# Credit risk assessment in real estate investment trusts: A perspective on blockholding and lending networks

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**Abstract**

This study assesses the credit risk of Japan's real estate investment trusts (J-REITs) in two related markets during the fiscal years 2008–2017. The first J-REIT market involves blockholders, while the second is a lending market of institutions (i.e., banks and insurers). Unlike investment trusts, a J-REIT is an investment security issued by an investment corporation and thus, has corporate credit risk. Consequently, a J-REIT's sponsor and as its financial variables have a substantial effect on the investment corporation's credit risk. A sponsor's probability of default is a leading indicator of the investment corporation's default and double default probability acts as a coincident indicator of default. Network analysis indicates that some network centralities are proxies for funding liquidity via blockholding and lending networks. Rather than increases in other centralities, an increase in the degree of lending to an investment corporation explains a decrease in the issued J-REIT's credit risk.

*Keywords:* REIT; investment corporation; credit risk; double default; centrality measure
*JEL classification:* G32; G10; D85; L14.

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## 1. Introduction

Real estate investment trusts (REITs) have become an increasingly popular vehicle for alternative investments; global market capitalization for REITs was approximately 1.7 trillion USD as of September 30, 2017. Since 2010, the US REIT market has grown by almost 150%, while the market capitalization of non-US REITs in USD has more than doubled (Data source: FTSE EPRA Nareit Global Real Estate Index Series).

The market for Japan's REITs (J-REITs) is currently the second-largest REIT market in the world after the US market. A few years after the J-REIT market was launched in 2001, the Nikkei 225 bottomed at around 7,600 in April 2003. In the following years, more than 40 J-REITs were listed, and the Tokyo Stock Exchange (TSE) J-REIT index had a bull run from 1,000.00 at its inauguration on March 31, 2003 to a high of 2,592.16 in May 2007, an increase of 2.6 times over 4 years.

As a result of the US subprime mortgage crisis, several mortgage US-REITs defaulted or voluntarily quit their listings. Mortgage REITs that filed for bankruptcy protection include New Century Financial Corp (February 2007), American Home Mortgage (July 2007), Luminent Mortgage Capital (July 2007), HomeBanc Corp (July 2007), and Impac Mortgage (October 2007), while General Growth Properties (April 2009) is an equity REIT that filed for bankruptcy. In addition, some US-REITs were delisted, such as Feldman Mall Properties (July 2008) and CBRE Realty Finance (November 2008).[1]

The first J-REIT bankruptcy case involved New City Residence Investment Corporation (New City Residence), which filed for court protection with debt of 112 billion JPY in October 2008; its bankruptcy style was "surplus bankruptcy," caused by failure to manage cash flow. The REIT, which started trading on the TSE in 2004, had difficulty raising money to repay its debt. The global financial crisis has left real estate-related companies struggling to raise funds, pushing some into bankruptcy.[2]

[1] There are two categories of equity REITs and mortgage REITs among US-REITs. An equity REIT is a publicly traded company that buys, manages, renovates, maintains, and occasionally sells real estate properties. By law, equity REITS must pay out at least 90% of their net income as dividends to its investors for tax exemption. Meanwhile, a mortgage REIT primarily invests in mortgages and mortgage-backed securities, providing financing for residential and commercial properties (Block, 2012).

[2] To qualify for tax exemption, J-REITs must distribute more than 90% of available

Such circumstances show that credit risk management plays an important role in managing and investing REITs. However, because the structure and credit risk factors for REITs depend on their issued market, it is effective to compare J-REITs with US REITs.

US-REITs are real estate companies first authorized in the United States in 1960 as a way to undertake equity and mortgage debt investment in diversified and professionally managed real estate portfolios. Originally, the management was legally obliged to hire outside companies to provide property leasing and management services. However, The Tax Reform Act of 1986 allowed US-REITs to perform these essential services internally. Hence, the majority of today's US-REITs are fully integrated operating companies that can internally handle all aspects of real estate operations, such as acquisitions and sales of properties (Block, 2012, p.35).

By contrast, J-REITs, which are established under an amendment to the Act on Investment Trusts and Investment Corporations in November 2000, are investment securities issued by investment corporations that primarily invest in and manage real estate. Under external management structures, J-REITs cannot hire employees or conduct substantive activities by themselves, and by law, their actual management activities are consigned to an outside asset management company. J-REITs are responsible for the functions of monitoring asset management activities through the board of directors and the general meeting of unit holders. For these reasons, J-REITs cannot accumulate their retained earnings, even when their earnings are large. Hence, J-REITs must rely on external financing, and the majority of its sponsors are real estate companies (e.g., Mitsubishi Estate and Mitsui Fudosan), affect as blockholders of both the asset management companies and investment corporations. There are both strong business relationship and parent-subsidiary relationship between J-REITs and their sponsors. Hence, if a sponsor gets into financial distress, the J-REIT can be affected from the distress.

Since the US subprime mortgage crisis, only five of the listed J-REITs posted unrealized gains on property holdings between August 2008 and March 2009. J-REITs remain under pressure because while their banks renew existing loans, they do not provide new loans. In addition, the failures of the J-REIT sponsors themselves seriously hinder the ability of J-REITs to ob-

earnings as dividends. Therefore, it is difficult for J-REITs to retain earnings and accumulate capital.

tain refinancing and roll over maturing bond issues, as property appraisers sharply lowered appraised values, particularly on residential properties, owing to falling residential property prices. Alternatives for fundraising, such as issuing preferred shares, are not an option for J-REITs. As a result, there were only 92 property acquisitions by J-REITs in fiscal year (FY) 2008 versus 501 in FY2007, and the market for J-REITs and private real estate funds declined by 1% in the second half of 2008 to around 217 billion Japanese yen (JPY).

J-REIT mergers and acquisitions were hopeful instruments for enlarging the scale of the J-REIT market. However, because J-REITs fully depend on sponsors, the measure resulted in the reorganization of J-REIT sponsors. In addition, a J-REIT investment corporation raises its own capital by borrowing from institutions, such as banks and insurers. Hence, in terms of credit risk management, it is very important to investigate the interconnectedness of a J-REIT investment corporation and its blockholders, including sponsors.

First, as a fundamental analysis, this study explores the research motivation for the credit risk management of J-REITs and calculates credit risk exposure based on the credit rating migration approach. Second, it analyzes the interconnectedness in J-REIT blockholding and lending networks using various network centrality measures (Jackson, 2010; Kanno, 2015, 2018). This network analysis is based on the outstanding datasets for holdings of REIT investment units and lending contracts in the Nikkei NEEDS–FinancialQUEST database provided by Nikkei Inc. Thus, the dataset covers almost all holdings by blockholders and lending by institutions. Third, a credit risk analysis is conducted using a binary logistic regression model. In this analysis, we consider the following credit risk factors of REIT investment corporations: its own financial health, the downside risk in the asset value or cash flow of its property holdings, its sponsor's support circumstances, and some network centralities as proxies for the interactions in the blockholding and lending networks.

The rest of this paper proceeds as follows. Section 2 reviews the literature on credit risk related analyses in REIT markets and the interconnectedness in various financial networks. Section 3 conducts the fundamental analyses to clarify J-REIT credit risk factors and obtain credit risk exposures. Section 4 contains a network structure analysis of the blockholding and lending networks, while Section 5 presents a credit risk analysis using logistic regression. Section 6 concludes.

## 2. Literature review

This study contributes to the REIT literature through its novel use of a combined credit risk and network analytical approach to investigate the network structure of REIT markets.

First, to the best of our knowledge, almost no academic literature exists that addresses the credit risk of investment corporations in REIT markets. As an exception, Swanson et al. (2002) show that firms became more sensitive to credit risk by an analysis of REIT leverage ratios. As alternatives, studies that consider REIT credit rating methodology are effective for understanding a REIT's credit risk. Moody's Investors Service (2018) determines a credit rating using a scorecard, in which the only factors included are those used to evaluate general companies. The weights in the scorecard are scale (5%), business profile (25%), liquidity and access to capital (i.e., refinancing) (25%), and leverage and coverage (45%). By contrast, R&I (2016), a Japanese rating agency's paper, considers the REIT's financial health and the support circumstances of the sponsor, which is the parent company of the asset manager performing the actual investment activities. Furthermore, R&I (2016) also considers the sponsor's creditworthiness. During the global financial crisis in the second half of 2008, refinancing risk was actualized at REITs where the sponsor's creditworthiness was weak.

Second, in terms of networks in REIT markets, network analysis is a highly effective approach for examining the interconnectedness of relationships in REIT investments. Such investments represent complex holding networks using sets of "nodes" connected by "edges." In a REIT blockholding network, a node represents a REIT investment corporation or blockholder, including a sponsor, and an edge represents the holding relationship between two entities. In a REIT lending network, a node represents a REIT investment corporation or an institution and an edge represents the lending relationship between the two entities.

Using Standard and Poor's (S&P) weekly REIT indexes and stock market indexes for 10 selected REIT markets from July 2004 to June 2017, Liow and Huang (2018) assess the dynamics of volatility connectedness, which is based on dynamic variance decompositions from vector auto-regression (VAR) in volatilities, and find that a dissimilar integration process is taking place in global REIT markets. The local stock market is a major source of REIT volatility connectedness shocks 80% of the time.

To a lesser extent, some studies have investigated the interconnectedness

of REIT markets through the real estate contagion in cross-markets during the global financial crisis. For example, Guo et al. (2011) utilize a regime-switching approach to investigate the contagion effects among the stock, real estate, credit default, and energy markets. They conclude that the contagion effects among markets are more prominent in the larger mean and high volatility regime after 2007.

Finally, this study reviews the literature on the application of network theory to financial areas such as systemic risk and credit risk. An analytically tractable example of financial networks is the interbank network characterized by bilateral exposure in the interbank market. In this context, studies of financial networks adopt two approaches. The first assesses the strength of contagion channels and network resilience by observing the responses of financial network structures to shocks. Introducing a shock assumes a specific transmission mechanism, such as defaults by counterparties. Alves et al. (2013) refer to this approach as "dynamic network analysis." Cocco et al. (2009), Elsinger et al. (2006), and Haldane and May (2011) analyze contagion effects in their network analyses.

The second approach describes network structures using topological indicators, often relating these to model graphs based on network theory. This approach does not assume a mechanism through which shocks propagate within the network; thus, it is referred to as "static network analysis" (Alves et al., 2013). The studies by Boss et al. (2004), Eisenberg and Noe (2001), and Kanno (2015, 2018, 2019) are examples of this approach. The current study adopts static network analysis.

## 3. Fundamental analyses

In this section, this study explores motivation and calculates credit risk parameters for the analyses that follow.

### *3.1. Motivation*

To qualify for tax exemption, a J-REIT investment corporation cannot accumulate its retained earnings, even when its earnings are large. Hence, a J-REIT investment corporation must rely on external financing to conduct its asset management businesses and maintain financial health. There are three types of external financing: issuing investment securities, borrowing from financial institutions, and issuing investment corporation bonds.

In light of credit risk management for a J-REIT investment corporation, failure to refinance leads to default, as seen in the example of New City Residence. A sponsor's presence, as well as the investment corporation's financial health, has a substantial effect on the internal growth of a J-REIT. In particular, it is frequently essential to utilize sponsor group functions for tenant leasing. Hence, a sponsor's business development capabilities in the real estate sector should be adequately considered.

Table 1 provides the list of J-REITs and their defaulted sponsors (blockholders), with the exception that New City Residence (an investment corporation) rather than Pacific Holdings (a sponsor) defaulted on October 9, 2008. In addition, Table A.10 in Appendix A shows the list of sponsors since the launch of the J-REIT market in 2001 by REIT.

New City Residence, whose sponsor defaulted after its corporation's default, is given as an example. The corporation was listed on the REIT Section of the TSE on December 14, 2004 and its sponsor, Pacific Holdings, was listed on the first section of the TSE. The sponsor was unable to raise funds either by borrowing or public offering, owing to the worsening of the J-REIT market environment following the bankruptcy of Lehman Brothers, and defaulted by filing for application under the Corporate Reorganization Act on March 10, 2009. Preceding the sponsor's default, New City Residence defaulted by filing for application under the Civil Rehabilitation Law on October 9, 2008. Thus, the J-REIT was delisted on November 7, 2008. The correlation between New City Residence's unit price and Pacific Holdings' stock price for the downtrend period of the end of December 2005 to the end of October 2008 is high at 0.78 (Figure 1).

Next, we consider the joint probability of default pertaining to New City Residence and Pacific Holdings. To do this, we derive a formula to calculate the joint probability of default for an investment corporation and its sponsor. In the context of the structural approach to credit risk modeling (Merton, 1974), the default indicator $y_i$ for firm $i$ for counterparty $i$ can be then represented as follows:

$$y_i = \begin{cases} 1 & ; A_i \leq d_i \\ 0 & ; otherwise \end{cases}, \tag{1}$$

where $A_i$ is a latent variable representing firm $i$'s asset value, which follows a standard normal distribution at a 1-year time horizon, and $d_i$ is the threshold

value that marks the default of borrower $i$ if variable $A_i$ falls below it.

The joint probability of default between two entities is then as follows:

$$P(y_i = 1, y_j = 1) = P(A_i \leq d_i, A_j \leq d_j) = \Phi_2(d_i, d_j, \rho_{ij}), \tag{2}$$

where $\Phi_2(\cdot, \cdot, \rho)$ denotes a bivariate standard normal distribution function with asset correlation $\rho$. The standalone probability of default $p_i$ is defined as follows:

$$p_i := P(A_i \leq d_i) = \Phi(d_i), \tag{3}$$

where $\Phi(\cdot)$ denotes the cumulative standard normal distribution function. If the standalone probability of default $p_i$ is given from the empirical data, then the threshold is expressed as

$$d_i = \Phi^{-1}(p_i), \tag{4}$$

where $\Phi^{-1}(\cdot)$ is the inverse of the cumulative standard normal distribution function. Hence, Equation (2) is rewritten as

$$P(y_i = 1, y_j = 1) = \Phi_2(\Phi^{-1}(p_i), \Phi^{-1}(p_j), \rho_{ij}). \tag{5}$$

Using equation (5), we calculate the joint default probability between a sponsor and its investment corporation for 6 months until the default time of a sponsor or an investment corporation. Asset correlation is calculated from 6 months of time-series data of a sponsor's stock price and an investment corporation's unit price.

Each panel of Figure 1 corresponds to each pair in Table 1 and denotes the time-series of the firm's probability of default[3] and joint probability of default. As shown in Figure 1, in six panels, an investment corporation's default follows a sudden rise in its sponsor's probability of default during a period of 6 months to 1 year. Thus, a sponsor's probability of default is a leading indicator for an investment corporation's default, and the joint probability of default also acts as a coincident indicator of default.

Hence, in the following sections, to analyze the credit risk of an invest-

[3]As described in Sec 5, the data for the probability of default are obtained from the publicly accessible Credit Research Initiative (CRI) database, published by the National University of Singapore (NUS).

Table 1: Defaulted sponsors and supporting investment corporations

| SEQ | Date | Sponsor | Investment corporation |
|---|---|---|---|
| 1 | 2008/09/24 | [8936] Re-plus | 8986 Re-plus Residential |
| 2 | 2008/10/09 | 8902 Pacific Holdings | [8965] New City Residence |
| 3 | 2008/11/28 | [8899] Morimoto | 8984 BLife |
| 4 | 2009/01/09 | [8888] Creed | 8983 Creed Office |
| 5 | 2009/03/10 | [8902] Pacific Holdings | 8962 Nippon Residential |
| | | | 3229 Nippon Commercial |
| 6 | 2009/05/29 | [8874] Joint | 8973 Joint REIT |

**Notes:** Each four-digit number indicates the number given by the Securities Identification Code (SIC) Committee. "Date" denotes the declaration date of a defaulted entity, whose number is boxed. In the case of SEQ 2, New City Residence defaulted on October 9, 2008. Some mergers were conducted after the sponsor defaults pertaining to the above investment corporations: SEQ 4 (SIC 8983 → SIC 9985) and SEQ 5 (SIC 8962 → SIC 3269; SIC 3229 → SIC 8960), whose names after the mergers are provided in Table A.10.

ment corporation, interconnectedness with the sponsors in blockholding and lending networks is examined carefully.

### *3.2. Credit risk exposure for blockholding*

A J-REIT investment corporation can borrow from financial institutions as well as issue investment security. Hence, because the exposure to a J-REIT is treated as equivalent to equity exposure under the standardized approach or the internal ratings-based approach in the Basel regulation, the risk weight is 100% (BCBS, 2005). Therefore, credit risk exposure for blockholding is assumed to be the same as the amount held by blockholders in reference to the treatment in the Basel regulation.

### *3.3. Credit risk exposure for lending*

Credit risk exposure for lending is calculated in the following manner.

#### *3.3.1. Method for credit risk exposure analysis*

Credit rating migration is an essential component of credit risk assessment. This study outlines a framework for gauging the effects of credit rating migration on credit risk exposure calculations. The approach is based on

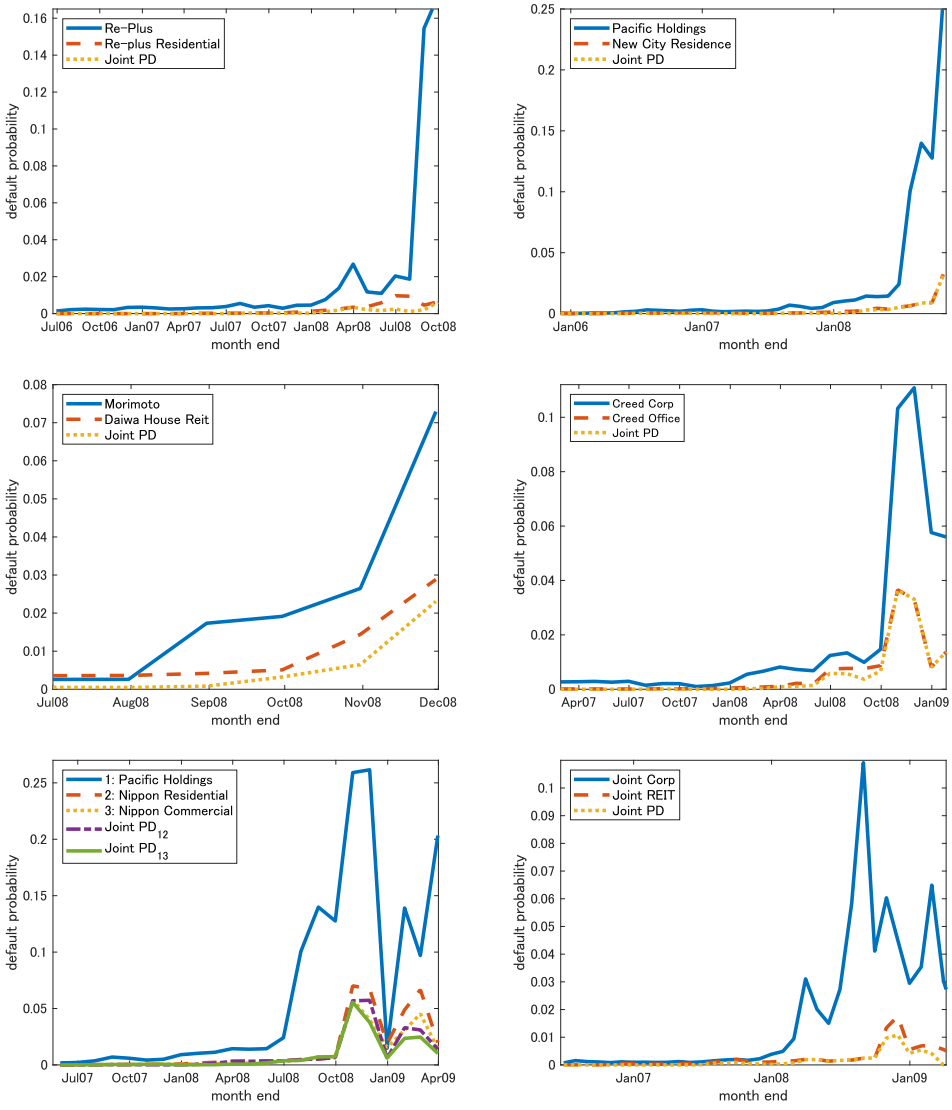


Figure 1: Standalone probabilities of default and joint probability of default between a sponsor and its investment corporation

**Notes:** Each panel shows the standalone probabilities of default and the joint probability of default, for 1: Re-Plus / Re-plus Residential; 2: Pacific Holdings / New City Residence, from the upper-left panel to the upper-right panel, for 3: Morimoto / BLife; 4: Creed/Creed Office, from the middle-left panel to the middle-right panel, and for 5: Pacific Holdings / Nippon Residential and Nippon Commercial; and 6: Joint/Joint REIT, from the lower-left panel to the lower-right panel. The number is the same as the SEQ in Table 1.

discounted cash flow valuation, whereby a lending asset is valued based on its discounted expected cash flows using a discount rate adjusted for credit risk. The risk adjustment can take the form of a higher discount rate. Discount rates adjusted for credit risk are obtained from credit rating curves provided by credit rating agencies, such as Moody's and S&P.

Throughout this study, the filtered probability space, $(\Omega, \mathcal{F}, \mathcal{F}_t, Q)$, is also incorporated, thereby supporting the credit rating migration process in terms of discrete time, $t = 0, 1, \ldots, T$, where $Q$ is a physical probability measure and the horizon, $T$, is assumed to be a positive integer indicating maturity. The filtration, $\mathcal{F}_t$, models the flow of all observations available to lenders. Formally, given an initial rating, $C_0$, of a borrower, future changes in the rating are described by a stochastic migration process, $C$.

This study assumes that the set of rating classes is $\{1, \ldots, K\}$, where the state, $K$, is assumed to correspond to the default event. In addition, according to the convention in Jarrow et al. (1997), the order of the states is fixed so that the state, $j = 1$, represents the highest ranking, whereas the state, $j = K - 1$, represents the lowest non-default ranking.

With regard to lending exposures that are not in default, the theoretical price of a lending asset with certain future cash flows at time $t$ is expressed as an aggregate discounted present value, $P$, as follows:

$$P = E^Q \left[ \sum_{t=1}^{T} \frac{CF_t}{(1 + r(C_t^i))^t} \middle| \mathcal{F}_t \right], \tag{6}$$

where $E$ refers to taking an expectation under a physical probability measure, $Q$, and the lending type corresponds to a term loan of equal monthly payments with interest. Thus, maturity $T$ corresponds to 3 years in the case of city banks and trust banks and 5 years in other cases. $CF_t$ is cash flow scheduled at time $t$. $r(C_t^i)$ is a discount rate adjusted for credit risk with regard to rating $C_t^i$ at time $t$ provided by rating agency $i$.

*3.3.2. Data for credit risk exposure calculation*

For the purpose of the subsequent credit risk analysis, this study calculates the credit risk exposure of a lending contract, discounting its cash flows at a discount rate adjusted for credit risk. To this end, firm-level outstanding lending contracts and financial data for the first half of FY2008 to the first half of FY2017 are used. The analysis requires outstanding data with borrowers' and lenders' names. These are obtained from the Nikkei NEEDS–

FinancialQUEST database (Table 2). The database contains lending information on institution-to-investment corporations. Thus, the coverage ratio is very high overall, which is related to the outstanding lending contracts on institution-to-investment corporations in the database. The banks include city banks, trust banks, Shinsei Bank and Aozora Bank, Norinchukin Bank, regional banks (i.e., regional banks I), second-tier regional banks (i.e., regional banks II), Shinkin banks and credit unions, other private financial institutions, government financial institutions, and foreign banks. The insurers include life insurers and non-life insurers. Finally, a small amount of outstanding data for the lending contracts of unknown institutions (about 0.5%) are included in the database (Table 2).

In addition, this study uses average interest rates for new lending contracts by bank type (i.e., city banks, regional banks I/II, and Shinkin banks) from the Bank of Japan. City banks set interest rates that are higher in the long term than the short term, whereas the other banks adopt the reverse approach. Furthermore, after the global financial crisis, long- and short-term interest rate levels decreased year by year. Interest rate levels also fell after the Bank of Japan initiated a negative interest rate policy on February 16, 2016.

In terms of credit rating information, this study also uses credit rating history data, including "date of change" and "old and new credit ratings" by entity from the Nikkei Astra Manager database provided by the QUICK Corporation. The data concern long-term issuer ratings related to the certainty of fulfillment as promised of issuers' individual financial obligations. However, not all listed firms are endowed with a credit rating. Thus, for such firms, outstanding lending is substituted for credit risk exposure.

Furthermore, as discount rates, this study employs yield curves by credit rating obtained as a "credit rating matrix" from the homepage of the Japan Securities Dealers Association (JSDA).[4] Yield by credit rating means the mathematical average of the compound interest yield for over-the-counter bond transactions, calculated using the quotations reported to the JSDA. As shown in Figure 2, yield curves are provided for each business day by four credit rating agencies: Rating and Investment Information, Inc. (R&I),

[4]The JSDA is an association that functions as a self-regulatory organization and interlocutor between market participants and various stakeholders, including government authorities. JSDA members comprise securities firms and other financial institutions that operate securities businesses in Japan.

Table 2: Lending exposure and other related variables

| Item | Description | Sources |
|---|---|---|
| Lending outstanding | Data on bilateral lending relations | Nikkei NEEDS–FinancialQUEST |
| Lending interest rates | Average interest rates for lending outstanding by bank type | Bank of Japan |
| Credit ratings | Credit rating history data including both "date of the change" and "old and new credit ratings" by entity | Nikkei Astra Manager |
| Yield curves by credit rating | Yield curves added credit risk premium by rating assigned by four credit rating agencies | JSDA |

Japan Credit Rating Agency (JCR), Moody's, and S&P.

To correct for the rate difference issues among the four credit rating agencies, this study adopts the lowest credit rating when two or more different credit ratings are assigned to a firm.

*3.3.3. Credit risk exposure estimation results*

The results of estimating credit risk for blockholding and lending are discussed in this subsection. Table 3 reports the quartiles and mean as well as standard deviations for unit holdings in the upper tier, and the quartiles and mean, standard deviations, and outstanding sums by financial institution for lending, which are related to credit risk exposure calculated by using equation (6) in the lower tier, at the end of the period FY2008–FY2017. In addition, the left panel of Figure 3 illustrates the percentile distribution of bilateral credit risk exposure for blockholding by year, whereas the right panel of Figure 3 does so for lending by year.

As shown in the upper tier of Table 3 and in the left panel of Figure 3, all blockholding exposure sizes are small at the median (i.e., 50th percentile); however, the sizes increase sharply from the 90th percentile to the maximum, and range from JPY 49 trillion in the first half of FY2010 to a maximum of JPY 176 trillion in the first half of FY2014. Similarly, from the lower tier of Table 3 and the right panel of Figure 3, all corporate lending exposure sizes are small at the median; however, the sizes increase sharply from the 90th percentile to the maximum, and range from JPY 68 trillion in the first half

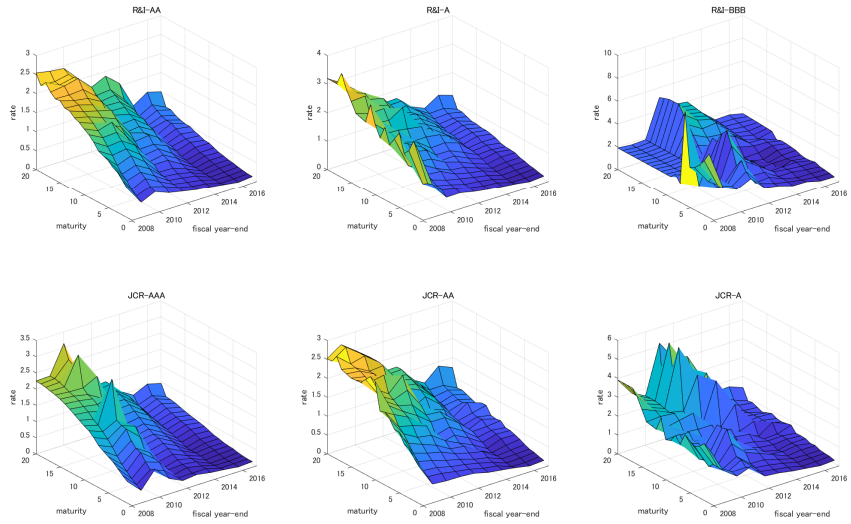


Figure 2: Credit yield curves as discount rates

**Notes:** The six panels show credit rating curves for the end of March 2009 to March 2018. The AA to BBB ratings of R&I extend from the upper-left panel to the upper-right panel. The AAA to A ratings of JCR extend from the lower-left panel to the lower-right panel.

of FY2013 to a maximum of JPY 88 trillion in the first half of FY2017.

Furthermore, as shown in the bottom row of Table 3, the grand total outstanding for both networks decreased by approximately 4% per year just after the Lehman Brothers' bankruptcy and increased gradually thereafter. In addition, major banks and other large banks have a share of 65% to 74% of the total amount less unknowns in the lending market, from the first half of FY2008 to the first half of FY2017. By contrast, regional banks (I and II) have almost constant shares of 6% to 8%, and insurers decreased their share from 9% to 4% during this period.

Table 3: Descriptive statistics and outstanding amounts with regard to bilateral credit risk exposure for blockholding and lending (in billion JPY)

| | 2008FH | 2009FH | 2010FH | 2011FH | 2012FH | 2013FH | 2014FH | 2015FH | 2016FH | 2017FH |
|---|---|---|---|---|---|---|---|---|---|---|
| Blockholding exposure | | | | | | | | | | |
| 25% | 1,202 | 600 | 871 | 1,127 | 861 | 1,578 | 1,436 | 1,746 | 1,113 | 1,003 |
| Median | 2,635 | 1,830 | 2,322 | 2,336 | 2,098 | 3,582 | 3,501 | 4,291 | 3,860 | 3,288 |
| 75% | 6,050 | 4,798 | 5,406 | 6,416 | 5,887 | 9,927 | 11,230 | 12,290 | 12,910 | 10,856 |
| Maximum | 50,875 | 50,750 | 49,350 | 62,089 | 76,280 | 136,951 | 175,974 | 146,623 | 168,588 | 169,305 |
| Mean | 4,796 | 3,696 | 4,514 | 5,322 | 5,366 | 8,962 | 10,451 | 11,517 | 11,831 | 10,584 |
| SD | 6,898 | 5,908 | 6,608 | 8,039 | 9,041 | 14,742 | 18,219 | 18,657 | 20,784 | 19,191 |
| Total outstanding amount | 1,400 | 1,109 | 1,314 | 1,607 | 1,680 | 3,074 | 4,243 | 5,206 | 5,986 | 6,022 |
| Corporate lending exposure | | | | | | | | | | |
| 25% | 1,433 | 2,013 | 2,017 | 1,521 | 1,520 | 1,024 | 1,023 | 1,023 | 1,028 | 1,021 |
| Median | 3,948 | 4,033 | 4,040 | 4,042 | 4,078 | 4,029 | 3,512 | 3,236 | 3,302 | 3,048 |
| 75% | 8,439 | 8,903 | 8,470 | 9,186 | 9,171 | 9,104 | 9,151 | 9,284 | 9,777 | 9,480 |
| Maximum | 70,712 | 72,580 | 72,946 | 67,877 | 68,380 | 67,611 | 66,583 | 71,469 | 85,049 | 88,252 |
| Mean | 6,391 | 7,000 | 7,111 | 6,906 | 7,586 | 7,518 | 7,295 | 7,365 | 7,935 | 7,986 |
| SD | 8,338 | 8,496 | 8,914 | 8,504 | 9,701 | 10,102 | 9,898 | 10,415 | 11,506 | 12,036 |
| City banks | 536 | 633 | 740 | 904 | 1,115 | 1,460 | 1,753 | 2,127 | 2,592 | 2,998 |
| Trust banks | 485 | 539 | 531 | 651 | 806 | 997 | 1,056 | 1,191 | 1,410 | 1,611 |
| Shinsei bank & Aozora bank | 162 | 155 | 173 | 203 | 211 | 225 | 267 | 293 | 0 | 0 |
| Norinchukin bank | 119 | 102 | 93 | 114 | 93 | 91 | 128 | 142 | 145 | 167 |
| Regional banks (I & II) | 120 | 125 | 144 | 195 | 233 | 276 | 333 | 377 | 456 | 531 |
| Shinkin banks & Credit unions | 28 | 34 | 47 | 51 | 54 | 50 | 53 | 59 | 66 | 95 |
| Other private FIs | 71 | 73 | 73 | 68 | 70 | 70 | 78 | 81 | 118 | 142 |
| Government FIs | 117 | 208 | 248 | 297 | 329 | 372 | 409 | 445 | 529 | 597 |
| Other foreign banks | 10 | 2 | 0 | 0 | 3 | 10 | 9 | 13 | 18 | 17 |
| Life insurers | 145 | 145 | 157 | 160 | 144 | 148 | 147 | 143 | 171 | 183 |
| Non-life insurers | 25 | 28 | 20 | 20 | 17 | 19 | 21 | 23 | 29 | 34 |
| Unknowns | 66 | 14 | 0 | 3 | 35 | 20 | 28 | 3 | 5 | 5 |
| Total outstanding amount | 1,885 | 2,058 | 2,226 | 2,666 | 3,110 | 3,736 | 4,282 | 4,898 | 5,539 | 6,381 |
| Grand total outstanding amount | 3,286 | 3,167 | 3,539 | 4,273 | 4,790 | 6,810 | 8,525 | 10,103 | 11,525 | 12,403 |

**Notes:** Abbreviations: SD: standard deviation; FIs: financial institutions; FH: the first half of a fiscal year. Regional banks include regional banks and second-tier regional banks (I and II, respectively). Three mega banks, the Mitsubishi UFJ Financial Group, Mizuho Financial Group, and Sumitomo Mitsui Financial Group, fall into the categories of city banks and trust banks. A category of "unknowns" includes financial institutions with names that are unknown on the Nikkei NEEDS–FinancialQUEST database.

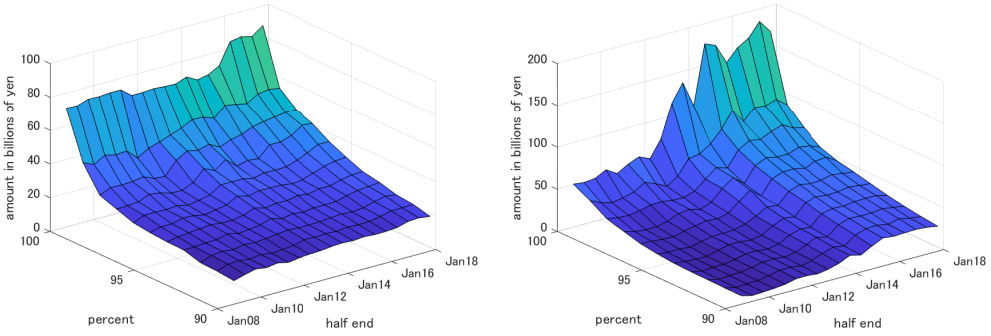


Figure 3: Risk exposure distributions of both blockholding (left panel) and lending (right panel) for investment corporations

**Notes:** Exposure amounts are expressed in billion JPY. The distribution shows the range from the 90th percentile to the 100th percentile.

## 4. Network analysis

This section describes the analysis of the network structures of both the J-REIT market and the lending market. The analysis is based on the market value of exposures held by blockholders in the J-REIT market and the credit risk exposure in the lending market. This approach differs from one based on the no risk-sensitive nominal exposure that is examined in most literature on credit risk management.

### *4.1. Data for network analysis*

The following $(N \times N)$ matrix, $X$, represents the relationships for unit holding or lending:

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1j} & \cdots & x_{1N} \\ \vdots & \ddots & \vdots & \iddots & \vdots \\ x_{i1} & \cdots & x_{ij} & \cdots & x_{iN} \\ \vdots & \ddots & \vdots & \iddots & \vdots \\ x_{N1} & \cdots & x_{Nj} & \cdots & x_{NN} \end{bmatrix}, \tag{7}$$

where $x_{ij}$ denotes the outstanding exposure pertaining to corporation $i$ in terms of the lending or holding of institution or blockholder $j$. The summation across row $i$ provides entity $i$'s total outstanding exposure of its borrowing liabilities or holding units. The summation of column $j$ provides the total outstanding exposure of entity $j$'s holding units or lending assets. Thus, matrix $X$ is asymmetric.

Because the analysis requires outstanding data on ownership for the blockholding exposure or lending exposure matrix, $X$, this study utilizes details by entity, as shown in Table 3.

*4.2. Methodology and analytical results*

Using the matrix expressed in equation (7), this study calculates network indicators and centrality measures per entity for the first half of FY2008 to the first half of FY2017. In terms of network indicators, network size indicates the total number of links in the blockholding and lending networks, and exposure size indicates the total number of exposures in the networks. Four centrality measures are also calculated: (lending) degree centrality for the lending network, and degree, weighted degree, and hyperlink-induced topic search (HITS) hub centrality for the blockholding and lending networks. Table 4 reports the semiannual averages for each of these. The left panel of Figure 4 shows that both network size (left y-axis) and exposure size (right y-axis) increase gradually for the period. By contrast, as the right panel of Figure 4 shows, the Pearson's correlations between all pairwise degree centralities are from 0.7 to 0.8, whereas the correlations between hub centrality and the other centralities (i.e., lending degree, degree, and weighted degree) are negative from $-0.18$ to $-0.52$.

*4.2.1. Degree centrality and weighted degree centrality*

In terms of degree centrality, an entity's total degree is the sum of its in- and out-degrees in the blockholding and lending networks. An entity's total "lending degree" is the sum of its in- and out-degrees in a lending network and its total blockholding degree is the sum of its in- and out-degrees in a blockholding network.

Because a financial institution is a lender, it has only one in-degree and no out-degree in terms of its relationship with an investment corporation, whereas an investment corporation has only one out-degree and no in-degree in terms of its relationship to an institution. An entity's degree is a proxy variable for its interconnectedness in a network. In a directed graph, all

liabilities of a set of entities are directed from one borrowing corporation to its lending institution in a lending network. Degree centrality and network size are the same numbers, owing to the one-way contract from an investment corporation as an issuer to a blockholder or from an investment corporation as an obligor to a creditor.

Degree has generally been extended to the sum of weights when analyzing weighted networks and labeled node strength, and hence, the weighted degree and the weighted in- and out-degree are calculated (Opsahl et al., 2010).

*4.2.2. HITS hub centrality*

In terms of HITS hub centrality, HITS is known as "hubs" and "authorities." The HITS algorithm was developed by Kleinberg (1999, 2000), and is a link analysis algorithm that helps identify the essential nodes in a graph. It consists of two scores, a hub score and an authority score. The authority score of a node is a measure of the amount of valuable information that the node holds. The hub score of a node shows how many highly informative nodes or authoritative nodes it points to.

Hence, a high hub score for a node (i.e., investment corporation) shows that the node points to many other authoritative nodes. By contrast, a high authoritative score for a node shows that it points to a large number of nodes, and thus, serves as a node of useful information in the network.

Hence, HITS authority centrality is not suitable for measuring the credit risk of an investment corporation as a unit issuer in the blockholding network or as a borrower in the lending network. By contrast, HITS hub centrality considers the credit risk of a blockholder or borrower in terms of hub scores based on its out-degree. Investment corporations with the highest hub centrality play a central role in the network. The weights are normalized to ensure that the sum of their squares is 1.

*4.2.3. Ranking by degree*

Table 5 shows the ranking of the top 20 entities based on interconnectedness, measured by their node degree. In terms of blockholder rankings, there are three to five trust banks, including three Japanese version master trust banks,[5]for the first half of FY2008 to the first half of FY2017. Trust banks

[5]The master trust banks are The Master Trust Bank of Japan, Japan Trustee Services Bank, and Trust & Custody Services Bank. Their master trust businesses specialize in unifying the management of pension funds held by some asset management firms. The

Table 4: Network measures in blockholding and lending networks

| FY | N size | E Size | L Degree | Degree | W Degree | Hub |
|---|---|---|---|---|---|---|
| 2008FH | 574 | 2,481 | 0.1733 | 0.333 | 1,441 | 0.000290 |
| 2008SH | 567 | 2,358 | 0.1722 | 0.329 | 1,369 | 0.000290 |
| 2009FH | 577 | 2,558 | 0.1727 | 0.340 | 1,509 | 0.000295 |
| 2009SH | 583 | 2,630 | 0.1804 | 0.344 | 1,552 | 0.000295 |
| 2010FH | 590 | 2,882 | 0.1839 | 0.348 | 1,700 | 0.000295 |
| 2010SH | 650 | 3,230 | 0.2186 | 0.383 | 1,906 | 0.000295 |
| 2011FH | 675 | 3,560 | 0.2267 | 0.398 | 2,100 | 0.000295 |
| 2011SH | 672 | 3,576 | 0.2266 | 0.396 | 2,108 | 0.000295 |
| 2012FH | 707 | 4,074 | 0.2406 | 0.417 | 2,401 | 0.000295 |
| 2012SH | 801 | 4,962 | 0.2805 | 0.472 | 2,924 | 0.000295 |
| 2013FH | 816 | 5,603 | 0.2918 | 0.481 | 3,304 | 0.000295 |
| 2013SH | 915 | 6,602 | 0.3301 | 0.540 | 3,894 | 0.000295 |
| 2014FH | 964 | 8,223 | 0.3449 | 0.569 | 4,851 | 0.000295 |
| 2014SH | 1,017 | 9,462 | 0.3713 | 0.600 | 5,582 | 0.000295 |
| 2015FH | 1,090 | 9,682 | 0.3908 | 0.643 | 5,714 | 0.000295 |
| 2015SH | 1,174 | 11,164 | 0.4314 | 0.693 | 6,588 | 0.000295 |
| 2016FH | 1,157 | 11,525 | 0.4102 | 0.680 | 6,772 | 0.000294 |
| 2016SH | 1,271 | 12,619 | 0.4525 | 0.747 | 7,414 | 0.000294 |
| 2017FH | 1,299 | 12,403 | 0.4696 | 0.763 | 7,288 | 0.000294 |

**Notes:** Abbreviations: N: Network; E: Exposure; L: Lending; W: Weighted. Network size is the total number of relationships for unit holdings and lending in the networks. Exposure size is expressed in billion JPY.

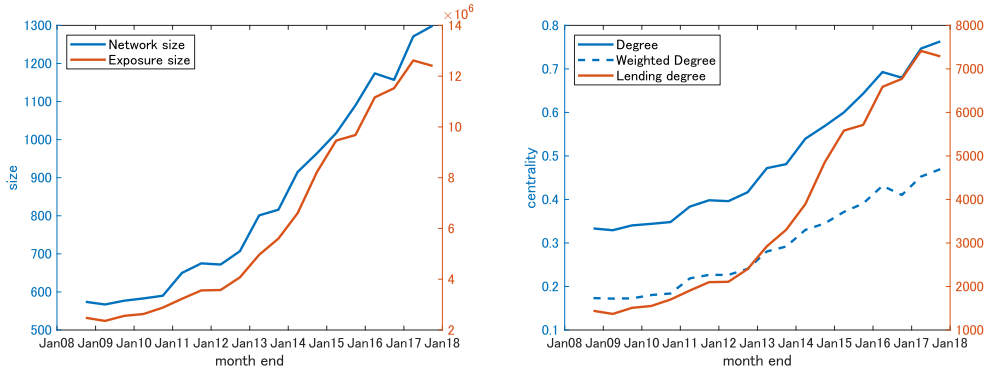


Figure 4: Network indicators and centrality measures

**Notes:** Right y-axis in each panel corresponds to the red color line(s).

manage J-REITs as investment trusts or annuity trusts. The share of trust banks was 43.4% as of August 2016. In contrast, in terms of lending ranking, the number of commercial banks grew yearly from zero to nine for the period. The commercial banks are major banks, including the Mitsubishi UFJ Financial Group (BTMU and MUTB), the Mizuho Financial Group (Mizuho Bank, Mizuho Trust & Banking), the Sumitomo Mitsui Financial Group (SMBC), Resona Holdings (Resona Bank), and Sumitomo Mitsui Trust Holdings.

The degree centralities for J-REITs correspond to out-degrees in terms of issuers in the blockholding network and obligors in the lending network, whereas the degree centralities for commercial banks correspond to in-degrees in terms of lenders in the lending network. The degree centralities for trust banks correspond to in-degrees in terms of blockholders in the blockholding network.

Figures 5 and 6 visually depict directed graphs based on degrees over 15 as of the first half of FY2008 and the first half of FY2017, respectively. The direction of the arrow is from an investment corporation as an issuer to a blockholder in the blockholding network or from an investment corporation as an obligor to a creditor institution in the lending network. For example, Nippon Building Fund has 10 in-degrees in the blockholding network and 25 in-degrees in the lending network. As shown in Figures 5 and 6, because the edge is weighted by exposure, some thick ingoing edges flow into blockholders and banks (insurers) from investment corporations.

Figure 7 presents the four time-transition panels pertaining to a directed graph based on degrees over 15 for the first half of FY2009 to the first half of FY2015. The graphs show that some mega banks had large credit risk exposure originating from some major investment corporations, such as Nippon Building Fund and Orix JREIT, during the first half of FY2009 to the first half of FY2015.

## 5. Credit risk analysis

We analyze J-REIT credit risk using data for all J-REITs. To this end, we conduct a panel regression analysis using the dataset for the period after Lehman Brothers' bankruptcy.

banks collectively undertake custody businesses of stocks and bonds, receipts of interest and dividends, and accounting reporting for corporate pension funds.

Table 5: Top 20 entities ranked by degree centrality in both blockholding and lending networks

| Rank | 2008FH | 2009FH | 2010FH | 2011FH | 2012FH |
|---|---|---|---|---|---|
| 1 | NPN BUIL. FUND (10,25) | NPN BUIL. FUND (10,26) | NPN BUIL. FUND (10,26) | NPN BUIL. FUND (10,25) | JPN PRIME REA. INV. (10,28) |
| 2 | ORIX JREIT (10,24) | ORIX JREIT (10,22) | JPN PRIME REA. INV. (10,22) | ORIX JREIT (10,24) | NPN BUIL. FUND (10,25) |
| 3 | FUKUOKA REIT (10,22) | FUKUOKA REIT (10,22) | FUKUOKA REIT (10,22) | UNITED URBAN INV. (10,24) | ORIX JREIT (10,24) |
| 4 | JPN RE INV. (10,19) | JPN RE INV. (10,19) | JPN RE INV. (10,20) | JPN PRIME REA. INV. (10,23) | FUKUOKA REIT (10,24) |
| 5 | NCT TR (27,0) | JPN PRIME REA. INV. (10,18) | ORIX JREIT (10,19) | FUKUOKA REIT (10,22) | JPN RE INV. (10,23) |
| 6 | JPN PRIME REA. INV. (10,15) | NCT TR (28,0) | JPN RETAIL FUND INV. (10,17) | JPN RE INV. (10,21) | UNITED URBAN INV. (9,22) |
| 7 | JPN TRUSTEE SERV. BK (25,0) | JPN TRUSTEE SERV. BK (28,0) | UNITED URBAN INV. (10,17) | NOMURA TR (29,0) | JPN TRUSTEE SERV. BK (30,0) |
| 8 | NPN ACCOMMO. FUND (10,14) | UNITED URBAN INV. (10,15) | JPN TRUSTEE SERV. BK (27,0) | JPN TRUSTEE SERV. BK (29,0) | NOMURA TR (29,0) |
| 9 | TOKYU REIT (10,14) | MASTER TR BK (25,0) | TR & CUST. SERV. BK (26,0) | TR & CUST. SERV. BK (29,0) | TR & CUST. SERV. BK (29,0) |
| 10 | UNITED URBAN INV. (10,14) | NPN ACCOMMO. FUND (10,14) | DAIWA OFFICE INV. (10,15) | ADVANCE RESI. INV. (10,18) | ADVANCE RESI. INV. (9,19) |
| 11 | MASTER TR BK (24,0) | TOKYU REIT (10,14) | JPN RENT. HOUS. INV. (12,13) | DAIWA OFFICE INV. (10,17) | JPN RETAIL FUND INV. (10,18) |
| 12 | MORI TR SOGO REIT (10,12) | TR & CUST. SERV. BK (24,0) | MASTER TR BK (25,0) | MASTER TR BK (27,0) | DAIWA OFFICE INV. (10,18) |
| 13 | JPN RENT. HOUS. INV. (10,12) | JPN RETAIL FUND INV. (10,12) | NPN ACCOMMO. FUND (10,14) | NOMURA AM UK (27,0) | MASTER TR BK (28,0) |
| 14 | JPN EXCELLENT (10,12) | JPN EXCELLENT (10,12) | TOKYU REIT (10,13) | NPN ACCOMMO. FUND (10,16) | SMBC (0,25) |
| 15 | TR & CUST. SERV. BK (22,0) | JPN RENT. HOUS. INV. (10,11) | JPN EXCELLENT (11,12) | JPN RETAIL FUND INV. (10,16) | NOMURA AM UK (25,0) |
| 16 | KENEDIX OFFICE INV. (11,10) | NOMURA TR (21,0) | NOMURA TR (23,0) | MORI HILLS REIT INV. (10,14) | NPN ACCOMMO. FUND (9,15) |
| 17 | JPN RETAIL FUND INV. (10,10) | MORI TR SOGO REIT (10,10) | MORI TR SOGO REIT (9,12) | PREMIER INV. (10,14) | MORI HILLS REIT INV. (9,15) |
| 18 | ICHIGO OFFICE REIT (9,11) | KENEDIX OFFICE INV. (10,10) | MORI HILLS REIT INV. (9,11) | TOKYU REIT (10,13) | MORI TR SOGO REIT (10,14) |
| 19 | PREMIER INV. (10,9) | MORI HILLS REIT INV. (9,10) | FRONTIER RE INV. (10,10) | GLOBAL ONE RE INV. (10,13) | RESONA BK (0,24) |
| 20 | DAIWA OFFICE INV. (10,9) | MUTB (0,19) | SMBC (0,20) | JPN RENT. HOUS. INV. (10,13) | MUTB (0,24) |
| Rank | 2013FH | 2014FH | 2015FH | 2016FH | 2017FH |
| 1 | ORIX JREIT (10,27) | JPN PRIME REA. INV. (10,30) | JPN RE INV. (8,37) | NOMURA TR (49,0) | NOMURA TR (55,0) |
| 2 | JPN PRIME REA. INV. (10,27) | ORIX JREIT (10,29) | NOMURA TR (44,0) | MASTER TR BK (49,0) | MASTER TR BK (55,0) |
| 3 | DAIWA OFFICE INV. (10,26) | NOMURA TR (38,0) | MASTER TR BK (44,0) | JPN TRUSTEE SERV. BK (49,0) | JPN TRUSTEE SERV. BK (55,0) |
| 4 | NPN BUIL. FUND (9,26) | MASTER TR BK (38,0) | JPN TRUSTEE SERV. BK (44,0) | TR & CUST. SERV. BK (49,0) | TR & CUST. SERV. BK (55,0) |
| 5 | JPN RE INV. (9,24) | JPN TRUSTEE SERV. BK (38,0) | TR & CUST. SERV. BK (44,0) | SMBC (0,46) | SMBC (0,53) |
| 6 | NOMURA TR (33,0) | TR & CUST. SERV. BK (38,0) | ORIX JREIT (10,30) | JPN RE INV. (8,36) | MIZUHO BK (0,49) |
| 7 | MASTER TR BK (33,0) | DAIWA OFFICE INV. (10,27) | SMBC (0,40) | MIZUHO BK (0,43) | SMTB (0,48) |
| 8 | JPN TRUSTEE SERV. BK (33,0) | NPN BUIL. FUND (9,27) | MIZUHO BK (0,39) | RESONA BK (0,43) | RESONA BK (0,47) |
| 9 | TR & CUST. SERV. BK (33,0) | UNITED URBAN INV. (8,28) | SMTB (0,39) | SMTB (0,42) | STATE STRUSTEET (45,0) |
| 10 | JPN RETAIL FUND INV. (8,24) | JPN RETAIL FUND INV. (8,27) | NPN BUIL. FUND (9,29) | NOMURA RE MASTER F (8,31) | DBJ (0,45) |
| 11 | FUKUOKA REIT (10,22) | SMBC (0,35) | UNITED URBAN INV. (9,29) | UNITED URBAN INV. (8,31) | JPN RE INV. (7,36) |
| 12 | ADVANCE RESI. INV. (9,22) | JPN RE INV. (8,26) | RESONA BK (0,38) | BTMU (0,39) | BTMU (0,42) |
| 13 | UNITED URBAN INV. (9,22) | FUKUOKA REIT (10,23) | JPN RETAIL FUND INV. (9,27) | DBJ (0,39) | MUTB (0,42) |
| 14 | SMBC (0,30) | MIZUHO BK (0,33) | DAIWA OFFICE INV. (10,26) | STATE STRUSTEET (38,0) | FUKUOKA BK (0,41) |
| 15 | PREMIER INV. (10,19) | ADVANCE RESI. INV. (9,23) | BTMU (0,36) | MUTB (0,37) | UNITED URBAN INV. (7,32) |
| 16 | MUTB (0,29) | SMTB (0,32) | MUTB (0,34) | NPN BUIL. FUND (9,27) | NOMURA RE MASTER F (7,31) |
| 17 | NOMURA AM UK (29,0) | BTMU (0,31) | DBJ (0,34) | ORIX JREIT (9,27) | MIZUHO TR & BKG (0,37) |
| 18 | GLOBAL ONE RE INV. (10,18) | RESONA BK (0,31) | ADVANCE RESI. INV. (9,24) | FUKUOKA BK (0,33) | JPN RETAIL FUND INV. (8,28) |
| 19 | NPN ACCOMMO. FUND (9,17) | MUTB (0,31) | JPN PRIME REA. INV. (9,24) | MIZUHO TR & BKG (0,33) | ORIX JREIT (7,28) |
| 20 | FRONTIER RE INV. (9,17) | DBJ (0,31) | FUKUOKA REIT (10,23) | ADVANCE RESI. INV. (8,24) | NPN BUIL. FUND (7,27) |

**Notes:** Abbreviations: NPN: Nippon; JPN: Japan; TR: Trust; CUST: Custody; SERV: Services; HOUS: Housing; RENT: Rental; BTMU: Bank of Tokyo-Mitsubishi UFJ; SMBC: Sumitomo Mitsui Banking Corporation; MUTB: Mitsubishi UFJ Trust & Banking; DBJ: Development Bank of Japan. Figures in parentheses indicate degree centrality pertaining to blockholding (first figure) and lending (second figure), respectively.

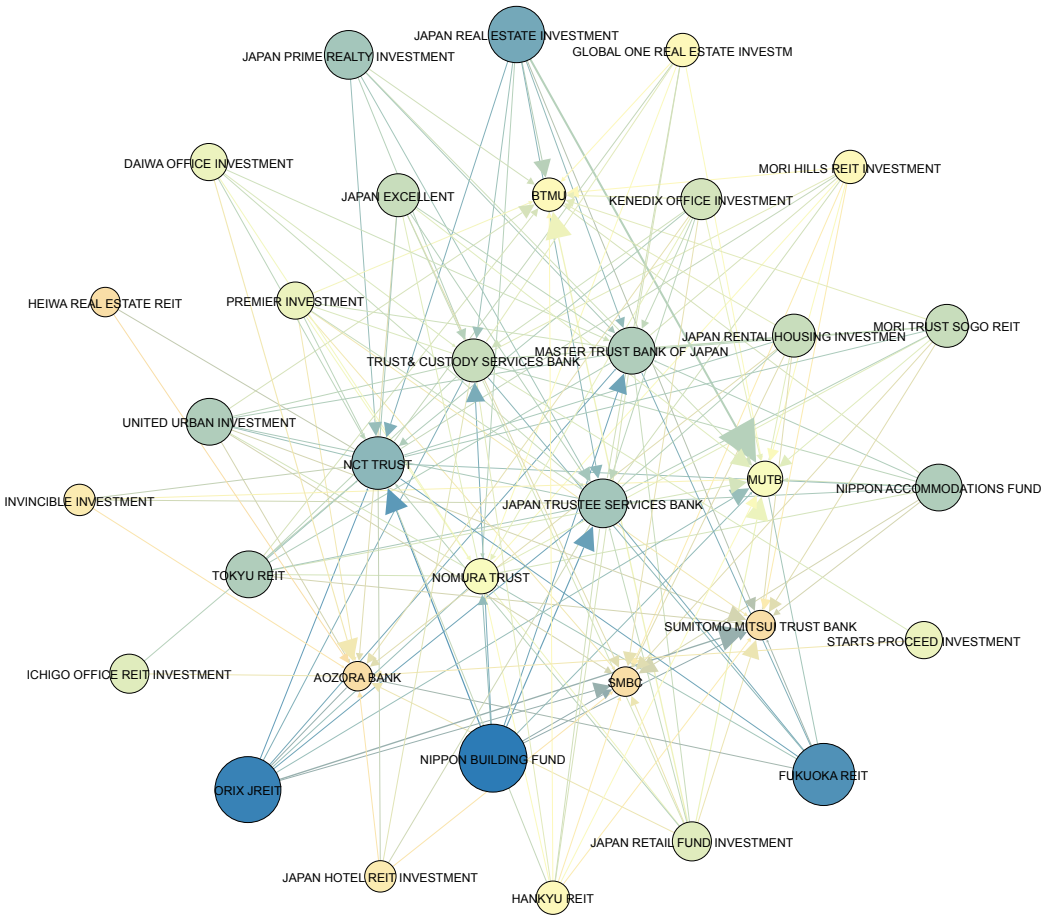


Figure 5: Directed graph of nodes of over 15 degrees in blockholding and lending networks, first half of FY2008 (just after the bankruptcy of Lehman Brothers)

**Note:** These graphs are drawn in accordance with the Fruchterman–Reingold algorithm.

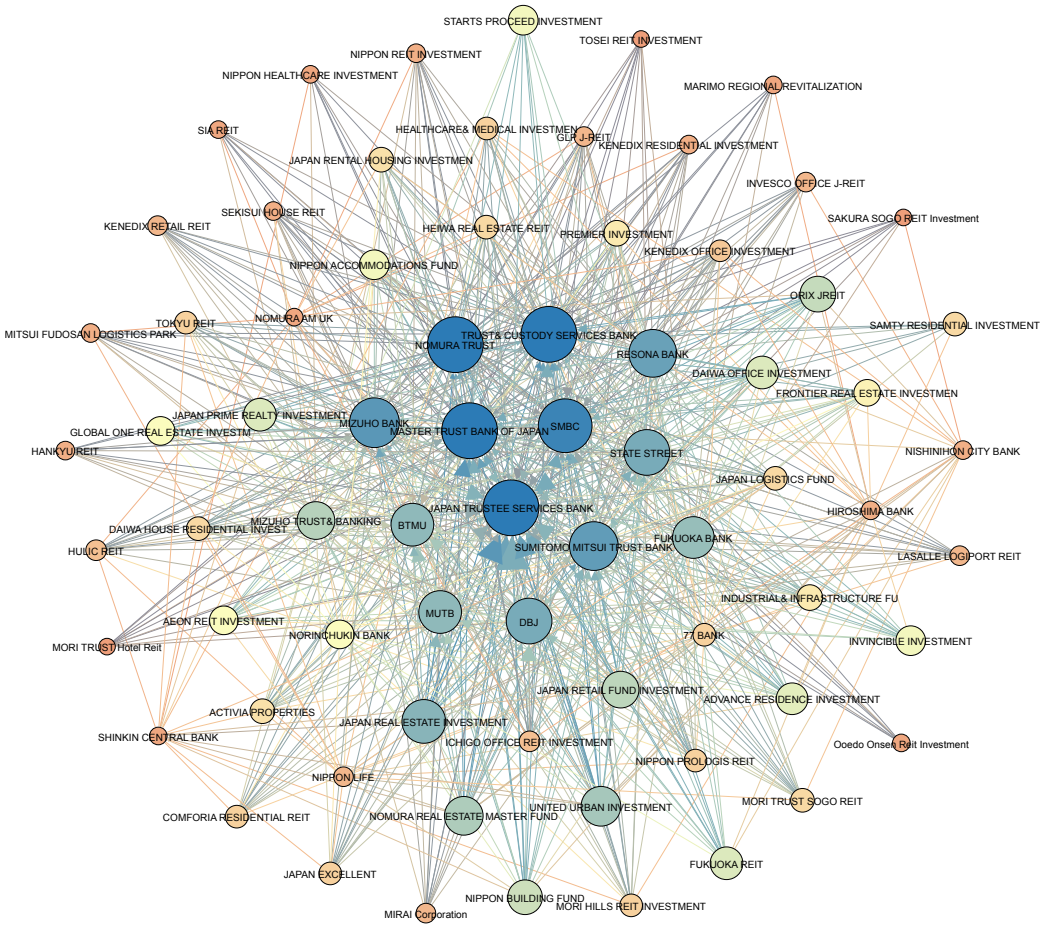


Figure 6: Directed graph of nodes of over 15 degrees in blockholding and lending networks, first half of FY2017

**Note:** These graphs are drawn in accordance with the Fruchterman–Reingold algorithm.

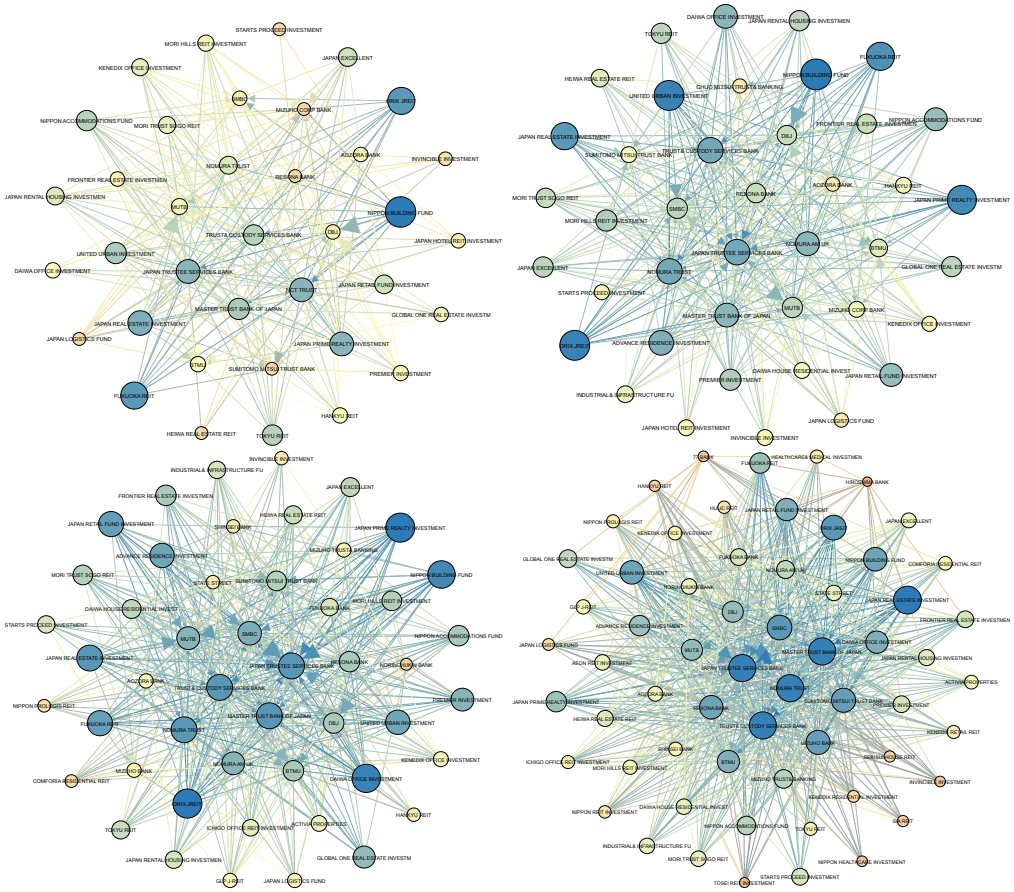

Figure 7: Directed graph of nodes of over 15 degrees in blockholding and lending networks, first half of FY2009, FY2011, FY2013, and FY2015

**Notes:** The four panels show directed graphs for the first half of FY2009 and FY2011 from the upper-left panel to the upper-right panel and for the first half of FY2013 and FY2015 from the lower-left panel to the lower-right panel.

*5.1. Data for panel analysis*

For the panel regression analysis, we use firm-level data, such as financial variables, probability of default, sponsors' holdings, and property acquisition, in addition to the centrality measures calculated in Section 4 (Table 6). We obtain the financial data and data for sponsors' unit holdings and property acquisition from the Thomson Reuters Eikon database, which offers earnings reports for all J-REITs. In addition, the data for the probability of default are obtained from the publicly accessible CRI database, published by the NUS.[6] The CRI's probability of default is computed as a function of different input variables using the forward intensity model[7], which is a reduced-form model (Duan et al., 2012).

Table 7 shows the expected sign by variable, mean and standard deviation, mode, and quartile, along with values for the financial variables used as control variables (Panel 1) and the cross-correlation matrix (Panel 2). In Panel 1, the sign ($\pm$) indicates that the variable can take any sign and "Num" indicates that there are 7,156 relationships pertaining to unit holdings and lending for the first half of FY2008 to the first half of FY2017. Panel 2 shows the correlations among logarithmic odds ratios, centrality measures, financial variables, and sponsor and property variables. Most correlations among the financial variables are relatively low, with few above an absolute value of 0.25. By contrast, correlations among total assets (logarithm) and the three degree-related centralities (i.e., lending degree, degree, and weighted degree) are relatively high, from 0.49 to 0.66.

[6]The initiative is a non-profit undertaking by the Risk Management Institute at the NUS, which seeks to promote research and development in the credit risk area. The CRI uses the probability of default model (NUS, 2014) as its foundation, which was developed using a database of more than 68,000 exchange-listed firms in Asia Pacific, North America, Europe, Latin America, the Middle East, and Africa.

[7]The Poisson process with stochastic intensities is often used to model the occurrence of defaults. The stochastic intensity is a function of some state variables, such as S&P500, Treasury rate, DTD (firm's distance-to-default), CASH/TA (ratio of the sum of cash and short-term investments to total assets), NI/TA (ratio of net income to total assets), SIZE (logarithm of the ratio of a firm's market equity value to average market equity value of S&P500 firms), M/B (market-to-book asset ratio), and SIGMA (1-year idiosyncratic volatility), but the dynamics of these state variables are not affected by default. Since the relationship is unidirectional from state variables to the Poisson process, such a doubly stochastic model is easy to work with both in terms of computing quantities of interest and estimating the model parameters. This approach has been widely applied in the literature, such as Duffie et al. (2007).

Definitions of variables[8] listed in Table 7 are as follows: financial leverage is the total assets-to-capital ratio and the inverse of the capital adequacy ratio. An increase in financial leverage leads to lowering the capital adequacy ratio and hence, an increase in default risk. The EBITDA margin is the target's annual earnings before interest, taxes, and depreciation expressed as a percentage of total annual revenue. The current ratio indicates short-term debt-paying ability and is calculated as the ratio of current assets to current liabilities. A financial variable similar to the current ratio, the quick ratio is often referred to as a typical indicator of surplus bankruptcy. Because investment corporations have no inventory, their current ratio is the same as their quick ratio. Hence, the current ratio is considered an indicator for monitoring the standalone or double default of an investment corporation. Occupancy rate shows the percentage of leased space that is occupied by tenants at the end of the period. The property acquisition variable requires information about property purchase dates, sellers, and buyers' names (i.e., investment corporations), and property prices. Hence, property acquisition (dummy) equals 1 if the property is acquired prior to the accounting date, and 0 otherwise.[9] A sponsors' holding ratio is expressed as the ratio of the sponsors' holdings in a J-REIT's investment units.

The expected sign for each variable listed in Panel 1 of Table 7 is explained as follows. The greater the financial leverage, the higher the proportion of liabilities to capital. Thus, we expect a positive sign on financial leverage. Total assets are a proxy for corporation size and have no directional impact on an investment corporation's credit risk, and therefore, can be either positive or negative. The higher the current ratio, the greater the corporation's ability to meet its short-term debt payments. Thus, we expect a negative sign on the current ratio. A higher occupancy rate leads to larger cash flows received from tenants. Thus, we expect a negative sign on occupancy rate. Property acquisition prior to the accounting date contributes to improving

[8]Besides the variables listed in the panel, we consider the net asset value per share (NAVPS) as a control variable for the regression analyses conducted hereafter. NAVPS is an expression for net asset value that represents the value per unit of a REIT. As a result of analyses, NAVPS is excluded because it does not necessarily contribute to a J-REIT's credit risk.

[9]In addition, a variable pertaining to amounts for property acquisitions is obtained. However, in the panel analysis, the independent variable is excluded owing to its incorrect sign.

Table 6: Financial ratios and other related variables

| Item | Description | Sources |
|---|---|---|
| Financial ratios, sponsor and property variables | Historical data by investment corporation | Thomson Reuters Eikon |
| PDs | Parameter values calculated by the probability of default model (NUS, 2014) | CRI, NUS |
| Centrality measures | Indicators on relationships of networks | Calculation in Section 4 |

an investment corporation's financial health at the accounting date. Thus, the expected sign for property acquisition (dummy) is negative. A higher sponsors' holding ratio leads to increased sponsors' financial support. Thus, the expected sign for sponsors' holding ratio is negative.

Figure 8 illustrates the histogram of the logarithmic odds ratios (dependent variable) and financial variables (independent variables). Financial leverage peaks around 2, and the current ratio is almost below 1, which is confirmed by the fact that the mode is 0.14. The occupancy rate is distributed in the range of 0 to 1 and has a peak at 1. There are some holdings by sponsors in the database.

*5.2. Methodology*

The credit risk for a REIT investment corporation is driven by its own financial health, the downside risk in the asset value or cash flows of its property holdings, its sponsor's support circumstances, and the interactions in the blockholding and lending networks. Hence, we investigate the REIT investment corporation's credit risk. The probability of default is a proxy variable for credit risk.

We estimate the regression model, which is essentially a binary logistic regression model, as follows:

$$\begin{aligned} \ln \frac{PD_{i,t}}{1-PD_{i,t}} = \alpha\ (centrality\ measure)_{i,t} + \boldsymbol{\beta}\ \mathbf{Controls}_{i,t} \\ + \sum_{k} (asset-type)_k + \sum_{t} year_t + \epsilon_{i,t}, \end{aligned} \tag{8}$$

Table 7: Summary statistics of financial variables

Panel 1: Descriptive statistics

| | Sign | Mean | SD | Mode | 25% | 50%(Med.) | 75% | Max | Num |
|---|---|---|---|---|---|---|---|---|---|
| Log odds ratio 6mo | | -9.891 | 2.454 | -13.816 | -11.870 | -9.965 | -8.056 | -3.368 | 7,156 |
| Log odds ratio 1yr | | -8.576 | 2.261 | -6.535 | -10.232 | -8.563 | -6.905 | -2.811 | 7,156 |
| Financial leverage | + | 2.036 | 0.279 | 1.940 | 1.920 | 2.040 | 2.170 | 4.010 | 7,156 |
| EBITDA margin | − | 0.655 | 0.084 | 0.679 | 0.604 | 0.647 | 0.701 | 0.940 | 7,156 |
| Total assets (logarithm) | ± | 12.038 | 1.014 | 9.762 | 11.637 | 12.167 | 12.602 | 13.916 | 7,156 |
| Current ratio | − | 1.695 | 4.675 | 0.140 | 0.360 | 0.610 | 1.100 | 107.680 | 7,156 |
| Occupancy rate | − | 0.972 | 0.026 | 1.000 | 0.961 | 0.975 | 0.992 | 1.000 | 7,156 |
| Property acquisition (dummy) | − | 0.028 | 0.164 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | 7,156 |
| Sponsors' holding ratio | − | 0.756 | 5.541 | 0.000 | 0.000 | 0.000 | 0.000 | 100.000 | 7,156 |

Panel 2: Correlation matrix

| | Financial leverage | EBITDA margin | Total assets | Current ratio | Occupancy rate | Property | Sponsor |
|---|---|---|---|---|---|---|---|
| Log odds ratio 6mo | 0.108** | -0.055** | -0.150** | -0.098** | -0.262** | -0.074** | -0.003 |
| Log odds ratio 1yr | 0.125** | -0.078** | -0.143** | -0.104** | -0.265** | -0.073** | -0.004 |
| Lending degree | 0.040** | -0.165** | 0.662** | -0.154** | 0.053** | 0.075** | -0.090** |
| Degree | -0.043** | -0.111** | 0.493** | -0.107** | 0.173** | 0.074** | -0.114** |
| Weighted degree | -0.072** | -0.071** | 0.643** | -0.101** | 0.192** | 0.083** | -0.053** |
| Hub | 0.108** | -0.061** | -0.046** | -0.141** | -0.297** | -0.067** | -0.015 |
| Financial leverage | | -0.110** | -0.037** | -0.140** | -0.093** | -0.017 | -0.003 |
| EBITDA margin | | | -0.155** | 0.233** | 0.252** | -0.002 | 0.054** |
| Total assets (logarithm) | | | | -0.280** | 0.029* | 0.054** | -0.174** |
| Current ratio | | | | | 0.117** | 0.011 | 0.113** |
| Occupancy rate | | | | | | 0.018 | 0.007 |
| Property acquisition (dummy) | | | | | | | 0.212** |

**Notes:** Abbreviations: SD: standard deviation; Med: Median; Num: Number of units holding or lending; Property: Property acquisition (dummy); Sponsor: Sponsor holding ratio (%). Total assets (logarithm) are expressed as the logarithm of the amounts in million JPY. The upper panel provides the descriptive statistics for logarithmic odds ratios, financial variables, and sponsor and property variables. The expected sign is positive if the probability of default increases with the variable. ± means that the variable can be either positive or negative. The lower panel shows the correlation matrix among logarithmic odds ratios, centrality measures, financial ratios, and sponsor and property variables. * and ** represent two-sided significance at the 5% and 1% levels, respectively.

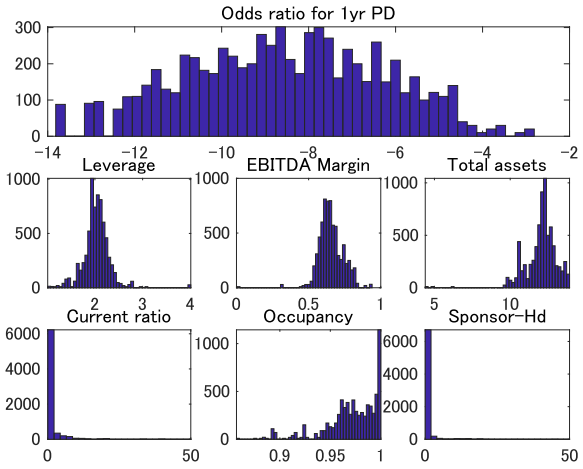


Figure 8: Histogram of logarithmic odds ratio and financial variables

**Notes:** Abbreviation: Sponsor-Hd: Sponsor holding ratio. Total assets (logarithm) are expressed as the logarithm of the amounts in million JPY.

where the left-hand side is the logarithmic odds ratio, which expresses the logarithm of the proportion of the probability of default $PD_{i,t}$ to the probability of survival $(1 - PD_{i,t})$ of corporation $i$ at time $t$ (i.e., from the end of March 2008 to the end of September 2017). The risk horizon implied in the probability of default is 6 months or 1 year.[10] On the right-hand side, the centrality measures reflect the interconnectedness of each REIT investment corporation with blockholders and financial institutions in the blockholding and lending networks, respectively.

To validate the explanatory power of each centrality measure, we assign only one measure to an independent variable. Three centralities, namely, degree centrality, weighted degree centrality, and HITS hub centrality, are introduced in Section 4. As the degree centralities focus on the lending

[10]For the purpose of corporate credit risk management, the risk horizon is typically 1 year. In addition, as shown in Figure 1 (i.e., lower panel of SEQ 2), 6 months is added considering the case for New City Residence's default owing to its sponsor's failure to raise funds.

network, lending degree is considered. The vector of controls includes the following variables: financial leverage, EBITDA margin, total assets (logarithm, in million JPY), current ratio, occupancy rate, property acquisition prior to accounting date (dummy), and sponsors' holding ratio. In addition, we control for year and asset-type effects. Assets are classified into eight types: office, residential, commercial facilities, hotel, logistics facilities, comprehensive, complex, and healthcare. The standard errors are clustered at the investment corporation level.

*5.3. Analytical results*

Table 8 reports the results estimated using equation (8) for 6-month probability of default as a dependent variable for the first half of FY2008 to the first half of FY2017. We check for multicollinearity using the variance inflation factor (VIF) and identify no values above 3.3 except case (4) with a maximum of 5.3. The preliminarily predicted signs of the independent variables are all as expected from Table 7. The estimates in cases (1)–(4) are all significant at the 1% level for financial leverage, EBITDA margin, total assets (logarithm), current ratio, and occupancy rate. For all cases, property acquisition (dummy) and the sponsor holding ratio are not significant, even at the 10% level. The adjusted R-squared values are all near 0.6, which supports the goodness-of-fit of the model. Three centrality measures (i.e., lending degree centrality, degree centrality, and weighted degree centrality) have the expected negative sign, while HITS hub centrality has the expected positive sign.

Lending degree expresses the number of relationships (edges) of an investment corporation with institutions in the lending network. An investment corporation's lending degree comprises only its lending out-degrees owing to zero lending in-degrees, whereas an institution's or firm's lending degree comprises only its in-degrees. From this perspective, an increase in the lending degree of an investment corporation means that an increase in the number of its counterparty institutions leads to an increase in the number of institutions supplying funding liquidity and thus, leads to a decrease in its credit risk.

At first glance, this assertion seems directly opposite to Gai and Kapaida's (2010) logic in an interbank network and the empirical results of Kanno (2019) in a cross-shareholding network. Gai and Kapadia (2010) in-

sist that the vulnerability[11] of a bank in an interbank network depends on its in-degree, and the probability of a bank being vulnerable is proportional to the joint degree distribution of the in- and out-degrees. Contagion risk in an interbank network arises from the behavior of financial institutions under distress or in default. Hence, weak interconnectedness among financial institutions results in low probability of default in a bidirected network, such as an interbank network or a cross-shareholding network. By contrast, blockholding and lending networks are directed networks from a blockholder or a financial institution to an investment corporation and the corporation's funding liquidity is proportional to the number of institutions.

Degree is the sum of the lending degree and blockholding degree. Hence, degree expresses the sum of the number of relationships (edges) of an investment corporation with institutions in the lending network and the number with blockholders in the REIT network. Hence, an investment corporation's degree comprises only its blockholding out-degree and its lending out-degree. As a result, an increase in the degree of an investment corporation means that an increase in the number of counterparties (i.e., institutions and blockholders) as suppliers of funding liquidity leads to a decrease in the corporation's credit risk. As shown in Table 8, an increase in the number of blockholders may have a smaller effect on credit risk than an increase in the number of institutions.

Weighted degree expresses the number of exposure-weighted edges in both networks. This centrality reflects the extent of its credit risk exposure implied in the contracts of an investment corporation with its counterparties in both networks. As shown in Table 8, an increase in the number of blockholders may have a smaller effect on credit risk than an increase in the number of institutions would.

Finally, HITS hub centrality expresses the importance of an investment corporation through its connections to counterparties in the blockholding and lending networks. As proposed by León and Pérez (2014), high hub centrality scores for an investment corporation would be regarded as a signal of the extent of the disruption that would follow its failure to pay its debts. Hence, the higher its HITS hub centrality, the larger its default risk.

Next, comparing the results for 6-month probability of default with those

[11] They define banks exposed to the default of a single neighbor as vulnerable and other banks as safe.

for 1-year probability of default, we conduct a regression analysis with 1-year probability of default as the dependent variable. We check for multicollinearity using the VIF and identify no values above 3.3 except case (4) with a maximum of 5.3. The preliminarily predicted signs of the independent variables are all as expected from Table 7. The estimates in cases (1)–(4) are all significant at the 1% level for financial leverage, EBITDA margin, total assets (logarithm), current ratio, and occupancy rate. As a result, selected financial variables are effective as control variables for both probabilities of default. However, for all cases, property acquisition (dummy) and the sponsor holding ratio are not significant even at the 10% level, although both are very important as control variables. The adjusted R-squared values are all close to 0.6, which supports the goodness-of-fit of the model.

Table 8: Credit risk factors for the logarithmic odds ratio of 6-month probability of default

| | Dependent variable: Logarithmic odds ratio | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Centrality measure | Lending degree | Degree | Weighted degree | Hub |
| | -0.0259*** | -0.0185*** | -5.68E-07*** | 254.8365*** |
| | (-6.74) | (-4.941) | (-3.753) | (39.037) |
| Financial leverage | 0.7724*** | 0.7628*** | 0.786*** | 0.7684*** |
| | (9.561) | (9.427) | (9.692) | (9.482) |
| EBITDA margin | -1.394*** | -1.4085*** | -1.3506*** | -1.3465*** |
| | (-5.059) | (-5.101) | (-4.893) | (-4.874) |
| Total assets (logarithm) | -0.1947*** | -0.2377*** | -0.251*** | -0.3234*** |
| | (-6.455) | (-8.165) | (-8.277) | (-13.805) |
| Current ratio | -0.0145*** | -0.0151*** | -0.0137*** | -0.0144*** |
| | (-3.072) | (-3.186) | (-2.9) | (-3.045) |
| Occupancy rate | -7.7685*** | -7.7185*** | -7.4277*** | -7.7588*** |
| | (-8.256) | (-8.191) | (-7.843) | (-8.22) |
| Property acq. (dummy) | -0.1141 | -0.1072 | -0.1142 | -0.126 |
| | (-0.927) | (-0.869) | (-0.926) | (-1.021) |
| Sponsor holding ratio | 0.0009 | -0.001 | 0.001 | 0.0001 |
| | (0.242) | (-0.274) | (0.272) | (0.014) |
| Constant | -3.0189*** | -2.2321** | -3.0363*** | -6.3772*** |
| | (-3.051) | (-2.277) | (-2.979) | (-6.383) |
| Year fixed effects | Yes | Yes | Yes | Yes |
| Asset-type fixed effects | Yes | Yes | Yes | Yes |
| Observations | 7,156 | 7,156 | 7,156 | 7,156 |
| Adjusted R-squared | 0.587 | 0.586 | 0.585 | 0.584 |

**Notes:** The data cover the first half of FY2008 to the first half of 2017. The dependent variable in these fixed-effects models is the natural logarithm of the odds ratio in terms of 6-month probability of default. We measure a firm's credit risk by its own centrality measures and financial ratios, such as financial leverage, EBITDA margin, total assets (logarithm), and current ratio. The centrality measures are those calculated at firm level in Section 4. We compute robust standard errors clustered at investment corporation level. T-statistics are in parentheses. *, **, and *** represent significance at the 10%, 5%, and 1% levels, respectively. The financial information for an investment corporation comes from Thomson Reuters Eikon. We include a half-year dummy and seven asset-type dummies.

Table 9: Credit risk factors for the logarithmic odds ratio of 1-year probability of default

| | Dependent variable: Logarithmic odds ratio | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Centrality measure | Lending degree | Degree | Weighted degree | Hub |
| | -0.0241*** | -0.018*** | -5.72E-07*** | 218.0504*** |
| | (-7.023) | (-5.398) | (-4.225) | (37.342) |
| Financial leverage | 0.7436*** | 0.7344*** | 0.7576*** | 0.7399*** |
| | (10.293) | (10.15) | (10.446) | (10.208) |
| EBITDA margin | -1.215*** | -1.2313*** | -1.1748*** | -1.1708*** |
| | (-4.931) | (-4.987) | (-4.759) | (-4.737) |
| Total assets (logarithm) | -0.1733*** | -0.2095*** | -0.2203*** | -0.2932*** |
| | (-6.424) | (-8.047) | (-8.124) | (-13.992) |
| Current ratio | -0.0133*** | -0.0138*** | -0.0125*** | -0.0132*** |
| | (-3.14) | (-3.266) | (-2.949) | (-3.112) |
| Occupancy rate | -7.932*** | -7.8835*** | -7.5896*** | -7.9229*** |
| | (-9.427) | (-9.356) | (-8.961) | (-9.384) |
| Property acq. (dummy) | -0.1135 | -0.1062 | -0.1128 | -0.1247 |
| | (-1.031) | (-0.963) | (-1.022) | (-1.129) |
| Sponsor holding ratio | -0.0006 | -0.0025 | -0.0005 | -0.0014 |
| | (-0.192) | (-0.744) | (-0.138) | (-0.429) |
| Constant | -1.4214 | -0.6995 | -1.5165* | -4.2161*** |
| | (-1.606) | (-0.798) | (-1.664) | (-4.718) |
| Year fixed effects | Yes | Yes | Yes | Yes |
| Asset-type fixed effects | Yes | Yes | Yes | Yes |
| Observations | 7,156 | 7,156 | 7,156 | 7,156 |
| Adjusted R-squared | 0.575 | 0.574 | 0.573 | 0.572 |

**Notes:** This case is the same as that of 6-month probability of default except that the dependent variable is the logarithmic odds ratio of 1-year probability of default.

## 6. Conclusions

This study contributes to the literature by assessing credit risk in the blockholding and lending networks of J-REITs.

First, this study proposed a sponsor's probability of default as a leading warning indicator of its supporting investment corporation's default and the joint probability of default as a coincident indicator of default.

Second, it analyzed the network structures of J-REIT blockholding and lending networks using major centrality measures. Trust banks and commercial banks, as well as J-REITs, play central roles in their respective networks in terms of degree centrality. With regard to lending ranking, the number of commercial banks has increased gradually following the global financial crisis. This fact reflects an increase in corporate lending exposure.

Third, with regard to credit risk management of J-REITs, this study evaluated credit risk exposure for all J-REIT investment corporations and thereafter analyzed credit risk factors driving the default risk of J-REITs. The fundamental analysis for joint probability of default and binary logistic regression model analysis proved that a sponsor's support plays an important role in assessing the credit risk of the sponsor's supporting investment corporation, in addition to the corporation's financial health and occupancy rate.

Finally, this study's analyses of credit risk from the perspective of interconnectedness in the blockholding and lending networks can serve as warnings to related entities, such as blockholders and financial institutions, about risk perceptions.

In conclusion, because our data are related to Japan's REIT market, it would be effective to apply our methodology to other financial markets for further studies. An important limitation for such future studies is that the analysis requires outstanding data with bilateral organization names.

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## Appendix A. List for investment corporations and their sponsors

The investment corporations and their sponsors for the analyses are listed in Tables A.10.

Table A.10: List for investment corporations and their sponsors

| SIC | REIT Name | Type | Sponsor 1 | Sponsor 2 | Sponsor 3 | Sponsors 4&5 |
|---|---|---|---|---|---|---|
| 3226 | Nippon Accommo. Fund | 2 | Mitsui Fudosan | Itochu | Kyoritsu M | |
| 3227 | MCUBS MidCity | 1 | Mitsubishi | Morgan S | | |
| 3234 | Mori Hills REIT | 1 | Mori Building | | | |
| 3249 | Industrial & Infra. Fund | 7 | Mitsubishi | Morgan S | | |
| 3269 | Advance Residence | 2 | Itochu | | | |
| 3278 | Kenedix Residential Next | 7 | Kenedix | | | |
| 3279 | Activia Properties | 6 | Tokyu Fudosan | | | |
| 3281 | GLP J-REIT | 5 | GLP Capital | | | |
| 3282 | Comforia Residential REIT | 2 | Tokyu Fudosan | | | |
| 3283 | Nippon Prologis REIT | 5 | Bear Stearns | | | |
| 3287 | Hoshino Resorts REIT | 4 | JA Kyosai | | | |
| 3290 | One REIT | 1 | Mizuho T&B | | | |
| 3292 | AEON REIT | 3 | Aeon | | | |
| 3295 | Hulic REIT | 6 | Hulic | | | |
| 3296 | Nippon REIT | 6 | Sojitz | C&W AM | | |
| 3298 | Invesco Office J-REIT | 1 | Tokyo Tatemono | Tokyu Fudosan | Invesco | |
| 3308 | Nippon Healthcare | 8 | Daiwa Sec G | | | |
| 3309 | Sekisui House REIT | 6 | Sekisui House | | | |
| 3451 | Tosei REIT | 6 | Tosei | | | |
| 3453 | Kenedix Retail REIT | 3 | Kenedix | | | |
| 3455 | Healthcare & Medical | 8 | Ship Healthcare | NEC Capital Sol. | | |
| 3459 | Samty Residential | 2 | Samty | Daiwa Sec G | | |
| 3460 | Japan Senior Living | 8 | Kenedix | Shinsei Bank | Haseko | |
| 3462 | Nomura RE Master Fund | 6 | Nomura RE | Mizuho T&B | | |
| 3463 | Ichigo Hotel REIT | 4 | Ichigo | | | |
| 3466 | LaSalle LOGIPORT REIT | 5 | Riplas | | | |
| 3468 | Star Asia | 6 | Simplex Inv. Adv. | | | |
| 3470 | Marimo Regional R REIT | 6 | Marimo | | | |
| 3471 | Mitsui Fudosan Logi. Park | 5 | Mitsui Fudosan | | | |
| 3472 | Ooedo Onsen REIT | 4 | Ooedo Onsen Monogatari | | | |
| 3473 | Sakura Sogo REIT | 6 | Galileo G | | | |
| 3476 | MIRAI | 6 | Mitsui | Idera Cap. M | | |
| 3478 | Mori Trust Hotel REIT | 4 | Mori Building | | | |
| 3481 | Mitsubishi Es Logi. REIT | 5 | Mitsubishi Es | | | |
| 3487 | CRE Logi. REIT | 5 | CRE | | | |
| 3488 | XYMAX REIT | 6 | Hulic | Xymax | | |
| 3492 | Takara Leben RE | 1 | Takara Leben | HULIC | | |
| 3493 | Itochu Advance Logi. | 5 | Itochu | | | |
| 8951 | Nippon Building Fund | 1 | Mitsui Fudosan | Sumitomo Life | | |
| 8952 | Japan RE | 1 | Mitsubishi Es | Mitsui | | |
| 8953 | Japan Retail Fund | 3 | Mitsubishi | Morgan S | | |
| 8954 | Orix JREIT | 6 | Orix | | | |
| 8955 | Japan Prime Realty | 6 | Tokyo Tatemono | Taisei | SJNK | Yasuda RE/Meiji Yasuda Life |
| 8956 | Premier | 7 | NTT Urban Dev. | | | |
| 8957 | Tokyu REIT | 6 | Tokyu | | | |
| 8958 | Global One RE | 1 | MUFJ FG | Kintetsu G | Meiji Yasuda Life | Mori Building |
| 8960 | United Urban | 6 | Marubeni | | | |
| 8961 | Mori Trust Sogo REIT | 6 | Mori Building | | | |
| 8963 | Invincible | 6 | Calliope | | | |
| 8964 | Frontier RE | 3 | Mitsui Fudosan | | | |
| 8965 | New City Residence | 2 | Pacific HD | CBRE Investors | | |
| 8966 | Heiwa RE REIT | 6 | Heiwa RE | | | |
| 8967 | Japan Logi. Fund | 5 | Mitsui & Co. | Kenedix | SMTB | Mitsubishi Es |
| 8968 | Fukuoka REIT | 6 | Kyushu Electric P | Nomura RE | | |
| 8972 | Kenedix Office | 1 | Kenedix | | | |
| 8975 | Ichigo Office REIT | 1 | Ichigo | | | |
| 8976 | Daiwa Office | 1 | Daiwa Sec G | | | |
| 8977 | Hankyu Hanshin REIT | 6 | Hankyu Hanshin HD | | | |
| 8979 | Starts Proceed | 2 | Starts Corp. | | | |
| 8984 | Daiwa House REIT | 6 | Daiwa House | | | |
| 8985 | Japan Hotel REIT | 4 | Kyoritsu Mainte. | Hulic | Mitsui Fudosan | SC Cap. Partners |
| 8986 | Japan Rental Housing | 2 | Daiwa Sec G | | | |
| 8987 | Japan Excellent | 1 | Dai-Ichi Life | Ueda Yagi Tanshi | Sekisui House | |

**Notes:** Each four-digit number indicates the number given by Securities Identification Code (SIC) Committee. Type: 1: Office; 2: Residential; 3: Commercial facilities; 4: Hotel; 5: Logistics facilities; 6: Comprehensive; 7: Complex; 8: Healthcare.

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