. When the investment period is more than eight years or 96 months, the allocation of direct real estate is more than 75% with a lower allocation to liquid assets. For investment horizons more than 14 years or 168 months, we consider a 100% allocation for direct real estate assets. For the office sector, we consider a portfolio allocation dominated by office REITs for an investment horizon where k is less than 18 months. For the period between 18 and 48 months, the allocation to office DRE and allocation of stocks falls between 20% and 35%. The allocation of office REITs reduces from 80% to 20%. For a k of 60 to 84 months, the portfolio consists of allocations for both office DRE and office REITs, whereas for k from 96 to 144 months the allocations are 80% to office DRE and 20% to office REITs and stocks. We also observe that office REITs become a negligible asset in this period and as the investment horizon expands. Similarly, with the composite, our illustration shows the full allocation of office DRE, for investment horizons between 14 and 20 years.

In the retail sector, the allocation to retail REITs reduces to 40%, with 20% of stocks and a 20% allocation to retail DRE at an approximate k equal to 24 months. For time horizons from six to eight years, we consider a 70% allocation to retail DRE and a 30% allocation to stocks. As the time horizon reaches 120 months (ten years), our results indicate the increasing dominance of investment in retail DRE with a 75% allocation, and the remaining allocation of 15% to retail REITs and 10% to stocks. In the longer investment holding period, we maintain an allocation to retail REITs and stocks of no more than 10%, with the highest allocation to retail DRE.

We identify hotel REITs to be a dominant asset in the investment horizon of less than 12 months. For investment horizons where k is between 12 and 24 months the assets have been displaced by stock, with allocation ranges between 50% and 70%. There is a 20% to 30% allocation to hotel REITs in the investment horizon of 24 to 36 months. In the period of 48 to 96 months, there is an increased allocation to hotel DRE and a reduced allocation to stocks, whereas, for an investment period greater than 96 months, the portfolio is a mixture of hotel DRE and stocks with a higher allocation to hotel DRE.

Since there is no cointegration between REITs, direct real estate and stocks in the residential sector, we present the optimal buy-and-hold portfolio using a variance-covariance matrix implied from the VAR framework. We find a mixture of residential DRE, REITs and stocks in the period of k from 24 months to 60 months. The allocation of residential DRE increases to 50%. The allocation of residential REITs is between 20% and 40%, and stocks between 30% and 60%. As the time horizon is more than six years, the allocation to residential DRE increases to 70% and the remaining 30% allocation is to stocks. There is a low allocation to residential REITs of not more than 5% for investment horizons between 18 and 20 years.

In addition, we present the optimal portfolio based on the variance-covariance matrix implied from VAR estimates in other property sectors. In the composite case, for a time horizon of less than one year, the portfolio consists of REITs. For the period between 24 months to 60 months, the allocation to DRE increase to 45%, whilst the allocation to REITs reduces from 40% to 10%, and the allocation to stocks is between 30% and 40%. For a time horizon of five years or 60 months, the optimal portfolio comprises 60% DRE and 40% stocks. As the time horizon exceeds 14 years, the portfolio consists of 70% DRE and 30% stocks.

For a time horizon of two to four years, the allocation of office REITs decreases from 40% to 10%, and stocks fluctuate between 30% and 40%. Office DRE increases steadily, with the allocation up to 80% and the remaining 20% to stocks, with the increase in investment period up to 20 years. For the retail sector, we observe the allocation of its DRE increases gradually, as the investment horizon is more than two years, whereas for a period of two to five years, the allocation to stocks ranges from 30% to 45%, and the allocation of retail REITs decreases from 40% to 10%.

For the optimal portfolio in the hotel sector based on VAR estimates, we consider the mixture of three assets in the timespan of two to eight years. Hotel REITs fluctuate between 7% and 40% and the allocation of stocks between 20% and 60%. We observe the allocation to stocks increases as the allocation to hotel REITs decreases and vice versa. The allocation to hotel DRE peaks at the time horizon of 120 to 144 months, before plunging from 80% to about 50%, with the mixture of stocks.

We also present the optimal allocation for each asset in Table 3.4. We show each asset allocation for investment horizons of one, four, eight and sixteen years. We compare the allocations of each asset for an optimal portfolio implied from VECM versus VAR. The optimal portfolio implied from VECM shows an allocation to REITs greater than in the optimal portfolio implied by VAR. As can be seen from the left panel, the allocation to REITs is more than 80% for a one-year horizon. For an investment horizon of four years, there is an allocation of more than 20% to REITs. Also, there is an allocation of at least 5% to REITs for an eight-year horizon. In the right panel, the portfolio allocation implied from VAR shows a relatively low allocation of REITs, and a greater allocation to stocks. For the 16-year horizon, we observe the allocation to DRE for the optimal portfolio implied by VECM. In contrast, based on the VAR-based optimal portfolio we observe a mixed allocation of DRE and stocks.

Our estimated portfolio using the variance-covariance matrix implied from VAR highlights the limited diversification benefit of REITs in the short-run. First, there is a high level of correlation between REITs and stocks. Second, our estimated variance based on VAR shows REITs as the most volatile asset. Hence, there is little benefit to be attained for REITs, even though the low correlation between REITs and DRE suggests potential diversification benefits for REITs both in the short- and long-term. However, the low level of correlation between DRE and stocks permits a mixed allocation of these two assets for an investment horizon of more than six years. Since DRE is less volatile than stocks, the allocation of DRE is higher than stocks. Our estimated portfolio implied by VAR is consistent with previous literature, where the diversification benefit of REITs can be limited to the short- and medium-term (Delfim & Hoesli, 2019). Nevertheless, our findings underline the proposition by Campbell & Viceira (2005b) on predictability in asset returns, which results the liquid assets such as stocks can be included in a long-term asset allocation.

The optimal portfolio based on the variance-covariance matrix implied by the VECM is detrimental to the correlation between asset returns. We argue that for an investment period of fewer than 24 months, portfolio allocation is driven by the correlation between REITs and stocks. In contrast, for a medium-term horizon, the mixed allocation is dependent on the correlation between REITs and stocks and DRE and stocks correlation pairs. However, the correlation between DRE and stocks helps in the optimal portfolio allocation between these two assets in the long-run. Moreover, the high level correlation between REITs and DRE limits the diversification benefits of REITs, especially in the long-term.

In addition, the term structure of risk of each asset's returns contributes to their optimal allocation in different time horizons. Despite the increase in the volatility of direct real estate in the long-run, the asset is the least volatile amongst the others. In terms of REITs, the term structure of risk implied by the VAR is lower than that exhibited by the VAR model. In the long run, the REITs are less volatile than stocks. As a result, our analysis of the optimal portfolio using the variance-covariance matrix implied by the VECM shows that REITs, on average, have a higher allocation than stocks, whereas for stocks, even though they have been excluded from the long-run cointegrating relation, we observe that their role as portfolio diversifier is rather limited to the short- and medium-term horizon, as they are more volatile than REITs in the long run.

Our hypothetical portfolio exercise using VECM has several important implications. Our estimated variance-covariance matrix derived from VECM indicates that the substitutability of REITs as a real estate asset is horizon-dependent. We show that the substitutability of REITs is profound with a short-term investment horizon. Their substitutability role then declines with the increase in time horizon and there is an increase in allocation to direct real estate, DRE. We contend that DRE is suitable for a long-term horizon, given its illiquidity and high-level transaction costs. These two characteristics underpin the absence of DRE as a real estate asset in short-term investment. We present little evidence on the effect of excludable assets (i.e., stocks) on the long-run relation in the VECM framework. The diversification benefit of stocks in a portfolio is subject to their volatility and correlation structure with other assets at different time horizons.

All in all, our estimated buy-and-hold portfolio implied by the VECM framework suggests that the diversification benefits amongst cointegrated and non-cointegrated assets, and the role of real estate assets in the mixed-asset portfolio, are relative to holding periods. For an institutional investor in a buy-and-hold portfolio with an investment horizon of one-year, the investor should allocate their investment in both REITs and stocks. Given a medium-term horizon of 4 to 8 years, an institutional investor should allocate their funds in the three assets. In the 8-year investment horizon, the investor should allocate their funds more to direct real estate than to both REITs and direct real estate. Lastly, for a time horizon of more than 14 years, the investor should allocate their funds to direct real estate.

Table 3.4

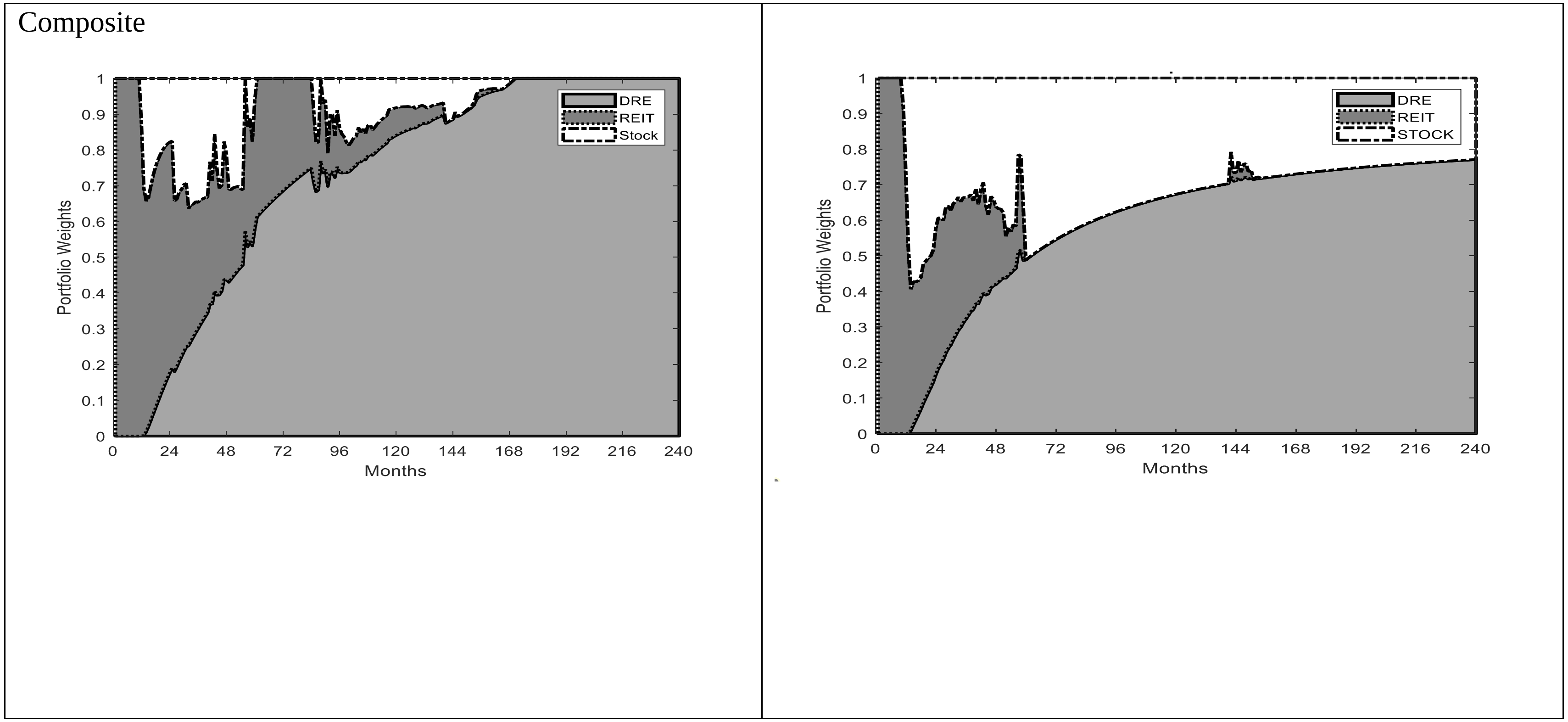
Optimal Portfolio Allocation of Each Asset Implied from VECM and VAR

VECM				**VAR**		
	DRE	REITs	Stocks	DRE	REITs	Stocks
Composite						
1-year	0.0000	0.8702	0.1298	0.0000	0.7285	0.2715
4-year	0.4379	0.3514	0.2107	0.4205	0.2188	0.3607
8-year	0.7374	0.1237	0.1389	0.6262	0.0000	0.3738
16-year	1.0000	0.0000	0.0000	0.7531	0.0000	0.2469
Office						
1-year	0.0000	0.8078	0.1922	0.0000	0.7041	0.2959
4-year	0.4270	0.2109	0.3621	0.4102	0.1891	0.4007
8-year	0.7258	0.0439	0.2303	0.6159	0.0000	0.3841
16-year	1.0000	0.0000	0.0000	0.7430	0.0000	0.2570
Retail						
1-year	0.0000	0.8412	0.1588	0.0000	0.6734	0.3266
4-year	0.4185	0.3466	0.2349	0.4074	0.1057	0.4869
8-year	0.7084	0.1868	0.1048	0.6249	0.0000	0.3751
16-year	0.9272	0.0000	0.0728	0.7486	0.0000	0.2514
Hotel						
1-year	0.0036	0.2684	0.7280	0.0048	0.2401	0.7551
4-year	0.4679	0.0000	0.5321	0.3759	0.2688	0.3553
8-year	0.9426	0.0000	0.0574	0.3491	0.0676	0.5833
16-year	0.8351	0.0000	0.1649	0.6085	0.0000	0.3915

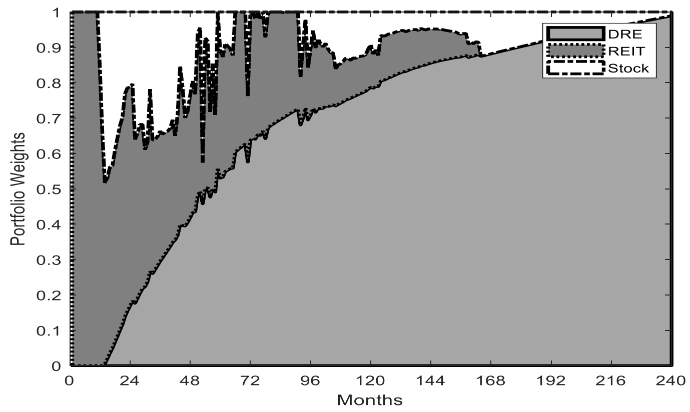
Notes. This table shows the optimal portfolio allocation (in %) for REITs, direct real estate (DRE) and stocks. We show the optimal portfolio by varying the holding period of one-year (12-months), four-year (48 months), eight-year (96-months), and sixteen-year (192 months) horizons. We classify the real estate according to a specific property class. The left panel shows the optimal portfolio implied by VECM and the right panel shows the optimal portfolio implied by the VAR framework.

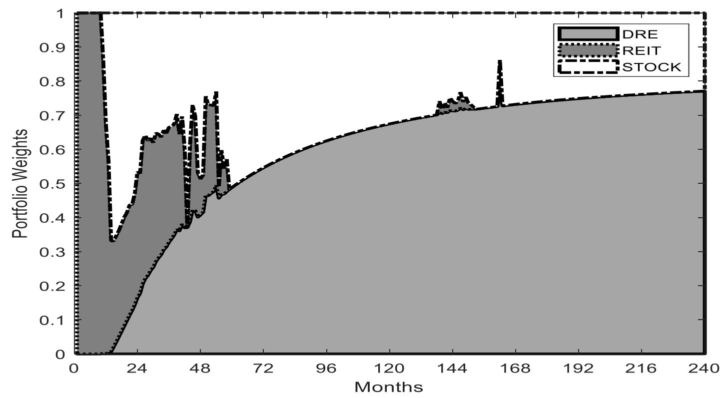
Figure 3.3

Optimal Portfolio Allocation Plot Implied from VECM versus VAR

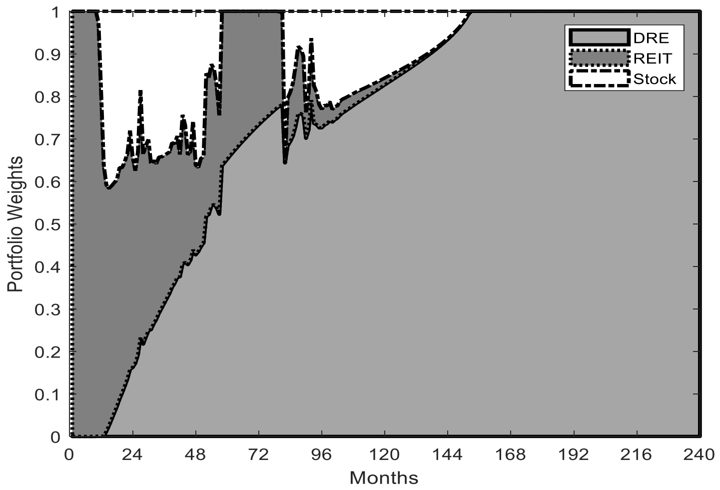


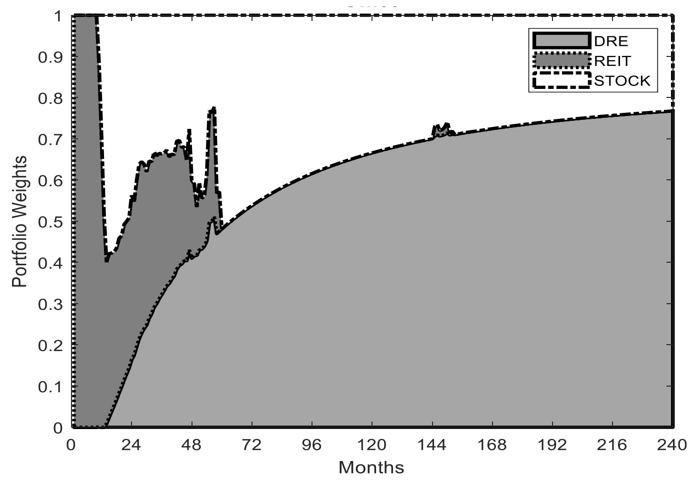
Retail



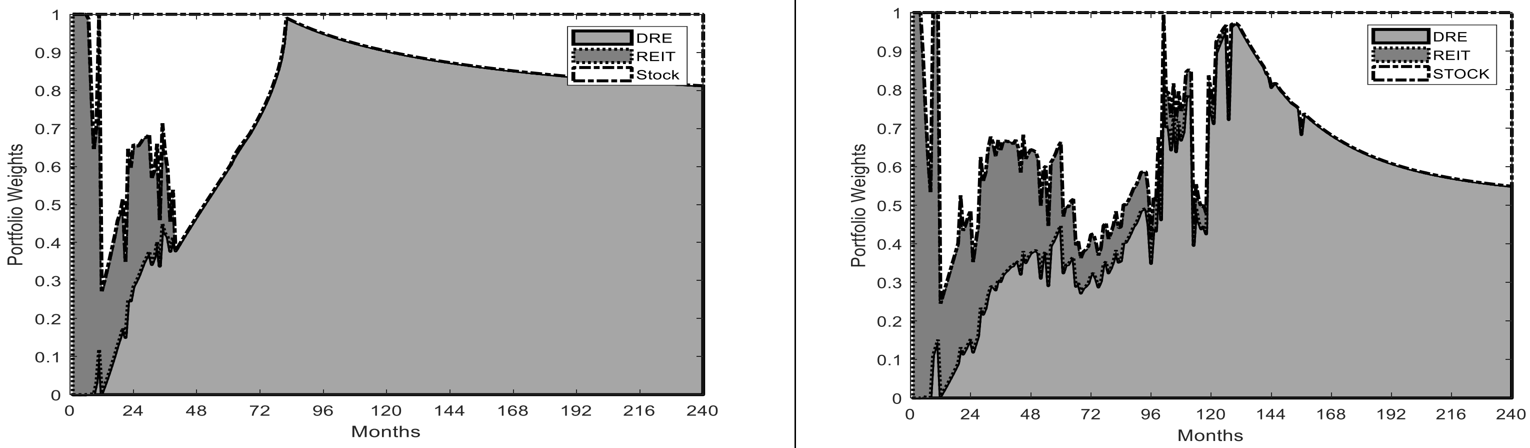


Office

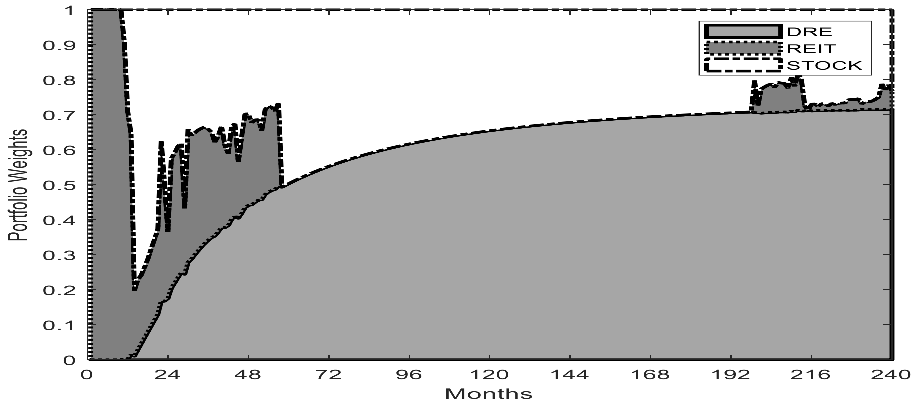




Hotel



Residential



Notes. These figures show the optimal portfolio allocation for each asset implied from VECM (in the left panel) and VAR (1) (in the right panel) for REITs and direct real estate in composite and specific property sectors for investment horizon between one and 240 months (or 20 years). The exception is the residential sector where we derived the term structure of risk implied by VAR (1).

3.5.5 Robustness Check

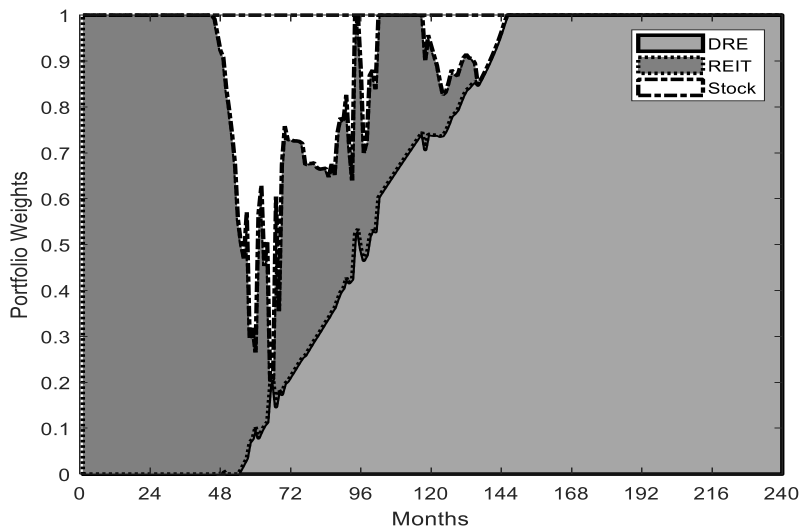
We further test the estimated variance-covariance matrix and correlation derived from the vector error correction model into an optimal portfolio with direct real estate, REITs and stocks by changing the term structure of expected returns, net of transaction costs. To be specific, we follow Delfim and Hoesli (2019) by modifying the transaction costs for each asset, in two different scenarios. First, we increase the transaction cost to twice that quoted in the early estimation, so the transaction cost for direct real estate now becomes 16% and the cost for REITs and stocks is 2%. Second, we deflate the transaction cost to half of the quoted cost, so the transaction cost for DRE will be 4% and, for REITs and stocks, just 0.5%.

We show the changes in the optimal portfolio involving three assets derived from the vector error correction model in Figure 3.4. For scenario one, we observe the inclusion of direct real estate is delayed, at least to an investment horizon of more than four years. Liquid real estate REITs are the chosen assets for an investment horizon of fewer than four years. Stocks are included in an investment horizon of between 48 and 120 months, and between 120 and 144 months. With the doubling in the transaction cost, there is a reduction in the average optimal weight of direct real estate, but the average weight of REITs and stocks increases. For scenario two, the allocation to direct real estate begins at a time horizon of one year (12 months). Also, there is an increase in the allocation in the medium- and long-term horizons. Overall, the allocation of REITs and stocks falls, whilst the weight of direct real estate increases, in line with the abrupt drop in transaction costs for direct real estate assets.

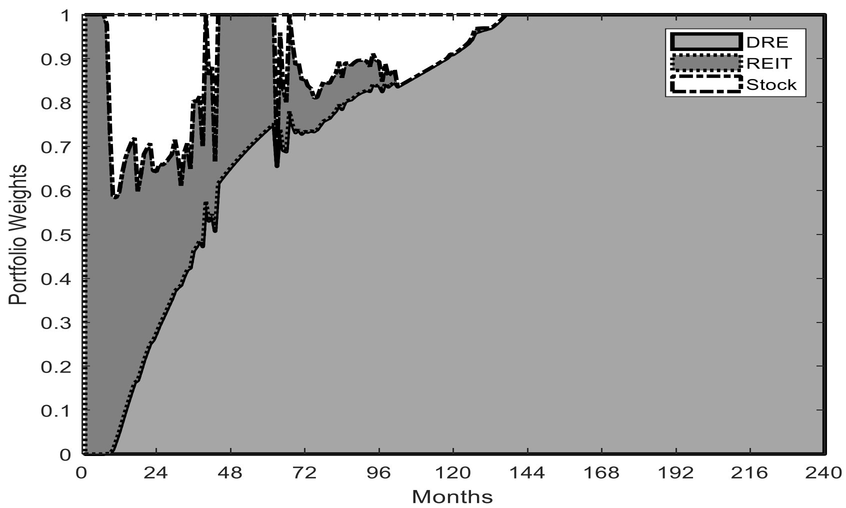
Figure 3.4

Optimal Portfolio Derived from VECM with Changes in the Term Structure of Expected Return

(a) Scenario 1 Composite



(b) Scenario 2



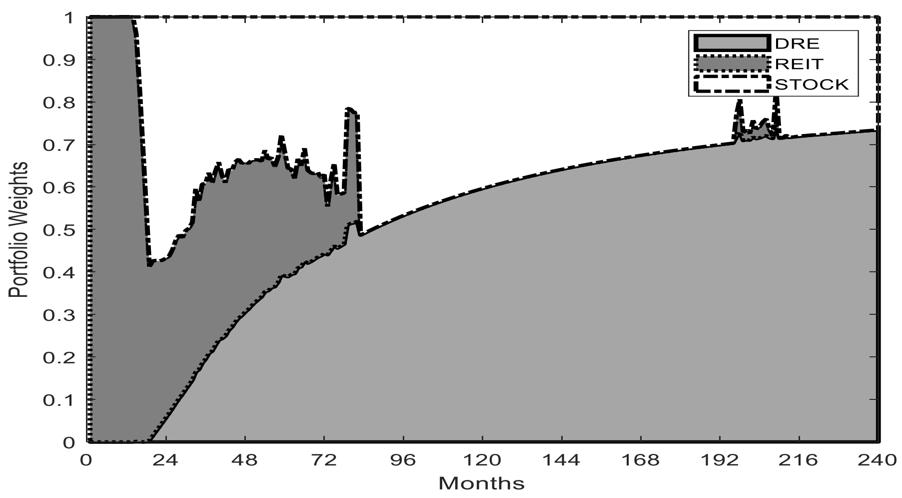
Notes. These figures show the optimal portfolio allocation for each asset implied from the VECM for REITs and direct real estate in composite (all property sectors) for investment horizons between one month and 240 months (or 20 years). Here, we assume the optimal portfolio allocation in two different scenarios, where panel (a) is for the scenario when we double the initial transaction cost for each asset and panel (b) is for the scenario when we minimise the initial transaction cost by one half for each asset.

Similar results can be seen in the case of the optimal portfolio derived from the VAR. When the transaction cost is doubled, we observe the allocation for direct real estate begins to occur as the investment horizon approaches 24 months. If we alter the cost as in the second scenario, we observe that the allocation to direct real estate begins as the time horizon reaches about 12 months. The allocation to direct real estate is higher in the medium and long term as the expected (net) return is higher. The allocation to REITs falls and becomes negligible as the time horizon exceeds four years. Also, the allocation to stocks reduces to provide more space for direct real estate. Based on the estimated portfolio implied from VECM and VAR, we show that the optimal portfolio tends to be sensitive to changes in the term structure of expected returns (net of transaction costs). In short, our results endorse the robustness of the estimated variance-covariance matrix of asset returns for different time horizons, derived from the VECM and the VAR frameworks.

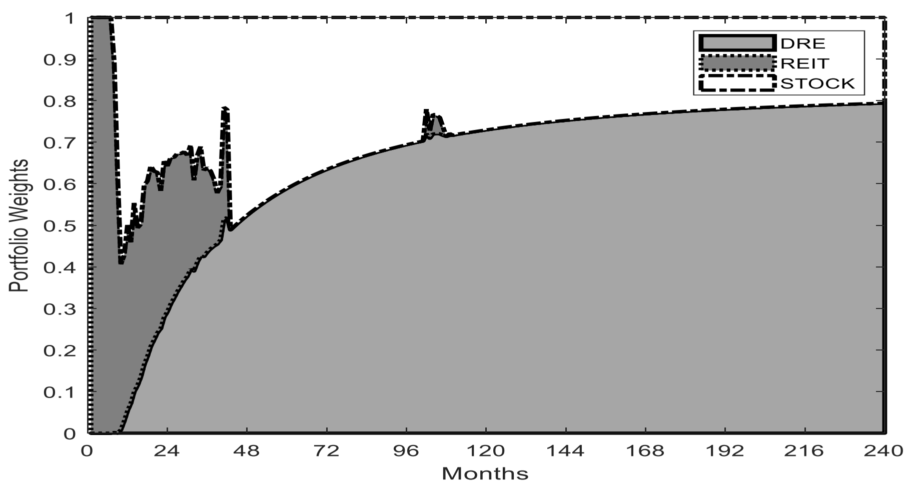
Figure 3.5

Optimal Portfolio Derived from VAR with Changes in Term Structure of Expected Return

a) Scenario 1 Composite



b) Scenario 2



Notes. These figures show the optimal portfolio allocation for each asset implied from VAR (1) for REITs and direct real estate in composite (all property sectors) for investment horizons between one and 240 months (or 20 years). Here, we assume the optimal portfolio allocation in two different scenarios, where panel (a) is for the scenario when we double the initial transaction cost for each asset and panel (b) is for the scenario when we minimise the initial transaction cost to one half for each asset.

3.6 Conclusion

Existing studies had established the horizon-dependent buy-and-hold portfolio optimal portfolio choice framework involving direct real estate assets, and taking into account their illiquidity and transaction costs, and the predictability of asset returns. However, this framework fails to account for the cointegration relation between REITs and direct real estate. The presence of REITs as another real estate asset bewilders investors as to how the dynamics of real estate allocation should operate?

In this chapter, we propose a novel method for deriving the covariance and correlations of REITs with direct real estate and the stock market in Japan. In particular, we develop a model based on the vector error correction model, a framework that can account for the long-run interdependence and short-run dynamics of these assets. In particular, we attempt to derive a variance-covariance matrix for any investment horizon from the VECM. We modify the Campbell and Viceira (2005a) long-horizon portfolio allocation model to accommodate cointegration between REITs and direct real estate. We allow direct real estate and REITs to participate in an error-correction mechanism. Also, we exclude stocks from the long-run relation.

Our estimates of the covariance matrix derived from the VECM give us the term structure of volatility for each asset return. Our results for the term structure of risk for all assets show a mean-aversion pattern. We find the term structure of volatility of REITs is lower than stocks and higher than direct real estate in the long run. The term structure of volatility for direct real estate increases, although at a low magnitude. Our estimated covariance matrix gives us the correlation structure between asset returns, where the REITs and direct real estate correlation increases in the long run. Also, we find that REITs are more correlated with stocks; than stocks with direct real estate. The correlation between stocks and direct real estate is the lowest. Similar results can be seen based on the observation of each property sector.

In general, our pseudo portfolio exercise for different holding periods indicates the allocation of REITs in the short and medium term, whereas, over the long run, direct real estate is the chosen asset for real estate investment. Our estimated portfolio derived from the VECM shows REITs have a higher allocation than in a VAR-based optimal portfolio. Our results reveal the importance of cointegration in a horizon-dependent variance-covariance matrix in-between asset returns, in particular, regarding the substitutability between REITs and direct real estate plus the role of non-cointegrated assets (i.e. stocks). In other words, the assessment of an optimal allocation for each asset needs to take into account the holding period, consistent with the variance-covariance matrix derived from the VECM framework.

CHAPTER 4

The Dynamic Role of the Japanese Property Sector REITs in a Mixed Asset Portfolio

4.1 Introduction

Numerous studies have been conducted examining the return characteristics of property sector REITs (Milcheva, 2021; Plazzi et al., 2011; Van Nieuwerburgh, 2019). As a result, we can now distinguish the differences between one property sector's REITs and another, as each sector has a distinct line of business. In terms of asset selection, property sector REITs provide added value to investors, particularly in the multiple-choice of liquid real estate investment. Besides, with lower transaction costs and the ability to invest in a small unit, property sector REITs have a comparative advantage over commercial direct real estate properties for investors seeking a short-term investment.

However, as with any other publicly-traded assets, REITs react to economic shocks. Their interaction with other financial assets causes their risk and return characteristics to be time-varying (Hoesli, Kadilli, & Reka, 2017). An increase in the volatility of REITs causes the correlation with other financial assets to increase. Given this circumstance, the assessment of the linkages of property sector REITs and other financial assets needs to take into account the aspect of short- and long-run persistence in shocks which can affect their volatility and correlation dynamics. An empirical estimation on these two aspects would be necessary to determine whether or not property sector REITs give rise to a greater diversification benefit in a mixed-asset portfolio.

The objective of this chapter is to examine the time-dynamics volatility and correlation structure between REITs in each property sector, and stocks and bonds in the Japanese market. For this purpose, the conditional volatility is modelled in the Glosten, Jagannathan, & Runkle-generalised autoregressive conditional heteroskedastic (GJR-GARCH) process and the conditional correlations are estimated in the dynamic conditional correlation (DCC) model. We examine the portfolio implications of each property sector's REITs with stocks and bonds. In particular, we use the estimated DCC-GJRGARCH parameters to generate the forecast variance-covariance matrix and incorporate them into the mean-variance optimal portfolio on a daily frequency. Then, we evaluate the diversification benefits of each property sector's REITs in a mixed-asset portfolio. We construct the optimal portfolio of stocks and bonds with no REITs and a portfolio with REITs. Accordingly, we use each property sector's REITs to create five different sets of optimal portfolios together with stocks and bonds. Related to these issues, our study in this chapter seeks to address the following questions:

i) What are the characteristics of volatility and correlation of property sector REITs with stocks and bonds and other assets?

ii) Given the dynamics of volatility and correlation of each property sector's REITs with stocks and bonds, what is their portfolio implication for the investor in Japanese markets?

iii) Do property sector REITs in the Japanese market provide diversification benefits to investors?

Our present study adds to the existing literature in a number of ways. First, we extend the prior work of Liow et al., (2009) and Liow (2012), which have analysed the linkages of the Japanese REITs and stocks in local and international markets. In our study, we analyse the volatility and correlation dynamics of Japanese REITs and other financial assets by accounting for REITs in a specific property sector. By doing so, our findings show that each property REITs is distinguishable, where each asset exhibits a distinct volatility structure and a significant time-varying dynamic correlation with stocks and bonds. For that reason, to assess the diversification benefit of each property sector REITs, our findings suggest a time-varying dynamic allocation of property sector REITs with other financial assets in a mixed-asset portfolio.

Secondly, with regards to assess the diversification benefit of Japanese property sector REITs in a mixed-asset portfolio, past studies have applied the unconditional estimates in the variance-covariance matrix by using quarterly or annually data (Cho, 2017; Y. C. Lin et al., 2019). Instead, our study follows a different approach. That is, we use daily data to forecast the dynamic variance-covariance matrix between each property sector's REITs, stocks and bonds. Then, we translate the forecast dynamic variance-covariance matrix into a dynamic portfolio allocation of each property sector's REITs, stocks and bonds daily.

Our evaluations across each property sector show that portfolio with a property sector REITs performs better than a portfolio of stocks and bonds. We manage to show that property sector REITs improve a daily portfolio investor risk-adjusted return, as measured by the Sharpe ratio. In addition to that, our estimation of utility for an investor with REITs is higher than for an investor without REITs. The improvement in utility indicates the additional compensation received by taking an additional risky asset in their portfolio. Thus, the findings reflect the evidence of diversification benefits for each of the Japanese property sector REITs on a daily investment, where the benefit also outweighs the transaction costs associated with portfolio rebalancing. Taken together, we contend our approach that account for the dynamics in framing the variance-covariance matrix perceives the Japanese property sector REITs as a portfolio diversifier, particularly for an investor with a daily investment horizon.

4.2 Literature Review

4.2.1 Interdependence of REITs with Stocks

Numerous studies have analysed the impact of economic shocks on the dynamics and volatility of REITs as well as interdependence with stocks. For instance, the 1997 Asian financial crisis was a shock that increased the volatility of securitised real estate (including REITs) in several Asian countries and the US market (Bond, Dungey, & Fry, 2006; Gerlach, Wilson, & Zurbruegg, 2006). Previous literature has established that the crisis caused a regime shift in the relation between REITs and stocks in return and volatility dynamics (Kallberg, Liu, & Pasquariello, 2002; Stevenson, 2002).

Another strand of literature examines the impact of the global financial crisis in the US on REITs in local and international markets. Hoesli and Reka (2013) present a model to study the contagion and volatility spillover from the US market. They report how shocks from the US affect REITs in the UK market. Chiang, Tsai, and Sing (2013) examine the spillover risk from the US market. They show the significance of volatility spillover to several Asian REITs, where REITs' volatility increased abruptly after the subprime mortgage crisis. In a related study, Chiang, Sing, and Tsai (2017) measure the spillover risk in US REITs, where the lagged volatility spillover negatively impacts the returns of REITs. Quite recently, Boudry, Connolly, and Steiner (2019) examined the returns of REITs during the flight to safety (FTS), featuring both large negative stocks returns and large positive bond returns. Their findings show that on the FTS day, REITs reported lower negative returns than financial sector stocks.

The transmission (particularly) of negative shocks has a significant impact on the dynamic linkages between REITs and the stock market. It contributes to asymmetric dependence, where the correlation between REITs and stocks is higher during a bear market than during a bull market. Several studies examine and document the increase in asymmetric linkages between REITs and stocks. Knight, Lizieri and Satchell (2005) explore the increased correlation between the two assets in both the downturn and upturn in the UK market. Trück and Rong (2014) report the significance of asymmetry dependence between REITs and stocks during the downturn in the Australian market. Simon and Ng (2009) explore the correlation between REITs and stocks after the collapse of the real estate bubble in the US market. The burst in the real estate bubble led to a shift in correlation between these two assets. Their finding is consistent with later studies that indicate increased volatility in these two assets, particularly during the crisis period and closer correlation compared to the non-crisis period (M. C. Huang et al., 2016; M. Huang & Wu, 2015).

The presence of shocks in the stock market contributes to the increased linkages between REITs and stocks, where the correlation of these two assets increases and causes both assets to decline in prices (Hoesli & Reka, 2015; Hui & Chan, 2018; Luchtenberg & Seiler, 2014). The increase in the interlinkages between these two assets motivates investors to price the sensitivity of REITs returns to the shocks in the stock market. M. C. Chen, Tsai, Sing,and Yang (2015) calculate the time-varying beta of REITs to measure their sensitivity to stock market returns by taking account of the downside risk. Glascock and Lu-Andrews (2018) examine the conditional beta of REITs in relation to stocks in the US market. Using monthly data from January 1992 to December 2014, the study considers the significance of downside beta. The REITs returns increase during market downturns, particularly in the global financial crisis of 2007 to 2009. Their findings highlight the importance of asymmetric risk embedded in REITs' rate of return and their linkages with the stock market. The increase in correlation between the REITs and stocks in a market downturn causes the investor to demand a higher return or premium over their investment in REITs (Alcock & Andrlikova, 2017).

4.2.2 Assessment of Diversification Benefit of REITs with Other Assets

The close linkages between REITs and stocks raises the question as to whether they are a diversifiable asset in a mixed-asset portfolio. In particular, the assessment of REITs as a diversifier need to take into account both conditional volatility and correlation between REITs, stocks and other assets. Often changes in the economic situation, both good and bad, mean that the volatility and correlation structure are time-varying. Consequently, the use of conventional rolling correlation, may not be adequate, as this measurement tends to be biased upward during periods of increased volatility in one asset market (Case, Yang, & Yildirim, 2012).

A substantial number of studies examine the dynamic correlation between REITs and other financial assets. Cotter and Stevenson (2006) investigate the correlation between different types of REITs, mortgage, equity, and hybrid REITs. Using the t-BEKK specification, the study reports a mixed positive and negative correlation between equity REITs and mortgage REITs, and a positive correlation between equity and hybrid REITs. Equity REITs are positively correlated with stocks, but other REITs can be negatively correlated with stocks. Chong, Krystalogianni and Stevenson (2012) explore the dynamic correlation of REITs in different property sectors. The sectors in REITs are dynamically positively correlated between 0.8 and 0.9. Michayluk, Wilson and Zurbruegg (2006) use synchronised trading data to study the asymmetry in the dynamic correlation between REITs in the US and UK markets. Their findings reveal that negative shocks in the two markets cause an increase in the correlation between the UK and US REITs.

Case et al. (2012) examine the conditional volatility and correlation between REITs, stocks and bonds in the US market. Using monthly data from July 1978 to September 2008, it shows the dynamic changes in correlation between the asset returns, with the correlation between REITs and stocks fluctuating around 06 in the late 1970s to the early 1990s. The correlation fluctuates between 0.3 and 0.7, particularly in the early 90s to early 2000. The correlation between these two assets fluctuates around 0.6 as REITs are included in the broad stock market index. The correlation between REITs and bonds is around 0.1 to 0.3, while the correlation between REITs and bonds fluctuates around -0.5 to 0.5 across all periods. Peng and Schulz (2013) test for different volatility models in individual assets and correlation between REITs, stocks and bonds. By using daily data, the study finds that each asset exhibits a distinct volatility structure where stocks show asymmetric volatility. Meanwhile, the correlation amongst the three assets is dynamic as the hypothesis of a constant correlation between asset returns is rejected.

The dynamics in correlation and volatility are not limited to the domestic market. Liow, Ho, Ibrahim, and Chen (2009) consider these two aspects in relation to REITs and stocks, particularly in the US, the UK, Japan and Hong Kong. These two assets show persistent volatility, where they are time-varying and changing in the same direction. By using monthly data on these two assets, estimation based on DCC-GARCH analysis indicates that the correlation between stocks of these countries is higher than the correlation amongst the REITs. Liow (2012) applies the asymmetry DCC–GARCH to examine the correlation between REITs and stocks within Asian countries and their global counterparts. The study reports that the correlation between REITs and stocks in the local market is higher than the correlation amongst peers in Asian markets. Somewhat contrarily, the correlation between REITs in Asian countries and the global market is lower than the correlation of REITs in Asian markets. Liow, Zhou and Ye (2015) study the correlation spillover by constructing a correlation dependence index. They find that 80% of the forecast error variance in correlation spillover comes from the global market, with the balance of 20% generated by the local market. Their findings accentuate that REITs are linked by means of both asymmetric correlation and correlation spillover between local and global markets.

The linkages of REITs and other assets are not limited to stocks. For instance, Yang, Zhou, and Leung (2012) consider the correlation of REITs and stocks, with debt securities like commercial mortgage-backed securities and bonds. Their findings indicate the prevalent asymmetry in correlation between REITs and stocks, particularly when both asset returns are negative. Instead, these two assets have a negative correlation with debt securities. Fei, Ding, and Deng (2010) examine the dynamic correlation between REITs, direct real estate and stock. Using monthly data, the study indicates the absence of an asymmetric correlation between the three assets. The dynamic correlation between REITs and direct real estate is low, ranging between -0.15 and 0.25. The correlation between REITs and stocks fluctuates around 0.2 to

0.7. Chong, Miffre and Stevenson, 2009) explore the bivariate dynamic conditional correlation between REITs and stocks, bonds and commodities. On average REITs and stocks are moderately correlated with an average correlation of 0.4. REITs and government bonds have a low correlation, with an average of 0.1. Also, REITs and commodities are negatively correlated, with an average correlation of -0.20. The regression between conditional correlation and conditional volatility indicates that the increase in correlation between REITs and stocks is associated with the increase of volatility, whereas the decline in correlation between REITs and bonds, and between REITs and commodities are related to the decline in the volatility for both assets.

4.2.3 Dynamic Correlation and Implications for the Optimal Portfolio

Several studies assess the role of REITs in a mixed-asset portfolio and compare their performance against other types of assets. For instance, Sa-Aadu, Shilling, and Tiwari (2010) sequentially add commodities, precious metals, and REITs in a mixed-asset portfolio of stocks and government bonds. Using quarterly data, the inclusion of REITs can improve portfolio risk and magnify the portfolio Sharpe ratio significantly. In a regime-switching framework, with a quarterly portfolio rebalancing, they report that REITs are included in good times for the economy rather than the bad, as the asset helps to act as a hedge against economic shocks.

Huang and Zhong (2013) test the dynamic correlation of REITs, commodities and TIPS with stocks and bonds in the US market. Their observations on daily data from January 1999 to June 2010 based on DCC-GARCH indicate that the correlation between REITs and stocks fluctuates around 0.3 prior to 2007, before steadily increasing to between 0.5 and 0.8 in the later years. The correlation of REITs and bonds is low, fluctuating around -0.2. Their spanning test indicates that the diversification benefit of each asset would vary over the investment period. None of these three assets helps to diversify portfolio risk during the global financial crisis. However, on average, REITs are the most important diversifiers in the portfolio, as compared to other assets, as they help to improve the portfolio Sharpe ratio, especially after the financial crisis.

The study by Case et al. (2012) considers the differences in correlation estimates and the implications for an optimal portfolio. Using monthly observations in the pre- and post-modern REIT era in the US market, they form an optimal portfolio of REITs, stocks and bonds with correlation implied from the DCC as opposed to the rolling correlation model. Their mean-variance portfolio indicates that the application of the DCC helps to improve overall portfolio performance, both in terms of higher return and lower portfolio risk, as compared to the estimated portfolio based on rolling correlation. Lee (2014) assesses the correlation structure of REITs and stocks in several countries, rejecting a constant correlation structure. Using daily data their findings, based on DCC estimation, contribute to dynamics in the time-varying allocation of these two assets, with on average more weight to REITs than stocks.

Peng and Schulz (2013) conduct a forecasting exercise on the dynamic correlation and optimal portfolio of REITs, with stocks and bonds for the US and other developing countries. Their out-of-sample portfolio indicates the optimal portfolio based on DCC helps to reduce overall portfolio risk, as compared to a static buy-and-hold portfolio. Although the benefits are underweighted given the higher cost of rebalancing, the use of the dynamic covariance model rather than a constant covariance structure helps buy-and-hold investors to evaluate their portfolio risk. Abuzayed et al., (2020) assesses the diversification benefits of REITs and stocks in the UK, Germany and France. The study uses daily data for these two assets and includes two major financial crises, namely the global financial crisis and the European sovereign debt crisis. Their estimates of DCC indicate the correlation of REITs and stocks increases during the two crises. Their optimal portfolio exercise indicates the allocation of REITs reduces in the three countries during the global financial crisis, but increases during the debt crisis, as the latter event is more conducive to volatility in stock markets.

Existing studies offer successive assessments of dynamic linkages of REITs with other financial assets and the implications for dynamic portfolio allocation. By using the sample in the Japanese market, our study aims to explore the time-varying volatility and dynamic correlations of REITs in composite and specific property sectors, together with stocks and bonds. We also consider the implications of dynamic linkages on the dynamic optimal portfolio allocation involving REITs, by assessing the benefits of including REITs in the portfolio over traditional investments in stocks and bonds.

4.3 Methodology

4.3.1 DCC-GJRGARCH Model Specification

We design the research in this study by dividing the methods in two parts. First, we perform the time-series analysis of asset returns, REITs, stocks and bonds. We model the volatility and correlation of each property sector's REITs with stocks and bonds. We use the same empirical model to forecast the variance-covariance matrix and take out the volatility and correlation amongst the asset returns. In the second step, we use the forecast variance-covariance matrix to construct an optimal portfolio allocation of the three assets.

A substantial number of studies have documented the close linkages of REITs with financial assets. Thus, a suitable model needs to capture the conditional volatility and correlations of REITs with stocks and bonds. The present case gives rise to impractical use of the unconditional estimates of volatility, and correlation may not be feasible since it assigned equal weights to past and recent observations, regardless of any point observation. Nevertheless, conditional estimation is necessary for the current estimates of volatility and correlation amongst the asset returns which account for the past information. Thus, we employ the dynamic conditional correlation (DCC) model by Engle (2002) to estimate the time varying correlations between REITs, stocks and bonds. According to T. C. Chiang, Jeon, & Li, (2007), the DCC model is the parsimonious way to estimate a time-varying correlation for more than two asset returns, since there are fewer parameters to be estimated as compared to Engle & Kroner's (1995) Multivariate BEKK model. The DCC model also overcomes the problem of heteroskedasticity as the model estimates the correlation of the standardised residuals. Despite the simplicity, the DCC model gives flexibility for modelling the volatility of an individual asset return. We allow for the asymmetry in the volatility of each asset return, where the volatility of an asset is higher due to receipts of negative shocks than positive shocks. Thus, our study sets out to model the volatility of each property 's REITs, stocks and bonds in the form of Glosten, Jagannathan, & Runkle's (1993) GJR-generalised autoregressive conditional heteroskedastic (GJR-GARCH) process.

We begin to estimate DCC-GJRGARCH by modelling the asset returns. Let RI_t^i be the total return indices for each asset, $i\epsilon\{REIT\ Stock, Bond\}$. For each of RI_t^i, we take the logs, $log\ RI_t^i$. The difference in log for each series can be expressed as $r_t^i = log\ RI_t^i - log\ RI_{t-1}^i$. Suppose that r_t is the vector of index return, $r_t = \{r_t^j, r_t^k, r_t^l\}$, where j=REITs, k=stocks and l=bonds respectively. We model the asset returns by assuming the Vector Autoregressive of lag q , VAR(q) processes where

$$r_t = \mu + \sum_{h=1}^{q} \varphi_h r_{t-h} + \varepsilon_t \qquad (4.1)$$

where μ us the drift term, $\mu = \mu_j, \mu_k, \mu_l$. We define $\varphi_h$as a 3x3 matrix of autoregressive terms with q as a maximum number of lags. The disturbance term, ε_t is modelled as $\varepsilon_t = \left\{\varepsilon_t^j, \varepsilon_t^k\ \varepsilon_t^l\right\}$. ε_t is iid and normally distributed, $\varepsilon_t \sim N(0, H_t)$. The subscripts for each type of REIT are omitted for ease of model representation.

The variance-covariance matrix, H_t can be defined as

$$H_t = D_t R_t D_t \qquad (4.2)$$

where R_t is the 3x3 conditional correlation matrix and D_t is the 3x3 diagonal matrix. Each element in the diagonal is defined as $\sqrt{h_t^{\tau}}$,$\tau \in j, k, l$ that is the standard deviation from the separately fitted univariate GJR-GARCH (1,1) model. In particular,

$$h_t = c_i + a_i \varepsilon_{i,t-1}^2 + \gamma_i \varepsilon_{i,t-1}^2 I(\varepsilon_{t-1} < 0) + b_i h_{t-1} \tag{4.3}$$

where c_i is the constant term, a_i short-run impact of shocks (ARCH effects), γ_i is the asymmetry effect when $\varepsilon_{t-1} < 0$ and b_i is the long-run persistent effect of shock (GARCH effect) on the disturbance variance for each asset return.

We use a two-stage approach to estimate H_t. Firstly, the estimates of h_t are derived from the univariate volatility model for each asset returns. Secondly, the residuals from asset return equations are transformed as $\eta_t = \frac{\varepsilon_t}{\sqrt{h_t}}$. The transformed parameter is then used to estimate the dynamic conditional correlation parameter.

The dynamic conditional correlation DCC model by Engle (2002) is given by

$$Q_t = (1 - \alpha - \beta)\bar{Q} + \alpha \eta_{t-1} \eta_{t-1}' + \beta Q_{t-1} \tag{4.4}$$

and $R_t = Q_t^{*-1} Q_t Q_t^{*-1}$ (4.5)

where $\bar{Q} = E[\eta_{t-1} \eta_{t-1}']$ as 3x3 unconditional variance-covariance matrix of η_t , and α and β are scalars capturing the past shocks and conditional covariance on the current covariance, such that $\alpha + \beta < 1$. The closer the sum of the two coefficients is to one then the stronger the degree of persistence in correlation. As long as Q_t is positive definite, R_t^* is a correlation matrix with ones on the diagonal and every off-diagonal element would be less than 1 (in absolute value).

4.3.2 Out-of-Sample Evaluation

Forecasting Future Volatility and Dynamic Covariance Matrix Implied from DCC-GJR GARCH Model

Another important aspect of using the DCC-GJR-GARCH model is to perform a forecast of volatility and covariance matrix for a future time horizon. Suppose that, on a day t, an investor needs the estimates of volatility and correlations of REITs, stocks and bonds, using a set of information up to day t-1. We use a rolling window estimation in order to perform an out-of-sample forecast of volatility and correlation. In particular, we first divide our data set into a training sample and an evaluation sample. Suppose that on evaluation day t, we estimate the DCC-GJR-GARCH based on the training sample up to day t-1. Then, we use the estimated variance-covariance on day t-1 and the estimated coefficients from the DCC-GJR-GARCH to forecast the covariance matrix on day t. The training sample shifts one day to forecast the variance-covariance matrix on the next day in the evaluation period. This process continues until the forecasting exercise in the evaluation sample is completed.

Estimation of Variance

The forecast of variance for each asset return can be conducted based on the H_t equation where $H_t = D_t R_t D_t$ in which, $D_t = diag(\sqrt{h_{i,t}}, \ldots, \sqrt{h_{i,t}})$, where j refers to the number of assets. In a GJR-GARCH (1,1) process, the one-step forecast for the variance for each asset return can be implemented by using the equation where

$$h_{t+1} = c_i + a_i \varepsilon_{i,t}^2 + \gamma \varepsilon_{i,t}^2 I(\varepsilon_t < 0) + b_i h_t \tag{4.6}$$

Estimation of Correlations

According to Engle and Sheppard (2001), the forecast covariance matrix for future time horizons based on the estimated DCC GARCH model can be started by exploiting the following Rt equation using the following equation:

$$R_t = Q_t^{*-1} Q_t Q_t^{*-1} \tag{4.7}$$

From this equation, we can define the one step ahead of correlation of standardised residuals as:

$$Q_{t+1} = (1 - \alpha - \beta)\bar{Q} + \alpha[\epsilon_t \epsilon_t'] + \beta Q_t \tag{4.8}$$

where $E_t[\epsilon_{t+h-1}\epsilon_{t+h-1}'] = E_t[R_{t+r-1}]$ and $R_{t+r} = {Q_{t+r}^*}^{-1} Q_{t+r} {Q_{t+r}^*}^{-1}$

Based on this relation, the forecasting exercise for the correlation matrix cannot, unfortunately, be done directly. Engle and Sheppard (2001) suggest two ways to find a closed-form solution to solve this issue; by proposing two different sets of approximation. The first method is to generate the k step ahead forecast of Q by using an approximation that $E_t[\epsilon_{t+h-1}\epsilon_{t+h-1}'] \approx Q_{t+1}$ for $i \in [1, \dots, r]$. Using this approximation, the r-step ahead of forecast of Q would be:

$$E_t[Q_{t+k}] = \sum_{i=0}^{k-2} (1 - \alpha - \beta)\bar{Q}(\alpha + \beta)^i + (\alpha + \beta)^{k-1} Q_{t+1} \tag{4.9}$$

For the second method, an alternative approximation would be that $\bar{Q} \approx \bar{R}$ and that $E_t[Q_{t+1}] \approx E_t[R_{t+1}]$. From this approximation, we can forecast R_{t+k} directly using the relationship:

$$E_t[R_{t+k}] = \sum_{i=0}^{k-2}(1-\alpha-\beta)\bar{R}(\alpha+\beta)^i + (\alpha+\beta)^{k-1}R_{t+1} \tag{4.10}$$

For this study, we are going to apply the second approximation. This selection is consistent with the suggestion by Engle and Sheppard, given that their forecast is simpler and less biased compared to the first approximation.

4.3.3 Mean Variance Portfolio with a Required Return

We test the estimated variance-covariance matrix for optimal portfolio application. For a day t, we intend to minimise portfolio risk, subject to a required daily portfolio return, on day t-1. We define the objective function as

$$\min h_t = w_t' H_t w_t \tag{4.11}$$

subject to

$$w_t' \mu = \mu_0 \tag{4.12}$$

where μ is the expected return for each asset, and μ_0 is the required daily portfolio return. For the purposes of an empirical evaluation, we assume μ_0 to be 0.030%. We forecast the expected return μ for each asset on day t, based on a rolling sample up to t-1 and derived from the mean equation modelled as the VAR(1) process. Consistent with the forecasting exercise in the variance-covariance matrix, our estimation will generate 1305 optimal portfolios.

4.3.4 Approximation of Utility Function for a Minimum Variance Portfolio with a Required Portfolio Return

We construct an optimal portoflio for an investor with a mean-variance utility function . Following Peng & Schulz (2013), we denote the approximation of average realised utility $\bar{U}(.)$ generated by a given initial wealth , W that we assume W = 100, a is the coefficient of relative risk aversion $a = 5$ and $r_{p,t}$ as the realised time series of portfolio return at time t . *Thus,*

$\bar{U}(.) = W \sum_{t=1}^{T} (r_{p,t} - \frac{a}{2} r_{p,t}^2)$	(4.13)

From equation, (4.13), we estimate the average realised utility of two separate portfolio settings. First, we let a portfolio A, that is an portfolio consisting of stocks and bonds. Secondly, portfolio B is an optimal portfolio of REITs, stocks and bonds. We equate the average utility of portfolios A and B and compute the differences between the two sets of expressions by accounting for the compensation fee, f. The compensation fee measures the improvement of utility expressed in (percentage terms) for an investor with a mean-variance preference that has a specific coefficient of relative risk aversion, a. We represent the equations of average utility of portfolio A and portfolio B and compensation fee, f in the equation 4.14.

$$\sum_{t=1}^{T} r_{B,t}^{p} - f - 0.5a\left(r_{B,t}^{p}\right)^2 = \sum_{t=1}^{T} r_{A,t}^{p} - 0.5a\left(r_{A,t}^{p}\right)^2 \qquad (4.14)$$

Where t= 1 to 1305 days. r^p, is the portfolio return, and a is the coefficient of risk aversion, which we assume equal to 5, $r_{A,t}^{p}$ is the realised return on the conventional optimal portfolio, which consists of stocks and bonds, and $r_{B,t}^{p}$ is the return on an optimal portfolio consisting of REITs, stocks and bonds. We compute the portfolio consisting of REITs by considering specific property classes, which are not limited to composite REITs, but also the individual office, retail, hotel or residential property sectors REITs.

4.3.5 Estimation of Transaction Cost of Portfolio Rebalancing

We also measure the costs associated with the portfolio rebalancing. For each day, t, we compute the transaction cost of rebalancing for each individual asset REITs, stocks and bonds. We define the transaction cost of rebalancing for each individual asset where

$c_{i,t} = sp\left|w_{i,t+1} - w_{i,t}\right|$	(4.15)

With sp is defined as the relative bid-ask spread from the individual asset in the portfolio. We assume the *sp*= 0.20%, consistent with Ahn, Cai, Hamao and Ho (2002) for the Japanese stock market.

Then, we compute the total cost of rebalancing for the three assets, on day t, TC_t

$$TC_t = \sum_{i=1}^{3} c_{i,t} \tag{4.16}$$

Nevertheless, for the purpose of empirical estimation and reporting, we then compute the average transaction cost, denoted as Average TC, over 1305 days of the out-of-sample period. This approach is used to compare the relative improvement of the investor's average realised utility as measured by the compensation fee over the average transaction cost of portfolio rebalancing incurred due to the inclusion of REITs in the portfolio.

We follow Peng and Schulz (2013) to perform the forecasting exercise use a rolling window out-of-sample estimation. First, we set 1.1.2008 to 31.12.2014 or 1826 days as training (in-sample) and 1.1.2015 to 31.12.2019 (1305 days) as evaluation (out-of-sample) periods.

For each day of the evaluation period, we use the previous 1826 days of observations to estimate the time-varying covariance matrix. Suppose that we consider 1.1.2015 as a first evaluation day of portfolio construction. The portfolio on the first evaluation will be formed based on the forecast covariance matrix estimated from 1.1.2008 to 31.12.2014. On the second evaluation day, 2.1.2015, the portfolio is created based on the forecast covariance matrix estimated from 2.1.2008 to 1.1.2015. The training sample shifts by one day and so on. In sum, we produce a total of 1305 days of estimated dynamic variance-covariance matrix and portfolios, by considering REITs for each sector.

4.4 Data

In this study, we use the total return indices for each property sector's REITs, stocks and bonds. For REITs, as in the first two empirical chapters, we apply the Datastream constructed total return indices, for composite REITs in general and other property sectors, including office, retail, residential, and hotel REITs. We use the TOPIX total return indices as the proxy for investment in common stocks. Finally, we apply the Datastream Japanese Benchmark 10-year Government Bond as the proxy for investment in bonds.

The listing of Japanese REITs provides access for investors in real estate securities on a daily basis. Hence, for a daily investor, REITs are a feasible alternative to direct real estate, as the latter is an illiquid asset. Furthermore, according to Maheu & McCurdy (2011), the use of high-frequency data is necessary to forecast the volatility and correlations between asset returns, as implied from the DCC-GJR-GARCH model. Thus, in this study, we use the daily frequency data of the indices of each property sector's REITs, stocks and bonds.

The early development of Japanese REITs in 2001 primarily focused on office properties. Other property sectors - retail, residential and hotel REITs emerged in 2003, 2004 and 2006 respectively. For purposes of a level playing field in the empirical estimation, we set daily observations of 3130 days, from 01.01.2008 to 31.12.2019. Of these we set 1.01.2008 to 31.12.2014 or 1826 days as training (in-sample) and 01.01.2015 to 31.12.2019 (1305 days) as evaluation (out-of-sample) periods.

We assume the daily returns are continuously compounded and we compute the returns by taking the differences in logs. The descriptive statistics for the collected data series are presented in Table 4.1. In general, stocks has the highest mean compared to REITs and Bonds. hotel REITs have the highest mean return. The standard deviation of REITs indices ranges between 0.00850 and 0.01160. The standard deviation for the stock market is lower compared to the hotel REITs and retail REITs. Bonds have the lowest level of volatility. All return series are positively skewed. Our daily sample series dataset has the kurtosis fluctuates around 3.00

Table 4.1

Descriptive Statistics for the Collected Data at Daily Frequency

Variables	Mean	Standard Deviation	Min	Max	Skewness	Kurtosis
ΔSTOCK	0.00050	0.01050	-0.02980	0.02990	-0.00410	3.19770
Δ REIT	0.00029	0.00850	-0.02420	0.02450	0.02070	3.36800
ΔBOND	0.00013	0.00130	-0.00360	0.00370	0.1380	3.37900
ΔResidential _REIT	0.00034	0.00970	-0.02730	0.02760	0.00810	3.3562
ΔRetail_ REIT	0.00023	0.01030	-0.02930	0.02960	0.00500	3.39210
ΔOffice_ REIT	0.00024	0.00880	-0.02470	0.02500	0.01650	3.30450
ΔHotel_REIT	0.00044	0.01160	-0.03210	0.03250	0.05000	3.41650

Notes. This table reports the descriptive statistic for all indices. We report the statistics for all series (REITs, direct real estate and stocks) by taking the differences in logs.

We present the unconditional conditional correlation between REITs, stocks and bonds. The pairwise correlation between REITs and stocks is 0.584, retail REITS and stock 0.537, and office REITs and stocks is 0.573. The correlation between hotel REITs and stocks is 0.287. There is a negative correlation between each type of REIT with bonds: office REITs and bonds (-0.176), retail REITs and bonds (-0.177), hotel REITs and bonds (-0.085) and residential REITs and bonds (-0.114). Also, bonds and stocks are negatively correlated, as the correlation is -0.386.

Table 4.2

Correlation Matrix Between REITs, Stocks and Bonds (Daily Data)

	ΔREIT	Δ*RETAIL_* REIT	Δ*OFFICE* _REIT	Δ*HOTEL_* REIT	Δ*RESIDEN TIAL*_REIT	ΔSTOCK	ΔBOND
ΔSTOCK	0.58400	0.53700	0.57300	0.28700	0.46500	1.00000	-0.38600
ΔBOND	-0.18200	-0.17700	-0.17600	-0.08500	-0.11140	-0.38600	1.00000

Notes. This table reports the correlation between the variables used in the chapter. We present the correlation by treating all variables in their form of difference in logs, denoted by “Δ" notation.

4.5 Results

4.5.1 The Vector Autoregressive VAR Estimates

We present the mean equation for estimates of vector autoregressive VAR of the lag 1 VAR(1). We tabulate the estimated coefficients as in the equation (4.1) but in a matrix form[31]. We report the estimated coefficients corresponding to the individual asset return, REITs, stocks and bonds. For each individual equation, we report the constant term for each asset and their respective autoregressive coefficients. Also, we report the estimated coefficients by controlling for the specific sector REITs. For instance, we have the estimated VAR(1) coefficients which involve office REITs, stocks and bonds in our system of equations.

Our estimates indicate that the autoregressive coefficients of a_{RS} are significant for each of the REITs in specific property sectors. Similar results can be seen in terms of autoregressive processes between lagged bonds and REITs a_{BR}. There is a bidirectional autoregressive relation between REITs and stocks as evidenced by the significance of a_{SR} coefficients. Also, we examine the significance of the autoregressive term between lagged stocks and bonds, a_{BS}, but find no significant autoregressive relation between lagged bonds and stocks a_{BS}.

[31] The VAR(1) in a matrix form can be written as

$$\begin{bmatrix} \Delta\mathrm{REIT}_t \\ \Delta\mathrm{Stock}_t \\ \Delta\mathrm{Bond}_t \end{bmatrix} = \begin{bmatrix} \mu_R \\ \mu_S \\ \mu_B \end{bmatrix} + \begin{bmatrix} a_{DD,1} & a_{DR,1} & a_{DS,1} \\ a_{RD,1} & a_{RR,1} & a_{RS,1} \\ a_{SD,1} & a_{SR,1} & a_{SS,1} \end{bmatrix} \begin{bmatrix} \Delta REIT_{t-1} \\ \Delta Stock_{t-1} \\ \Delta Bond_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_t^{REIT} \\ \varepsilon_t^{Stock} \\ \varepsilon_t^{Bond} \end{bmatrix}$$

Table 4.3

The Estimates of VAR (1) Output

	Panel A ΔREIT				Panel B ΔStock				Panel C ΔBond			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(10)	(11)	(12)	(13)
Sector	μ_R	a_{RR}	a_{Rs}	a_{RB}	μ_S	a_{SR}	a_{SS}	a_{SB}	μ_B	a_{BR}	a_{BS}	a_{BB}
All	-0.00390	0.032170	0.15470*	0.82470*	-0.00630	0.05570†	-0.03070	-0.04320	0.00130*	-0.00360	0.0096†	-0.03440
	(0.00410)	(0.02860)	(0.03530)	(0.00120)	(0.00360)	(1.33380)	(0.03650)	(0.18650)	(0.00490)	(0.00340)	(0.00420)	(0.02530)
Retail	0.007300	-0.03510	0.17990*	0.87450*	-0.00690	0.05030†	-0.02750	-0.03630	0.00130*	-0.00250	0.00890†	-0.03510
	(0.00460)	(0.02770)	(0.03790)	(0.23780)	(0.84820)	(0.0217)	(0.02970)	(0.18630)	(0.00490)	(0.00300)	(0.00400)	(0.02530)
Office	-0.00580	0.03360	0.16660*	0.85240*	-0.00630	0.05000†	-0.02740	-0.04210	0.00130*	-0.00310	0.00930†	-0.03450
	(0.00430)	(0.02830)	(0.03630)	(0.22200)	(0.00360)	(0.02380)	(0.03050)	(0.18660)	(0.00490)	(0.00320)	(0.00410)	(0.02540)
Hotel	-0.00270	0.19940[1]	0.06800*	0.84920*	-0.00700	0.02010	-0.00160	-0.02640	0.00130*	-0.00160	0.00720†	-0.03590
	(0.00580)	(0.02390)	(0.04240)	(0.29970)	(0.00360)	(0.01490)	(0.02640)	(0.18640)	(0.00490)	(0.02640)	(0.00360)	(0.02530)
Reside -ntial	-0.00240	0.02590	0.10360*	0.67750*	-0.00550	0.03440	-0.01190	-0.02960	0.00170*	-0.00490	0.00990†	-0.00340
	(0.00240)	(0.02660)	(0.03350)	(0.21750)	(0.00360)	(0.02280)	(0.02670)	(0.18650)	(0.00490)	(0.00310)	(0.00390)	(0.02530)

Notes. This table shows the estimates for VAR(1), which is the mean equation for DCC-GJR GARCH Model. We use the observation from 01 January 2008 to 31 December 2019. Figures in parentheses are standard error and *, † and ‡ report the significance at 1%, 5% and 10% levels.

4.5.2 The DCC-GJR GARCH Estimates

We present the multivariate DCC-GJR GARCH estimation in Table 4.4. The first part of the DCC-GJRGARCH output gives us the estimates from the variance equation corresponding to each individual asset. Similarly, with the VAR(1) mean equation, we also control for the property sector REITs in the DCC-GJRGARCH estimation. Our estimated variance equation indicates the significance of ARCH, a_i and GARCH b_i effects on the conditional variance for all asset returns, $i \in \{REITs, Stock, Bond\}$. In REITs, the ARCH effects range between 0.07 and 0.19. The ARCH coefficient of retail REITs is the highest, whilst hotel REITs are the lowest. The GARCH coefficients in the property sector REITs are higher than the composite REITs. The GARCH coefficients of bonds are higher than stocks. The significance of ARCH and GARCH terms indicates the importance of short-run and long-run persistence of the past shock to affect the volatility of each asset return. The asymmetry coefficient γ_i is significant for all assets except for hotel REITs. Their significance reflects that the volatility of each asset's returns is higher for negative shocks than positive shocks. The coefficients of α and β capture the short and long-run conditional correlations. The sum of both coefficients is close to one and thus, the results show the high degree of past shocks and conditional covariance towards the current conditional correlations between asset returns.

Table 4.4

The DCC-GJR Model Estimates

Coefficients	Composite	Office	Retail	Hotel	Residential
c_{REIT}	0.00530*	0.00570†	0.00780†	0.00016	0.00640†
	(0.00025)	(0.00028)	(0.00032)	(0.00074)	(0.00029)
a_{REIT}	0.13610*	0.12203*	0.12610*	0.04360*	0.00870*
	(0.02960)	(0.02620)	(0.03403)	(0.02777)	(0.03034)
γ_{REIT}	0.10060†	0.08160†	0.10990*	0.05820	0.07580†
	(0.04550)	(0.04260)	(0.04220)	(0.04050)	(0.03260)
b_{REIT}	0.81111*	0.829514†	0.81462*	0.91017*	0.85764*
	(0.03558)	(0.03338)	(0.04069)	(0.04239)	(0.03203)
c_{Stock}	0.00079*	0.00079*	0.00079*	0.00079*	0.00079*
	(0.00029)	(0.00029)	(0.00029)	(0.00029)	(0.00029)
a_{Stock}	0.03165	0.03165	0.03165	0.03165	0.03165
	(0.02062)	(0.02062)	(0.02062)	(0.02062)	(0.02062)
γ_{Stock}	0.11713*	0.11713*	0.11713*	0.11713*	0.11713*
	(0.05165)	(0.05165)	(0.05165)	(0.05165)	(0.05165)
b_{Stock}	0.86690*	0.86690*	0.86690*	0.86690*	0.86690*
	(0.02844)	(0.02844)	(0.02844)	(0.02844)	(0.02844)
c_{Bond}	0.00037‡	0.00037‡	0.00037‡	0.00037‡	0.00037‡
	(0.00019)	(0.00019)	(0.00019)	(0.00019)	(0.00019)
a_{Bond}	0.04046*	0.04046*	0.04046*	0.04046*	0.04046*
	(0.01112)	(0.01112)	(0.01112)	(0.01112)	(0.01112)
γ_{Bond}	0.03241‡	0.03241‡	0.03241‡	0.03241‡	0.03241‡
	(0.01897)	(0.01897)	(0.01897)	(0.01897)	(0.01897)
b_{Bond}	0.93703†	0.93703†	0.93703†	0.93703†	0.93703†
	(0.01219)	(0.01219)	(0.01219)	(0.01219)	(0.01219)
α	0.03106†	0.03234†	0.02359†	0.01216*	0.02014*
	(0.01210)	(0.01055)	(0.01050)	(0.00785)	(0.00560)
β	0.91738*	0.91298*	0.93823*	0.96606*	0.94510*
	(0.04373)	(0.03991)	(0.03954)	(0.03210)	(0.01737)

Notes. This table shows the estimate for VAR(1), the mean equation for the DCC-GJR GARCH Model. We use the observation from 01 January 2008 to 31 December 2019. Figures in parentheses are standard error, and superscript of *, † and ‡ report the significance at 1%, 5% and 10% levels. The parameters, a_i denotes ARCH effect, b_i denotes GARCH effect, and γ_i as the asymmetry effect. The parameters of α and β are scalars capturing the past shocks and conditional covariance on the current covariance.

4.5.3 The Forecast of Time-Varying Volatility and Correlations

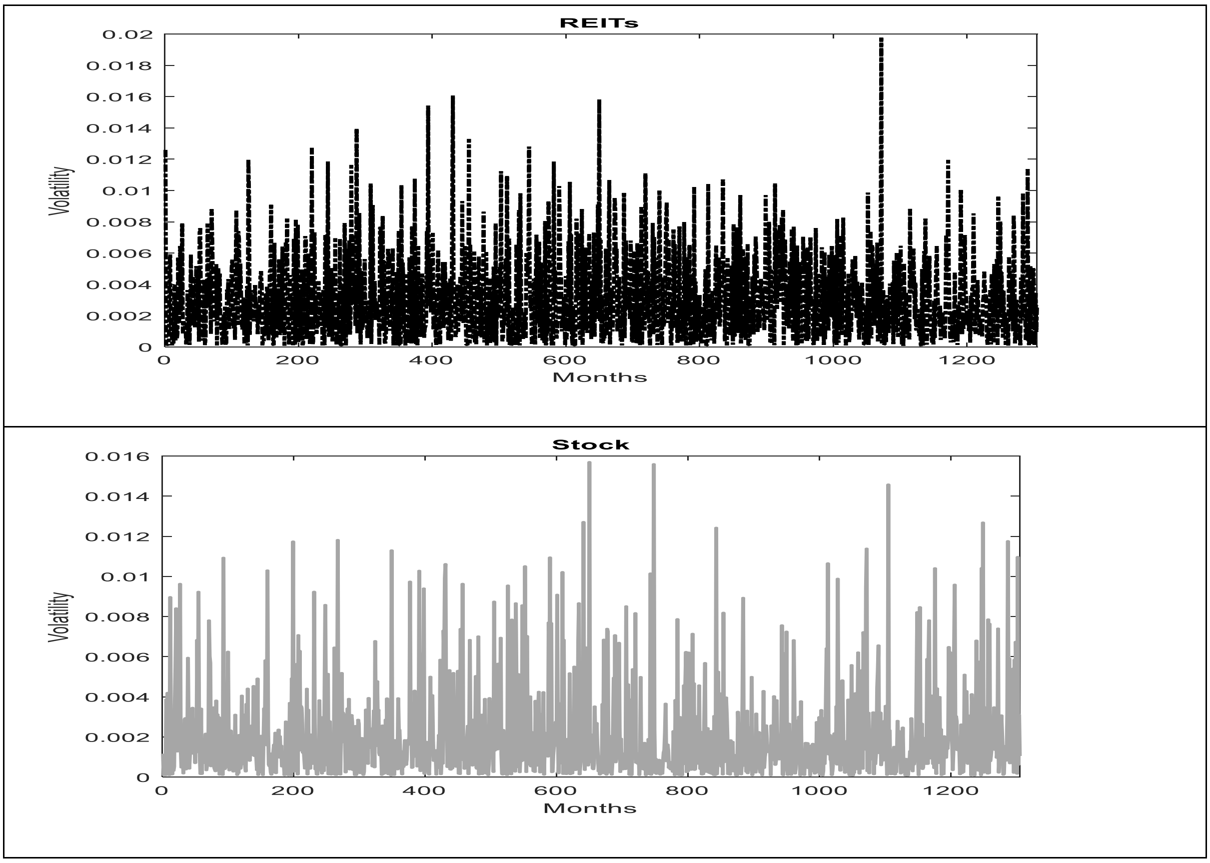
This subsection presents findings regarding the time-varying volatility and correlations of REITs and other assets, namely stocks and bonds. We form the forecast of volatility and correlations based on the estimation of the dynamic variance-covariance matrix implied from the DCC-GJRGARCH model. We conduct the forecasting exercise based on out-of-sample estimation, that is, we first divide our data set into a training sample and an evaluation sample. Suppose that on evaluation day t, we estimate the DCC-GJRGARCH based on the training sample up to day t-1. Then, we use the estimated variance-covariance on day t-1 and the estimated coefficients from the DCC-GJRGARCH to forecast the covariance matrix on day t. The training sample shifts one day to forecast the variance-covariance matrix on the next day in the evaluation period. This process continues until the forecasting exercise in the evaluation sample is completed.

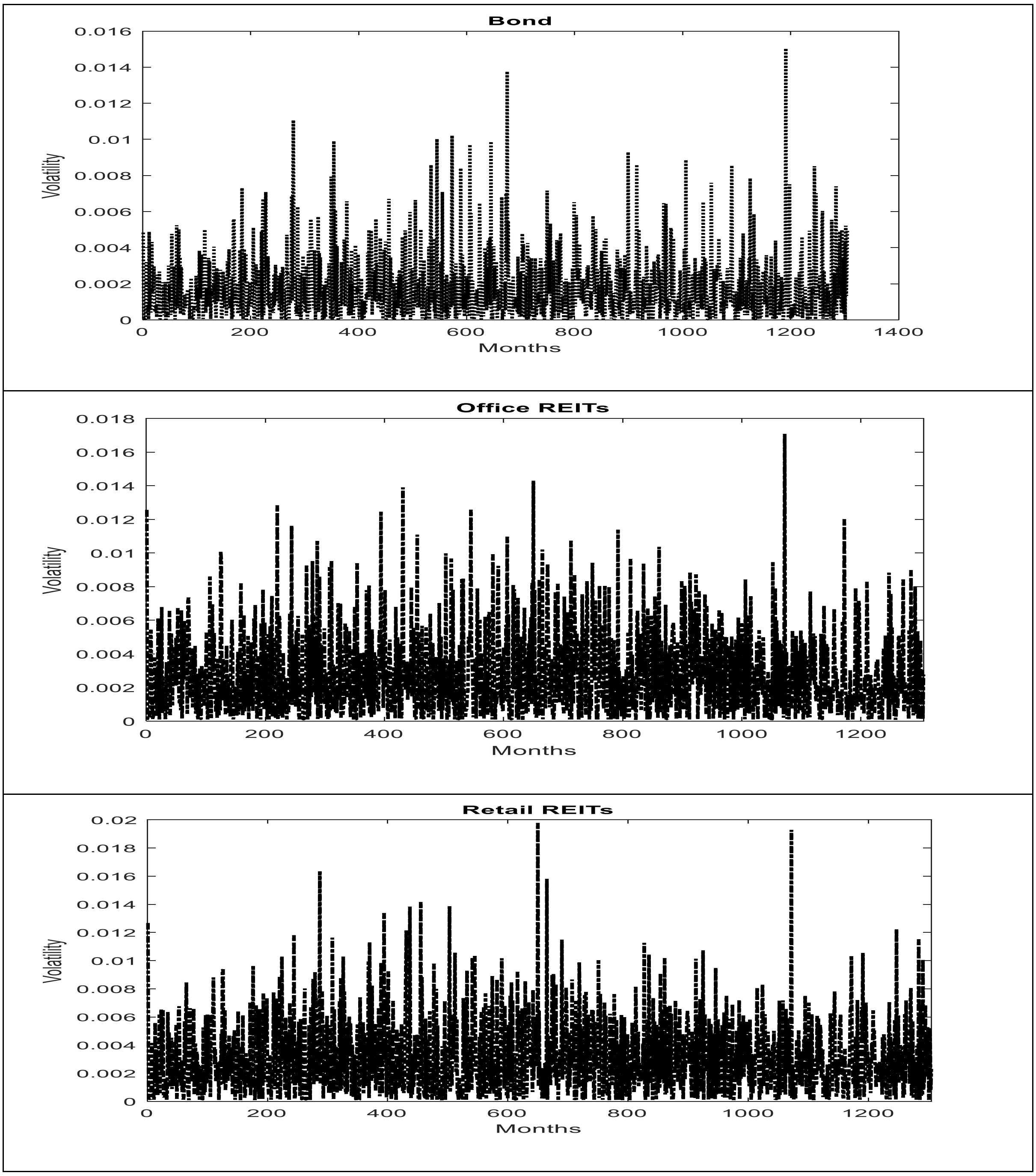
The forecast of the variance-covariance matrix gives us the time-varying volatility and the correlations between one asset and another asset. We present the out-of-sample forecast of volatility for each asset's returns in Figure 4.1. In general, our forecast shows the time-varying volatility structure of each asset, REITs, stocks and bonds. The volatility of each property sector's REITs and stocks shows a synchronised trend in the increase and decrease in their volatility structure. When the volatility of REITs increases, the volatility of stocks also increases and vice-versa. However, the volatility of REITs and stocks is different in magnitude, where REITs, on average is more volatile than stocks. Bonds are the least volatile compared to REITs and stocks.

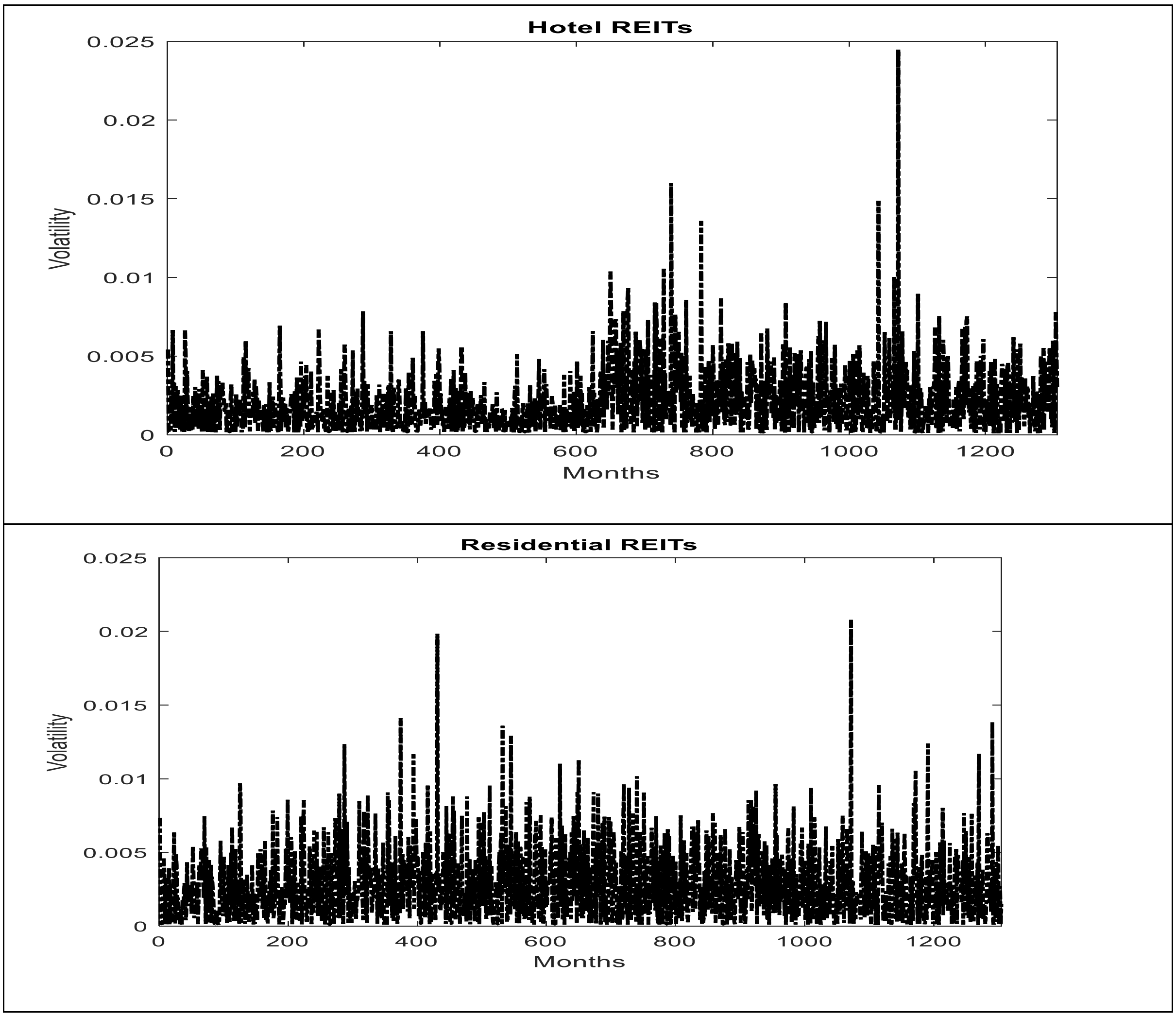
The time-varying volatility spikes for REITs in each of the property sectors are observed. The volatility of office REITs is greater than 1%, with its highest level around 1.8%. In retail REITs, we observe that volatility fluctuates between 0.6% and 2%. In the early observations, the volatility of hotel REITs fluctuates below 1%, but the volatility shows some increasing trend where the volatility of REITs may be greater than 1.5% and up to 2.5%. In residential REITs, volatility is between 0.5% and 1.5% throughout the out-of-sample period, although in some observations, we could see spikes of 2%. Our results show REITs in each property sector have distinct volatility dynamics since they fluctuate with different levels of magnitude.

Figure 4.1

Forecast Volatility Plot for Each Asset Returns




Bond
Volatility
Months
Office REITs
Volatility
Months
Retail REITs
Volatility
Months



Notes. This figure presents the forecast of time-varying volatility for each asset return derived from DCC-GJRGARCH estimates. The out-of-sample evaluation period commences from 1.1.2015 to 31.12.2019 (with a total of 1305 days).

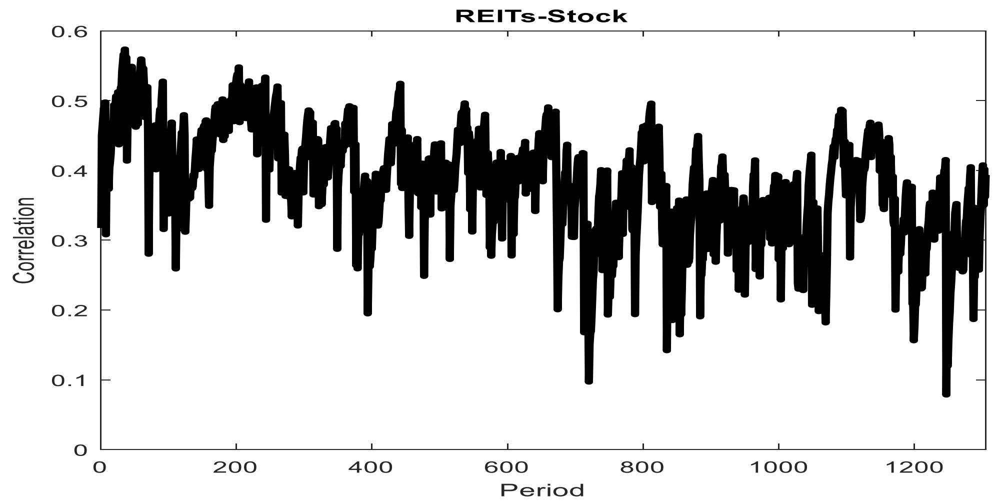
Since then, the differences between the volatility structures of each property sector's REITs indicate variation in the correlation structure of REITs and stocks. The forecast of the time-varying correlations between REITs, stocks and bonds are presented in Figure 4.2. The correlation between REITs and stocks is the highest and is always positive. The correlation between REITs and stocks occurs in the range of 0.1 to 0.6. There is a positive correlation between office REITs and stocks, where the correlation is between 0.15 and 0.55. The correlation between retail REITs and stocks is lower than the correlation between office REITs and stocks, which ranges between 0.05 and 0.5. The correlation between hotel REITs and stocks is from 0.15 to 0.4, while the correlation between residential REITs and stocks ranges between 0.10 and 0.53. Whilst the volatility of two assets, REITs and stocks increases, the correlation between the two assets also increases, though in different magnitude. Similarly, when the volatility of stocks and REITs decreases, the correlation between REITs and stocks also decreases. Accordingly, the differences in the magnitude of the volatility of each property sector REITs and stocks contribute to the significance of the time-varying correlation between the two assets returns.

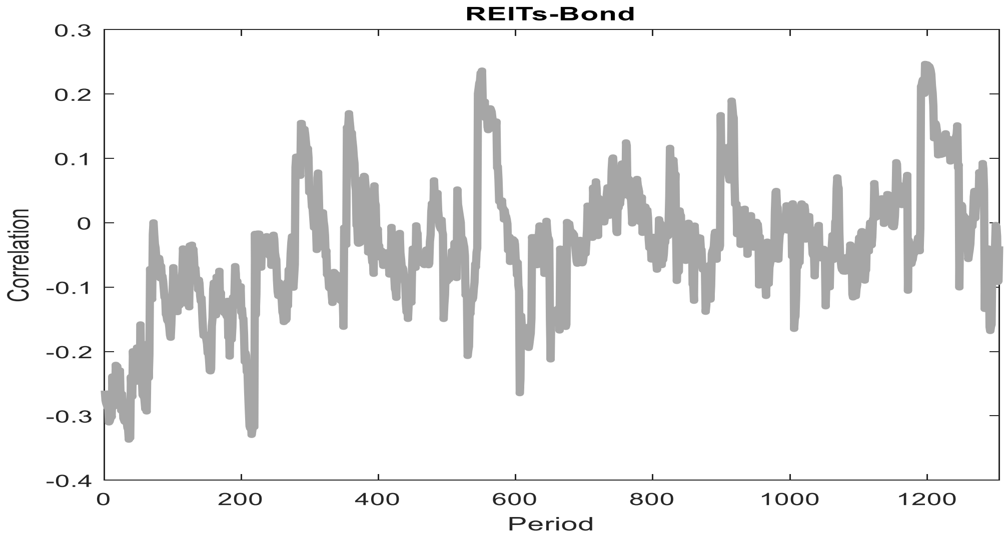
Stocks and bonds are negatively correlated, where the lowest correlation occurs is -0.5. The correlation between REITs and bonds is between -0.3 and 0.2 and is more frequently negative than positive. Similar results can be seen for the correlation between office REITs and bonds and also retail REITs and bonds. The correlation between hotel REITs and bonds is higher, between -0.15 to 0.20. Residential REITs and bonds are negatively correlated in most observations, the lowest correlation being -0.3. In some observations, we can see residential REITs and bonds show a positive correlation greater than 0 but less than 0.2. The correlation between stocks and bonds is found to be lower than the correlation between REITs and bonds. Although bonds are the least volatile asset, the negative correlation of REITs and stocks with bonds suggests that the volatility of bonds moves in the opposite direction. In other words, when the volatility of bonds increases, the volatility of stocks or REITs decreases, or *vice versa*.

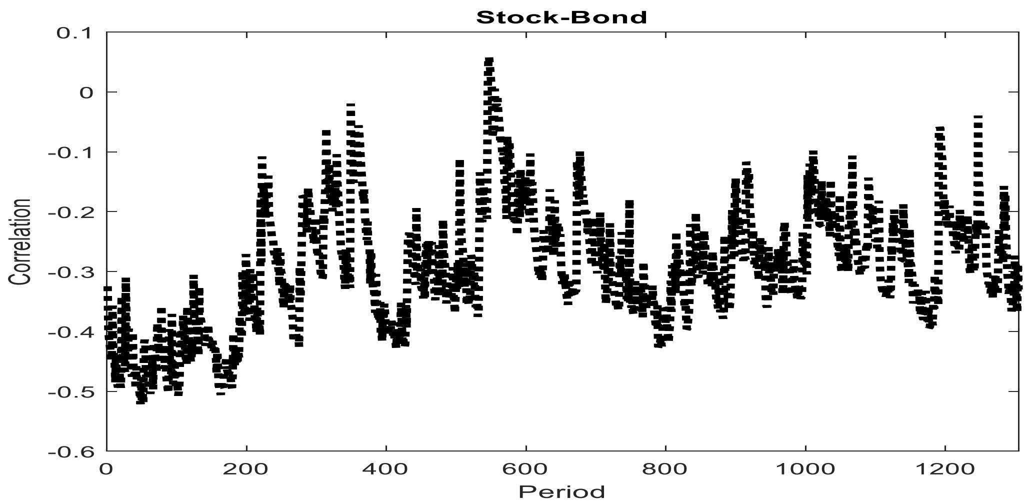
Our results based on daily data on Japan REITs in each property sector exhibit individual characteristics, in their time-varying volatility structure and correlation dynamics with other assets. For instance, the high level of volatility and correlation between REITs and stocks suggests a limited potential diversification benefit between the two assets. However, there is a greater chance of potential diversification between REITs and bonds as the correlation pair is low, and bonds are less volatile than REITs. Although the findings are not relatively new to investors, our analysis gives rise to time-varying allocations for each of property sector REITs in a mixed-asset portfolio, comprising stocks and bonds in the Japanese market. We will explore the aspect of dynamic asset allocation for each property-sector REITs with stocks and bonds in the next subsection.

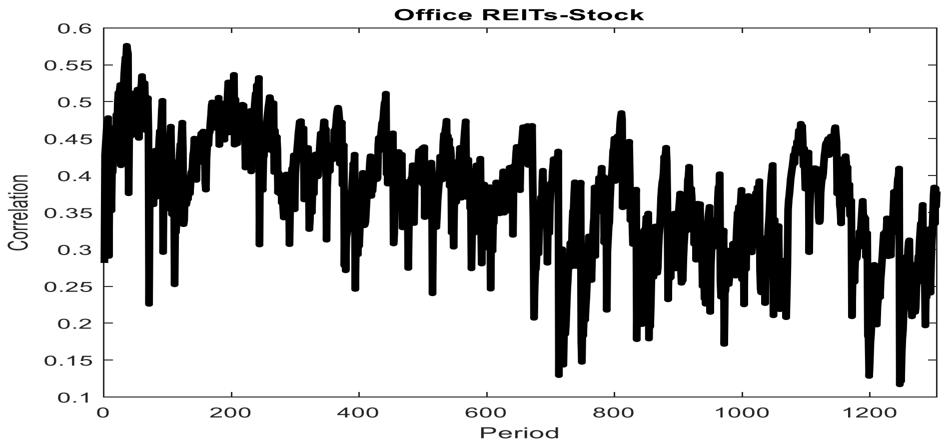
Figure 4.2

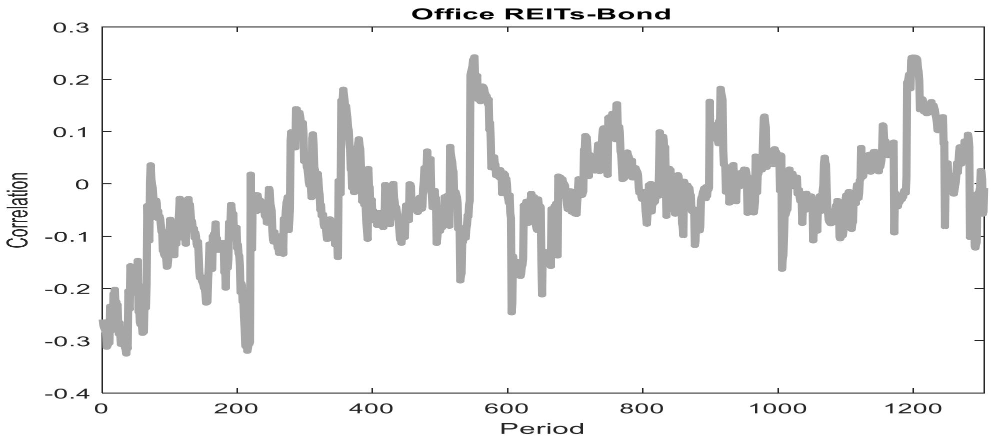
Forecast Correlations Plot Between REITs, Stocks and Bonds

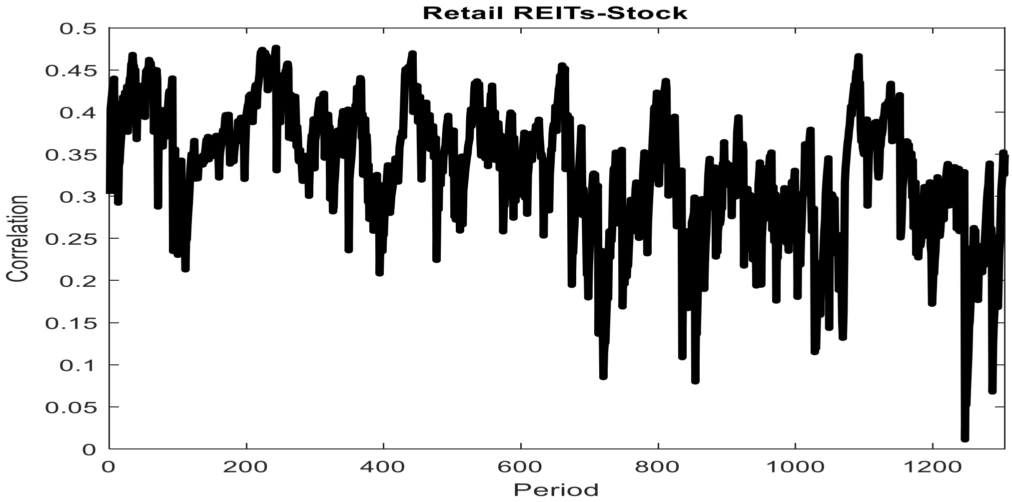


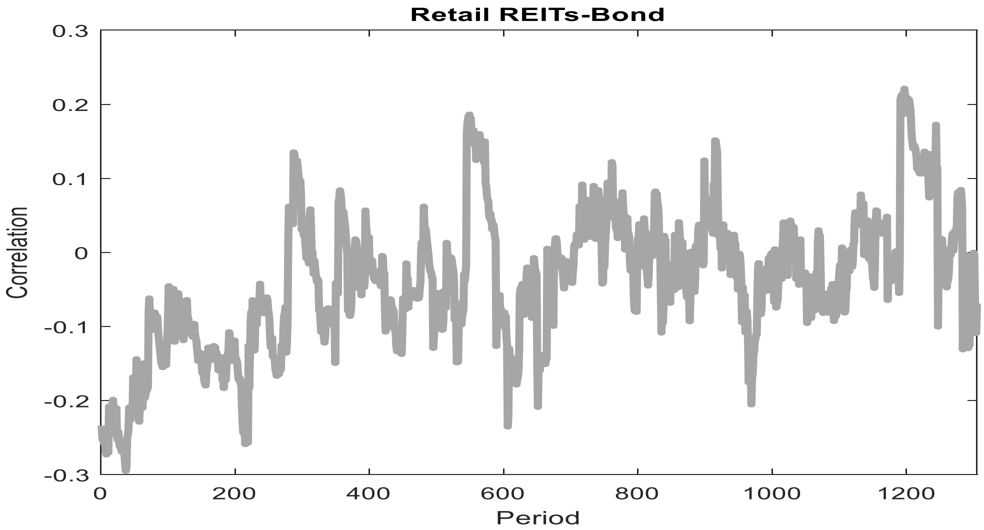

REITs-Bond
Correlation
Period
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
0
200
400
600
800
1000
1200

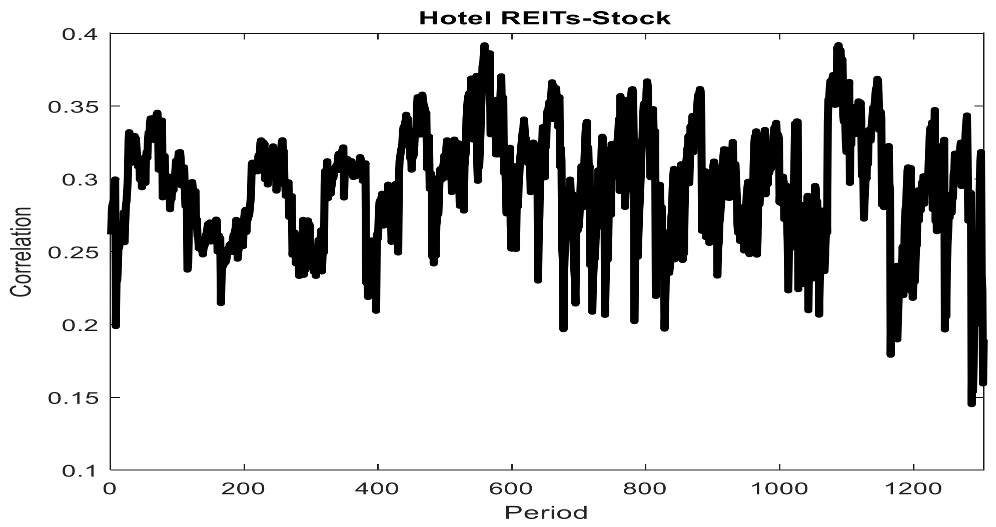

Stock-Bond
Correlation
Period
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
0
200
400
600
800
1000
1200

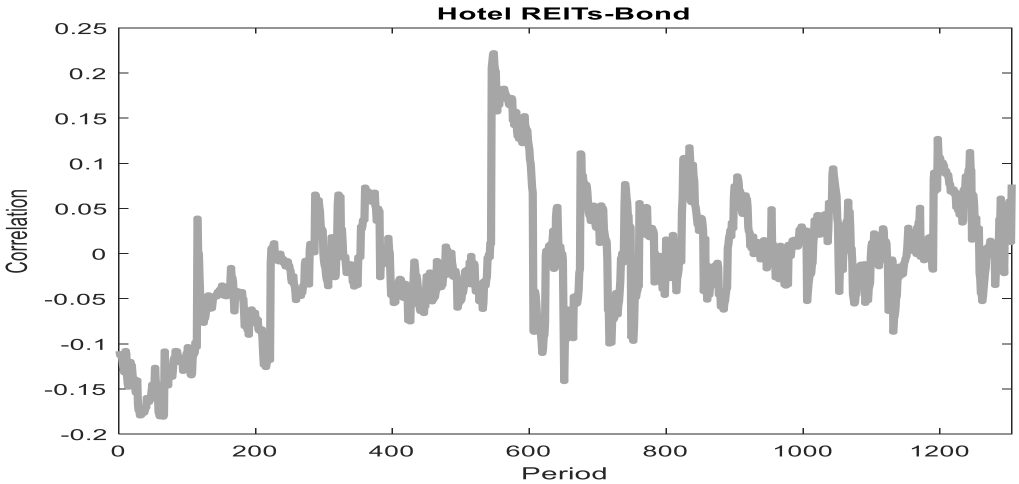

Office REITs-Stock
Correlation
Period
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
200
400
600
800
1000
1200

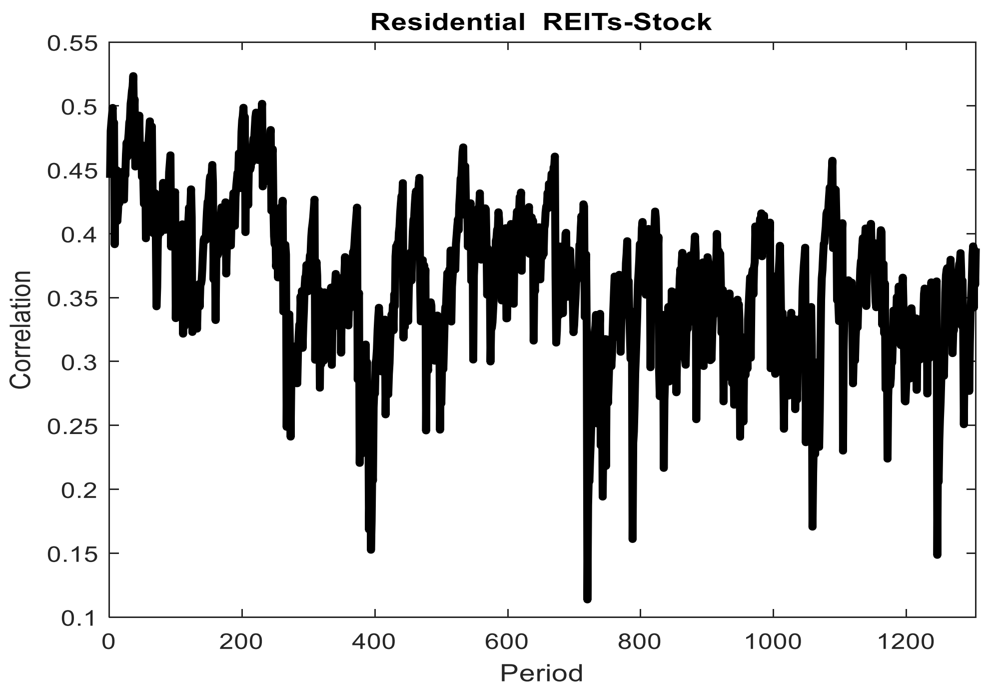

Office REITs-Bond
Correlation
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
0
200
400
600
800
1000
1200
Period

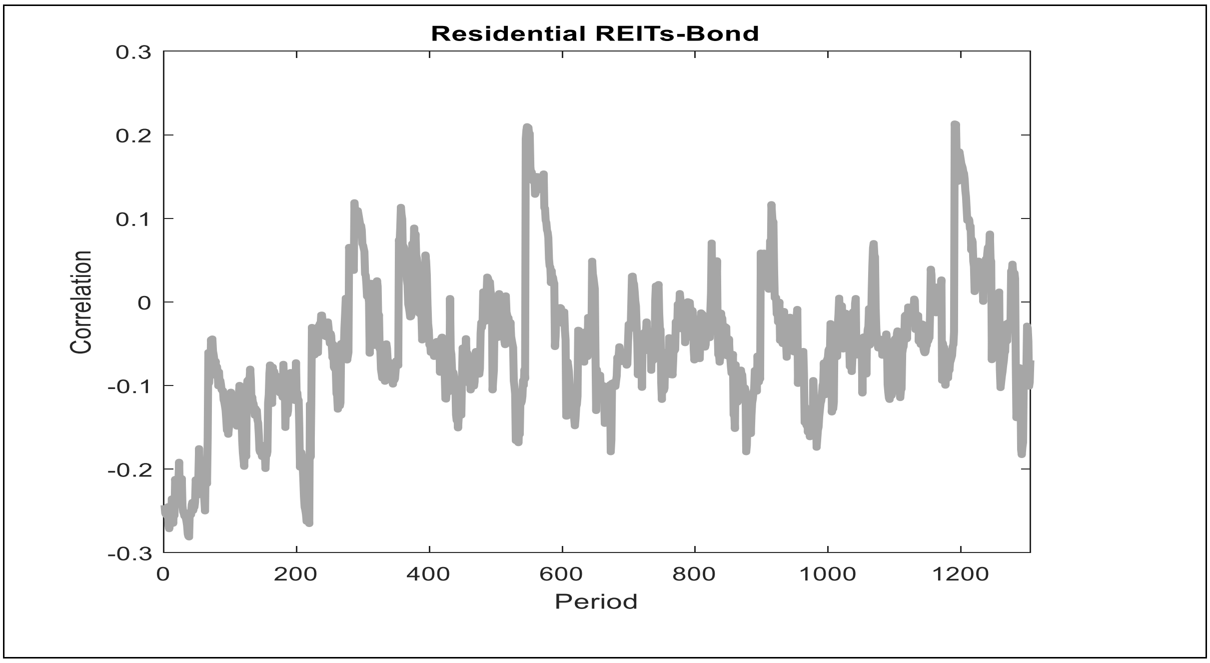

Retail REITs-Stock
Correlation
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
200
400
600
800
1000
1200
Period


Retail REITs-Bond
Correlation
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
0
200
400
600
800
1000
1200
Period


Hotel REITs-Stock
Correlation
Period


Hotel REITs-Bond
Correlation
Period


Residential REITs-Stock
Correlation
Period



Notes. These figures present the forecast dynamic correlation derived from DCC-GJRGARCH estimates. We present the correlation between stocks and bonds, and each property sector REITs with stocks and also with bonds. Our out-of-sample evaluation period starts from 1.1.2015 to 31.12.2019 (with a total of 1305 days).

4.5.4 Dynamic Optimal Portfolio Exercise

We perform an out-of-sample portfolio exercise based on the estimated variance-covariance matrix derived from DCC-GJRGARCH estimates. For each day t, we construct an optimal portfolio using the estimated variance-covariance matrix derived from DCC-GJRGARCH based on the rolling sample up to day t-1. For the purposes of forecasting the expected return for each asset, we use the VAR (1) process as in equation 4.1. For each day t, the training sample up to day t-1 is used to estimate the VAR(1) equation. The observation on day t-1 and the estimated VAR(1) coefficients are then used to estimate the expected return on day t.

We model our portfolio inclusive of REITs, stocks and bonds, setting out six different portfolios with different permutations of assets. Portfolio 1, as a benchmark portfolio, consists of stocks and bonds. REITs are included in portfolios 2 to 5, by classifying REITs into composite (all-property REITs) in portfolio 2, and office, retail and hotel, and residential REITs in portfolios 3, 4, 5, and 6 respectively. For each portfolio, we perform a total of 1305 days of portfolios. Consistent with the forecasts of the time-varying variance-covariance matrix, we also allow for a daily portfolio rebalancing.

On the basis of the optimal portfolio exercise on the out-of-sample evaluation period, the average portfolio allocation and portfolio performance are presented in Table 4.5. Portfolio 1 consists of two assets, with an average of 56.8% allocation to stocks and 43.2% to bonds. Based on the 1305 days in the out-of-sample evaluation period, the average portfolio return is 0.025% with a standard deviation of 0.062%. Portfolio 2 consists of a 28.6% allocation to composite REITs, 29.5% to stocks and 41.9% to bonds. This portfolio reports an average return of 0.027% and a standard deviation of 0.049%. Portfolio 3 comprises a 28.6% allocation to office REITs, 27.7% to stocks and 43.7% to bonds, and it reports an average return of 0.026% and a standard deviation of 0.045%. Portfolio 4 consists of a 28.4% allocation to retail REITs, 32.7% to stocks and 38.9% to bonds. The portfolio has an average return of 0.028% with a standard deviation of 0.038%. Portfolio 5 comprises a 20.6% allocation to hotel REITs, 35.5% to stocks and 43.9% allocation to bonds, and reports an average return of 0.029% and a standard deviation of 0.046%. For residential REITs, as in Portfolio 6, there is an average allocation of 21.9% to residential REITs, 29.7% to stocks and 48.4% to bonds. The average return is 0.026% with a portfolio risk of 0.042%. The Sharpe ratio for the portfolio consisting of stocks and bonds is 0.40. With the inclusion of REITs, the Sharpe ratio for portfolio 2 to portfolio 6 ranges between 0.55 to 0.74, and the portfolio consisting of retail REITs has the highest Sharpe ratio.

Table 4.5

Out-of-Sample Portfolio Performance

Portfolio	1	2	3	4	5	6
$\overline{w}$ Reit	-	0.28600	0.28600	0.28400	0.20600	0.21900
$\overline{w}$Stock	0.56800	0.29500	0.27700	0.32700	0.35500	0.29700
$\overline{w}$ Bond	0.43200	0.41900	0.43700	0.38900	0.43900	0.48400
Portfolio return $\tilde{r}_p$	0.00025	0.00027	0.00026	0.00028	0.00029	0.00026
Std deviation $\sigma(r_p)$	0.00062	0.00049	0.00045	0.00038	0.00046	0.00042
Sharpe Ratio	0.40322	0.55102	0.57778	0.73684	0.63044	0.61905
Compensation fee, f		0.00751	0.00287	0.01152	0.01926	0.00564
Average TC	0.00006	0.00010	0.00012	0.00013	0.00014	0.00011

Notes. This table reports the mean portfolio return $\tilde{r}_p$, standard deviation $\sigma(r_p)$ and average portfolio weight for each asset, $\overline{w}$ in the out-of-sample portfolio estimation. Average TC is the average transaction cost for the portfolio rebalancing over 1305 days of the out-of-sample period. Compensation fee, f, measures the relative improvement in an investor's average realised utility with the inclusion of REITs in their portfolio and the average realised utility for a portfolio consisting of stocks and bonds. The average realised utility for the two sets of portfolio is calculated by assuming the coefficient of relative risk aversion a=5.The Sharpe ratio is calculated by assuming a risk free rate of 0.010%. Portfolio 1 consists of stocks and bonds. Portfolio 2 to portfolio 6 contain REITs, including composite, office, retail, hotel, and residential REITs. The figures are reported in %.

From our results, it appears that the inclusion of REITs on average is 28% for composite, office, and retail REITs. The exceptions are hotel and residential property-sector REITs, where there is a 20% allocation to the REITs. We observe that the higher allocation of stocks leads to higher average returns, as can be seen in portfolios 4 and 5 in the case of retail and hotel REITs. Our estimated portfolios, in cases 2 to 6 highlight the improvement in performance with the inclusion of property sector REITs, as compared to portfolio 1, that consist of stocks and bond. In particular, for the portfolio with REITs, we observe the returns on a portoflio increase by 4% to 16%, and reduction in the portoflio risk by 20% to 38%, compared to the portfolio with stocks and bonds.

Also, we estimate the approximation of utility function of a portfolio of stocks and bonds, and a portfolio of stocks, bonds and REITs, in a specific property sector. We equate the utility of the two sets of portfolios (with and without REITs) and compute the compensation fee, f. Our results in the table 4.5 shows that the compensation fee for the portfolio with each property sector REITs, is positive. The portfolio with Hotel REITs reports the highest compensation fee, of 1.92%. Portfolio with retail REITs reports a fee of 1.15% and portfolio with composite REITs reports a fee of 0.75%. The portfolio with residential and office REITs report a fee of 0.28% and 0.56% respectively.

In the out-of-sample period, we report the average transaction costs of portfolio rebalancing, and average TC involving the portfolio, with and without REITs. The portfolio of Stocks and Bond has an average transaction cost of 0.006%. Meanwhile, the portfolio containing REITs reports the average transaction cost of 0.010% for the composite and between 0.011% to 0.014% for residential, office, retail and hotel property sector REITs respectively.

The results on positive compensation fee reflects the improvement of utility for a mean variance investor with the inclusion of REITs. For instance, on average, the utility for an investor that invest in Residential REITs will be improved by 0.56% daily. Therefore, for an investor with a portfolio of stocks and bonds, our results suggest the investor shall not be hesitated to include property sector REITs in their portfolio. As a matter of fact, the positive fee indicates the investor has been compensated for including additional risky asset, REITs, in which the increase in their utility outweighs the associated cost of portfolio rebalancing.

In comparison to the portfolio of stocks and bonds, our results across the property sector indicate the 50% reduction, on average, in the allocation of stocks in order to include REITs in a mixed-asset portfolio. The average allocation to stocks is higher than the property sector REITs. The results on the optimal portfolio of REITs and stocks are consistent with the volatility dynamics, whereby on average, property sector REITs are more volatile than stocks. Whilst each property sector REITs, is positively correlated with stocks. Nonetheless, the allocation of property sector REITs helps to improve the portfolio performance in both aspects of return and reduction of the portfolio risk. Hence, property sector REITs helps to improve the risk-adjusted return of an optimal portfolio, as evidenced by the improvement of the Sharpe ratio.

For bonds, our results show the average allocation is around 40%. This allocation is consistent with the dynamics found in their volatility, where bonds is the least volatility asset. In terms of correlations, on average the correlations between stocks and bonds as well as their correlations with REITs are negatively correlated. Therefore, our result suggests that the inclusion of bonds in the portfolio serves as a buffer that may help to reduce portoflio risk, in a portfolio consisting of stocks and a mixed-asset portfolio of stocks and property sector REITs.

The estimation of volatility and correlation in the DCC-GJRGARCH framework provides us an important aspect to examine the linkages of property sector REITs with other financial assets. In particular, we show that each property sector REITs in the Japanese market has a distinct volatility and correlation structure with stocks and bonds. Against this background, our analysis that primarily focus on property sector REITs expand the literature on understanding the dynamics between the Japanese REITs and stocks (Y. H. Lee, 2014; Liow, 2012; Liow et al., 2009). Therefore, the ability to capture conditional volatility and correlation help to form the forecast of future variance-covariance matrix between assets for optimal portfolio construction between REITs, stocks and bonds. In this regard, by using the estimated variance-covariance matrix on optimal portfolio with and without REITs, our results shed the light on diversification benefit of including property sector REITs. In particular, our results show that the inclusion of property-sector REITs improves the risk-adjusted return and investors' utility as measured by the compensation fee. Our findings on the Japanese market are comparable with the existing studies in the US and other international markets that using the dynamic estimation of variance-covariance matrix, which also indicates the inclusion of REITs helps to reduce the risk and to improve the Sharpe ratio of a portfolio (J. Huang & Zhong, 2013; Peng & Schulz, 2013).

Moreover, the benefits of including property sector REITs are similar to the recent studies in the Japanese market (Cho, 2017; Y. C. Lin et al., 2019). Notwithstanding, we claim our studies provides an added value to model the estimation of the variance-covariance matrix. In particular, instead of applying an unconditional estimation, we account for the dynamics in the volatility and correlation of the property sector REITs with stocks and bonds in the Japanese market. Related to this, to construct an optimal portfolio, our approach in framing the variance-covariance matrix appraises the Japanese property sector REITs as a portfolio diversifier, where an investor can invest in liquid real estate security daily.

4.5.5 Robustness Check

We repeat the out-of-sample portfolio exercise based on the estimated covariance matrix implied from DCC-GJRGARCH, by allowing for short selling in these three assets in the portfolio. We adopt the same portfolio settings, where portfolio 1 consists of stocks and bonds. REITs are included in portfolios 2 to 5, by classifying REITs into composite (all-property REITs) in portfolio 2, and office, retail and hotel, and residential REITs in portfolios 3, 4, 5, and 6 respectively. For each portfolio, we perform a total of 1305 portfolios corresponding to the out-of-sample evaluation period.

The average portfolio allocation and portfolio performance are reported in Table 4.6. The results show changes in the average weight for each asset in the portfolios including REITs. Portfolio 2 consists of a 42.3% allocation to REITs, 13.8% to stocks and 43.9% to bonds, and reports an average return of 0.029% and a standard deviation of 0.051%. Portfolio 3 comprises 47.4% office REITs, 17.8% stocks and 34.8% bonds, and reports an average return of 0.028% and a standard deviation of 0.044%. Portfolio 4 consists of 34.5% retail REITs, 21.8% stocks and 43.7% bonds. The portfolio has an average return of 0.030% with a standard deviation of 0.044%. Portfolio 5 comprises 16.7% hotel REITs, 39.4% stocks and 43.9% bonds, and reports an average return of 0.030% and a standard deviation of 0.059%. For residential REITs, as in portfolio 6, the average allocation to residential REITs is 17.8%, with 36.7% to stocks and 45.5% to bonds. The average return is 0.027% with a portfolio risk of 0.052%.

Table 4.6

Optimal Portfolio Results with no Short-Selling Constraint

	1	2	3	4	5	6
$\overline{w}$ Reit	-	0.42300	0.47400	0.34500	0.16700	0.17800
$\overline{w}$Stock	0.51700	0.13800	0.17800	0.21800	0.39400	0.36700
$\overline{w}$ Bond	0.48300	0.43900	0.34800	0.43700	0.43900	0.45500
Portfolio return $\tilde{r}_p$	0.00024	0.00029	0.00028	0.00030	0.00030	0.00027
Std deviation $\sigma(r_p)$	0.00065	0.00051	0.00044	0.00044	0.00059	0.00052
Compensation fee, f		0.01503	0.01067	0.01922	0.01926	0.00781
Average TC	0.00007	0.00018	0.00018	0.00019	0.00019	0.00017

Notes. This table reports the mean portfolio return $\tilde{r}_p$, standard deviation $\sigma(r_p)$ and average portfolio weight for each asset, $\overline{w}$ in the out-of-sample portfolio estimation with no short-selling constraint. Portfolio 1 consists of stocks and bonds. Portfolio 2 to portfolio 6 contain REITs, with composite, office, retail, hotel and residential REITs respectively. The figures are reported in %.

Our results show that, when we permit short-selling, the estimated portfolio leads to an increase in average portfolio return and an increase in portfolio risk. We observe that there is no significant change in the average weight for bonds. There is a lack of short-selling activity in portfolio 1, involving stocks and bonds, as there is only a slight change in average allocation for these two assets. We observe the reduction in the average allocation to stocks, as evidenced in portfolios 2, 3, and 4 with the average increase in the allocation of REITs, office REITs and retail REITs. However, the average allocation to hotel REITs and residential REITs falls as the average allocation to stocks increases. The average transaction cost ranges between 0.017% to 0.019%. The transaction cost increase is higher when short-selling is allowed.

The results reveal that the inclusion of REITs contributes to speculative behaviour due to short-selling activity. We show that the average allocation of REITs increases in composite, office and retail sectors, while we observe a decrease in the average allocation of residential and hotel REITs. We presume investors use either REITs or stocks for short selling while optimally managing their portfolio. Although involving additional risk, our results show an improvement in the utility as measured by the positive compensation fee. Our results in the robustness check are quantitatively similar to the former (with short-selling constraint) regarding the role of bonds as a buffer to risky investment in stocks and REITs, with the additional role of mitigating the risk associated with short-selling. In short, the introduction of an additional asset, REITs, provides time-varying diversification benefits over investment in stocks and bonds. Our results are robust across the REITs in specific property sectors.

4.6 Conclusion

The liquid nature of REITs is of practical importance for understanding their characteristics in terms of volatility and linkages with financial assets. Several studies mark the short- and long-run persistence of shocks affecting the volatility of REITs and the dynamic correlation with other assets, like stocks. The implication has been incorporated into the dynamics of optimal portfolio construction with rebalancing instead of the buy-and-hold optimal portfolio.

In this chapter, we first examine the individual property sector REITs, stocks and bonds volatility structure by accounting for the short-, long-run persistence and asymmetry in economic shocks by using daily data from the Japanese market. We then consider the dynamic linkages in a framework that models the time-varying conditional correlation between these three assets. We further perform an out-of-sample forecast on the dynamics in volatility and correlation amongst the asset returns and test the importance of implications for the portfolio. We use the forecast covariance matrix and assess the optimal portfolio allocation of REITs, stocks and bonds, with the allowance of daily portfolio rebalancing. By accounting for the REITs in a specific property sector, we evaluate the optimal portfolio with REITs over the portfolio of stocks and bond REITs. We assess the optimal portfolio performance between the two sets of portfolios. We evaluate the approximation of utility of the portfolios of REITs and no REITs and compute the gains of including REITs, by means of the compensation fee. Lastly, we compare the gains in utility over the cost of portfolio rebalancing.

We contribute to the literature on the dynamics of Japan REITs in which we present the evidence of time-varying volatility and correlation for each property-sector's REITs with stocks and bonds. Our exercise of optimal portfolio allocation of REITs in each property sector shows the improvement in risk-adjusted returns over the portfolio of stocks and bonds. In similar manner, the inclusion of REITs helps to improve the utility of an investor, where the benefit outweighs the cost of portfolio rebalancing. Therefore, our study supports the importance of quantifying the conditional time-varying volatility and correlations of each property sector's REITs with other asset returns. For a daily investor in the Japanese market, our study suggests investment in a property sector REIT, as an additional risky asset to diversify their portfolio.

CHAPTER 5

Conclusion

5.1 Overall Conclusion

This thesis examines the return dynamics and diversification benefits of property sector Japanese REITs from three different perspectives. Chapter 1 presents an overview of the past literature on Japanese REITs and various characteristics of individual property sector REITs. Our study attempts to fill a gap in the literature by examining their return characteristics and investigating the linkages between REITs and their underlying direct real estate and the general stock market. We further explore the implications of the linkages for an optimal buy-and-hold portfolio for investment in the short- and long-term horizon. We also test the role of REITs in a mixed-asset portfolio by accounting for the dynamics in volatility and correlation in a dynamic portfolio optimisation.

In Chapter 2, we consider the long-run linkages and short-term dynamics between Japanese REITs, direct real estate and stocks. We contribute to the literature by first linking the REITs with direct real estate rather than only with stocks, using the vector error correction model. By controlling for a specific property sector, our results present evidence on the return characteristics of Japanese REITs, closely linked to their underlying direct real estate rather than stocks, as the latter can be excluded from the long-run relation. Our short-term dynamics show the causal relation between REITs and stocks, and feedback causality between REITs and direct real estate. Further analysis of variance decomposition and impulse response indicates that REITs and direct real estate are vulnerable to external shocks either to REITs or direct real estate. Our results conform to the findings of a tight long-run relationship between REITs and direct real estate, as presented in past literature for the US and other developed REITs markets.

In Chapter 3, we seek to expand the vector error correction model by developing a portfolio choice framework. To be specific, instead of focusing on short-term dynamics or predictability structure between past and current returns, we also consider the long-run cointegration relation between REITs and direct real estate. We translate the relation into an estimation of covariance and correlation between asset returns over a different time horizon. We show that, across property sectors, the correlation between REITs and direct real estate increases and becomes unity in the long-run. Our term structure of risk for each asset's returns is rising in the long run, with the volatility of REITs lower than stocks. Our optimal portfolio exercise suggests a horizon-dependent aspect to the substitutability between real estate assets and the potential diversification benefits of stocks in a portfolio, which is absent from the long-run cointegrating relation.

In Chapter 4, we examine the role of REITs in a mixed-asset portfolio. This contributes to the literature by expounding the vital characteristic of time-varying volatility for individual assets and correlation dynamics between asset returns in a variance-covariance framework that accounts for the short- and long-run impact persistence of past shocks. We test the implications of the dynamics in an optimal portfolio with daily rebalancing. Consistent with the dynamics found in the correlation and covariance structure, our results show that including REITs improves the average portfolio performance and minimises portfolio risk. Our results show that the investment in either one of the property sector REITs improves investor utility over a conventional portfolio of stocks and bonds. All in all, while REITs allow for investment in real estate assets as short-term as daily, our results illustrate their diversification role, acknowledging their dynamics in time-varying volatility and correlation with other assets in a mixed-asset portfolio.

5.2 Limitation of the Study

One potential concern the construction of the ARES Japan Property Index data used in our study does include direct properties owned by the Japanese REITs. In spite of this, to our knowledge, the index is no different from the MSCI (the then Investment Property Databank, IPD) direct real estate index. The MSCI index also tracks the performance of direct real estate assets held by professionally managed real estate funds, inclusive of REITs, unlisted pooled funds and listed property companies. The indices cover the real estate markets in European countries and the Australian market (MSCI, 2014, 2020). To name a few, a number of subsequent analysis conducted in the UK, Australian and European markets in the past have used the MSCI index for direct real estate assets (Hoesli & Oikarinen, 2012, 2016, 2021; Sebastian & Schatz, 2009; Yunus et al., 2012).

5.3 Practical and Policy Implication of the Study

In our opinion, the results from this thesis indirectly deliver some practical and policy implications. First, the evidence of a long-run cointegration relation between REITs and direct real estate in specific property sector endorses Japanese REITs as a real estate asset. The finding implies that Japanese REITs are a real estate investment which offer investors a wide array of property sectors with liquidity and lower transaction costs as compared to investment in direct real estate properties. The findings on the dynamic role of Japanese REITs support this, where investors can choose a specific property sector to invest in real estate assets on a daily basis.

Secondly, our result on the predictability of REITs by direct real estate suggests an important policy implication, namely to promote the direct participation of institutional investors, such as pension funds (both private and public) in investing in the Japanese REITs. The Japanese government could provide tax incentives to pension funds for income received from the REITs dividend. Accordingly, the participation of institutional investors helps in information production, which informs investors on recent changes in the market (Boehmer & Kelley, 2009). Thus, REITs can be an informationally efficient real estate asset that can deter direct real estate from predicting the REITs (Aguilar, Boudry, & Connolly, 2018; Pavlov et al., 2018). Since the participation of pension funds helps other small groups of investors to be informed regarding recent changes in the market, the Japanese REITs can be an informationally efficient asset, acting as a channel to transmit changes in real estate information to the direct real estate. Last but not least, the use of VECM to derive the variance-covariance matrix between REITs, direct real estate and stocks indirectly increases the attractiveness of REITs, in particular, by reducing volatility, despite the increase in positive correlation with direct real estate in the long run. This finding could motivate institutional investors to allocate between the two real estate assets with respect to holding periods. In other words, our results suggest REITs should be favoured in the short-term. In the medium-term, the two assets can be combined in a portfolio with a gradual increase in the allocation to direct real estate, while in the long-term, institutional investors shall invest in direct real estate.

5.4 Suggestions for Future Research

We offer a number of suggestions with respect to local studies on Japanese REITs. First, further analysis could explore the linkages of REITs with their sponsoring listed property companies. At the index level, the investigation could be conducted within the vector error correction model framework and explore the long-run cointegrating relation and price discovery processes in the short-term causal relationship between these two assets. In firm-level analysis, the linkages between REITs and listed property companies could be studied. As the dividend payment of listed property companies is within their discretion, future research could examine the changes in dividend payment structure made by listed property companies before and after establishing REITs in the Japanese market.

Secondly, further study in Chapter 4 could compare the relative performance of portfolios with and without property sector REITs, by using the mean variance spanning test. The test assumes each property sector's REITs as a test asset, and portfolio of stocks and bonds as a benchmark. The spanning test examines any incremental effects in the mean variance efficient frontier with the inclusion of property sector REITs.

Third, a potential future research study could examine the reproducibility of the optimal portfolio implied from the cointegration structure between REITs and direct real estate with respect to the vector error correction model framework. Subject to the availability of data, the studies could be extended into other real estate markets, such as the US and UK. With the potential to replicate, it is hoped that this framework could serve as an alternative for optimal allocation of real estate assets, both REITs and direct real estate. From a theoretical perspective, we suggest that future research exploits the error correction process between REITs and direct real estate, and explores whether this mechanism can trigger changes in asset allocation between the two assets for any investment horizon. We leave these issues for future research.

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