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Quantitative analysis of haircuts: evidence from the Japanese repo and securities lending markets[1]

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[1] This presentation was prepared for the conference. The views expressed are those of the authors and do not necessarily reflect the views of the BIS, the IFC or the central banks and other institutions represented at the event.

Quantitative Analysis of Haircuts: Evidence from the Japanese Repo and Securities Lending Markets[1]

Kazuya Suzuki[2] and Kana Sasamoto[3]

Abstract

Given the absence of comprehensive studies on market structure and haircuts for repo and securities lending transactions, this study provides a quantitative analysis of the subject using government bonds and equities transaction data covering most of the Japanese market. Specifically, we conducted a panel data regression analysis of government bond repo transactions, controlling for factors such as transaction entities and transaction types, and provided a detailed analysis of the haircut-setting mechanism. Accordingly, we determined that explanatory variables affecting credit risk, market risk, and liquidity risk, such as the credit quality of government bonds, the residual maturity of government bonds, and the presence of foreign exchange risk, significantly impact haircut setting. Furthermore, financial institutions closer to the center of the network, which engage in transactions with additional financial institutions, tend to set lower haircut rates through more efficient matching of borrowing and lending needs for cash and securities. Thus, the credit quality of government bonds transacted, exchange rate stability, and the presence of intermediaries important to the trading network significantly impact the degree of market functioning. The results were robust, paving the way for further discussions on trends and risk management of securities financing transactions, which are essential to financial markets.

Keywords: Securities Financing Transactions; Repurchase Agreement; Haircut; Network Analysis

JEL classification: D80, E43, G10, G20, L14

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1. Introduction

Securities Financing Transactions (SFTs) refer to transactions where cash and securities are exchanged with a counterparty and returned after a certain period. They are of two types: repurchase agreements and lending transactions. SFTs are secured and combine the characteristics of lending and borrowing cash and securities, making them the primary means for financial institutions to exchange cash and securities in the short term (Duffie, 1996; Baba and Inamura, 2004; Kinugasa and Nagano, 2017).

However, SFTs were also key to the risk-taking that induced the 2007–2009 financial crisis, during which the funding environment for financial institutions rapidly deteriorated as the haircut rate (i.e., the multiplier used to discount collateral) was raised through bilateral transactions in the US market (funding was actively raised using high-risk securitized products and other instruments). With asset prices also falling sharply, the sale of financial asset holdings accelerated in response to counterparty demands for additional collateral—margin calls—inducing a spiral of falling asset prices and higher haircut rates (Brunnermeier and Pedersen, 2009; Gorton and Metrick, 2012). Thus, many hedge funds defaulted in the fall of 2008 (Adrian et al., 2014). In tri-party transactions, money market funds (MMFs), the main cash lenders, sharply curtailed transactions with financial institutions with a high potential to default, contributing to the cash crunch at Bear Stearns and Lehman Brothers (Copeland et al., 2014). Moreover, during the European debt crisis, the haircut rate on government bonds was raised in response to a significant drop in prices, inducing a decline in liquidity in the repo market (European Securities and Markets Authority, 2016; Boissel et al., 2017).

Evidently, SFTs significantly impact leverage build-up in the financial system. Specifically, large fluctuations in haircut rates reduce market function by impeding the smooth lending of cash and securities and contribute to business cycle fluctuations through increased or decreased leverage (i.e., procyclicality) (Financial Stability Board [FSB], 2014). Accordingly, studies have examined the theoretical aspects of the mechanism of changes in haircuts. However, many note that underdeveloped data collection of SFTs impedes empirical research. Therefore, prior empirical research employs limited data and focuses mainly on the financial crisis period.[4] In this context, the G20 and FSB initiated discussions on regulation and supervision, including the collection of SFT data. The FSB's November 2015 report recommended that national authorities collect transaction data on individual trading units on a monthly or more frequent basis (FSB, 2015a) and introduce regulations to establish minimum haircut floors for non-centrally cleared SFTs (FSB, 2015b).[5] Later, the Financial Services Agency (FSA) of Japan and the Bank of Japan established a framework for collecting SFT data from financial institutions in Japan and began collecting in January 2019. Since January 2020, monthly aggregates of data portions have been published on the Bank's website[6](Ono et al., 2015; Sasamoto et al., 2020).

[4] See Adrian et al. (2014), Shimamura et al. (2017), Julliard et al. (2019), and Gorton et al. (2020).

[5] Minimum haircut floors are set for each transacted security and residual maturity to redemption period. Transactions using sovereign bonds, such as government bonds, are excluded.

[6] See Bank of Japan website: "Statistics on Securities Financing Transactions in Japan," available at https://www.boj.or.jp/en/statistics/bis/repo/index.htm/

As a result, this study employs such comprehensive transaction data to reveal the market structure and standard mechanisms for transaction haircut settings using government bonds and equities. Specifically, we regressed various explanatory variables that could not be analyzed in previous studies due to data limitations, in conjunction with entity, collateral type, and time fixed effect on the haircut rate. The results are generally robust and of value to financial authorities and practitioners in trading and risk management of SFTs at financial institutions.

The remainder of the paper is structured as follows: Section 2 reviews the definition and role of haircuts in SFTs as presented in prior studies. Section 3 outlines the study data and explains the market structure of transactions using government bonds and equities, respectively. Section 4 presents the regression analysis method using panel data and reports the analysis results for government bond repo transactions. Finally, Section 5 concludes the study and discusses the scope for future research.

2. Haircuts in Securities Financing Transactions

2-1 Definition of Haircut Rate

The haircut rate in SFTs is the multiplier used to calculate the collateral value.[7] We consider the effective haircut rate consistent with the FSB (2021) definition in view of the haircut rate as the multiplier used to calculate the valuation of securities in repo transactions. The study also considers the "ratio for calculating cash collateral," a multiplier for securities used along with the multiplier to calculate the valuation of cash and other securities in securities lending transactions (see Figure 1).

2-2 Role of Haircuts in Securities Financing Transactions

As noted, SFTs are secured. For instance, regarding secured bank loans, collaterals preserve the rights of the creditor in the event of default and help reduce "information asymmetry."[8] In other words, even if a borrower's credit profile appears inadequate from the creditor bank's perspective, collateral is pledged with a haircut per the collateral liquidity and creditworthiness. Thus, counterparties are screened so that business is conducted with only counterparties that agree to the terms.[9]

[7] Generally, it refers to securities in the case of repurchase agreements and cash or collateral securities in the case of securities lending transactions.

[8] Typical markets in which "information asymmetry" occurs include those for medical insurance (Arrow, 1963) and the used car (Akerlof, 1970) market. Typical methods of addressing information asymmetry include "screening" by information-disadvantaged parties and active disclosure by information-advantaged parties (signaling).

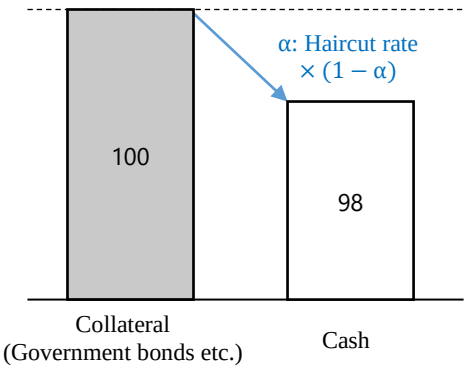
[9] Bester (1985) shows that in secured bank loans, borrowers with a low (high) probability of default are more (less) likely to accept higher haircuts to reduce interest rates because they have sufficient liquidity to pledge collateral, and haircuts help banks screen borrowers.

Hence, the role of haircuts in SFTs is analogous to bank loans; however, SFTs are somewhat more complex because they combine the characteristics of lending and borrowing cash and securities. Beyond transactions with a cash lending aspect—General Collateral (GC) transactions—as in general bank loans, transactions with a securities lending aspect—Special Collateral (SC) transactions—to cover short positions and fails are also actively conducted.[10] The consequences of such characteristics are as follows: First, the lender of cash is the real creditor in GC transactions as well as the lender of securities in SC transactions. Therefore, haircuts are set for cash collateral in the event of default by a borrower of cash in GC transactions and for an increase in security prices (cost of repurchasing the securities and rebuilding the position) in the event of default by a borrower of securities in SC transactions. Thus, per the rates defined in Figure 1, the haircut rate for SC transactions is smaller than that for GC transactions and can even be negative in some cases (Bank for International Settlements [BIS], 2010; Baklanova et al., 2019; Gottardi et al., 2019).

Haircut for repurchase agreements and securities lending

Definition of Haircut Rate — Figure 1

Panel A: Haircut rate for repurchase agreements

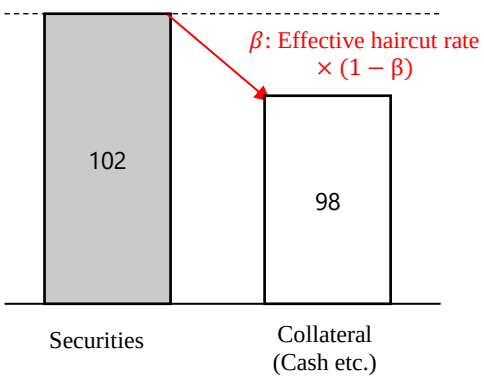


Haircut rate α

$$= 1 - \frac{\text{Amount of cash}}{\text{Market value of collateral (government bonds etc.)}}$$

$$= 1 - \frac{98}{100} = +2.00\%$$

Panel B: Haircut rate for securities lending transactions



Effective haircut rate β

$$= 1 - \frac{\text{Market value of collateral (cash etc.)}}{\text{Market value of securities}}$$

$$= 1 - \frac{98}{102} = +3.92\%$$

[1] Repurchase agreements and securities lending transactions are economically equivalent but are often distinguished because there is a difference in legal ownership. The figure illustrates GC transactions; in SC transactions, the "effective haircut rate" can be negative because the market value of cash exceeds that of the securities.

[10] Securities financing transactions may experience temporary delays in settlement (i.e., fails). For more information on the occurrence of fails, please refer to the Bank of Japan's monthly publication "Basic Figures on Fails" (https://www.boj.or.jp/en/statistics/set/bffail/index.htm/). For more information on practices surrounding fails in Japan's securities financing transactions, see Kasai et al. (2001).

2-3 Prior Studies

Prior studies focus on theoretical aspects of the factors affecting haircuts in SFTs, holding that they are generally explained by credit and market risk (Martin et al., 2014; Gottardi et al., 2019) and liquidity risk (Brunnermeier and Pedersen, 2009; Martin et al., 2014; Parlatore, 2019). Others consider counterparty risk (Dang et al., 2013; Gottardi et al., 2019) or operational risks regarding the efficiency of the non-defaulting party in margin management and custody (International Capital Market Association, 2012). In the US market, studies examine the differences in haircut-setting mechanisms between bilateral and tri-party transactions.[11]

However, to the best of the author's knowledge, most empirical studies were conducted using central counterparty (CCP)-cleared transaction and tri-party transaction data, for which data are comparatively easy to collect, or limited bilateral transaction data.[12] For the US market, Copeland et al. (2014) use tri-party transaction data collected by the Federal Reserve Bank of New York. Additionally, Baklanova et al. (2019) use bilateral transaction data collected on a pilot basis by the Office of Financial Research and the Federal Reserve Board, and Gorton et al. (2020) use transaction data for the Emergency Facility introduced by the Federal Reserve Board during the financial crisis. For the UK market, Julliard et al. (2019) use data from six major financial institutions collected by a financial authority.

3. Data

3-1 Data Sources

Since January 2019, this study has used granular transaction data collected by the FSA and the Bank of Japan from financial institutions in Japan. Detailed information is recorded for each transaction that is outstanding at the end of each month. Our data covers the parties included in the transaction (lender and borrower of securities), type of securities traded, market value of cash and securities traded, transaction maturity, repo rate, haircut rate, whether a transaction is a bilateral or agency-intermediated [13] transaction, and whether a transaction is CCP-cleared or -uncleared. However, there are certain limitations: data on the issues of securities traded in repo and securities

[11] Copeland et al. (2014) show that during the financial crisis, haircut rates were lower and more stable in tri-party transactions than bilateral transactions. Hu et al. (2021) indicate that haircut and repo rates are almost unaffected by counterparties in tri-party transactions conducted by US MMFs. However, Auh and Landoni (2015) demonstrate that transaction maturity and collateral quality (credit quality and liquidity) significantly affect the haircut rate in bilateral transactions conducted by hedge funds.

[12] A CCP intermediates between parties to a financial transaction (obtaining and assuming claims and obligations) and the counterparty to the settlement. Beyond netting the claims and obligations assumed in settlement, the system serves as a guarantee for participants by fulfilling the obligations assumed from the relevant participants in the event of default on settlement by a participant.

[13] "Agency-intermediated transactions" are where a third-party financial institution mediates the parties to a securities financing transaction to provide services regarding the management of the collateral exchanged between the parties to the transaction.

lending transactions is absent, and data coverage of information about securities in securities lending transactions is low (Table 1).

The data is reported by approximately 50 top financial institutions in terms of transaction amount, selected to capture more than 90% of SFTs to which the institutions in Japan (including overseas financial institutions based in Japan) are a party.[14] Thus, this data has high coverage and contains detailed information on transactions, including bilateral and non-cleared transactions, which are typically challenging to ascertain.

Summary of transaction information on collected data[1]

Table 1

Series	Repo	Securities Lending
Counterparty		
・Counterparty name	○	○
・Counterparty jurisdiction (pure locational approach)	○	○
・Counterparty sector	○	○
Security		
・Security issue (e.g., ISIN code)	×	×
・Security type (e.g., Government Bonds, Equities, Corporate Bonds)	○	○
・Market value	○	○
・Jurisdiction of the issuer of the underlying security	○	×
・Currency	○	○
・Residual maturity	○	×
・Credit rating	○	×
・Collateral re-use eligibility	○	×
・On a pure principal-to-principal basis or with the intermediation of an agent	○	×
・Haircut rate	○	△
Cash		
・Currency	○	○
・Amount	○	○
・Management party	×	○
Transaction information		
・CCP cleared or not	○	○
・GC or SC	○	○
・Bilaterally or Agent-intermediated	○	○
・Transaction Maturity	○	○
・Repo rate	○	△

[1] This table presents the main information of the data by repo and securities lending transaction. "○" represents collected data, "△" represents uncollected data but calculation is possible, and "×" represents uncollected data. In securities lending transactions, non-cash collateral (bonds, equities, etc.) are collected in addition to cash collateral, and the repo rate is calculated as the difference between the collateral interest rate and lending rate.

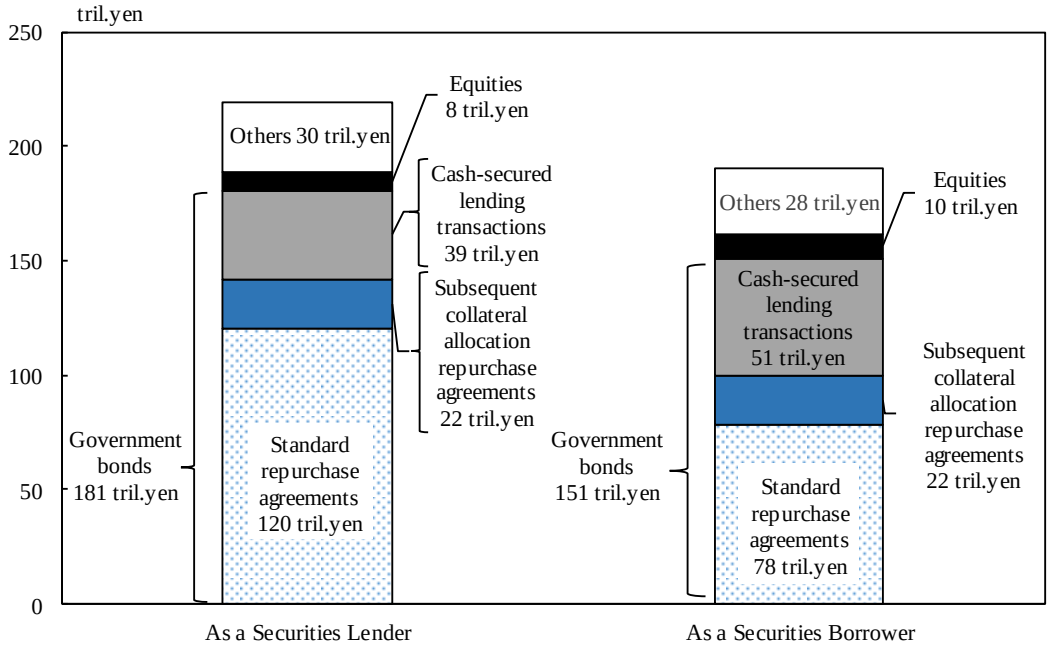
[14] In addition to transactions with corporations in Japan, the data covers transactions with corporations overseas as counterparties, those between head and overseas offices, between different corporations within the same group, and those with international organizations. However, they do not cover internal transactions within the same legal entity in Japan, transactions conducted between overseas offices of the reporting financial institution and overseas offices, those with individuals, those in which the reporting financial institution provides advice only, and those with central banks and the BIS.

3-2 Overview of the Securities Financing Transaction Market

Reviewing average transaction balances by security type (average end of month balances from January 2019 through December 2021, which applies hereafter, unless otherwise noted) based on this data, securities lenders (borrowers) reported 219 (190) trillion yen [15] (Figure 2). Transactions using "government bonds" comprise approximately 80% of the total, with 181 (151) trillion yen reported by lenders (borrowers) of securities. Those using "equities," which have the next largest balance, are reported by lenders (borrowers) of securities at 8 (10) trillion yen. Moreover, agency bonds, corporate bonds, securitized products, collateral swap transactions where securities are exchanged for each other, and basket transactions where multiple issues are traded at once total 30 (28) trillion yen, as reported by lenders (borrowers) of securities.

Outstanding balance of securities financing transactions in Japan by security type[1]

Figure 2



[1] Average outstanding balance has been calculated at the end of every month from January 2019 to December 2021. Foreign currency has been converted into Japanese yen using the exchange rates at the end of the month. The average exchange rate for 1 US dollar is 108.6 Japanese yen. The amount reported "as a securities lender" does not match that reported "as a securities borrower" because of transactions with data non-reporting parties. "Government bonds" include government-guaranteed bonds and other sovereign bonds. "Equities" regard transactions where the only security associated with the transaction is equity, and the only collateral is cash. "Others" include transactions using agency bonds, securitized products, corporate bonds, and supra bonds, as well as collateral swap transactions where securities (e.g., government bonds and equities) are exchanged for each other and basket transactions where several types of securities are traded at once.

Below is a description of the characteristics of the market structure, including haircut and repo rates, for transactions using "government bonds" and "equities," which are typical in Japan. Using the data makes it possible to ascertain previously unidentified information; for instance, in addition to data on the jurisdiction of

[15] The amounts reported by the lenders of securities do not match those of the borrowers of the securities because of transactions with data non-reporting parties.

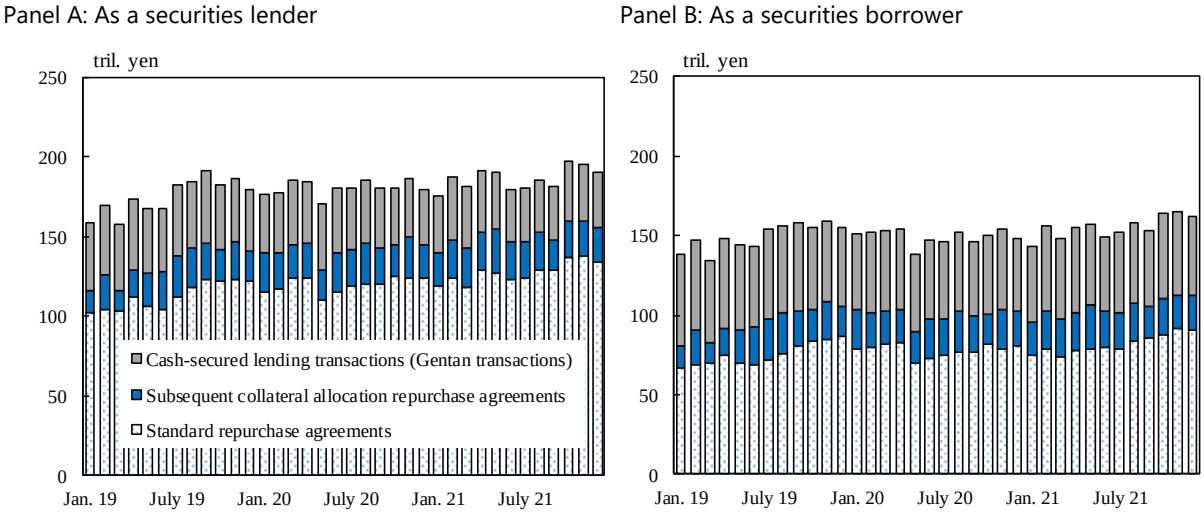
government bond and cash currency, the characteristics of trading securities are classified based on the level of their combination.

(1) Government bonds

Transactions using government bonds are classified into three categories per type of transaction: (1) standard repurchase agreements, (2) subsequent collateral allocation repurchase agreements, and (3) cash-secured lending transactions (called "Gentan" transactions in Japan) (see Table 2). Historically, cash-secured lending transactions have been the mainstream in Japan (Kanno and Kato, 2001). After that, repo transactions increased following the introduction of subsequent collateral allocation repurchase agreements in conjunction with the shortening of Japanese government bond settlement cycle to T+1 in 2018 (Fujimoto et al., 2019). Repurchase agreements have been increasing moderately since 2019, while cash-secured lending transactions have been declining (Figure 3).

Outstanding balance of transactions using government bonds by transaction type[1]

Figure 3



[1] Average outstanding balance has been calculated at the end of every month from January 2019 to December 2021. Foreign currency has been converted into Japanese yen using the exchange rates at the end of the month.

Standard repurchase agreements

Standard repurchase agreements are currently the largest type of SFT in Japan. Table 2 shows that the exchange of Japanese government bonds for Japanese yen is top of the list, accounting for more than 80% of standard repurchase agreements. Moreover, transactions occur where US government bonds are exchanged for US dollars or where European government bonds are exchanged for euros. Cross-currency transactions are also undertaken, where Japanese government bonds are exchanged for US dollars.

Taking the US dollar as an example of a currency other than Japanese yen, while the data reporters' funding of US dollars is approximately 16 trillion yen, their supplying of US dollars is approximately 2 trillion yen. Thus, on a net basis, Japanese

financial institutions procured US dollars equivalent to approximately 14 trillion yen via repurchase agreements using US and Japanese government bonds.

By combining the type of government bonds transacted (jurisdiction, denomination) with the currency of the cash being transacted, the characteristics of haircut and repo rates can be more clearly identified. First, transactions involving the exchange of Japanese government bonds and Japanese yen of the greatest transaction volume were traded at a haircut (repo) rate of almost 0% (-0.10%) at the median and weighted average values. On US dollar transactions, the haircut rate for transactions exchanging US government bonds for US dollars was almost 0%, and a weighted average repo rate was trading at around +0.9%. However, cross-currency transactions exchanging Japanese government bonds for US dollars have a weighted average haircut rate of +5.31% (repo transactions) and +2.85% (reverse repo transactions).[16] This indicates that the haircut rate level in cross-currency transactions differs significantly from that of same-currency transactions. The haircut rate is often set at +2.00% in transactions exchanging European government bonds for euros. A time series of weighted average haircut rates for these representative transactions demonstrates that they have remained stable despite the COVID-19 turmoil upsetting the financial markets (Figure 4).

Overnight transactions account for approximately 40% of the total in terms of residual transaction maturity (Table 2). Only approximately 3% of all transactions exceed three months' maturity. The weighted average of the haircut and repo rates increases as the transaction maturity lengthens, thereby reflecting the increased market risk and term structure associated with a transaction maturity.[17] However, margin calls, where additional collateral is delivered in response to changes in the market value of collateral during the transaction period, may reduce the impact of transaction maturity. Section 4 examines the magnitude of the impact using panel regression data analysis.[18]

Similarly, many transactions use government bonds with a residual maturity of more than one year. In theory, given that the price volatility increases as the residual maturity to redemption increases, the haircut rate is expected to increase accordingly. Nevertheless, the haircut rate in Table 2 indicates that the rate is lower for transactions using government bonds with a residual maturity greater than one year in comparison to transactions with a remaining maturity of less than one year.[19] This is likely because many of the transactions exchanging Japanese yen and Japanese government bonds, for which the haircut rate is mostly set at 0%, are conducted using government bonds with a residual maturity of more than one year. Section 4 examines this point in detail via panel data analysis.

[16] Practically, "repo transactions" and "reverse repo transactions" refer to transactions where a party (i.e., the data reporter) acts as the lender and borrower of securities, respectively. However, these repurchase agreements are sometimes collectively referred to "repo transactions."

[17] In value-at-risk (a typical risk measurement method), the amount of market risk increases in proportion to the square root of the transaction period. Thus, the panel data analysis in Section 4 regresses the square root of the transaction period.

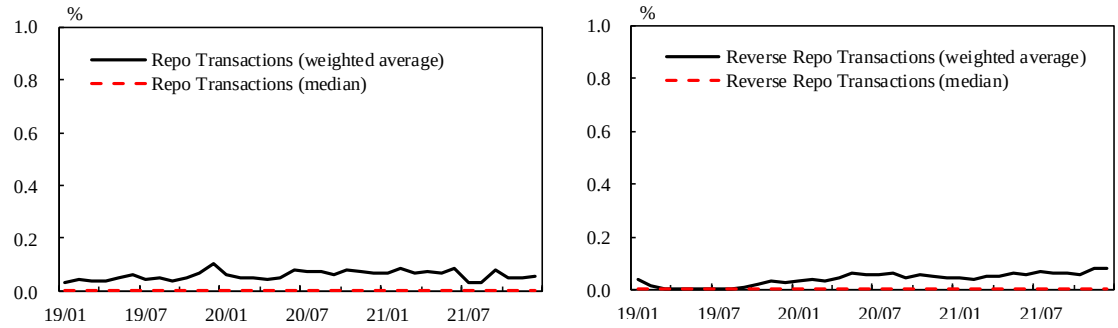
[18] For a detailed description of the margin call mechanism in Japan's repurchase agreements, see Kanno and Kato (2001).

[19] Where the bond price is B, the bond yield is y, and the residual maturity to redemption is D, the relationship between the change in bond price δB and that in yield δy is approximately $\delta B/B = -D\delta y$. Thus, the longer the residual maturity of the bond, the greater the price volatility in a linear relationship.

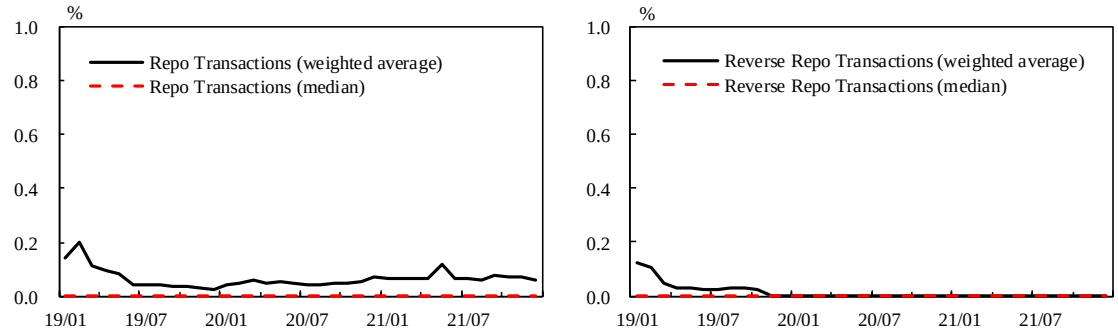
Trends in haircut rate[1]

Standard repurchase agreements with government bonds — Figure 4

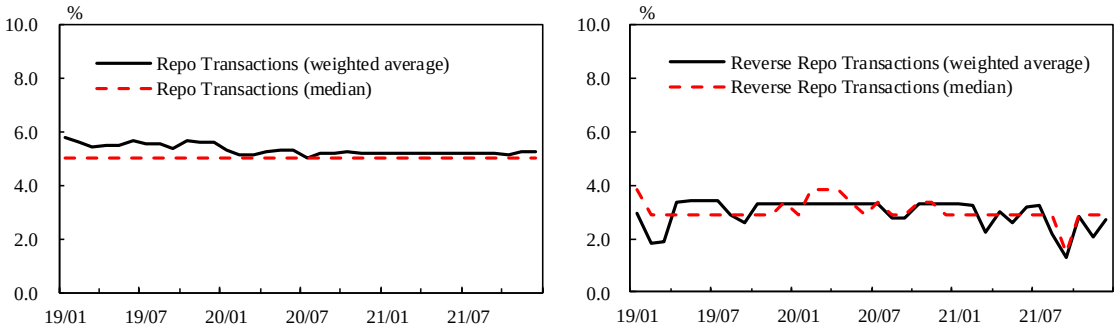
Panel A: Transactions of Japanese government bonds and Japanese yen



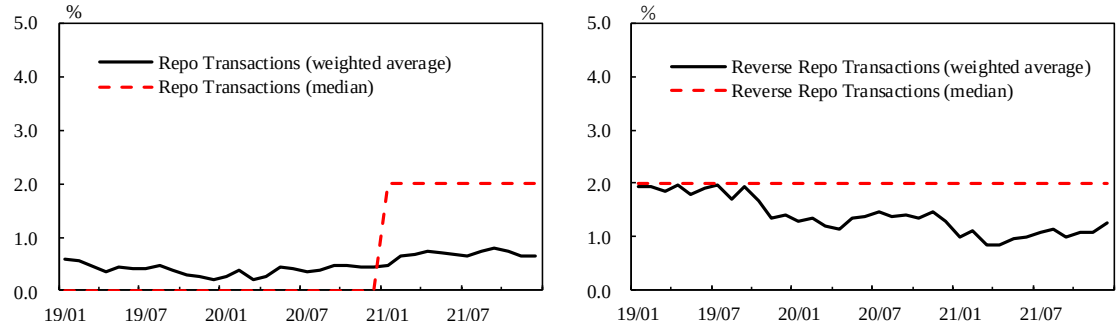
Panel B: Transactions of US treasuries and the US dollar



Panel C: Transactions of Japanese government bonds and the US dollar



Panel D: Transactions of French government bonds and the euro



Market structure of standard repurchase agreements with government bonds[1]

Table 2

Category	Breakdown items	Outstanding balance (100 mil. yen)		Haircut rate (%)				Repo rate (%)			
		Repo	Reverse Repo	Repo		Reverse Repo		Repo		Reverse Repo	
		Month-end average	Month-end average	Weighted average	Median	Weighted average	Median	Weighted average	Median	Weighted average	Median
Total average		1,201,575	781,917	0.33	0.00	0.19	0.00	0.02	-0.10	-0.08	-0.10
Jurisdiction of government bond ×Currency of government bond ×Currency of cash	JP×JPY×JPY	963,893	723,068	0.06	0.00	0.04	0.00	-0.11	-0.10	-0.10	-0.10
	US×USD×USD	127,463	14,990	0.06	0.00	0.01	0.00	0.83	0.22	0.94	0.28
	JP×JPY×USD	30,389	7,791	5.31	5.00	2.85	2.91	1.30	0.46	1.54	2.24
	FR×EUR×EUR	29,176	6,661	0.45	0.00	1.33	2.00	-0.47	-0.48	-0.56	-0.55
	DE×EUR×EUR	9,411	4,547	0.99	2.00	1.88	2.00	-0.51	-0.51	-0.62	-0.58
	IT×EUR×EUR	8,185	6,930	1.96	2.00	2.00	2.00	-0.47	-0.47	-0.56	-0.54
	ES×EUR×EUR	6,783	4,261	6.40	2.00	6.30	2.00	-0.48	-0.45	-0.57	-0.53
	GB×GBP×GBP	5,481	5,494	3.86	2.00	2.82	2.00	0.36	0.09	0.27	0.03
	BE×EUR×EUR	3,673	1,656	0.86	2.00	1.78	2.00	-0.48	-0.50	-0.59	-0.56
	AU×AUD×AUD	3,531	639	4.76	10.00	6.58	10.00	0.95	1.05	0.92	0.90
	Omitted below										
Currency of cash	JPY	963,949	723,079	0.06	0.00	0.04	0.00	-0.11	-0.10	-0.10	-0.10
	USD	160,920	23,033	1.13	0.00	1.09	0.00	0.93	0.26	1.16	1.20
	EUR	65,979	29,356	1.60	2.00	2.54	2.00	-0.47	-0.47	-0.56	-0.55
	GBP	6,553	5,757	4.20	2.00	2.74	2.00	0.37	0.25	0.26	0.04
	AUD	3,915	680	4.99	10.00	6.66	10.00	0.95	0.85	0.91	0.85
	Omitted below										

[1] This table presents the market structure of standard repurchase agreements with government bonds in Japan. Average outstanding balance, haircut rate, and repo rate have been calculated at the end of every month from January 2019 to December 2021. Currencies other than Japanese yen have been converted into Japanese yen using the exchange rates at the end of the month. The average exchange rate for 1 US dollar is 108.6 Japanese yen. The abbreviations for country and currency names are as follows: JP: Japan, US: United States, FR: France, DE: Germany, IT: Italy, ES: Spain, GB: United Kingdom, BE: Belgium, AU: Australia, JPY: Japanese yen, USD: US dollar, EUR: Euro, GBP: Sterling, AUD: Australian dollar.

Market structure of standard repurchase agreements with government bonds- *Continued* Table 2

Category	Breakdown items	Outstanding balance (100 mil. yen)		Haircut rate (%)				Repo rate (%)			
		Repo	Reverse Repo	Repo		Reverse Repo		Repo		Reverse Repo	
		Month-end average	Month-end average	Weighted average	Median	Weighted average	Median	Weighted average	Median	Weighted average	Median
Transaction maturity	Overnight	428,328	293,579	0.19	0.00	0.17	0.00	-0.07	-0.10	-0.12	-0.10
	From 2 days (included) to 1 week (included)	195,182	126,802	0.22	0.00	0.15	0.00	-0.00	-0.10	-0.09	-0.09
	From 1 week (not included) to 1 month (included)	344,269	221,312	0.16	0.00	0.03	0.00	0.01	-0.10	-0.07	-0.10
	From 1 month (not included) to 3 months (included)	183,993	110,614	0.37	0.00	0.16	0.00	0.12	-0.10	-0.02	-0.10
	From 3 months (not included) to 6 months (included)	24,664	16,259	0.60	0.00	0.34	0.00	0.04	-0.10	-0.03	-0.11
	From 6 months (not included) to 12 months (included)	3,915	2,281	2.66	0.00	1.85	0.00	0.81	0.01	0.66	-0.04
	One year (not included) and more	12,984	3,797	5.50	3.93	3.11	2.91	1.68	0.68	1.94	2.46
	Open or continuing terms contracts	13,662	10,794	3.74	2.00	3.25	2.00	-0.11	-0.15	-0.25	-0.30
Residual maturity of government bond	Below 1 month (included)	14,081	10,468	0.28	0.00	0.30	0.00	-0.08	-0.12	-0.04	-0.10
	More than 1 month (not included) and up to 3 months (included)	42,289	29,775	0.44	0.00	0.29	0.00	-0.05	-0.13	-0.03	-0.11
	More than 3 months (not included) and up to 6 months (included)	44,421	28,589	0.79	0.00	0.37	0.00	0.08	-0.11	-0.01	-0.11
	More than 6 months (not included) and up to 1 year (included)	61,943	36,159	0.86	0.00	0.39	0.00	0.13	-0.10	0.01	-0.10
	More than 1 year (not included) and up to 5 years (included)	388,439	247,055	0.31	0.00	0.13	0.00	0.06	-0.10	-0.07	-0.10
	More than 5 years (not included) and up to 10 years (included)	334,701	211,765	0.25	0.00	0.18	0.00	-0.02	-0.10	-0.10	-0.10
	More than 10 years (not included)	314,623	217,293	0.24	0.00	0.21	0.00	-0.02	-0.10	-0.09	-0.10
Clearing information	Centrally cleared transactions	581,917	515,661	0.00	0.00	0.00	0.00	-0.03	-0.10	-0.09	-0.10
	Not centrally cleared transactions	619,657	266,256	0.63	0.00	0.56	0.00	0.06	-0.11	-0.04	-0.10
Collateral management	Agency-intermediated transactions	197,129	61,300	0.00	0.00	0.00	0.00	-0.07	-0.07	-0.05	-0.08
	Bilateral transactions	1,004,446	720,617	0.39	0.00	0.21	0.00	0.03	-0.11	-0.08	-0.10
Transaction purpose	General collateral (GC) transactions	847,829	507,106	0.46	0.00	0.29	0.00	0.03	-0.10	-0.06	-0.10
	Special collateral (SC) transactions	353,746	274,811	0.01	0.00	0.00	0.00	-0.03	-0.10	-0.10	-0.10

From the data by bilateral or agency-intermediated and CCP-cleared or non-cleared transactions, the haircut rate is often set to 0% for agency-intermediated and cleared transactions. Thus, haircuts are utilized in transactions where risk management is relatively important, such as bilateral and non-centrally cleared transactions.

Finally, regarding GC or SC transactions, the haircut rate for SC transactions is smaller than that for GC transactions, and the repo rate is set lower for SC transactions than for GC transactions. As discussed in Section 2, it can be interpreted as stemming from the nature of SC transactions as securities lending rather than cash lending.

Subsequent collateral allocation repurchase agreements

Subsequent collateral allocation repurchase agreements are CCP-cleared transactions cleared by the Japan Securities Clearing Corporation (JSCC) and comprise a new form of transaction introduced in May 2018 (JSCC, 2018). Given that the issue of Japanese government bonds to be traded is unspecified in advance, it is a GC transaction with a cash lending aspect. Moreover, haircuts cannot be set (traded without haircuts) because the risk is managed through the margin and clearing fund by the JSCC.

Overnight transactions account for approximately 60% of all subsequent collateral allocation repurchase agreements (Table 3). The median and weighted average repo rates were -0.08% and were thus transacted at a rate somewhat higher than those for standard repurchase agreements and cash-secured lending transactions. As described by Fujimoto et al. (2019), standard repurchase agreements and cash-secured lending transactions include compensation, such as borrowing fees and administrative costs, because of the pre-designation of Japanese government bond issues. The term structure of the repo rate agrees with the "Tokyo Repo Rate" published by the Japan Securities Dealers Association (Figure 5).[20]

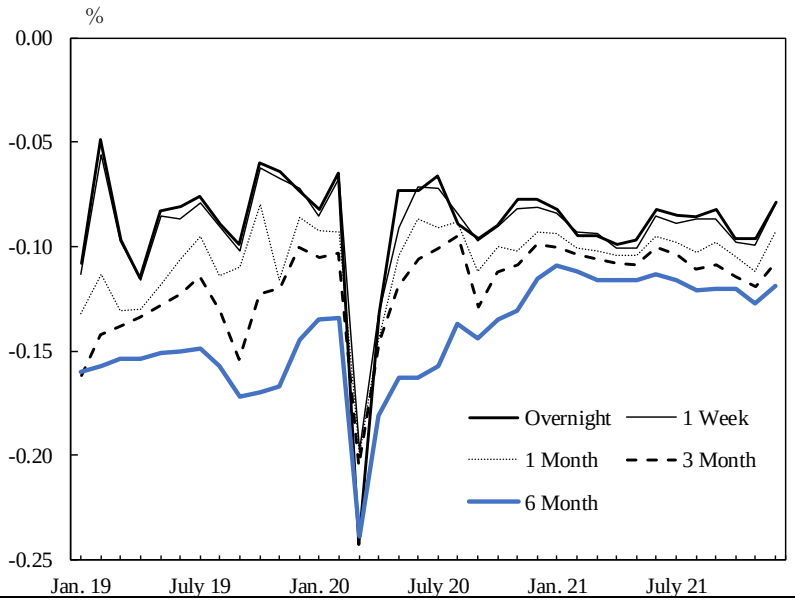
Cash-secured lending transactions

Despite the decline of cash-secured lending transactions with the expansion of repurchase agreements, they continue to comprise a certain proportion of the total balance, with 39 (51) trillion yen reported by the lenders (borrowers) of securities (Table 4). The breakdown indicates that, as with repurchase agreements, the most active transactions are those where yen-denominated Japanese government bonds are exchanged for Japanese yen.[21] Moreover, there are foreign currency transactions where US dollar-denominated government bonds are exchanged for US dollars, euro-denominated government bonds for euros, and cross-currency transactions, where yen-denominated government bonds are exchanged, for US dollars. As with standard repurchase agreements, cross-currency transactions have relatively high haircut rates.

[20] The "Tokyo Repo Rate" does not precisely match the rate for subsequent collateral allocation repurchase agreements because the survey covers GC repo rates for standard repurchase agreements, subsequent collateral allocation repurchase agreements, and cash-secured lending transactions (Japan Securities Dealers Association, 2017).

[21] Information on the jurisdiction where the securities are issued is not a data collection item for securities lending transactions (see Table 1).

Trends in the Tokyo Repo Rate[1] Figure 5



[1] Changes in the Tokyo Repo Rate have been calculated at the end of every month from January 2019 to December 2021. "Tokyo Repo Rate" covers GC repo rates for standard repurchase agreements, subsequent collateral allocation repurchase agreements, and cash-secured securities lending transactions (Japan Securities Dealers Association, 2017).

Source: Japan Securities Dealers Association, "Tokyo Repo Rate"

(2) Equities

Equities, having the second-largest trading value after government bonds, are traded in securities lending, and basket transactions with multiple equities exchanged under a single contract are common. Figures 6 and Table 5 identify and arrange transactions where the only equities are exchanged by cash collateral.[22]

Most transactions using equities involve the exchange of yen-denominated equities for Japanese yen (Table 5). From the remaining transaction period, open-ended transactions with no predetermined transaction period account for more than 70% of the total. In open-ended transactions, the median haircut rate is -4.76%, equivalent to pledging cash collateral corresponding to 105% of the equities. The weighted average repo rate for open-ended transactions reported by securities lenders (borrowers) is -0.21% (-0.31%),[23] suggesting that many transactions have an aspect of securities lending and borrowing by cash collateral (SC transactions).[24]

[22] Furthermore, there are transactions where multiple types of securities (e.g., government bonds and equities) and collateral (e.g., cash in multiple currencies and government bonds) are exchanged. However, they comprise a small portion of the total and are included under "Others" in Figure 2.

[23] In a securities lending transaction, the securities borrower (the collateral lender) pays a lending fee for the lent securities, and the securities lender (the collateral borrower) pays interest on the collateral. The repo rate is commonly defined as the difference (collateral interest rate and lending rate), and this definition has been used in this paper.

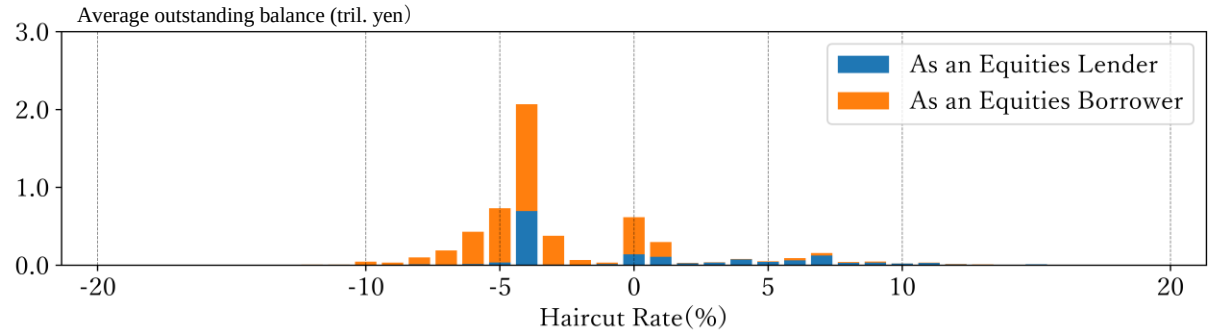
[24] Under the data reporting guidelines, if it is difficult to determine whether a transaction is a GC or SC transaction, the transaction is to be reported as a GC transaction. Given that transactions using

However, considering transactions predetermined outside of open-ended transactions, some show positive haircut and repo rates, suggesting that they include many transactions with an aspect of cash lending and borrowing by equities collateral (GC transactions).

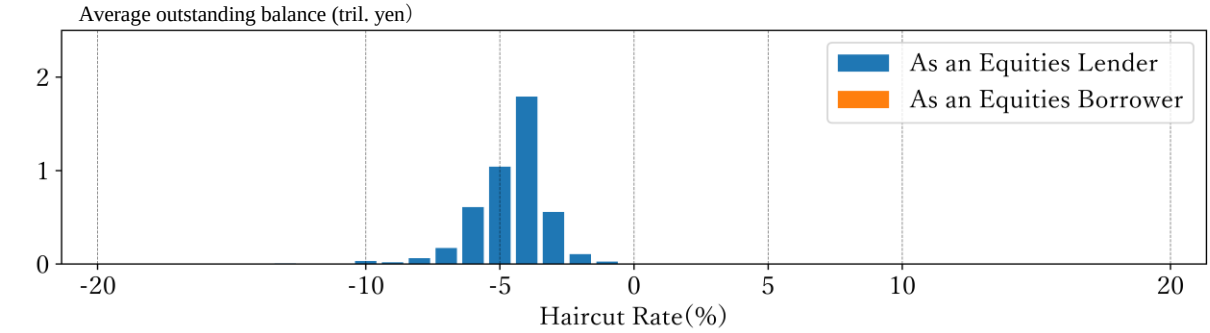
This distinction between transactions based on haircut and repo rates is supported by the distribution of haircut rates by business type, as in Figure 6. In other words, "Trust banks and asset management," the main investors of equities, trade as equity lenders with haircut rates concentrated within the range of -4% and -5%, whereas "*Tanshi* companies, banks, and other finance companies"[25] often trade as equity borrowers (cash lenders) and have positive haircut rates. "Securities companies" are involved in a wide range of transactions as intermediaries.

Distribution of haircut rates for transactions with equities (by business type)[1] Figure 6

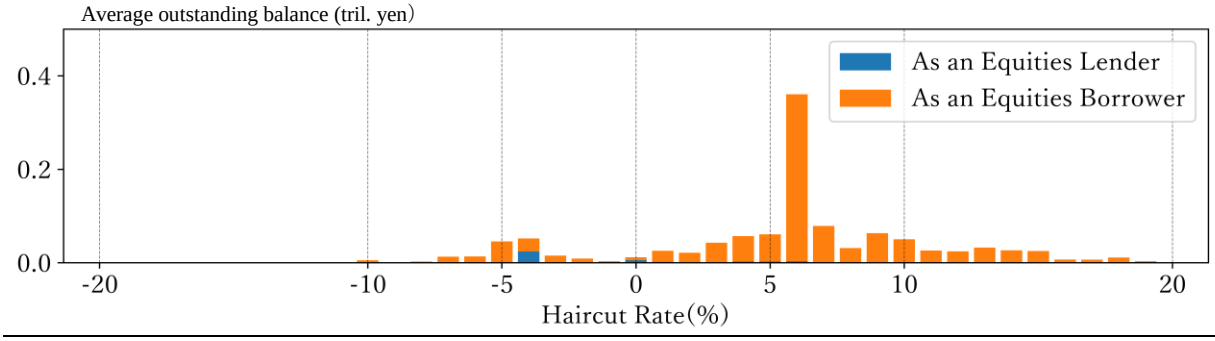
Panel A: Securities companies



Panel B: Trust banks and asset management companies



Panel C: *Tanshi* companies, banks, other finance companies



[1] Transactions have been calculated at the end of every month from January 2019 to December 2021, classified by haircut rate. Balances are average balances.

equities are often basket transactions, and it is difficult to distinguish between them in many cases, the share of SC transactions is thought to be larger in practice than that presented in Table 5.

[25] *Tanshi* companies mainly act as intermediaries for interbank loans and SFTs in Japan.

Market structure of subsequent collateral allocation repurchase agreements with government bonds[1]

Table 3

Category	Breakdown items	Outstanding balance (100 mil. yen)		Repo rate (%)			
		Repo	Reverse Repo	Repo		Reverse Repo	
		Month-end average	Month-end average	Weighted average	Median	Weighted average	Median
Total average		220,201	220,307	-0.08	-0.08	-0.08	-0.08
Jurisdiction of government bond ×Currency of government bond ×Currency of cash	JP×JPY×JPY	220,201	220,307	-0.08	-0.08	-0.08	-0.08
Currency of cash	JPY	220,201	220,307	-0.08	-0.08	-0.08	-0.08
Transaction maturity	Overnight	130,378	130,689	-0.06	-0.05	-0.06	-0.05
	From 2 days (included) to 1 week (included)	27,703	27,687	-0.08	-0.08	-0.08	-0.08
	From 1 week (not included) to 1 month (included)	39,627	39,438	-0.09	-0.09	-0.09	-0.10
	From 1 month (not included) to 3 months (included)	22,218	22,218	-0.11	-0.10	-0.11	-0.10
	From 3 months (not included) to 6 months (included)	2,891	2,891	-0.10	-0.10	-0.10	-0.10
Collateral management	Agency-intermediated transactions	2,311	94,300	-0.10	-0.10	-0.04	0.01
	Bilateral transactions	217,889	126,007	-0.08	-0.08	-0.10	-0.10

[1] This table presents the market structure of subsequent collateral allocation repurchase agreements with government bonds in Japan. The average outstanding balance and repo rate have been calculated at the end of every month from January 2019 to December 2021. The abbreviations for country and currency names are as follows: JP: Japan, JPY: Japanese yen.

Market structure of cash-secured lending transactions with government bonds[1]

Table 4

Category	Breakdown items	Outstanding balance (100 mil. yen)		Haircut rate (%)				Repo rate (%)			
		Securities out	Securities in	Securities out		Securities in		Securities out		Securities in	
		Month-end average	Month-end average	Weighted average	Median	Weighted average	Median	Weighted average	Median	Weighted average	Median
Total average		385,924	510,556	0.17	0.00	0.16	0.00	0.00	-0.09	0.01	-0.09
Currency of government bond ×Currency of cash	JPY×JPY	326,119	418,967	0.09	0.00	0.01	0.00	-0.09	-0.09	-0.09	-0.09
	USD×USD	23,867	38,277	0.23	0.00	0.39	0.00	1.23	0.43	1.06	0.27
	EUR×EUR	23,156	32,388	0.06	0.00	0.30	0.00	-0.47	-0.45	-0.47	-0.45
	JPY×USD	2,971	14,568	3.69	5.26	3.94	5.26	1.01	0.34	1.26	0.51
	Omitted below										
Currency of cash	JPY	328,969	423,364	0.05	0.00	-0.02	0.00	-0.09	-0.09	-0.09	-0.09
	USD	26,839	52,845	0.61	0.00	1.37	0.00	1.21	0.43	1.12	0.28
	EUR	23,159	32,395	0.06	0.00	0.30	0.00	-0.47	-0.45	-0.47	-0.45
	Omitted below										
Transaction maturity	Overnight	134,654	138,175	0.01	0.00	0.01	0.00	-0.08	-0.08	-0.05	-0.08
	From 2 days (included) to 1 week (included)	49,217	73,887	0.26	0.00	0.12	0.00	-0.05	-0.09	-0.01	-0.09
	From 1 week (not included) to 1 month (included)	112,899	179,387	0.16	0.00	0.15	0.00	-0.03	-0.10	-0.00	-0.10
	From 1 month (not included) to 3 months (included)	68,998	101,887	0.01	0.00	0.39	0.00	0.09	-0.10	0.12	-0.10
	From 3 months (not included) to 6 months (included)	11,345	15,796	-0.53	0.00	0.19	0.00	-0.06	-0.10	0.13	-0.10
	From 6 months (not included) to 12 months (included)	1,619	2,411	0.28	0.00	-0.04	0.00	0.02	-0.09	0.21	-0.08
	One year (not included) and more	0	1,067	NaN	NaN	0.43	0.00	NaN	NaN	-0.00	0.00
	Open or continuing terms contracts	535	0	0.00	0.00	NaN	NaN	-0.36	-0.27	NaN	NaN
Clearing information	Centrally cleared transactions	231,237	231,491	0.00	0.00	0.00	0.00	-0.08	-0.09	-0.08	-0.09
	Not centrally cleared transactions	154,687	279,065	0.43	0.00	0.29	0.00	0.13	-0.09	0.09	-0.09
Collateral management	Agency-intermediated transactions	70,411	56,430	0.61	0.00	0.00	0.00	0.14	-0.01	-0.02	0.01
	Bilateral transactions	315,513	454,126	0.07	0.00	0.18	0.00	-0.03	-0.10	0.02	-0.10
Transaction purpose	General collateral (GC) transactions	259,380	353,387	0.19	0.00	0.14	0.00	0.05	-0.08	-0.01	-0.09
	Special collateral (SC) transactions	126,543	157,169	0.13	0.00	0.19	0.00	-0.10	-0.10	0.06	-0.09

[1] This table presents the market structure of cash-secured securities lending transactions with government bonds in Japan. The average outstanding balance, haircut rate, and repo rate have been calculated at the end of every month from January 2019 to December 2021. Currencies other than Japanese yen have been converted into Japanese yen using the exchange rates at the end of the month. The average exchange rate for 1 US dollar is 108.6 Japanese yen. The abbreviations for currency names are as follows: JPY: Japanese yen, USD: US dollar, EUR: Euro.

Market structure of equities lending transactions[1]

Table 5

Category	Breakdown items	Outstanding balance (100 mil. yen)		Haircut rate (%)				Repo rate (%)			
		Securities out	Securities in	Securities out		Securities in		Securities out		Securities in	
		Month-end average	Month-end average	Weighted average	Median	Weighted average	Median	Weighted average	Median	Weighted average	Median
Total average		76,496	98,183	-3.12	-4.76	4.14	-4.76	-0.14	0.00	-0.20	0.00
Currency of equities ×Currency of cash	JPY×JPY	75,014	96,534	-3.27	-4.76	4.05	-4.76	-0.15	0.00	-0.21	0.00
	Omitted below										
Currency of cash	JPY	75,015	97,756	-3.27	-4.76	4.14	-4.76	-0.15	0.00	-0.21	0.00
	Omitted below										
Transaction maturity	Overnight	700	1,149	-1.72	-4.76	13.68	-4.76	-0.04	0.00	0.26	0.00
	From 2 days (included) to 1 week (included)	2,351	2,644	-0.25	-4.76	16.50	-4.76	0.01	0.00	0.24	0.00
	From 1 week (not included) to 1 month (included)	3,613	6,749	3.18	-4.76	72.37	4.49	0.01	0.00	0.85	0.07
	From 1 month (not included) to 3 months (included)	1,466	2,188	4.36	-4.76	69.82	-4.76	1.06	0.00	0.63	0.00
	From 3 months (not included) to 6 months (included)	2,342	1,832	4.18	5.26	8.87	-4.76	2.50	0.00	0.16	0.00
	From 6 months (not included) to 12 months (included)	741	2,155	4.27	4.49	10.49	-4.76	0.53	0.14	0.20	0.00
	One year (not included) and more	137	722	5.90	6.38	7.22	7.10	2.67	0.18	0.15	0.15
	Open or continuing terms contracts	56,972	74,418	-4.36	-4.76	-4.24	-4.76	-0.21	0.00	-0.31	0.00
Clearing information	Centrally cleared transactions	53,584	67,983	-4.59	-4.76	-4.28	-4.76	-0.18	0.00	-0.36	0.00
	Not centrally cleared transactions	22,911	29,316	0.31	-4.76	23.97	-4.76	-0.03	-0.54	0.16	-0.27
Collateral management	Agency-intermediated transactions	22,461	6,493	-5.13	-5.69	-6.04	-5.93	-0.26	-0.39	-0.14	-0.20
	Bilateral transactions	54,035	91,690	-2.28	-4.76	4.86	-4.76	-0.08	0.00	-0.21	0.00
Transaction purpose	General collateral (GC) transactions	33,916	47,469	-2.19	-4.76	12.27	-4.76	0.09	0.00	0.04	0.00
	Special collateral (SC) transactions	42,577	50,615	-3.86	-4.76	-3.50	-4.76	-0.31	0.00	-0.44	0.00

[1] This table presents the market structure of equities lending transactions in Japan. Transactions are extracted where the only securities linked to the transaction are equities, and the only collateral is cash. The average outstanding balance, haircut rate, and repo rate have been calculated at the end of every month from January 2019 to December 2021. Currencies other than Japanese yen have been converted into Japanese yen using the exchange rates at the end of the month. The average exchange rate for 1 US dollar is 108.6 Japanese yen. The abbreviations for country and currency names are as follows: JP: Japan, JPY: Japanese yen.

4. Panel Data Analysis

4-1 Estimation Methodology

This section furnishes a more detailed analysis of standard repurchase agreements for government bonds, the largest balance of SFTs in Japan. It employs the least squares dummy variable model, using panel data to estimate quantitatively which variables likely affect haircuts and to what extent. Specifically, we consider the following regression equation, with the haircut rate as the explained variable.

$$Haircut_j = \alpha_0 + \underbrace{\sum_k \alpha_{1,k} \mathrm{X}_{j,k} + \sum_l \delta_l \, 1(d_{j,l} = l)}_{\text{Explanatory Variables}} + \underbrace{\sum_m \rho_m \, 1(p_{j,m} = m) + \sum_n \theta_n \, 1(s_{j,n} = n)}_{\text{Fixed Effects}} + \varepsilon_j,$$

where j is a subscript representing a specific transaction, and $1(x = y)$ denotes a dummy variable with a function that takes 1 when $x = y$ and 0 otherwise. Further, k in the continuous variable $\mathrm{X}_{j,k}$ characterizes a transaction as a subscript that distinguishes between repo rate, transaction maturity, transaction amount, and network centrality (degree centrality). Moreover, l in $d_{j,l}$ is a subscript that distinguishes between a government bond credit rating dummy, a government bond residual maturity dummy, an open-end transaction dummy, a cross-currency transaction dummy, an agency-intermediated transaction dummy, an SC transaction dummy, and a CCP-cleared transaction dummy. Table 6 lists the explanatory variables, and Tables 7-1 and 7-2 summarize the descriptive statistics for continuous variable $\mathrm{X}_{j,k}$ and the explained variable, the haircut rate. This analysis mainly focused on the values and statistical significance of the regression coefficients $\alpha_{1,k}$ and δ_l for the explanatory variables.

The explanatory variables are expected to influence the setting of the haircut rate via the following pathways. First, the credit and market risk of government bonds depends on the transaction maturity and government bond credit rating, open-ended transaction, residual maturity of the government bond, and cross-currency transaction dummies. In addition to trading volume, the government bond residual maturity dummy is expected to affect liquidity risk through differences in trading volume by maturity in the bond market. The agency-intermediated transaction and CCP-cleared transaction dummies could potentially impact operational risk.

Furthermore, $p_{j,m}$ and $s_{j,n}$ are dummy variables treated as fixed effects; m in $p_{j,m}$ is a subscript that distinguishes the combination of data reporter, counterparty, and transaction reporting date, therefore $p_{j,m}$ is a time-fixed effect. Additionally, n in $s_{j,n}$ is a subscript that distinguishes between the combination of the jurisdiction of the bond, the denomination of the bond, and cash currency. Thus, by capturing combinations of data reporter, counterparty, and transaction reporting date in $p_{j,m}$ and jurisdiction of the bond, denomination of the bond, and cash currency in $s_{j,n}$ as fixed effects, we control for the effects of transacting entities and transaction types and measure, to the extent possible, the pure effects of each explanatory variable.

Description of the explanatory variables

Table 6

Variable [1]	Description
＜Continuous variable＞	
Transaction maturity	Maturity of the transaction in square root of days; substitute 0 if the transaction maturity is open-ended
Transaction amount	Log principal amount of the transaction in 100 million JPY
Repo rate	Percentage of repo rate
Network centrality	Data reporter's degree centrality, as of the transaction reporting month
＜Dummy variable＞	
Collateral quality	
Investment grade	Dummy variable = 1 if the credit rating of government bond is investment grade
Non-investment grade	Dummy variable = 1 if the credit rating of government bond is non-investment grade
Residual maturity of government bond	
Below 1 month	Dummy variable = 1 if residual maturity of government bond is below 1 month (included)
More than 1 month and up to 3 months	Dummy variable = 1 if residual maturity of government bond is more than 1 month (not included) and up to 3 months (included)
More than 3 months and up to 6 months	Dummy variable = 1 if residual maturity of government bond is more than 3 months (not included) and up to 6 months (included)
More than 6 months and up to 1 year	Dummy variable = 1 if residual maturity of government bond is more than 6 months (not included) and up to 1 year (included)
More than 1 year and up to 5 years	Dummy variable = 1 if residual maturity of government bond is more than 1 year (not included) and up to 5 years (included)
More than 5 years and up to 10 years	Dummy variable = 1 if residual maturity of government bond is more than 5 years (not included) and up to 10 years (included)
More than 10 years	Dummy variable = 1 if residual maturity of government bond is more than 10 years (not included)
Transaction maturity	
Open-end transactions	Dummy variable = 1 if the transaction maturity is open-ended
Transaction type	
Cross currency	Dummy variable = 1 if the currency of government bond and cash are different
Special collateral (SC)	Dummy variable = 1 if reported as special collateral (SC) transaction
Agency-intermediated	Dummy variable = 1 if reported as agency-intermediated transaction
Centrally cleared	Dummy variable = 1 if reported as centrally cleared transaction

[1] In addition to the above, the "**Collateral quality**" reporting category includes "no rating," and the "**Residual maturity of government bond**" reporting category also includes "no residual maturity."

Descriptive statistics for haircut rates and explanatory variables[1]

Standard repurchase agreements with government bonds

Table 7.1

Panel A: All samples

		Haircut rate	Repo rate	Transaction maturity	Transaction amount	Network centrality (Degree centrality)
Repo	Obs	595,392	595,392	550,102	595,392	595,392
	Mean	0.80	0.04	3.32	1.30	0.250
	Median	0.00	-0.10	2.45	1.65	0.233
	Std dev	2.87	0.69	2.64	0.99	0.170
	Min	-5.00	-3.10	1.00	-5.99	0.010
	Max	20.00	23.35	43.34	4.06	0.645
Reverse Repo	Obs	392,779	392,779	362,209	392,779	392,779
	Mean	0.62	-0.05	2.95	1.21	0.249
	Median	0.00	-0.10	2.24	1.48	0.200
	Std dev	2.62	0.45	2.31	1.06	0.186
	Min	-2.00	-3.10	1.00	-5.99	0.010
	Max	20.00	23.35	42.26	4.00	0.645

Panel B: Excluding zero-haircut samples

		Haircut rate	Repo rate	Transaction maturity	Transaction amount	Network centrality (Degree centrality)
Repo	Obs	88,784	88,784	44,873	88,784	88,784
	Mean	5.39	0.21	4.03	0.40	0.079
	Median	2.00	-0.16	2.83	0.99	0.043
	Std dev	5.53	1.28	3.99	1.65	0.065
	Min	-5.00	-1.38	1.00	-5.99	0.010
	Max	20.00	23.35	42.71	3.16	0.355
Reverse Repo	Obs	45,994	45,994	18,939	45,994	45,994
	Mean	5.29	0.10	2.75	0.10	0.058
	Median	2.00	-0.43	1.41	0.54	0.042
	Std dev	5.81	1.10	4.13	1.78	0.051
	Min	-2.00	-1.49	1.00	-5.99	0.010
	Max	20.00	23.35	33.09	3.40	0.355

[1] All transactions were calculated at the end of every month from January 2019 to December 2021. "Haircut rate" and "Repo rate" are in percentages (%). "Transaction maturity" is the square root of the number of days remaining (excluding open-ended transactions). "Transaction amount" is the common log of the principal amount (100 million yen).

Distribution of haircut rates[1]

Standard repurchase agreements with government bonds — Table 7.2

Panel A: All samples

Haircut rate		< 0%	[0%, 2%)	[2%, 4%)	[4%, 6%)	[6%, 8%)	[8%, 10%)	[10%, 12%)	≥ 12%	Sum
Repo	Obs	1,535	518,984	40,849	7,373	578	48	18,463	7,562	595,392
	Share	0.3%	87.2%	6.9%	1.2%	0.1%	0.0%	3.1%	1.3%	100.0%
Reverse Repo	Obs	611	348,679	28,702	1,590	606	77	7,847	4,667	392,779
	Share	0.2%	88.8%	7.3%	0.4%	0.2%	0.0%	2.0%	1.2%	100.0%

Panel B: Excluding zero-haircut samples

Haircut rate		< 0%	[0%, 2%)	[2%, 4%)	[4%, 6%)	[6%, 8%)	[8%, 10%)	[10%, 12%)	≥ 12%	Sum
Repo	Obs	1,535	12,376	40,849	7,373	578	48	18,463	7,562	88,784
	Share	1.7%	13.9%	46.0%	8.3%	0.7%	0.1%	20.8%	8.5%	100.0%
Reverse Repo	Obs	611	1,894	28,702	1,590	606	77	7,847	4,667	45,994
	Share	1.3%	4.1%	62.4%	3.5%	1.3%	0.2%	17.1%	10.1%	100.0%

[1] All transactions have been calculated at the end of every month from January 2019 to December 2021.

4-2 Estimate Results and Discussion

Tables 8 and 9 present a summary of the regression analysis results. Table 8 shows the estimated results for all samples, whereas Table 9 conveys the estimated results, excluding transaction data samples with zero-haircut, separated into repo and reverse repo transactions. The robustness of the results is ensured by comparing the estimated results for all samples, including transactions with zero-haircut and excluding transaction data samples with zero-haircut.[26] The explained variables are haircut rates, with the regression coefficients for the various explanatory variables displayed. Model (1) in Tables 8 and 9 is the baseline model in this study, and the estimate results are based on the following explanatory variables: government bond characteristics (government bond credit rating [residual maturity] dummy); transaction period (residual transaction maturity and open-ended trading dummy); transaction terms (principal amount); type of transaction (SC trading, agency-intermediated trading, and CCP-cleared trading dummies). Model (2) adds transaction terms (repo rate) to the explanatory variables in Model (1), while Model (3) incorporates transaction type (cross-currency transaction dummy) to the explanatory variables in Model (1); only the government bond-issuing jurisdiction is considered in fixed effect $s_{j,n}$. Model (4) adds a network centrality (degree centrality) to the explanatory variables in Model (1); only the combination of counterparty and transaction reporting date is considered in the time-fixed effects $p_{j,m}$.

Further, to examine quantitatively how and to what extent each explanatory variable has an impact, based on the descriptive statistics of the explanatory variables (Table 7-1) and the results of regression analysis (Tables 8 and 9), Table 10

[26] Baklanova et al. (2019) estimate regression analysis on a sample that excludes transactions through the Fixed Income Clearing Corporation, which does not set haircuts, and transactions with zero haircuts to avoid sample bias in their analysis of bilateral transactions using US treasuries.

summarizes the absolute value of the regression coefficient for each explanatory variable multiplied by the standard deviation (for dummy variables, the absolute value of the regression coefficient). From Table 10, it is possible to compare the extent to which each explanatory variable influences the haircut setting.

As noted below, the explanatory variables that affect credit, market, and liquidity risk, such as the credit quality of government bonds traded (government bond credit rating dummy), residual maturity of government bonds dummy, and foreign exchange risk (cross-currency transaction dummy), significantly impact the haircut setting.

Characteristics of government bonds

The credit rating of the government bonds traded has a significant impact on haircut setting. Table 10 indicates that the difference in haircut rates between investment-grade and non-investment-grade bonds is 1.72% and 1.59% for all samples, 2.90% and 3.20% for the samples without zero-haircuts (repo and reverse repo transactions, respectively, which is the same hereinafter, unless otherwise noted), confirming that the higher the credit rating, the lower the haircut rate.[27]

The government bond residual maturity dummy should reflect the impact on price volatility and the liquidity of the government bond market by residual maturity. Table 10 shows that lengthening the residual maturity of government bonds boosts the haircut rate by 0.40% and 0.10% for all samples and 1.02% and 0.95% for samples without zero-haircuts, with a commensurate boost to the haircut rate. Furthermore, to examine the contribution by residual maturity more closely, Figure 7.1 illustrates that the longer the residual maturity of government bonds, the more the haircut rate increases. The price volatility of Japanese government bonds has remained low under the Bank of Japan's monetary policy. Therefore, we examined whether similar results could be obtained when examining Japanese government bonds alone. Figure 7.2 illustrates that the effect of the government bond residual maturity dummy for Japanese government bonds is smaller than that of other government bonds, partly because the price volatility of Japanese government bonds has remained lower than that of other government bonds.

Transaction maturity

Transaction maturity can affect haircut rates, primarily through an increase or decrease in market risk. From the estimated results, lengthening the remaining duration of the transaction contributes to increasing the haircut rate. Of course, the magnitude of the effect is 0.04% and 0.03% for all samples and 0.10% and 0.06% for samples without zero-haircuts; thus, it does not significantly affect the haircut rate (Table 10). Notably, this result may be due to margin calls, where collateral is delivered in response to changes in the price of government bonds during the term of the transaction, which may mitigate the effect of the residual maturity of the transaction. However, the impact of the open-ended transaction dummy was 0.38% and 0.25% for all samples and 0.49% and 0.31% for samples without zero-haircuts. This indicates that open-ended transactions with no predetermined transaction period increased the haircut rate correspondingly.

[27] Transactions using non-investment-grade bonds comprise only a small portion of all standard repurchase agreements with government bonds—approximately 1% regarding the number of transactions and 0.05%, outstanding transactions.

Regression results for all transactions[1]

Table 8

Category	Variable	Repo				Reverse repo			
		(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Collateral quality	Investment grade	-0.5958***	-0.6006***	-0.4729***	-0.5675***	-0.6912***	-0.6865***	-0.6580***	-0.6240***
	Non-investment grade	1.1247***	1.2262***	4.9440***	0.8852***	0.9018***	0.9592***	8.4993***	0.9446***
Residual maturity of government bond	Below 1 month (included)	-0.9352***	-0.2925	-0.7230***	0.6928***	-0.1117***	-0.1066***	-0.0900***	0.3928***
	More than 1 month (not included) and up to 3 months (included)	-0.7852***	-0.1437	-0.5708**	0.7303***	-0.1447***	-0.1376***	-0.1341***	0.3801***
	More than 3 months (not included) and up to 6 months (included)	-0.5973***	0.0392	-0.3564	0.7902***	-0.0179	-0.0127	-0.001	0.5080***
	More than 6 months (not included) and up to 1 year (included)	-0.5383**	0.0948	-0.2847	0.8351***	0.0562***	0.0565***	0.0889***	0.5715***
	More than 1 year (not included) and up to 5 years (included)	-0.5227**	0.1174	-0.2834	0.7509***	-0.0120***	-0.0065*	0.0160***	0.4947***
	More than 5 years (not included) and up to 10 years (included)	-0.4949**	0.1443	-0.2811	0.6512***	-0.0099**	-0.0079**	0.006	0.4859***
	More than 10 years (not included)	-0.5347**	0.0970	-0.3586	0.6447***				0.4921***
Transaction maturity	Transaction maturity days	0.0151***	0.0162***	0.0198***	0.0102***	0.0141***	0.0138***	0.0208***	0.0036***
	Open-end transactions	0.3830***	0.3589***	0.4183***	2.1581***	0.2530***	0.2285***	0.2655***	0.5553***
Transaction terms	Transaction amount	0.0282***	0.0238***	0.0221***	-0.0380***	0.0130***	0.0138***	0.0207***	0.0151***
	Repo rate		0.5367***				0.6431***		
Transaction type	Cross currency			3.6807***				0.9625***	
	Special collateral	-0.1021***	-0.0901***	-0.1118***	-0.1225***	-0.0149**	-0.0171**	-0.0064	-0.0530***
	Agency-intermediated				0.0161**	-0.4118***	-0.5307***	-0.2751**	0.0494***
	Centrally cleared	-0.2320***	-0.2861***	-0.6408***	0.0259***	0.4681***	0.5092***	0.3758***	-0.1050***
Network centrality	Degree centrality				-1.2889***				-0.1782***
Fixed effect	Data Reporter ×Counterparty ×Transaction reporting date	YES	YES	YES	NO	YES	YES	YES	NO
	Counterparty ×Transaction reporting date	NO	NO	NO	YES	NO	NO	NO	YES
	Jurisdiction of government bond ×Currency of government bond ×Currency of cash	YES	YES	NO	YES	YES	YES	NO	YES
	Jurisdiction of government bond	NO	NO	YES	NO	NO	NO	YES	NO
Number of transactions		595,392	595,392	595,392	595,392	392,779	392,779	392,779	392,779
R^2(Within)		0.660	0.664	0.614	0.760	0.791	0.794	0.753	0.824

[1] This table presents estimate coefficients from fixed-effect panel OLS regressions of the haircut rate for all transactions. Table 6 presents the explanatory variables. Fixed effects are the combination of data reporter, counterparty, transaction reporting date, and the combination of jurisdiction of government bond, currency of government bond, and currency of cash. From the F-test, the fixed effects are supported at the 1% significance level in all models. Column (1) reports the baseline result. Column (2) adds a repo rate to column (1) to confirm the relationship between haircut and repo rates. Column (3) adds a dummy variable that identifies cross-currency transactions to column (1). Column (4) adds network centrality (degree centrality) to column (1) to confirm the network effect. The degrees of freedom for repo transaction are column (1): 585,337, column (2): 585,336, column (3): 585,417, and column (4): 593,542, and those of reverse repo transaction are column (1): 384,672, column (2): 384,671, column (3): 384,727, and column (4): 391,213. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Regression results for excluding zero haircuts samples[1]

Table 9

Category	Variable	Repo				Reverse repo			
		(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Collateral quality	Investment grade	-1.9139***	-1.9197***	-1.5925***	-1.7343***	-3.2007***	-3.1578***	-3.0419***	-3.0026***
	Non-investment grade	0.9816***	1.1714***	5.0264***	1.0193***	0.309	0.4176	7.7234***	0.3767
Residual maturity of government bond	Below 1 month (included)	-8.1009***	-6.6695***	-4.5594**	-8.2365***	-1.0822***	-1.0344***	-0.8342***	-0.9570***
	More than 1 month (not included) and up to 3 months (included)	-7.9593***	-6.5316***	-4.3968**	-8.0693***	-1.1946***	-1.1397***	-0.9314***	-1.1222***
	More than 3 months (not included) and up to 6 months (included)	-7.5967***	-6.1703***	-3.9361*	-7.5239***	-0.8023***	-0.7676***	-0.5535***	-0.7433***
	More than 6 months (not included) and up to 1 year (included)	-7.3122***	-5.9033***	-3.5984*	-7.3489***	-0.3878***	-0.3655***	-0.1170*	-0.3536***
	More than 1 year (not included) and up to 5 years (included)	-7.0446***	-5.6481***	-3.3503	-7.2253***	-0.0656**	-0.0653**	0.1794***	-0.0812***
	More than 5 years (not included) and up to 10 years (included)	-6.9140***	-5.5284***	-3.2929	-7.1256***	-0.1276***	-0.1295***	-0.0689**	-0.1148***
	More than 10 years (not included)	-7.0795***	-5.7103***	-3.7219*	-7.3199***				
Transaction maturity	Transaction maturity days	0.0241***	0.0232***	0.0136**	0.1013***	0.0151	0.0187	0.0101	0.0161
	Open-end transactions	0.4897***	0.4572***	0.5030***	0.4564***	0.3118***	0.2920***	0.3441***	0.3233***
Transaction terms	Transaction amount	0.0155**	0.0140*	0.0147*	0.0190**	-0.0144*	-0.0113	0.0127	-0.0125
	Repo rate		0.8049***				0.6385***		
Transaction type	Cross currency			0.1617				6.9901***	
	Special collateral	-1.6883***	-1.7374***	-2.2364***	-1.2634***				-0.6555***
	Agency-intermediated								
	Centrally cleared	-1.1390***	-1.2253***	-1.8109***	-1.2670***				
Network centrality	Degree centrality				-9.1367***				-15.290***
Fixed effect	Data Reporter ×Counterparty ×Transaction reporting date	YES	YES	YES	NO	YES	YES	YES	NO
	Counterparty ×Transaction reporting date	NO	NO	NO	YES	NO	NO	NO	YES
	Jurisdiction of government bond ×Currency of government bond ×Currency of cash	YES	YES	NO	YES	YES	YES	NO	YES
	Jurisdiction of government bond	NO	NO	YES	NO	NO	NO	YES	NO
Number of transactions		88,784	88,784	88,784	88,784	45,994	45,994	45,994	45,994
R^2(Within)		0.726	0.733	0.681	0.751	0.823	0.825	0.792	0.828

[1] This table presents estimate coefficients from fixed-effect panel OLS regressions of haircut rate for excluding zero haircuts sample. Table 6 presents the explanatory variables. Fixed effects are the combination of data reporter, counterparty, transaction reporting date, and the combination of jurisdiction of government bond, currency of government bond, and currency of cash. From the F-test, the fixed effects are supported at the 1% significance level in all models. Column (1) reports the baseline result. Column (2) adds a repo rate to column (1) to confirm the relationship between haircut and repo rates. Column (3) adds a dummy variable that identifies cross-currency transactions to column (1). Column (4) adds network centrality (degree centrality) to column (1) to confirm the network effect. The degrees of freedom for repo transaction are column (1): 87,534, column (2): 87,533, column (3): 87,611, and column (4): 88,367, and those of reverse repo transaction are column (1): 45,393, column (2): 45,392, column (3): 45,441, and column (4): 45,630. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Deviation of explanatory variables on haircut rate[1]

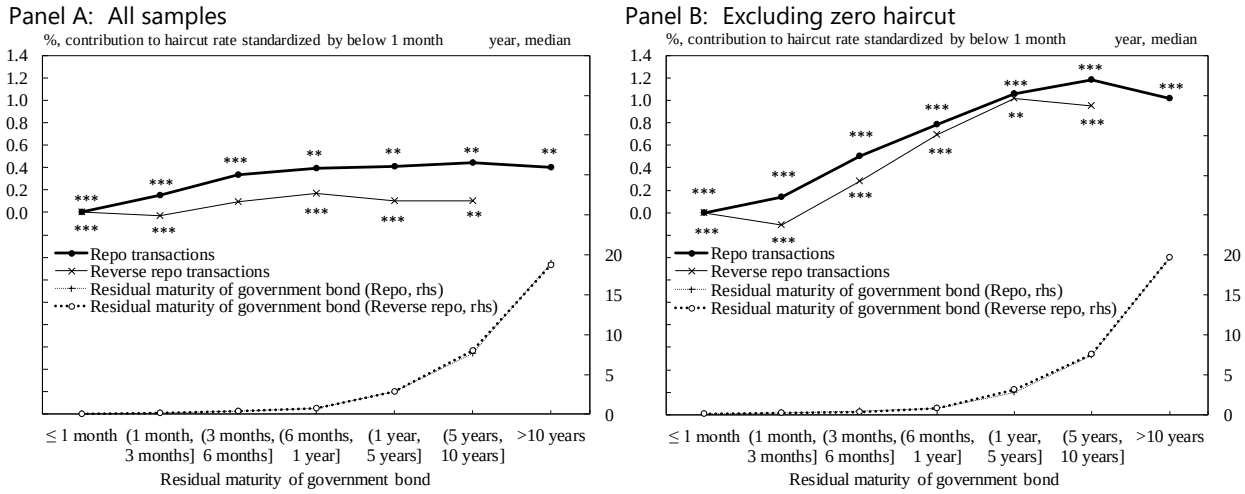
Table 10

Category/Variable	Regression model	All samples		Excluding zero haircut		Interpretation of Estimation Results
		Repo	Reverse repo	Repo	Reverse repo	
Characteristics of Government Bond						
Collateral quality (Dummy variable)	(1)	1.72***	1.59***	2.90***	3.20***	The higher the credit rating, the lower the haircut rate.
Residual maturity (Dummy variable)	(1)	0.40**	0.10***	1.02***	0.95***	The haircut rate of government bonds with a long residual maturity tends to be higher than that of government bonds with a short residual maturity.
Transaction Maturity						
Transaction maturity days	(1)	0.04***	0.03***	0.10***	0.06	Haircut rates increase with long transaction maturity, but the impact is not significant.
Open-end transactions (Dummy variable)	(1)	0.38***	0.25***	0.49***	0.31***	Open-end transactions increase haircut rates.
Transaction Terms						
Repo rate	(2)	0.37***	0.29***	1.03***	0.70***	There is a positive correlation between haircut rate and repo rate.
Transaction amount	(1)	0.03***	0.01***	0.03**	0.03*	The effect of transaction amount does not significantly affect the haircut rate.
Network Centrality						
Degree centrality	(4)	0.22***	0.03***	0.59***	0.78***	Low haircut rate for financial institutions near the center of the network.
Transaction Type						
Cross currency (Dummy variable)	(3)	3.68***	0.96***	0.16	6.99***	Cross-currency transactions increase haircut rates.
Special collateral (Dummy variable)	(1)	0.10***	0.01***	1.69***	—	Haircut rate for GC transactions is higher than that for SC transactions.
Agency-intermediated (Dummy variable)	(1)	—	0.41***	—	—	Haircut rate for bilateral transactions is higher than that for agency-intermediated transactions.
Centrally cleared (Dummy variable)	(1)	0.23***	0.47***	1.14***	—	In repo transactions, haircut rate for centrally cleared transactions is lower than that for non-centrally cleared transactions.

[1] The deviation of explanatory variables on haircut rate is the product of the absolute value of the regression coefficient and the standard deviation based on Tables 7 through 9. Regarding a dummy variable, it is simply the absolute value of the regression coefficient. "Collateral quality" is the absolute value of the difference between the regression coefficients of "Investment grade" and "Non-investment grade." If the significance level of "Non-investment grade" is less than 10%, it is the absolute value of the regression coefficient of "Investment grade." "Residual maturity" is the absolute value of the difference between the regression coefficients of "Below 1 month (included)" and "More than 10 years (not included)" or "More than 5 years (not included) and up to 10 years (included)." ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Term structure of residual maturity of government bonds[1]

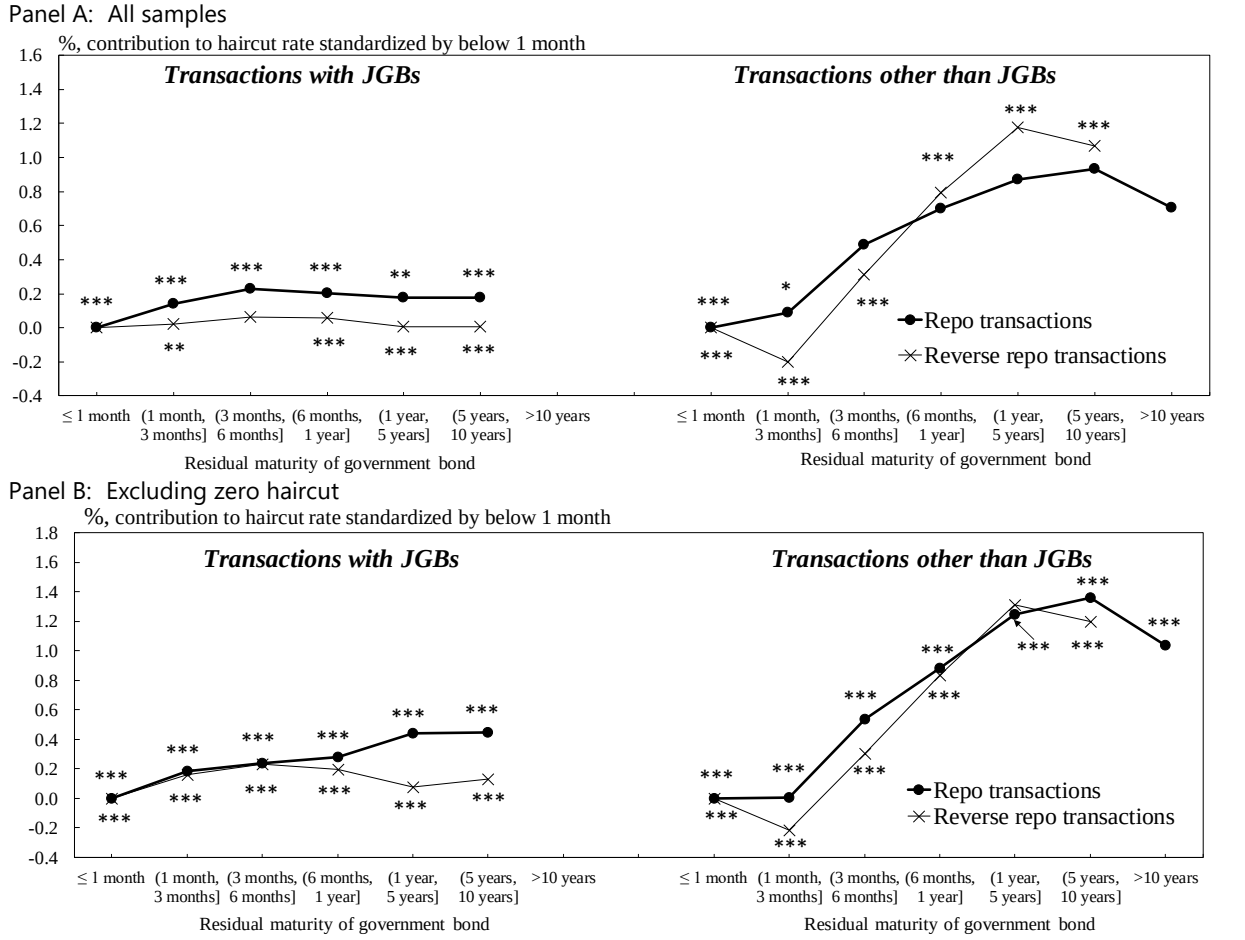
Comparison of all samples and samples excluding zero haircut — Figure 7.1



[1] ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Term structure of residual maturity of government bonds[1]

Comparison of jurisdictions for government bonds — Figure 7.2



[1] This figure presents the result of the jurisdiction government bond divided into "Japan" and "other than Japan," estimated by the same regression equation as model (1). ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Transaction conditions

Several prior studies have discussed the relationship between haircut and repo rates. Prior theoretical studies commonly hold that if haircut and repo rates can be determined simultaneously, then there is a complementary relationship and a negative correlation (e.g., Auh and Landoni, 2015). However, Baklanova et al. (2019), who analyze the US market, note that, in practice, haircut and repo rates are not always simultaneously determined. Haircut rates are predetermined by elements, including risk management departments, independent of front office traders, while repo rates are often determined independently by traders when creating contracts. Thus, they found no evidence of a negative correlation, even after controlling for trading entities and time effects. The results in this study also confirm a positive correlation between haircut and repo rates, likely influenced by haircut rates generally being set independent of repo rates in Japan.

The transaction amount may affect haircuts, as per the balance with overall market liquidity. The estimates demonstrate that the impact of the transaction amount is minimal, at 0.03% and 0.01% for all samples and 0.03% and 0.03% for samples without zero-haircuts (Table 10). Thus, the principal amount of each transaction is not sufficiently large enough to affect haircuts.[28]

Network effects

Referring to prior studies that analyzed the network structure of the interbank and Japanese government bond repo markets in Japan (Imakubo and Soejima, 2010; Horikawa et al., 2021), this study measures the importance of each financial institution on the trading network using network centrality indicators, such as "Degree centrality" and "PageRank," to analyze how network effects affect haircut setting.[29] Figure 8 illustrates the trading network for government bond standard repurchase agreements and the degree centrality of each trading entity. Financial institutions closer to the center of the network, with larger degree centrality values, exert a greater impact on the transaction network.

The estimated results indicate that, similar to prior studies in the UK market (Julliard et al., 2019), haircut rates are set lower at financial institutions closer to the center of the network.[30] The magnitude of the effect of degree centrality is 0.22% and 0.03% for all samples and 0.59% and 0.78% for samples without zero-haircuts (Table 10). Financial institutions' proximity to the center of the network indicates that they

[28] In Japan, when transactions have settlement values exceeding five billion yen, guidelines recommend that the settlement should be divided into smaller blocks to facilitate the settlement using the BOJ-net, the main settlement system (Japan Securities Dealers Association, 2016). In fact, these data also confirm that settlement values are often around five billion yen. Considering the bias such market practices may cause in the estimation, we conducted the same estimation by focusing on transactions with a settlement value of 10 billion yen or more. Even when doing so, the effect of the transaction amount on the haircut rate was small.

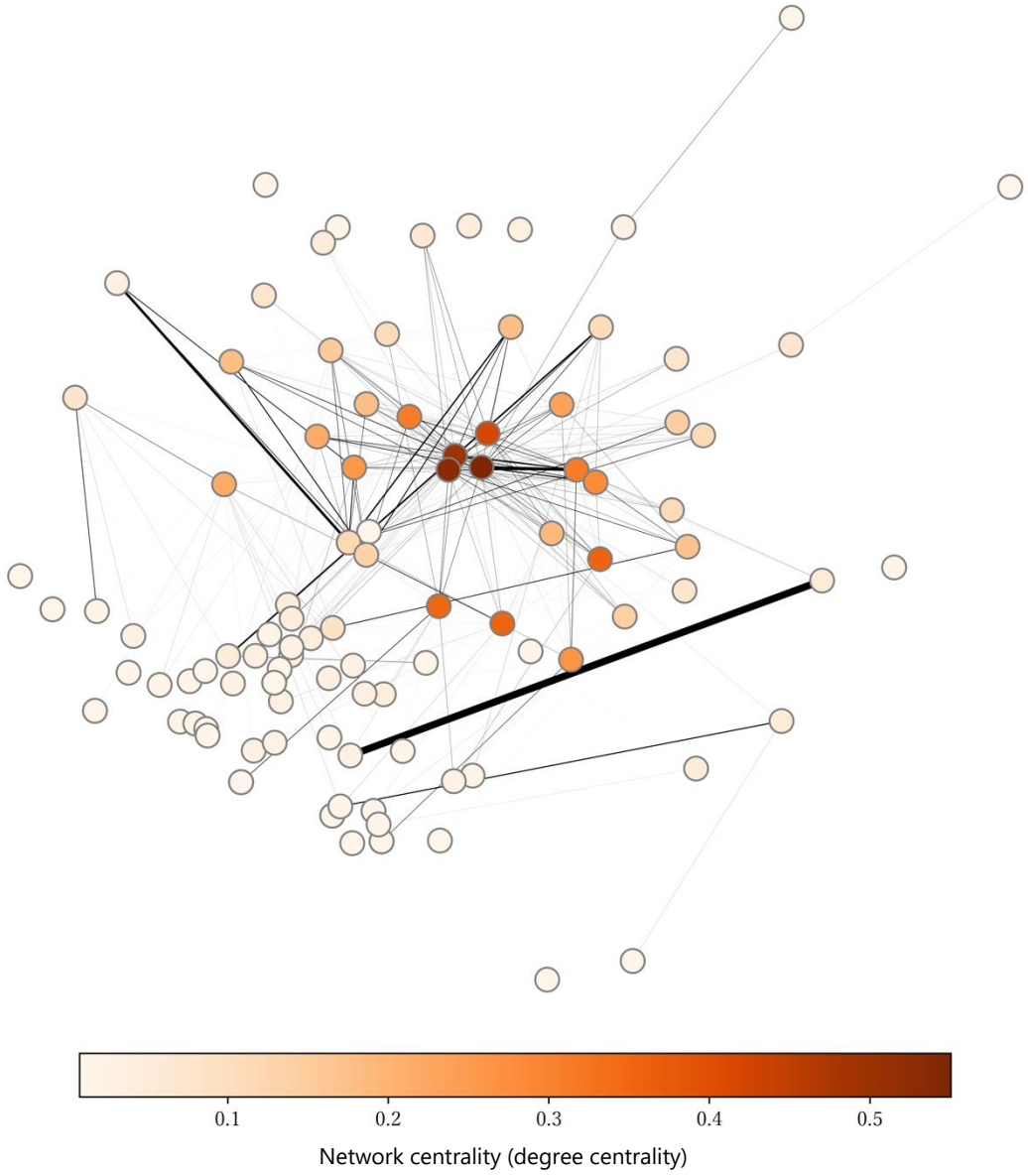
[29] Degree centrality is the simplest network centrality indicator, and when applied to repo transactions, the higher the number of counterparties for each financial institution, the higher the value. However, "PageRank" adopts a higher value for the size of each financial institution's transactions and the large transactions of the parties to which each financial institution is connected, thus measuring to what extent each financial institution affects the entire network.

[30] Similar estimates using "PageRank" instead of degree centrality indicate that financial institutions closer to the network center have lower haircuts. The impact magnitude is also comparable to that of degree centrality, though this is not presented in this article.

face numerous counterparties, effectively matching their funding and supply needs, thereby inducing lower haircut settings.

Transaction network in standard repurchase agreements[1]

Figure 8



[1] This figure illustrates Japan's transaction network in standard repurchase agreements using government bonds. Each node indicates a legal entity. Each legal entity is identified by the name of financial institution, business type, and location jurisdiction. Therefore, even the same financial group is divided into legal entities as much as possible. However, the names of financial institutions other than those provided by the data reporter may be classified as "domestic resident" or "domestic non-resident." In this case, multiple legal entities are counted in the same node. The layout of the nodes is based on the force-directed algorithm of Kamada and Kawai (1989), similar to that of Imakubo and Soejima (2010). The degree centrality in this figure is calculated based on all samples from January 2019 to December 2021, and the edge thickness is the sum of repo and reverse repo transactions from January 2019 to December 2021.

In this regard, Horikawa et al. (2021) demonstrated that in the Japanese government bond repo market, financial institutions close to the center of the network serve as transaction intermediaries, and ongoing business relationships are established around such actors. Such transaction relationships support the causal relationship assumed by this study, where financial institutions closer to the center of the network set lower haircuts. However, it is logically possible that the inverse is the case (i.e., the stance toward haircut setting changes the position of the financial institution in the network). Moreover, the influence of unobservable data reporter characteristics may introduce bias into the estimated results for the network centrality. Hence, to address such endogeneity issues, we followed Temizsoy et al. (2017), who analyzed network effects in the European interbank market and conducted a regression analysis using a lag term for the network centrality indicator as an instrumental variable (IV) as a robustness check (Table 11). The results indicate that the effect of degree centrality is robust, and the magnitude and statistical significance of the regression coefficients are almost the same relative to the case where no instrumental variable is used (Tables 8 and 9). Viewed in detail, the absolute value of the regression coefficient is slightly smaller than that without the instrumental variable for all samples. Further, the absolute value of the regression coefficient is slightly larger than when the instrumental variable is not used when excluding zero-haircut samples. Thus, the unobservable data reporter characteristics affect degree centrality and haircut setting, and the use of the instrumental variable can be considered to have removed the biases.[31]

Transaction type

Cross-currency transactions, where the government bond issue and cash currency are different, have higher haircut rates than transactions where the currencies are the same. This is likely because foreign exchange risk from currency mismatches is considered. The magnitude of the effect of the cross-currency transaction dummy is 3.68% and 0.96% for all samples and 0.16% and 6.99% for samples without zero-haircuts, which, together with government bond credit ratings, significantly impacts haircut settings (Table 10).

The haircut rate is higher for GC transactions than SC transactions, consistent with the role of haircuts in SFTs discussed in Section 2. The magnitude of the effect of the SC transaction dummy is 0.10% and 0.01% for all samples and 1.69% for repo transactions excluding zero-haircut samples (Table 10).

[31] The Wu-Hausman test for explanatory variable endogeneity rejected the null hypothesis that degree centrality is exogenous at the 1% and 10% levels (Table 11). Therefore, it is an endogenous variable.

Instrumental variable estimates of network effect[1]

Table 11

Category	Variable	All samples		Excluding zero haircut	
		Repo	Reverse repo	Repo	Reverse repo
		(4)	(4)	(4)	(4)
Credit rating of government bond	Investment grade	-0.5661***	-0.6233***	-1.7379***	-3.0045***
	Non-investment grade	0.8861***	0.9455***	1.3430***	0.3758
Residual maturity of government bond	Below 1 month (included)	0.6949***	0.3990***	-7.9154***	-0.9612***
	More than 1 month (not included) and up to 3 months (included)	0.7310***	0.3847***	-7.7479***	-1.1237***
	More than 3 months (not included) and up to 6 months (included)	0.7909***	0.5108***	-7.2022***	-0.7446***
	More than 6 months (not included) and up to 1 year (included)	0.8351***	0.5740***	-7.0273***	-0.3573***
	More than 1 year (not included) and up to 5 years (included)	0.7511***	0.5060***	-6.9009***	-0.0822***
	More than 5 years (not included) and up to 10 years (included)	0.6520***	0.4980***	-6.8020***	-0.1138***
	More than 10 years (not included)	0.6463***	0.4952***	-6.9972***	
Transaction maturity	Transaction maturity days	0.0096***	0.0030***	0.1029***	0.0067
	Open-end transactions	2.1580***	0.5630***	0.4513***	0.3092***
Transaction terms	Transaction amount	-0.0383***	0.0146***	0.0189**	-0.0126*
Transaction type	Special collateral	-0.1226***	-0.0533***	-1.2581***	-0.6812***
	Agency-intermediated	0.0141***	0.0469***		
	Centrally cleared	0.0337***	-0.0793***	-1.2740***	
Network centrality	Degree centrality	-1.2879***	-0.1727***	-9.3998***	-17.819***
Fixed effect	Counterparty ×Transaction reporting date	YES	YES	YES	YES
	Jurisdiction of government bond ×Currency of government bond ×Currency of cash	YES	YES	YES	YES
Number of transactions		595,217	392,748	88,784	45,994
Adj. R^2		0.786	0.862	0.755	0.829
Wu-Hausman endogeneity test (F-statistic)		39.011***	3.431*	10.838***	15.985***

[1] This table reports estimate coefficients from fixed-effect panel OLS regressions of haircut rate using an instrument variable. Specifically, we use degree centrality in $t-1$ as an instrumental variable for degree centrality in t. Tables 6 and 7, respectively, present a list of explanatory variables and descriptive statistics. Tables 8 and 9 present the results from the fixed-effect panel OLS regressions without the instrumental variable. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

For repo and reverse repo transactions, the effect of CCP-cleared transactions is mixed. For repo transactions, the haircut rate for cleared transactions is lower than that for non-cleared transactions, with the size of the CCP-cleared transaction dummy effect being 0.23% for all samples and 1.14% for samples without zero-haircuts (Table 10). Conversely, for reverse repo transactions, the haircut rate for cleared transactions is higher than that for the non-cleared. The haircut rate for agency-intermediated transactions is 0.41% lower than that for bilateral transactions for reverse repo transactions in all samples only; the other results are not statistically significant. Thus, the CCP-cleared transaction and agency-intermediated transaction dummies, which could potentially affect operational risk, did not produce stable results in the haircut setting, with insignificant effects. Notably, prior studies in the US and European markets (Copeland et al., 2014; European Securities and Markets Authority, 2016; Boissel et al., 2017; Nguyen, 2020) analyzed the repo market when it was under intense stress during the financial crisis. While the Japanese repo market was generally stable from January 2019 to December 2021, the COVID-19 pandemic exerted an impact (Bank of Japan Financial Markets Department, 2020). The impact of the CCP-cleared and agency-intermediated transaction dummies could also vary per financial environment.

5. Conclusion

This study is the first to analyze the market structure and haircut-setting mechanism of securities financing transactions in-depth using government bonds and equities transaction data from financial institutions located in Japan, collected by the FSA and the Bank of Japan.

From the panel data regression analysis, we determined that explanatory variables affecting credit, market, and liquidity risk, such as government bonds' credit quality, the residual maturity of government bonds, and the presence of foreign exchange risk, significantly impact haircut setting in government bond repo transactions. The results indicate that financial institutions closer to the center of the network, which engage in transactions with additional financial institutions, tend to set lower haircut rates through more efficient matching of borrowing and lending needs for cash and securities. Moreover, the credit quality of government bonds transacted, exchange rate stability, and the presence of intermediaries important to the trading network significantly impact the degree of functioning of the government bond repo market.

These findings can further discussions on trends and risk management of SFTs, including haircuts, as appropriate monitoring of SFTs, which are essential to financial markets and are conducted via ongoing data analyses. However, the study has some limitations that pave the way for future studies. First, this study failed to adequately probe the accumulation of knowledge concerning transactions using securities beyond government bonds and equities. Second, the low data coverage for securities lending transactions, including equities, prevents a detailed analysis. Thus, further studies can aim to bridge the gap for a better understanding of the issues to clarify the big picture of SFTs in Japan. Moreover, the accumulation of time-series data would also allow for empirical analysis of market stress.

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Quantitative Analysis of Haircuts: Evidence from the Japanese Repo and Securities Lending Markets

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Bank of Japan

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"Post-pandemic landscape for central bank statistics"
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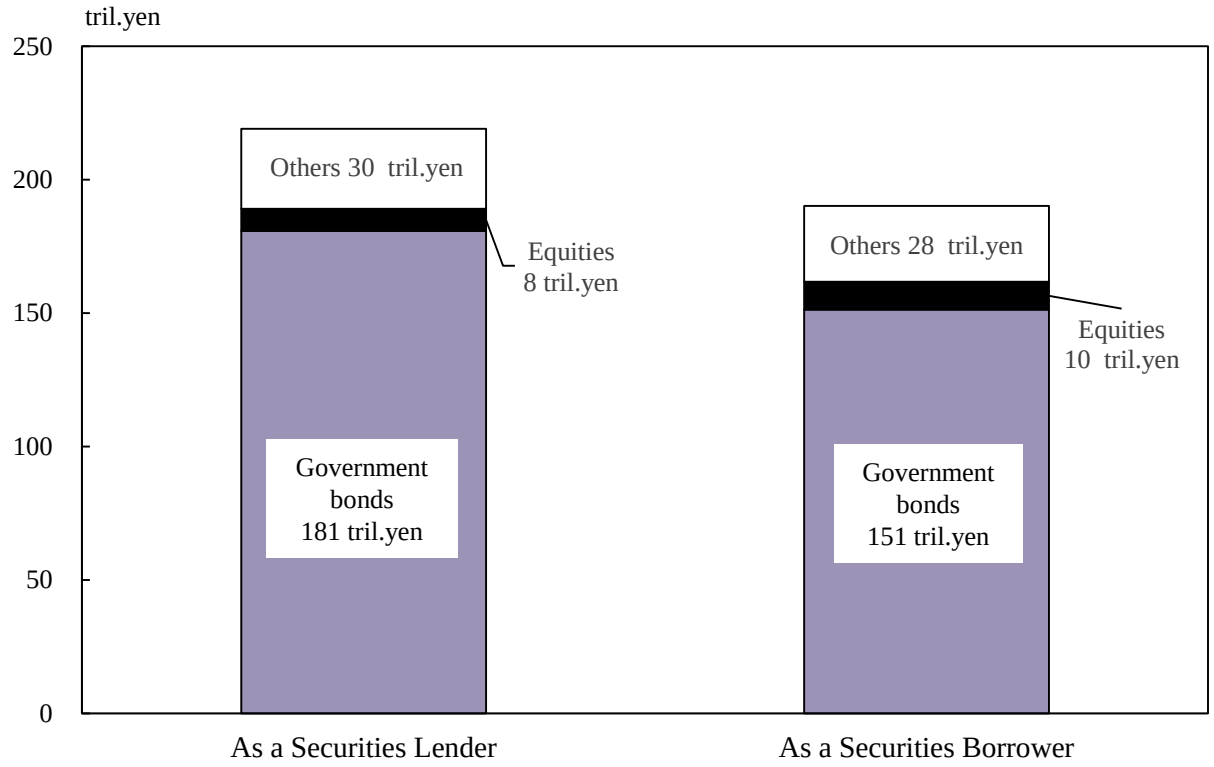
Introduction & Motivation

- Securities Financing Transactions (SFTs) were key to the risk-taking that induced the 2007–2009 global financial crisis. Funding environment rapidly deteriorated as the haircut rate was raised...
- Japan has a large SFT market, mainly in Japanese government bond transactions. The month-end average outstanding balance is 220 trillion JPY, or 2 trillion USD.
  - The Federal Reserve Board estimates the total repo outstanding in the US market as of September 2020 to be approximately 4 trillion USD.
- This paper reveals:
  - the market structure of Japan's SFT market
  - standard haircut setting mechanisms for government bond transactions.

Outstanding balance of SFTs in Japan by security and transaction type



Note: Average outstanding balance has been calculated at the end of every month from January 2019 to December 2021.

Prior Studies & Our Data

- Prior Studies includes:
  - **Theoretical studies**: credit and market risk (Martin et al., 2014; Gottardi et al., 2019) and liquidity risk (Brunnermeier and Pedersen, 2009; Martin et al., 2014; Parlatore, 2019).
  - **Empirical studies for the US market**: Copeland et al. (2014) use tri-party transaction data collected by the Federal Reserve Bank of New York. Additionally, Baklanova et al. (2019) use bilateral transaction data collected on a pilot basis by the Office of Financial Research and the Federal Reserve Board, and Gorton et al. (2020) use transaction data for the Emergency Facility introduced by the Federal Reserve Board during the financial crisis.
  - **Empirical study for the UK market**: Julliard et al. (2019) use data from six major financial institutions collected by a financial authority.
- **Our data captures over 90% of Japan's SFT market, including bilateral and CCP-uncleared transactions, which are typically challenging to ascertain**. The data is reported by approximately 50 top financial institutions, including overseas financial institutions based in Japan.

Transactions with government bonds in Japan

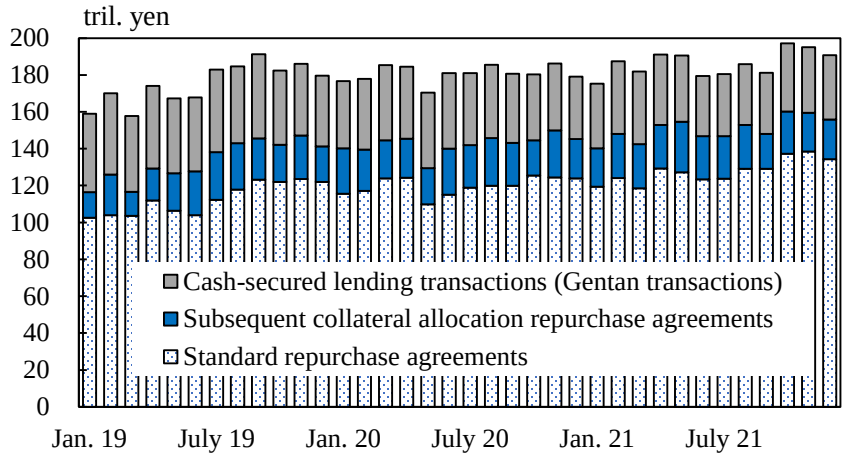
Transaction type

- Repurchase agreements increased following the shortening of the Japanese government bond settlement cycle to T+1 in 2018.
- Historically, cash-secured lending transactions (called "*Gentan*" transactions) have been the mainstream in Japan. Despite the decline with the expansion of repurchase agreements, they continue to comprise a certain proportion.

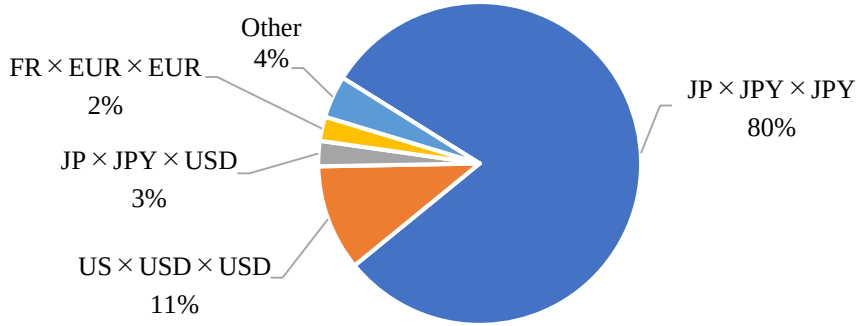
Combination of government bond and cash

- The exchange of Japanese government bonds for yen accounts for 80% of standard repurchase agreements.
- Moreover, US government bonds are exchanged for US dollars or European government bonds are exchanged for euros.
- Japanese government bonds are also exchanged for US dollars.

Outstanding balance of transactions using government bonds by transaction type



Combination by jurisdiction of government bond, currency of government bond, and currency of cash

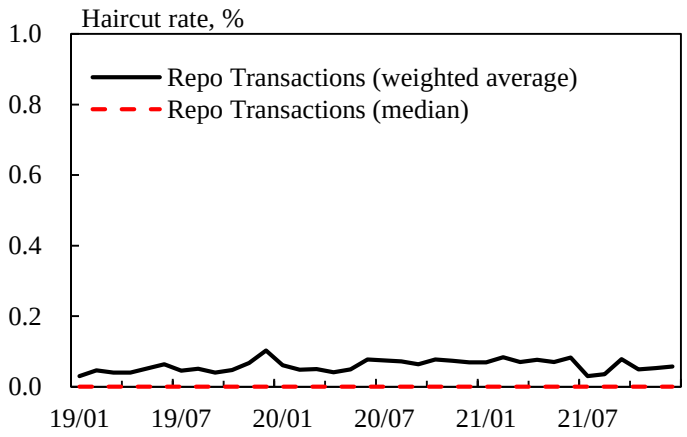


Note: In legends, "JP×JPY×JPY" means jurisdiction of government bond : JP, currency of government bond : JPY, and currency of cash : JPY.

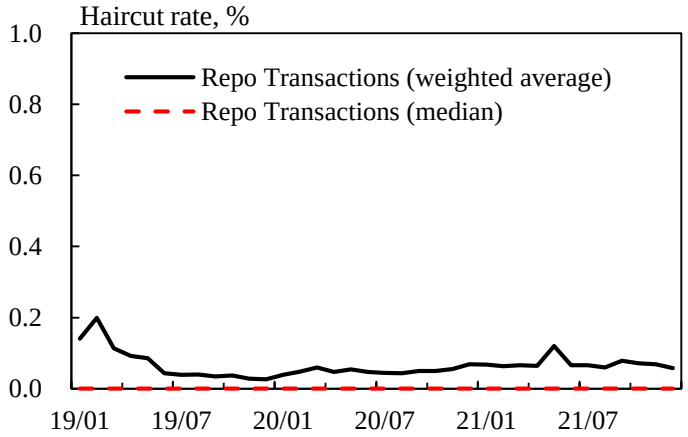
Haircut rate by transaction type

- Exchanging Japanese government bonds for Japanese yen and US government bonds for US dollars are traded at a haircut rate of almost 0%.
- The haircut rate level in cross-currency transactions to exchange Japanese government bonds for US dollars differs significantly from that of same-currency transactions due to foreign exchange risk.
- A time series of haircut rates have remained stable despite COVID-19 turmoil upsetting the financial markets.

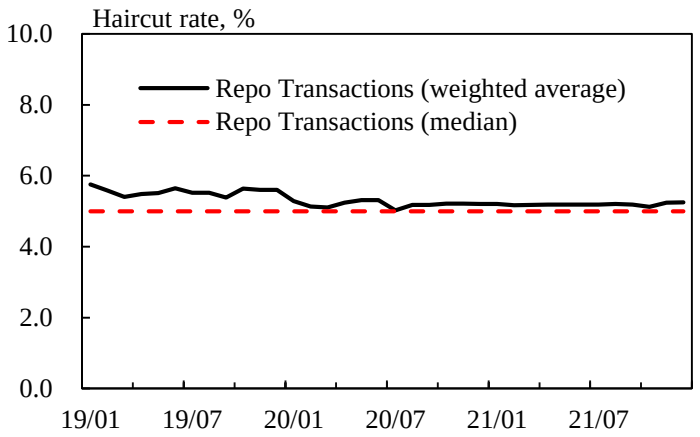
Japanese government bonds and JPY



US government bonds and USD



Japanese government bonds and USD



Note: Latest data as at December 2021.

Regression Model

- Analysis is conducted with an OLS dummy variable model.

$$Haircut_j = \alpha_0 + \underbrace{\sum_k \alpha_{1,k} X_{j,k} + \sum_l \delta_l \, 1(d_{j,l} = l)}_{\text{Explanatory Variables}} + \underbrace{\sum_m \rho_m \, 1(p_{j,m} = m) + \sum_n \theta_n \, 1(s_{j,n} = n)}_{\text{Fixed Effects}} + \varepsilon_j,$$

Where:

- $X_{j,k}$ are continuous variables (Transaction maturity days, Transaction amount, Repo rate, Network centrality)
- $d_{j,l}$ are dummy variables
  - Characteristics of Government Bond (Collateral quality, Residual maturity)
  - Transaction maturity (Open-end transactions)
  - Transaction type (Cross currency, Special collateral, etc.)
- $p_{j,m}$ are time fixed-effects on the transacting entities (Data reporter × Counterparty × Transaction reporting date)
- $s_{j,n}$ are fixed-effects on the transaction types (Jurisdiction of the bond ×currency of the bond × Cash currency)

Main Results

Characteristics of Government Bond

- **Collateral quality** : The higher the credit rating, the lower the haircut rate.
- **Residual maturity** : The haircut rate of government bond with a long residual maturity tends to be higher.

Transaction Maturity

- **Transaction maturity days** : Haircut rates increase with long transaction maturity, but the impact is not significant.
- **Open-end transactions** : Open-end transactions increase haircut rates.

Transaction Terms

- **Repo rate** : There is a positive correlation between haircut rate and repo rate.
- **Transaction amount** : The effect of transaction amount does not significantly affect the haircut rate.

Network Effect

- **Network centrality** : Low haircut rate for financial institutions near the center of the network.

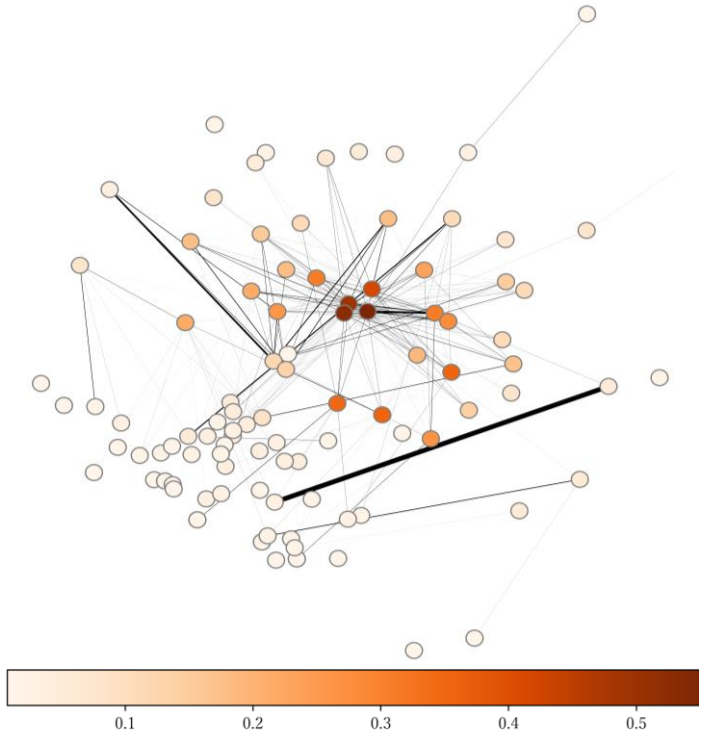
Transaction Type

- **Cross currency** : Cross-currency transactions increase haircut rates.
- **Special collateral** : Haircut rate for GC transactions is higher than that for SC transactions.

Main Results

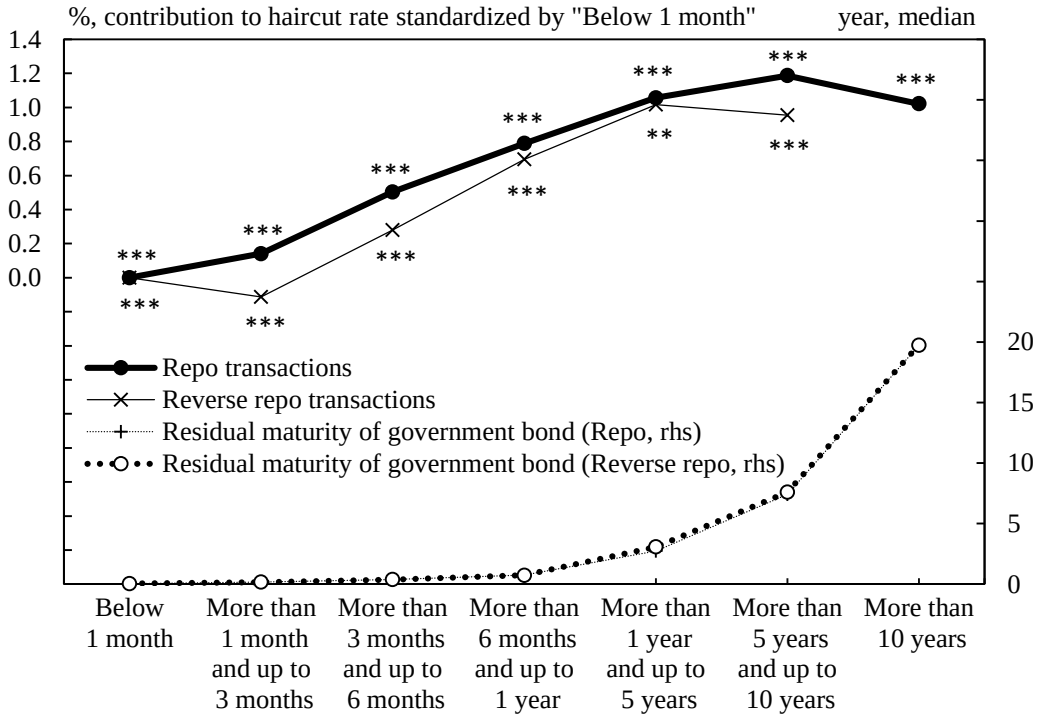
- Financial institutions near the center of the network can match borrowing and lending needs more efficiently.

Transaction network in standard repurchase agreements using government bonds



- As the residual maturity increases, the haircut rate is pushed up along with the higher price volatility.

Term structure of residual maturity of government bonds (excluding zero haircuts sample)



Conclusions

- First analysis of the market structure and haircut setting mechanism of SFTs in-depth using transaction data collected by the Financial Services Agency of Japan and the Bank of Japan.
- We determined that explanatory variables affecting credit, market, and liquidity risk, such as the collateral quality of government bonds, the residual maturity of government bonds, and the presence of foreign exchange risk, significantly impact haircut setting.
- Financial institutions closer to the center of the network tend to set lower haircut rates.
- The results are generally robust and of value to financial authorities and practitioners in trading and risk management of SFTs at financial institutions.

Thank you for your attention