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ANALYZING COLLATERAL REPO HAIRCUTS IN ASIAN COUNTRIES

Iman Gunadi*, Aryo Sasongko**, and Dian Fitriarni Sari***

*Bank Indonesia Institute, Bank Indonesia, Jakarta, Indonesia. Email: i_gunadi@bi.go.id
**Bank Indonesia Institute, Bank Indonesia, Jakarta, Indonesia. Email: aryo@bi.go.id
***Bank Indonesia Institute, Bank Indonesia, Jakarta, Indonesia. Email: dianfitriarnisari@gmail.com

ABSTRACT

We study repo haircut determinants and develop the haircut calculation model. Collateral securities are government and corporate fixed-incomes, and we examine the determinants in Indonesia, Malaysia, Thailand, and Hong Kong. Implementing the Generalized AutoRegressive-Conditional Heteroskedasticity (GARCH) process, we find that the changes in long-memory returns, liquidity, and currency influence haircuts. Then, we introduce the haircut model using the historical and parametric Value-at-Risk (VaR), burdening the borrower as much as the α-percentile collateral loss. When borrowers default, lenders get the collaterals and haircuts to compensate for the collateral-price change.

Keywords: Repo analysis; Risk tolerance; Historical value-at-risk; Repo haircut.
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I. INTRODUCTION

This study develops repo haircuts for a central bank to manage the financial market's liquidity in an open market operation, i.e., contraction and expansion policies. A repo contract is vital to alleviate liquidity problems during a systemic banking crisis (Gorton and Metrick, 2012). A repo contract is a loan accompanied by collateral. The borrower and lender must determine two prices, i.e., a repo rate and a haircut rate (see a trading ticket in Choudhry [2010]).

The first price, the repo rate, is the interest rate that the borrower must pay, depending on the loan amount. It has the theoretical formula, the implied repo rate, which is the forward-spot parity in its interest-rate spot term structure (Choudhry, 2010). For the monetary repo rate, Dawra (2014) argues that the repo rate is the cost of a central bank borrowing money from the domestic financial system. Therefore, the repo rate is as much as the policy rate (Gerlach, 2011; Fransson and Tysklin, 2016). The second price is a haircut, a percentage difference between the received cash and the market value (e.g., the clean price of a bond) of securities exchanged (Baklanova *et al*., 2019). It is an initial margin, or over-collateralization, compensating for collateral market risk, illiquidity of collateral, inherent volatility (such as across maturity price), and counterparty risk (Choudhry, 2010).

Since the policy and repo rates contain the real interest rates and all market risk premiums, the haircut rate represents the risk premium of the collaterals. Auh and Landoni (2016) find evidence that the repo rate is substitutable for the haircut rate. Furthermore, hardly do some central banks implement theoretical repo prices. Instead, they have collateral frameworks which manage the prices. The collateral framework policy generally covers the repo rate to represent the policy rate, collateral eligibility, and haircut depending on collateral ratings but excludes the counterparty risk. Nyborg (2017) discusses the collateral framework for Europan Central Bank (ECB) from 2013 to 2015. The ECB sets the Eurosystem collateral framework consisting of fixed haircuts, which reflect risk and liquidity, with a wide range of eligible collateral, including non-marketable securities (Nyborg, 2017). The bank revised the haircuts over three years against the daily market rate (Nyborg, 2015). Since 8 October 2008, the ECB has held a fixed-rate-tender auction at the policy rate with full allotment, in which the repo rate is as much as the policy rate (Nyborg, 2017).

The Asian central banks, namely Bank Indonesia, Bank Negara Malaysia, Bank of Thailand, and Hong Kong Monetary Authority, had virtual collateral frameworks consisting of repo rates, eligible collaterals, and haircuts (Table A.2 in Appendix). Some central banks require high-quality eligible collateral, i.e., government bonds. The remaining set a uniform haircut across maturities. However, Bank Negara Malaysia & Bank of Thailand accept unrated bank securities (Table A.2 in the Appendix).

Besides having its collateral framework, Bank Indonesia oversees the growing domestic financial market. The annual trading volumes of government securities, reverse repo, and government securities to reverse-repo outstanding ratio have increased over the years.[1] The increase in government securities to reverse-

[1] For instance, from 2017 to June 2021, annual trading volumes of government securities, reverse repo, and government securities to reverse repo outstanding ratio were, respectively, IDR 3,842 trillion , IDR 2,100 trillion, and 0.546 in 2017, and IDR7,711 trillion, IDR4,282 trillion, and 0.555 in June2021 (OJK, 2021).

repo outstanding ratio, in particular, indicates that reverse repo transactions are absorbing government securities' liquidity and that the central bank needs additionally available collaterals. One way to increase the bank's collaterals is to extend the eligible class of collaterals in its collateral framework. Bank Indonesia needs to improve its banking liquidity channel, which is getting more significant year by year, while the number of available government bonds is limited. It can no longer rely only on government securities but needs to accept non-governments as collateral, i.e., corporate bonds. As argued by prior research, the more eligible collateral, the less the systemic banking risk (Nyborg, 2017; Gorton and Metrick, 2012), and the higher the repo market volume. Our study highlights how to determine haircuts when the central bank widens asset-class eligibility within any collateral framework, such as corporate bonds.

The current collateral frameworks set a fixed haircut rate for all government securities. However, the literature identifies some determinants of varying haircuts. Garleanu and Pederson (2011) show that varying haircuts are related to asset prices, using a dynamic general-equilibrium model. In their study, Baklanova *et al*. (2019) found a strong relationship between haircuts and repo rates in the United States. They found that the higher the haircut, the lower the default risk and the borrowing cost/repo rate. In the same study, Baklanova *et al.* (2019) found an insignificant relation between haircuts and interest rates. Julliard *et al.* (2019) utilize the United Kingdom repo market data and find that haircuts are a function of maturity, collateral quality, market risk, and liquidity factors. Nguyen (2020) establishes that yield spread relates to credit default swaps spread, liquidity spread, and haircut spread. Abakah and Gil-Alana (2021), Asif and Frömmel (2022), and Jegadeesh and Titman (2002) find that fixed income generally has a long-memory return or momentum profit.

Besides the empirical results on haircut determinants, some previous studies use Value-at-Risk (VaR) methods to determine repo rates and haircuts. Adrian and Shin (2014) use VaR to measure haircuts for the leverage of commercial banks. Julliard *et al.* (2019) also model haircuts using VaR and establish other determinants such as notional maturity repo, collateral, rating and counterparty rating, and return on asset. Chebotarev (2020) develops a partial equilibrium model to optimize repo and haircut rates. He builds a repo transaction equilibrium model in which the seller maximizes the collateral's utility, and the buyer breaks even. He modeled the haircut and repo rates employing VaR and Expected Shortfall (ES) methods.[2] However, the VaR and ES methods gave different haircuts and repo rates. The ES method increased the haircut and repo rates, whereas the VaR method increased the haircut rate and reduced the repo rate. The formula showed that the repo and haircut rates were functions of borrower bankruptcy probability from the lender's point of view and VaR and ES with a 1-α confidence interval in which the α depended on the return rate of the borrower's projects and default risk. Chebotarev (2020) established the repo and haircut rates formula; however, the size of α was debatable, and the models did not match the existing collateral framework.

[2] Expected Shortfall is the average loss value conditional on the loss exceeding the VaR (Chebotarev, 2021).

The motivation of this study is to determine the haircuts of government and corporate guarantees when the central bank establishes the same repo rate. We limit our government securities data to developing Asian countries, i.e., Indonesia, Malaysia, and Thailand. These three countries have flexible exchange rate regimes and highly volatile exchange rates triggered by capital flows (Everaert and Genberg, 2020; Beja, 2007; Beja, 2006; Juhro *et al.*, 2021). Our robustness test focuses on Indonesian data because Indonesia has experienced high-risk economic periods. Some bonds are non-sensitive to exchange rate changes, i.e., *Perusahaan Listrik Negara* (PLN, an Indonesian corporate) and Hongkong government securities for an extension. [3]

We address three objectives. First, we identify the determinants of the collateral haircuts, such as collateral maturity (see Baklanova *et al.*, 2019; Julliard *et al.*, 2019), collateral quality (see Baklanova *et al*., 2019; Julliard *et al.*, 2019), bond yields (see Nguyen, 2020), and interest rates (see Julliard *et al*., 2019). Since developing Asian countries are prone to capital market inflows and outflows, we also consider exchange rate and implied volatility. Second, we identify haircut determinants in highly tensed economies. In a depressed economy, the repo is an essential tool of the lender of the last resort. The financial market climate can vary while central banks manage repo transactions. Third, we determine the central bank's implicit acceptable risk of the haircut rate. Repo participants need to know the central banks' risk tolerance used to determine haircuts. On the other side, the borrowers/commercial banks need to know the collateral haircuts, whereas the lender/the central bank wants to know the excessive risk beyond haircuts.

We contribute to the literature by introducing two methods to determine haircuts. The first is a negative return model with some determinants, including liquidity, credit default swaps, exchange rate, money market, and implied exchange rate volatility. The second method entails historic and parametric VaRs employing α-rank loss as a quantile measure of acceptable loss deduction by the central bank when the borrower fails to pay. The first and the second objectives convey the first method, while the third objective conveys the second method.

We implement the Generalized AutoRegressive-Conditional Heteroskedasticity (GARCH) and the Ordinary Least Squares (OLS) models with significant independent variables, such as long-memory returns/previous capital gain, liquidity, and exchange rates. [4] The robustness tests show that these determinants remain statistically significant in good and bad times. The -5% shocks of long-memory return and exchange rate depreciation lead to less than a 1% increase in haircuts. Based on the longest repo maturity (3 months) and bonds maturity bucket, we find the lowest and highest implicit tolerance are Malaysia (α=3.46%) and Hong Kong (α=29.88%), while Indonesia has α=18.22 %.

We proceed with this article; the following section describes the methodology, empirical procedures, and research data. Section three reports the tests and results. Then, the last section presents the concluding remarks and some implications.

[3] The issuer implements the currency board system.

[4] Bond's capital gain is the profit or loss from its clean price/Net Present Value (NPV).

II. DATA AND METHODOLOGY

A. Haircut Model and Determinants

A haircut compensates for bond market risk when a counterparty risk exposes the seller (Choudhry, 2010). Therefore, the haircut rate depends on a clean price movement of bond collateral. Julliard *et al*. (2019) find that maturity and collateral quality are the most critical determinants of haircut rates. Thus, we develop the bond's capital gain/return functions based on bond maturity and collateral quality. Since haircut compensates for collateral loss, haircut relates to negative percentage returns as follows:

$$R_{x\_y,t} = \frac{P_{x\_y,t} - P_{x\_y,t-1}}{P_{x\_y,t-1}} \tag{1}$$

$$HC_{x\_y,t} = min\left(-1 \times R_{x\_y,t}, 0\right) \tag{2}$$

where x_y is the collateral maturity bucket (a group of bonds with maturities between x [lower maturity boundary] and y [upper boundary]), t denotes time, R is the bond percentage return, HC is the haircut, and P is the clean price of the bond.

We develop a haircut model (Equation 2) as a function of market risk, liquidity, money market rate, and profit or loss momentum/long-memory return/previous capital gain factors (Julliard *et al*., 2019; Nguyen, 2020; Baklanova *et al*., 2019) as follows,

$$\because R_{x\_y} = \alpha + \beta_1\, AR(1) + \beta_2\, LIQ + \beta_3\, CDS + \beta_4\, EXRATE + \beta_5\, PUAB + \beta_6\, VOLER + \varepsilon$$

$$HC_{x\_y} = min\left(-R_{x\_y}, 0\right)$$

$$\therefore HC_{x\_y} = min\left(0, -\alpha - \beta_1\, AR(1) - \beta_2\, LIQ - \beta_3\, CDS - \beta_4\, EXRATE - \beta_5\, PUAB - \beta_6\, VOLER + \varepsilon\right) \tag{3}$$

where *AR(1)* is a long-memory return, *LIQ* is a liquidity measure, *CDS* is credit default swaps rates, *EXRATE* is the domestic exchange rate that represents capital flow, *PUAB* is the money-market interest rate, and *VOLER* is an implied exchange rate volatility.

The *AR(1)* is an autoregressive factor; specifically, it is a lagged return (*R[-1]*) (or -return(-1), previous capital gain) which depends on market information. Persistent positive or negative information will create a long memory for asset price movements or persistent price direction (Asif and Frömmel, 2022; Jegadeesh and Titman, 2002), including bond prices (Abakah and Gil-Alana, 2021). Thus, the long-memory of positive or negative price movements does not immediately reverse direction; hence haircut movements do not immediately reverse direction.

Liquidity indicates the ease with which the instruments can be bought or sold (see Bhattacharya and Gale, 1987). We have two liquidity (*LIQ*) measures, market price variation/total price movement (HL_{x_y}) and bid-ask spread (BAS_{x_y}). The

first measure, the Highest-Lowest price spread (HL_{x_y}) is the intraday difference between the highest and lowest prices of several bonds in a maturity bucket, from x maturity to y maturity (Mazza and Petitjean, 2016). This difference represents short-term movement since intraday shocks (Liu *et al*., 2020). Generally, market-fundamental information does not immediately change price direction, but the supply and demand imbalances (Liu and Park, 2015). The imbalanced participants cause price movements to increase and haircuts to decrease (Nguyen, 2020). The price movement factor is always positive when the price is moving either way. In this paper, we interact HL_{x_y} with price direction/return sign (RS_{x_y}). The second measure, the *BAS*, is the difference between *Px_Ask* and *Px_Bid* and is the cost of buying and selling government bonds (Demsetz, 1968; Amihud and Mendelson, 1986). This difference represents a transaction fee (Demsetz, 1968). The smaller the price gap, the more liquid the market is, and vice versa (Foucault *et al*., 2005). According to Amihud and Mendelson (1986), the higher the expected profit/loss of an asset, the wider the bid-ask spread. The bid-ask spread factor, BAS_{x_y}, always gives positive signs when prices move up or down. The return-sign dummy (RS_{x_y}) is so essential that their interactions ($BAS_{x\_y} \times RS_{x\_y}$) exhibit the up and down movements.

The *CDS* variable represents the insurance cost of the bond-issuing entity and reflects the domestic-fundamental (default) risk since the bonds are issued by governments. An increase in credit risk, *CDS*, will increase the sovereign risk premium and the nominal interest rate, decreasing bond returns; haircut is rising (Nguyen, 2020).

The variable *EXRATE* is the United States Dollar spot rate against the domestic currency, which reflects the flow of capital flows. Purchase and sale of domestic financial assets induce capital flows (Titiheruw and Atji, 2010; Goeltom, 2008; Warjiyo, 2013; Breuer, 2018; Basorudin *et al.,* 2021).

The *PUAB* variable is the interbank money market/short-term time deposit rate. *PUAB* increments will invite capital inflows/speculative investors leading to an appreciation of the rupiah and purchasing Indonesian assets, one of which is increasing bond prices (Titiheruw and Atji, 2010; Goeltom, 2008; Warjiyo, 2013; Breuer, 2018; Basorudin *et al*., 2021). Conversely, in 2020 during the COVID-19 pandemic, Indonesia's policy rate was decreasing, and investors sold over USD 5 billion of domestic stocks and bonds; this caused capital flight and a decrease in asset prices (Basorudin *et al*., 2021). The flow triggers domestic currency depreciation, an increase in the yield curve, and a decrease in clean prices. However, we have an alternative theory, the uncovered interest rate parity (Choudhry, 2010). According to the theory, the increasing *PUAB* will depreciate domestic currency instead of its appreciation.

We have three other reasons why the *PUAB* variable may not influence the haircut. The first reason, Baklanova *et al*. (2019) found a weak money-market effect on haircuts. The second reason, the preferred habitat, and market segmentation theories explain that investors' expectations of short-term and long-term instruments differ (Fama, 1970). The highest fixed income cash flow is at its maturity, which may be longer than *PUAB* maturity (see chapter 2 of Fabozzi and Fabozzi, 2021). Therefore, the changing *PUAB* will not move the long-term discount factor and bond clean price. The last reason is that increasing or

decreasing short-term interest rates may shift the parallel component movement across maturities (Nelson and Siegel, 1987). An increase in the money market rate will cause a parallel increase in the yield curve so that the bond's clean prices move downwards and add up the haircut.

The *VOLER* variable is an expected/*ex-ante*/implied domestic currency rate standard deviation reflecting fundamental domestic risks. Increasing market risk leads to increased risk premiums in the yield curve, increasing investor fears, lowering clean prices, and jumping up haircuts.

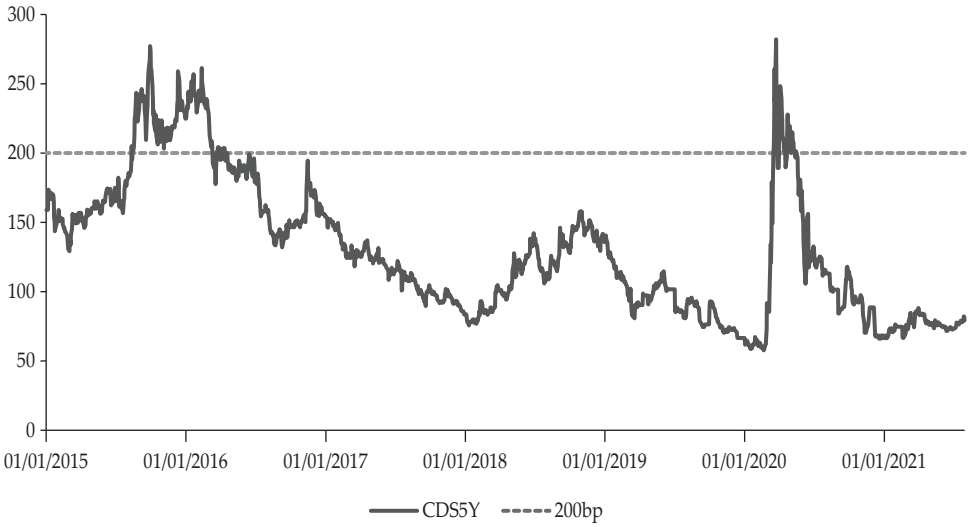
B. Robustness Tests

This study controls economic risk to ensure the model's reliability and its determinants. In particular, we observe the model during high-risk economic conditions and without currency effect.

High-risk economic conditions: We subjectively select 200bp sovereign CDS as a threshold of high-risk economic condition since the *CDS* rate seldom reaches this point (Figure 1). If the *CDS* rate is more than this threshold, then the economy is in a high-risk condition ("HR"); otherwise, the economy is in a normal condition ("not-HR").

Figure 1.
Indonesian Five-year Credit Default Swap

We use this daily graph to define "*HR*" period. *HR =1* between 1 August 2015 and 9 March 2016 and between 24 February 2020 and 08 June 2020. Source: Bloomberg (2021).



The model used to compare results for both the regular and high-risk economic conditions is as follows:

$$HC_{x\_y} = min(0, -\alpha - \beta_1\, AR(1) * HR - \beta_2\, LIQ - \beta_3\, CDS - \beta_4\, EXRATE * HR - \beta_5\, PUAB - \beta_6\, VOLER + \varepsilon) \quad (4)$$

where "*HR"* is a dummy variable that equals one if the Indonesian five-year *CDS* rate increases by more than 200 basis points (bp) and zero otherwise.

After getting the β_1 and β_4 in Equation 4, we simulate haircuts when the previous capital gain/long-memory return shocks are 5%, and the exchange rate depreciates by 5%. There are two simulations, "*HR*" and "*not-HR*." the simulation shows the haircut differences aftershocks between "*HR*" and "*not-HR*."

Our prediction of *AR(1)* × *HR* interaction is that the "HR" interaction sensitivity (β_1 of Equation 4) generates a higher positive value than the "not-HR" interaction. Since most investors are risk-averse, bond prices drop to avoid high-risk investments (Amato, 2005; Lizarazo, 2013). Therefore, the higher the default risk, the higher the "HR" interaction sensitivity.

Conditions without currency risk: this study regresses capital gain data of Hong Kong government bonds on *EXRATE* as an exchange-rate robust test since Hong Kong implements the Currency Board System regime. In addition, the PLN corporate bonds regressions are also a currency-robust test because the issuer only operates domestically and has no foreign currency risk exposure.

We predict that the *EXRATE* and "*HR*" interaction produces "*HR*" interaction sensitivity (β_4 of Equation 4) lower than "*not-HR*." We do not have an immediate explanation that *EXRATE* sensitivity during lower default risk is more substantial than higher default risk, but we can clarify it in some premises. Because the better the sovereign credit rating, the higher the capital flows (Kim and Wu, 2008). Therefore, the higher the capital inflow or, the lower the credit risk, the higher the *EXRATE* sensitivity (Rafi and Ramachandran, 2018; Grigorian, 2019) and bond price (Dou and Verdelhan, 2015; Grigorian, 2019). The capital flows' volatility in emerging countries, including our data countries, is 80 percent higher than in developed countries (Broner and Rigobon, 2004).

C. Implicit Risk Tolerance Hypothesis

According to the bond duration model (duration is equivalent to maturity), the higher the bond duration, the more sensitive the price is to changes in yield. Thus, our hypothesis for the risk hypothesis across the maturity bucket of collateral is:

$$H_0 : \alpha_q \geq \alpha_p, \text{ or } HC_q < HC_p$$

$$H_1 : \alpha_q < \alpha_p, \text{ or } HC_q > HC_p$$

where p and q are the bonds' maturities, $p>q$, HC and α are absolute numbers.

The longer the repo observation period, the more diverse the economic news flow and changes to the risk premium. Similarly, the longer the repo maturity period, the more information changes, and the more the risk premium variation affect the interest rate. Thus, our hypothesis for the risk hypothesis across repo maturity is:

$$H_0 : \alpha_n \geq \alpha_m, \text{ or } HC_n < HC_m$$

$$H_1 : \alpha_n < \alpha_m, \text{ or } HC_n > HC_m$$

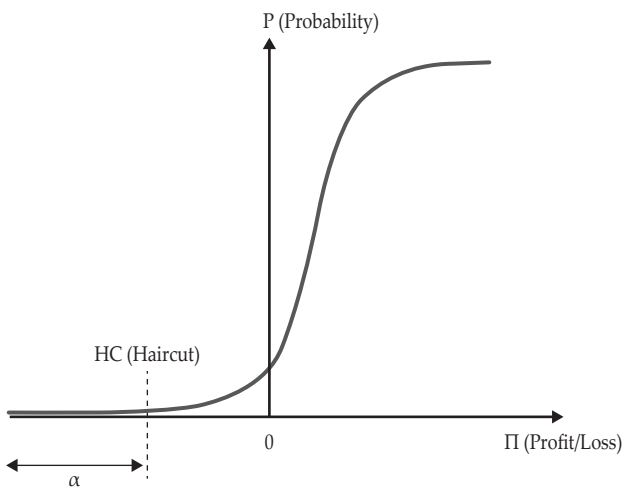
where m and n are repos maturities, and $m>n$, *HC*, and α are absolute numbers.

D. Value at Risk Method to Determine HC

Individual asset or asset group brings distinctive mean and standard deviation. Therefore, each asset inherently has a unique Cumulative Distribution Function (CDF) line (see Figure 2). The asset can be corporates and governments with different mean and standard deviations. The central bank (lender) sets the α-percentile, in which the bank (borrower) sacrifices a part of the loan, which the central bank keeps as an *HC*. The central bank bears the losses beyond the "*HC*" when there is a counterparty credit event. Therefore, we can say α is the central bank's risk tolerance.

Figure 2.
The Locations of α and *HC* in the Cumulative Distribution Function

The capital gain/profit (Π) probability is a cumulative distribution function of the collateral profit when the borrower fails to pay. A lender expects the collateral's market loss is no more than "*HC*." In this figure, α and "*HC*" are absolute numbers. The narrower the α (shifting α to the left) is, the bigger the losses and the higher the "*HC*."



Collateral asset price movement is random and follows a normal distribution function. A borrower provides an asset collateral as a lender settles up the loan that is less than or as much as the haircut-reduced collateral price. The borrower and the lender mitigate an insolvency problem and share the collateral's market risk to compensate for the decreasing collateral price. In the case of counterparty default, the loan amount should be less than or as much as the sale of collateral price. We use the Value-at-Risk method to measure the statistical loss of collateral asset price as much as α-percentile (Figure 2). Therefore, the borrower gives up a part of its receivable cash as much as a haircut to cover the potential lack of funds from collateral proceedings when a borrower fails to pay. However, a haircut can not be so big that the borrower/buyer has to share some risk with a lender/seller. The lender picks up the exposure below the α-percentile.

E. Steps on Grouping Bond Returns and Liquidity Measures

We group the capital gain/return, High-Low price spread (HL), and Bid-Ask Spread (BAS) across issuers, collateral maturities, and repo maturities in three separate sets. The steps are:

(i) Calculate each bond's price return, high-low price spread (HL), and bid-ask spread (BAS).
(ii) Do the following in case of liquidity measures,
    a) Establish a return-sign dummy (RS_{x_y}) which indicates the price direction. If the return is positive, the dummy equals one. Otherwise, the dummy is a negative one.
    b) Interact *HL* with the RS_{x_y}
    c) Interact *BAS* with the RS_{x_y}
(iii) Group each set across maturity bucket, consisting of 0-1.1-3, 3-5, 5-7, 7-10, 10-15, 15-20, and 20-30 years.
(iv) Group each set into repo maturity, consisting of one week, two weeks, one month, and three months.

F. Steps to Measure Implicit Risk Tolerance

To measure the central bank's implicit risk tolerance, we determine statistical parameters and calculate the α-percentile using parametric VaR, and the steps are as follows:

(i) Calculate the mean of group return;
(ii) Calculate the standard deviation;
(iii) Get the central bank's "HC,"
(iv) Calculate the α-percentile with the "HC," mean, and standard deviation.

G. Steps to Calculate Haircut

The central bank has two risk options to select "HC" as follows:

(i) Risky ($-\infty < \Pi < 0$, or $HC > 0$). We convert from the central bank's haircut to the α-tolerance (see Section II.F). Then, calculate the haircut based on α tolerance, α=1%, 5%, and 10%.
(ii) No-Risk ($\Pi \geq 0$, or $HC = 0$). Instead of parametric VaR, we use historical VaR since its lowest return point depends on data granularity. The central bank can choose a haircut depending on data tightness and the most prominent historical loss.

H. Data

Unlike studies such as Baklanova *et al.* (2019) and Julliard *et al.* (2019), we do not observe any repo transactions, instead fixed-income securities prices. Table 1 shows the security names and issuers. Our data spans from 1 January 2015 to 27 July 2021. The data contains high-risk periods (Figure 1) for robustness tests from 1 August 2015 and 9 March 2016 and between 24 February 2020 and 08 June 2020 (the COVID-19 pandemic). Table A.1 in the Appendix displays downloaded data, i.e., a statistical summary of daily government bond prices, exchange rate level

and implied volatility, sovereign (credit) default swaps, and money market rates. To prepare liquidity data, we derive it from bond prices.

Table 1: Total and Type of Bonds

This table shows the collaterals, their issuers, the number of bond series, and the issuer class—Source: Bloomberg. *PLNIJ is a name of corporate bonds. Their issuance is *Perusahaan Listrik Negara*.

Collateral	Full Name of Collateral	Issuer Country	Number of Bond Series	Issuer Class
INDOGB	Indonesia Government Bond	Indonesia	63	Government
MSG	Malaysia Government Bond	Malaysia	140	Government
THAIGB	Thailand Government Bond	Thailand	65	Government
HKGB	Hong Kong Government Bond	Hong Kong	114	Government
*PLNIJ**	Perusahaan Listrik Negara Bond	Indonesia	54	Corporate

Zaremba *et al*. (2021) observed 31 developed and emerging countries (North America, Europe, Asia, Africa, and Oceania). These governments responded to the COVID-19 outbreak by stabilizing their sovereign bond markets. Market stabilization has been instrumental in decreasing volatility. Bizuneh and Geremew (2021) found that the COVID-19 pandemic affected GDP growth and political stability, which enlarged the risk premium of government bonds. We do not separate the data into pre and during-COVID-19 periods; however, we group the data based-on credit risk level (Figure 1).

III. RESULTS AND DISCUSSION

A. Identifying Haircut Determinants under Different Economic Conditions

After grouping bond return and liquidity measures (Section II.E), we regress the haircut determinants under normal, high-risk, and without currency-risk conditions (Table 2). These results are the product of the GARCH(1,1) model subject to unit root and heteroscedasticity tests (Table A.3 and A.4 Appendix); otherwise, we use the OLS model for PLN data.

The regression displays commonly significant determinants, i.e., long-memory return or autoregression process, *LIQ*, and *EXRATE* across entities, maturity buckets, and repo maturities. Indonesia, Malaysia, and Thailand have common characteristics, namely flexible exchange rate regimes and highly volatile capital flows (Everaert and Genberg, 2020; Beja, 2007; Beja, 2006), which may cause significant determinants. The capital inflow/outflow causes exchange rate movement (Basorudin *et al.,* 2021; Juhro *et al*., 2021), significantly affecting the collateral return and haircut. Even though Malaysia implements an exchange rate targeting framework (Juhro *et al.,* 2021), Table 2 displays that 31 out of 32 models of the exchange rate in the country significantly influence bond price movement/haircut rate. Furthermore, *HL* price and *BAS* determinants are so significant that market price movement and bid-ask spread affect prices and haircuts when the market has a demand-supply imbalance.

Table 2.
Significant Determinants of Haircuts

This table shows the GARCH(1,1) regression output across repo maturities consisting of 1 week, two weeks, one month, and three months. The collateral maturity comprises eight bond-maturity buckets, i.e., 0-1, 1-3, 3-5, 5-7, 7-10, 10-15, 15-20, and 20-30, except PLN Indonesia and Hong Kong entities, which have six maturity buckets. The determinants are *AR(1)* (an autoregressive determinant), *AR*(1) × *HR* (the interaction between autoregressive and high-risk dummy), *LIQ* (liquidity indicators consisting of *BAS* and High-Low), *CDS* (credit default swaps), *EXRATE* (the USD/IDR exchange rate), *EXRATE* × *HR* (the interaction between USD/IDR exchange rate and a high-risk dummy), *PUAB* (the Interbank money market rates), and *VOLER* (implied volatility of exchange rate). The symbol ✓ mark denotes predominantly significant, while the - sign indicates insignificant. Below the marks, "a/b" consists of 'a,' a tally count of no rejection, and 'b' is the total trials.

Description:

(§) The HL is significantly positive, and *BAS* has a significantly negative sign. However, the sum of the two coefficients remains negative. Indonesian entity experiences this at maturity of one week in maturity bucket 10_15. The event on the Malaysian entity occurs at maturity of one week in maturity bucket 7_10. Events on the Thai entity occur at three months in maturity bucket 0_1.

(§§) HL, without *BAS*, has a positive significance. Hong Kong has an alternative event (see section 3.3.2) at three-month maturity and 0_1 maturity bucket.

(§§§) This study found alternative positive events. Malaysian entity shows the event at maturity of 1 week and maturity bucket 0_1, three trials of the Thai entity, three trials of the PLN entity, and four trials of the Hong Kong entity.

(§§§§) This study found an alternative adverse event in the normal and high-risk condition of the Indonesian entity, and the Malaysian entity has as many as 14. Thai entity gets as many as 5. PLN entity gets as many as 3. Hong Kong entity gets as many as 4.

(§§§§§) This study found a single alternative adverse event in Thailand and PLN entities.

† In the case of Indonesia high-risk, the interaction is *AR(1)* × *(1-HR)* or previous capital gain during normal economics.

†† In case of Indonesia high-risk, the interaction is *EXRATE(1)* × *(1-HR)* or exchange rate during normal condition.

	Indonesia Normal	Indonesia High-Risk	Malaysia	Thailand	PLN Indonesia	Hongkong
AR(1)†	✓	✓	✓	✓	✓	✓
	(32/32)	(19/19)	(32/32)	(28/28)	(24/24)	(24/24)
AR(1) × *HR*		✓				
		(7/7)				
LIQ	✓§	✓	✓§	✓§	✓	✓§§
	(26/32)	(23/26)	(31/32)	(28/28)	(24/24)	(23/24)
CDS	-	-	-	-	-	-
	(0/32)	(0/26)	(0/32)	(2/28)	(1/24)	(1/24)
EXRATE††	✓	✓	✓§§§	✓§§§	-§§§	-§§§
	(32/32)	(19/19)	(31/32)	(21/28)	(2/24)	(3/24)
EXRATE × *HR*		✓				
		(7/7)				
PUAB (*MONEY MARKET*)	-§§§§	-§§§§	-§§§§	-§§§§	-§§§§	-§§§§
	(0/32)	(0/26)	(2/32)	(1/28)	(0/24)	(1/24)
VOLER	-	-	-	-§§§§§	-§§§§§	-
	(1/32)	(1/26)	(0/32)	(1/28)	(1/24)	(1/24)

The regression determinants which are insignificant or significantly zero coefficients are *CDS*, *MONEY MARKET* (*PUAB*), and *VOLER*. Like Baklanova *et al*. (2019), the *MONEY MARKET* does not affect haircuts. Since the *MONEY MARKET* maturity is less than a year while bonds are more than a year, the short-

term interest rate may not affect the long-term interest rates. We find that *VOLER* does not affect haircut movement. Haircuts do not reflect domestic or market collateral risks, such as *CDS* and *VOLER*. However, the exchange rate depends on the short-term interest rate containing some domestic risk premiums, which *CDS* and *VOLER* represent the premiums.

B. Robustness and Stress Tests

B.I. Robustness Test

Table 2 reports two robustness tests, Indonesia entity's haircut during "HR" and other entities without foreign currency exposure. In the first robustness test, we compare regression coefficients for normal ("not-HR") and high-risk economic conditions ("HR"). Equation 3 is robust since the "not-HR" model, and "HR" shows no difference in Table 2. The absence of more severe Indonesian high-risk data (Figure 1) is debatable. The *AR(1)* interaction with "HR" and "not-HR" shows significant results with 19 outputs during "not-HR" and seven regressions during "HR," in line with Amato (2005) and Lizarazo (2013). "HR" output number, 26 regressions, has a reduction from unsegregated "HR" and "not-HR" tally count, 32 regressions, since insignificant output, i.e., 1-month repo with 15_20, 20_30 collateral maturities, and 3-month repo with 0_1, 1_3, 3_5, and 20_30 collateral maturities.

In the last test, Equation 3 is robust since the haircut models of PLN Indonesia, and Hong Kong governments' bonds are similar to those of the Indonesia, Thailand, and Malaysia governments but without *EXRATE* determinants. The table displays 24 significant regressions for each PLN Indonesia and Hong Kong government bond since they have limited issuances.

Consistently, *EXRATE* interaction with "HR" and "not-HR" shows significant results with 19 outputs during not "HR" and seven regressions during "HR," in line with Titiheruw and Atji (2010), Goeltom (2008), Warjiyo (2013), Breuer (2018) and Basorudin *et al*. (2021).

B.II. Haircut Stress-test

Table 3.
Haircut Stress Test under High-Risk and Normal Economic Conditions

Haircut increases when there are -5% shocks of AR(1)/long-memory return/capital gain and the rupiah depreciation. The table displays the haircuts under high-risk ("HR"), normal ("not-HR," with square brackets) conditions, and the spread between high-risk and normal conditions (with curly brackets). We attach a cross mark (†) when the haircut movement under normal conditions ("not-HR") is higher than high-risk ("HR"). Unfortunately, we cannot simulate some cells where *AR(1)* and *EXRATE* have insignificant coefficients.

*The highest difference between high-risk and normal haircuts. **The lowest difference between high-risk and normal haircuts.

1 Week	Additional HC	2 Weeks	Additional HC	1 Month	Additional HC	3 Months	Additional HC
AR(1) 0_1 †	3.57% [3.73%] {-0.16%}	*AR*(1) 0_1	4.46% [4.42%] {0.04%}	*AR*(1) 0_1	4.75% [4.75%] {0%}	*AR*(1) 5_7	4.94% [4.92%] {0.02%}
AR(1) 1_3	4.67% [4.23%] {0.44%}	*AR*(1) 1_3	4.55% [4.46%] {0.09%}	*AR*(1) 1_3	5.00% [4,91%] {0.09%}	*EXRATE* 7_10 †	0.62% [1.04%] {-0.42%}**
AR(1) 3_5	4.19% [4.19%] {0%}	*AR*(1) 3_5	4.70% [4.68%] {0.02%}	*AR*(1) 3_5	4.86% [4.86%] {0%}	*EXRATE* 10_15 †	0.84% [0.85%] {-0.01%}
AR(1) 5_7	3.95% [3.74%] {0.21%}	*AR*(1) 5_7	4.93% [4.81%] {0.12%}	*AR*(1) 7_10	4.88% [4.88%] {0%}	*EXRATE* 15_20 †	0.69% [1.07%] {-0.38%}
AR(1) 7_10	4.10% [3.83%] {0.27%}	*AR*(1) 7_10	4.80% [4.72%] {0.08%}	*EXRATE* 5_7 †	0.27% [0.58%] {-0.31%}		
AR(1) 10_15	3.91% [3.40%] {0.51%}	*AR*(1) 20_30	4.49% [4.26%] {0.23%}	*EXRATE* 10_15 †	0.58% [0.85%] {-0.33%}		
AR(1) 15_20	4.51% [3.86%] {0.65%}*	*EXRATE* 10_15 †	0.85% [1.01%] {-0.16%}				
AR(1) 20_30	4.08% [3.85%] {0.23%}	*EXRATE* 15_20 †	0.98% [1.09%] {-0.11%}				

Table 3 shows that *AR(1)* and "HR" interaction during "HR" delivers higher haircuts than "not-HR," except for the 1-week repo and 0_1 maturity bucket. The interaction behavior concurs with Amato (2005) and Lizarazo (2013) that risk-aversed investors make liquid bonds only during "not-HR." Contrarily, the table also displays that the *EXRATE* and "HR" interaction during "not-HR" yields higher haircuts than "HR." This conduct agrees with Rafi and Ramachandran (2018), Grigorian (2019), and Dou and Verdelhan (2015).

The highest "HR" condition is 5% of the 1-month repo and 1-3 maturity bucket. The highest "not-HR" is 4.92% of the 3-month repo and 5-7 maturity bucket. The 5% shocks of long-memory returns/capital gains and the exchange rate cause a small change, less than ±1%, in haircuts between high-risk and non-high-risk.

C. Implicit Risk Tolerance Hypothesis Tests

Table 4 shows the risk tolerances of some central banks (see Section II.F). Their bearable risks are as follows (in sequence): Indonesia (BI) 18.22%, Malaysia (BNM) 3.46%, Thailand (BoT) 21.62%, PLN (Hypothetical) 25.66%, and Hong Kong (HKMA) 29.88%.

Table 4.
Central Bank's Implicit Risk Tolerance

This table shows the risk that the central bank can tolerate.

Repo Maturity	Central Bank	*Maturity Bucket*							
		0_1	1_3	3_5	5_7	7_10	10_15	15_20	20_30
1 Week	Indonesia	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.04%	0.02%
	Malaysia	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Thailand	0.00%	0.00%	0.00%	0.00%		0.00%	0.00%	0.01%
	Hong Kong	0.00%	0.00%	0.00%	0.03%	0.52%	4.03%		
2 Weeks	Indonesia	0.00%	0.00%	0.00%	0.01%	0.14%	0.74%	1.34%	1.38%
	Malaysia	0.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%	0.05%
	Thailand	0.03%	0.00%	0.00%	0.00%		0.00%	0.11%	1.06%
	Hong Kong	0.00%	0.00%	0.00%	0.74%	3.66%	10.78%		
1 Month	Indonesia	0.00%	0.00%	0.00%	0.21%	1.13%	3.15%	4.46%	5.00%
	Malaysia	0.23%	0.00%	0.00%	0.00%	0.00%	0.03%	0.34%	0.72%
	Thailand	0.64%	0.00%	0.00%	0.00%		0.09%	1.40%	5.09%
	Hong Kong	0.00%	0.00%	0.06%	2.79%	8.44%	16.49%		
3 Months	Indonesia	0.00%	0.00%	0.60%	4.29%	8.11%	12.88%	15.56%	18.22%
	Malaysia	0.48%	0.00%	0.02%	0.00%	0.04%	0.96%	3.20%	3.46%
	Thailand	3.60%	0.00%	0.00%	0.00%		3.56%	13.42%	21.62%
	Hong Kong	0.00%	0.00%	3.70%	13.92%	23.24%	29.88%		

Tables 5 and 6 display the proven risk hypothesis tests across the maturity buckets and repo maturities (Section II.C).

Table 5.
Implicit Risk Hypothesis Test across the Maturity Buckets

This table reports the results of the implicit risk hypothesis test across the maturity buckets. The numerator is the tally counts of not rejecting H_0 over the number of trials (Denominator). Most of them are not rejecting H_0.

Entities	Number Not Reject H_0
Indonesia	27/28
Malaysia	23/28
Thailand	20/24
PLN Indonesia	20/20
Hong Kong	20/20

Table 5 displays strong evidence of non-rejection of H_0, which aligns with the duration theorem that the longer the maturity bucket, the smaller the α.

Table 6.
Implicit Risk Hypothesis Test across the Repo Maturity

This table reports the implicit risk hypothesis test results across the repo maturity buckets. The numerator is the tally count of not rejecting H_0 over the denominator, which is the trial number. Most of them are not rejecting H_0.

Entities	Number Not Reject H_0
Indonesia	24/24
Malaysia	24/24
Thailand	21/21
PLN Indonesia	18/18
Hong Kong	18/18

Table 6 displays strong evidence of non-rejection of H_0, which aligns with the longer the repo maturity, the smaller the α.

Tables 7 and 8 exhibit calculated haircuts under risky and zero-risk conditions (Section II.G).

Table 7.
Bank Indonesia Haircuts of Given Risk (α = 1%, 5%, and 10%)

This table reports the haircuts given α = 1%, 5%, and 10%. Govt. and Corp. denote government and corporate bonds (PLN Indonesia). The HC_{x_y} indicator denotes collateral haircut from x to y maturity.

Maturity	Type	α	HC0_1	HC1_3	HC3_5	HC5_7	HC7_10	HC10_15	HC15_20	HC20_30
1 Week	Govt.	1%	0.00166	0.00767	0.01247	0.01924	0.02837	0.03485	0.03748	0.036942
		5%	0.000819	0.00395	0.00819	0.01211	0.01638	0.02047	0.02193	0.021567
		10%	0.0005	0.00264	0.00592	0.00903	0.01161	0.01501	0.0165	0.013793
	Corp.	1%		0.00929	0.01515	0.02323	0.04479	0.07003	0.07258	
		5%		0.0054	0.0098	0.01704	0.01904	0.03217	0.05641	
		10%		0.00425	0.00738	0.00944	0.01133	0.01959	0.02811	
2 Weeks	Govt.	1%	0.00235	0.01092	0.01931	0.02996	0.04122	0.05263	0.06193	0.06781
		5%	0.00111	0.00663	0.01282	0.01886	0.02491	0.03086	0.03482	0.03571
		10%	0.00063	0.00451	0.01	0.01471	0.01839	0.02308	0.02563	0.02526
	Corp.	1%		0.01168	0.01926	0.02539	0.05061	0.11263	0.13307	
		5%		0.00771	0.01328	0.01965	0.03062	0.04216	0.06323	
		10%		0.00631	0.01106	0.01516	0.01873	0.03022	0.04304	
1 Month	Govt.	1%	0.0032	0.01308	0.02335	0.03651	0.04775	0.05874	0.06178	0.06939
		5%	0.0014	0.00809	0.01689	0.02517	0.03208	0.03909	0.04523	0.04538
		10%	0.00064	0.00611	0.01362	0.01998	0.02418	0.03145	0.03534	0.03581
	Corp.	1%		0.01469	0.02025	0.02574	0.04843	0.118	0.13745	
		5%		0.01138	0.01744	0.02313	0.0398	0.07379	0.08775	
		10%		0.00838	0.01575	0.02063	0.02768	0.04158	0.05584	
3 Months	Govt.	1%	0.00322	0.02214	0.04053	0.05834	0.0705	0.08055	0.09413	0.10229
		5%	0.00168	0.01237	0.02831	0.04186	0.05094	0.06074	0.06678	0.07213
		10%	0.00056	0.00852	0.02128	0.03092	0.03824	0.05031	0.05655	0.06198
	Corp.	1%		0.02128	0.04074	0.05274	0.06497	0.12173	0.19269	
		5%		0.01715	0.03062	0.0394	0.05888	0.09455	0.10805	
		10%		0.01558	0.02551	0.03452	0.05243	0.07619	0.08783	

Table 7 shows that the "HC" selection exposes risk to the central bank. The Indonesian government and corporate collaterals have different haircuts of each α, such as 10.22 % (α = 1%), 7.21% (α = 5%), 6.20% (α = 10%), and for a corporate bond is 19.27% (α = 1%), 10.81% (α = 5%), and 8.78% (α = 10%). The vertical relationship within an issuer; the smaller the α, the higher the haircut or collateral loss (see Figure 2). Horizontally at α=1%, 5%, and 10%, the longer the maturity bucket or repo maturity, the higher the haircut (hypothesis test in Tables 5 and 6).

Because the government's standard deviations are generally more minor than corporates (see Appendix Table A.5). The government's average return is higher than corporates, in contrast to modern portfolio theory (Markowitz, 1952), which expects returns to increase when risk increases. The difference between corporate and government bonds is that corporate bonds have a higher risk than government bonds, as indicated by the return's average and standard deviation. However, Hong and Warga (2000) and Black *et al.* (2013) argue that corporate bonds are less liquid than government bonds, leading to flawed prices.

Table 8.
Haircut of No-risk Collaterals of Bank Indonesia

This table shows the haircut rates taken from the minimum yield (historical), i.e., α=0. Govt. and Corp. denote government and corporate bonds (PLN Indonesia). The HC_{x_y} indicator denotes collateral haircut from x to y maturity.

Maturity	Type	HC0_1	HC1_3	HC3_5	HC5_7	HC7_10	HC10_15	HC15_20	HC20_30
1 Week	Govt.	0.00631	0.01636	0.02945	0.05358	0.06083	0.07033	0.0708	0.081879
	Corp.		0.01031	0.01091	0.02248	0.03317	0.04577	0.06348	
2 Weeks	Govt.	0.00941	0.02184	0.0456	0.08233	0.10185	0.12094	0.11687	0.14509
	Corp.		0.00992	0.01381	0.02564	0.05347	0.05204	0.05627	
1 Month	Govt.	0.01144	0.02334	0.05286	0.08322	0.10288	0.12552	0.11914	0.137
	Corp.		0.01288	0.01802	0.03271	0.04575	0.05349	0.07807	
3 Month	Govt.	0.02165	0.03315	0.04943	0.06797	0.08322	0.0991	0.1213	0.1196
	Corp.		0.00777	0.0106	0.01825	0.03009	0.05998	0.09929	

The historical VaR makes us possible to define a no-risk exposure to a central bank, i.e., α=0 (see Table 8). The haircut for all government bonds is 12.55%, and for corporate bonds is 9.929%, which means haircut is the only absorption of market risk. Most government haircuts increase along with the maturity bucket and the repo maturity, but corporate haircuts do not have this phenomenon of repo maturity. The missing characteristic is possibly due to insufficient corporate (PLN) data, 343, while government data was 1718 or the illiquidity problem.

IV. CONCLUSION AND IMPLICATIONS

There are some methods to set up the repo rate and repo haircuts, such as the implied repo rate formula and other rigorous pricing models. However, in the current trend of central banks establishing the repo rate, ECB's collateral framework, and substituting between repo rates and haircuts, most central banks set repo rates equal to central banks' interest rates, including policy rates and haircuts as much as the market risk premium of collaterals. We outline two methods to specify

repo haircuts: the linearly negative-return model and VaR methods. In the first method, the haircut regressions reveal that long-memory return/capital gain, liquidity, and exchange rate are commonly vital in repo haircuts in Indonesia, Malaysia, Thailand, and Hong Kong. We demonstrate that the negative-return model is robust, and given 5% shocks of long-memory returns and exchange rates, and they change the haircut by less than one percent. In the second method, we establish the haircut model that the α-percentile shares a borrower's risks if the collateral price decreases; the lender bears the remaining if the borrower can not repay. We prove that the historical and parametric VaR method can help to assign the central bank's implicit risk tolerance (α) and establish haircuts of government and corporate collaterals.

Our results imply that the negative return and VaR models may support central banks in assigning haircut rates in day-to-day operations. Using the negative return model, the repo dealer may prepare an economic forecast and market pressures related to exchange rates and liquidity (or do stress testing). Adopting the VaR method, in particular, can be helpful in pricing haircuts across entities, collateral-maturity buckets, and repo maturities. However, market participants may only implement the above methods with adequate data. Undoubtedly, the eligible collateral should be liquid securities with sufficient available data. Establishing haircuts decision, the central bank may not arrange a complex haircut structure which leads commercial banks to operational risks. Thus, the central bank needs to manage a simple haircut structure properly.

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APPENDIX

Table A.1
Research Data Statistic

This table shows the metadata of Indonesia, Malaysia, Thailand, Hongkong, and PLN fixed-income securities and CDS (Source: Bloomberg).

INDONESIA						
Data Field	**Field Description**	**Unit**	**Remark**	**Average**	**Max**	**Min**
Px_Last	Last price	%	Bonds price at 4 pm local time, Governments Bond	113.916	139.093	98.143
Px_High	Highest price	%		113.971	139.093	100.000
Px_Low	Lowest price	%		113.886	138.838	98.143
Px_Bid	Last Bid price	%		113.691	138.669	98.000
Px_Ask	Last Ask price	%		114.163	139.541	98.286
CDS	Credit Default Swaps	bp	Sovereign CDS	CDS1Y: 23.4316	CDS1Y: 67.7	CDS1Y: 9.8
				CDS2Y: 38.0868	CDS2Y: 99.2	CDS2Y: 21.59
				CDS3Y: 54.0968	CDS3Y: 131.4	CDS3Y: 32.36
				CDS4Y: 75.6190	CDS4Y 169.2	CDS4Y: 48.81
				CDS5Y: 100.317	CDS5Y 227.85	CDS5Y: 66.331
				CDS7Y: 129.682	CDS7Y 255.87	CDS7Y: 92.55
				CDS10Y: 161.720	CDS10Y: 288.96	CDS10Y: 122.92
EXRATE	Exchange rate		USD/IDR	14491.38	15766	13879
PUAB	Money Market	%		3.4495	5.515	1.00
VOLER	Implied volatility of exchange rate	%	USD/IDR	9.708	28.397	2.01

Table A.1
Research Data Statistic (Continued)

MALAYSIA						
Data Field	**Field Description**	**Unit**	**Remark**	**Average**	**Max**	**Min**
Px_Last	Last price	%	Bonds price at 4 pm local time, Governments Bond	104.165	125.259	1.973
Px_High	Highest price	%		104.204	125.475	1.973
Px_Low	Lowest price	%		104.104	124.590	1.860
Px_Bid	Last Bid price	%		104.048	124.792	1.991
Px_Ask	Last Ask price	%		104.292	125.725	1.948
CDS	Credit Default Swaps	bp	Sovereign CDS	CDS1Y: 16.3901	CDS1Y: 67.53	CDS1Y: 3.34
				CDS2Y: 32.4468	CDS2Y: 100.51	CDS2Y: 7.57
				CDS3Y: 50.4241	CDS3Y: 139.8	CDS3Y: 13.36
				CDS4Y: 71.5157	CDS4Y: 188.56	CDS4Y: 22.27
				CDS5Y: 93.7645	CDS5Y: 237.391	CDS5Y: 32.146
				CDS7Y: 120.371	CDS7Y: 287.77	CDS7Y: 47.77
				CDS10Y: 139.85	CDS10Y: 299.11	CDS10Y: 64.35
EXRATE	Exchange rate		USD/MYR	4.121	4.497	3.496
PUAB	Money Market	%		2.826	3.280	1.730
VOLER	Implied volatility of exchange rate	%	USD/MYR	9.223	53.835	3.135

Table A.1
Research Data Statistic (Continued)

THAILAND						
Data Field	**Field Description**	**Unit**	**Remark**	**Average**	**Max**	**Min**
Px_Last	Last price	%	Bonds price at 4 pm local time, Governments Bond	108.59	185.171	2.572
Px_High	Highest price	%		108.70	185.171	2.525
Px_Low	Lowest price	%		108.45	184.961	1.519
Px_Bid	Last Bid price	%		108.21	184.671	2.570
Px_Ask	Last Ask price	%		108.96	185.671	2.573
CDS	Credit Default Swaps	bp	Sovereign CDS	CDS1Y: 12.50427 CDS2Y: 22.98574 CDS3Y: 34.68995 CDS4Y: 48.67824 CDS5Y: 63.56941 CDS7Y: 83.52359 CDS10Y: 100.0483	CDS1Y: 60.2 CDS2Y: 81.87 CDS3Y: 106.29 CDS4Y: 137.67 CDS5Y: 171.99 CDS7Y: 198.39 CDS10Y: 217.75.	CDS1Y: 2.08 CDS2Y: 5.36 CDS3Y: 9.3 CDS4Y: 13.81 CDS5Y 19.429 CDS7Y: 29.35 CDS10Y: 38.16
EXRATE	Exchange rate		USD/THB	32.8575	36.45	29.705
PUAB	Money Market	%		1.276	1.975	0.475
VOLER	Implied volatility of exchange rate	%	USD/THB	6.004	19.325	1.650

Table A.1
Research Data Statistic (Continued)

HONG KONG						
Data Field	**Field Description**	**Unit**	**Remark**	**Average**	**Max**	**Min**
Px_Last	Last price	%	Bonds price at 4 pm local time, Governments Bond	102.779	126.195	86.331
Px_High	Highest price	%		102.782	126.195	86.331
Px_Low	Lowest price	%		102.778	126.195	86.331
Px_Bid	Last Bid price	%		102.770	126.195	86.331
Px_Ask	Last Ask price	%		102.778	126.195	86.331
CDS	Credit Default Swaps	bp	Sovereign CDS	CDS1Y: 7.70958 CDS3Y: 18.9011 CDS5Y: 34.1019 CDS7Y: 46.419 CDS10: 57.5372	CDS1Y: 36.5 CDS3Y: 49.09 CDS5Y: 70.21 CDS7Y: 84.83 CDS10Y: 99.58	CDS1Y: 0.01 CDS3Y: 9.62 CDS5Y: 18.71 CDS7Y: 26.39 CDS10Y: 32.28
EXRATE	Exchange rate		USD/HKD	7.786895	7.85	7.7498
PUAB	Money Market	%		0.5195	3.65	-0.08
VOLER	Implied volatility of exchange rate	%	USD/HKD	1.013	3.255	0.14

Table A.1
Research Data Statistic (Continued)

PLN INDONESIA						
Data Field	**Field Description**	**Unit**	**Remark**	**Average**	**Max**	**Min**
Px_Last	Last price	%	Bonds price at 4 pm local time, Governments Bond	102.837	125.540	84.930
Px_High	Highest price	%		102.984	125.595	85.010
Px_Low	Lowest price	%		103.515	126.040	85.720
Px_Bid	Last Bid price	%		102.225	125.040	84.139
Px_Ask	Last Ask price	%		102.760	125.305	84.918
CDS	Credit Default Swaps	bp	Corporate CDS	CDS1Y: 23.4316 CDS2Y: 38.0868 CDS3Y: 54.0968 CDS4Y: 75.6190 CDS5Y: 100.317 CDS7Y: 129.682 CDS10Y: 161.720	CDS1Y: 67.7 CDS2Y: 99.2 CDS3Y: 131.4 CDS4Y 169.2 CDS5Y 227.85 CDS7Y 255.87 CDS10Y: 288.96	CDS1Y: 9.8 CDS2Y: 21.59 CDS3Y: 32.36 CDS4Y: 48.81 CDS5Y: 66.331 CDS7Y: 92.55 CDS10Y: 122.92
EXRATE	Exchange rate		USD/IDR,	14491.38	15766	13879
PUAB	Money Market	%		3.4495	5.515	1.00
VOLER	Implied volatility of exchange rate	%	USD/IDR	9.708	28.397	2.01

Table A.2
The Virtual Collateral Frameworks of Bank Indonesia, Bank Negara Malaysia, Bank of Thailand, and Hong Kong Monetary Authority

The fixed haircuts across "collateral class" and "collateral maturity." The haircut announcements were from Bank Indonesia 2018, Bank Negara Malaysia 2019, Bank of Thailand 2017, and Hong Kong Monetary Authority 2020. Rather than real or formal collateral frameworks, we pull together those central banks' haircuts and arrange this table as if these were their collateral frameworks.

No	Country	Type of Collateral	Maturity	Haircuts
1	Indonesia	Bank Indonesia Certificate		0%
		Bank Indonesia Syariah Certificate		0%
		Bank Indonesia Certificate of Deposit		0%
		Sukuk Bank Indonesia	-	0%
		Government Bond consists of the: a. Government Debt Securities b. Government Sharia Securities		 5% 6.5%
2	Malaysia	AAA to AA-/A-1	≤ 1 year	0.5%
			> 1 year, ≤ years 5	2%
			> 5 years	4%
		A+ to BBB-/A-2 to A-3/P-3 and unrated bank securities/sukūk	≤ 1 year	1%
			> 1 year, ≤ years 5	3%
			>5 years	6%
		BB+ to BB-	All	15%
3	Thailand	Rating grade 1	≤ 1 year	0.5%
			> 1 year, ≤ 5 years	2%
			> 5 years	4%
		• Rating grades 2 and 3 • Unrated securities	≤ 1 year	1%
			> 1 year, ≤ 5 years	3%
			>5 years	6%
		Rating grade 4 of government securities	Any	15%
4	Hong Kong	• Exchange Fund Bills and Notes (EFBN) • HKSAR Government bonds (HKGB)		• EFBN and HKGB: 2% per year of remaining maturity, plus 2% (for cross-currency haircut)
		• RMB, USD, and EUR-denominated debt securities issued in offshore markets by (i) the People's Bank of China (PBOC); (ii) the Ministry of Finance of the People's Republic of China (CMOF); and (iii) the policy banks of the People's Republic of China (China Policy Banks), namely Agricultural Development Bank of China, China Development Bank, and Export and Import Bank of China	-	• RMB-denominated debt securities issued by PBOC, CMOF, and China Policy Banks: 2% per year of remaining maturity, minimum 2 %. USD and EUR-denominated debt securities issued by PBOC, CMOF, and China Policy Banks: 2% per year of remaining maturity, minimum 2%, plus 2% (for cross-currency haircut)

Table A.3
Unit Root Test

This table shows the error unit root test of Equation 3

Variable	Unit Root Test Indonesia		Unit Root Test Malaysia		Unit Root Test Thailand		Unit Root Test Hong Kong		Unit Root Test PLN	
	Level	1st Different	Level	1st Different	Level	1st Different	Level	1st Different	Level	1st Different
AR0_1 (Repo Maturity 1 Week)	-5.513***	-15.492***	-6.042***	-16.995***	-12.938***	-16.559***	-12.036***	-23.639***	-	-
AR1_3 (Repo Maturity 1 Week)	-6.862***	-16.572***	-9.971***	-19.240***	-5.502***	-13.278***	-7.927***	-16.843***	-3.321**	-9.471***
AR3_5 (Repo Maturity 1 Week)	-6.102***	-15.989***	-10.964***	-19.136***	-6.982***	-14.697***	-7.416***	-14.460***	-4.244***	-9.924***
AR5_7 (Repo Maturity 1 Week)	-6.761***	-14.865***	-8.091***	-19.171***	-7.352***	-13.286***	-7.628***	-14.711***	-4.886***	-12.495***
AR7_10 (Repo Maturity 1 Week)	-7.556***	-14.195***	-15.413***	-18.854***	-8.923***	-15.618***	-6.278***	-15.030	-4.881***	-13.208***
AR10_15 (Repo Maturity 1 Week)	-7.880***	-12.647***	-9.646***	-17.349***	-7.148***	-13.051***	-7.566***	-13.852***	-3.750***	-8.134***
AR15_20 (Repo Maturity 1 Week)	-8.026***	-12.682***	-10.733***	-20.022***	-6.957***	-15.943***	-	-	-4.045***	-7.406***
AR20_30 (Repo Maturity 1 Week)	-7.659***	-12.237***	-13.027***	-20.027***	-6.766***	-15.653***	-	-	-	-
AR0_1 (Repo Maturity 2 Week)	-4.816***	-18.611***	-6.809***	-13.571***	-8.436***	-36.566***	-8.608***	-23.234***	-	-
AR1_3 (Repo Maturity 2 Week)	-6.512***	-16.773***	-7.202***	-15.828***	-6.122***	-16.345***	-6.037***	-17.145***	-3.886***	-6.946***
AR3_5 (Repo Maturity 2 Week)	-5.814***	-14.785***	-7.916***	-15.823***	-7.256***	-16.216***	-6.033***	-21.058***	-4.158***	-8.106***
AR5_7 (Repo Maturity 2 Week)	-5.988***	-14.255***	-8.369***	-14.349***	-6.973***	-15.487***	-6.436***	-21.992***	-3.305**	-8.507***
AR7_10 (Repo Maturity 2 Week)	-6.909***	-14.741***	-8.153***	-14.394***	-9.011***	-15.635***	-6.377***	-21.817***	-3.938***	-6.762***

Table A.3
Unit Root Test (Continued)

Variable	Unit Root Test Indonesia		Unit Root Test Malaysia		Unit Root Test Thailand		Unit Root Test Hong Kong		Unit Root Test PLN	
	Level	1st Different	Level	1st Different	Level	1st Different	Level	1st Different	Level	1st Different
AR10_15 (Repo Maturity 2 Week)	-7.202***	-15.355***	-9.646***	-17.349***	-6.978***	-18.708***	-6.338***	-21.807***	-3.816***	-6.282***
AR15_20 (Repo Maturity 2 Week)	-6.930***	-16.223***	-10.733***	-20.022***	-6.892***	-15.752***	-	-	-4.721***	-5.773***
AR20_30 (Repo Maturity 2 Week)	-6.409***	-16.636***	-13.027***	-20.026***	-6.343***	-17.880***	-	-	-	-
AR0_1 (Repo Maturity 1 Month)	-3.805***	-12.259***	-7.676***	-14.322***	-10.176***	-23.971***	-4.837***	-15.069***	-	-
AR1_3 (Repo Maturity 1 Month)	-5.324***	-11.235***	-5.816***	-12.738***	-3.867***	-16.047***	-4.434***	-13.127***	-4.175***	-18.801***
AR3_5 (Repo Maturity 1 Month)	-4.841***	-11.228***	-5.964***	-13.015***	-5.425***	-15.003***	-4.450***	-12.891***	-3.911***	-17.395***
AR5_7 (Repo Maturity 1 Month)	-4.801***	-11.298***	-6.281***	-13.075***	-5.384***	-13.251**	-4.625***	-13.945***	-3.790***	-17.495***
AR7_10 (Repo Maturity 1 Month)	-5.593***	-11.574***	-6.155***	-13.106***	-9.487***	-15.448***	-4.712***	-15.683***	-3.934***	-20.528***
AR10_15 (Repo Maturity 1 Month)	-5.682***	-12.341***	-5.959***	-13.522***	-4.870***	-15.709***	-4.863***	-14.744***	-2.907**	-22.790***
AR15_20 (Repo Maturity 1 Month)	-5.509***	-12.681***	-5.938***	-13.748***	-4.157***	-16.946***	-	-	-3.440**	-16.802***
AR20_30 (Repo Maturity 1 Month)	-5.156***	-12.957***	-6.044***	-14.916	-3.931***	-16.943***	-	-	-	-
AR0_1 (Repo Maturity 3 Month)	2.746**	-38.450***	-4.755***	-9.477***	-5.572***	-9.508***	-3.823***	-41.486***	-	-
AR1_3 (Repo Maturity 3 Month)	-3.571***	-22.106***	-4.533***	-19.487***	-2.888**	-37.352***	-3.729***	-32.514***	-3.036**	-19.145***

Table A.3
Unit Root Test (Continued)

Variable	Unit Root Test Indonesia		Unit Root Test Malaysia		Unit Root Test Thailand		Unit Root Test Hong Kong		Unit Root Test PLN	
	Level	1st Different	Level	1st Different	Level	1st Different	Level	1st Different	Level	1st Different
AR3_5 (Repo Maturity 3 Month)	-2.995**	-25.282***	-4.302***	-24.819***	-4.276***	-34.711***	-3.344**	-32.621***	-2.582*	-17.789***
AR5_7 (Repo Maturity 3 Month)	-3.221**	-26.186***	-4.632***	-24.017***	-3.678***	-23.337***	-3.563***	-34.888***	-2.454	-18.076***
AR7_10 (Repo Maturity 3 Month)	-3.717***	-23.377***	-4.454***	-4.453***	-9.096***	-15.638***	-3.581***	-36.403***	-3.366**	-15.895***
AR10_15 (Repo Maturity 3 Month)	-3.751***	-24.475***	-4.208***	-26.053***	-3.450***	-37.258***	-3.955***	-38.869***	-2.635***	-16.623***
AR15_20 (Repo Maturity 3 Month)	-3.853***	-24.504***	-4.625***	-25.960***	-3.495***	-24.355***	-	-	-2.204	-11.879***
AR20_30 (Repo Maturity 3 Month)	-3.253**	-31.885***	-4.314***	-30.156***	-2.705***	-25.993***	-	-	-	-
HL0_1	-8.823***	-20.209***	-6.042***	-16.995***	-6.192***	-22.956***	-3.712***	-19.877***	-9.396***	-
HL1_3	-37.101***	-21.045***	-9.971***	-19.240***	-6.822***	-18.391***	-6.562***	-21.078***	-16.952***	-15.972***
HL3_5	-13.163***	-22.368***	-10.964***	-19.136***	-20.002***	-20.089***	-6.056***	-19.997***	-17.848***	-11.775***
HL5_7	-35.485***	-19.109***	-8.091***	-19.171***	-9.964***	-19.491***	-9.454***	-22.959***	-18.164***	-12.795***
HL7_10	-36.150***	-22.244***	-15.412***	-18.854***	-40.740***	-17.153***	-11.692***	-22.891***	-18.324***	-13.982***
HL10_15	-19.603***	-21.678***	-9.646***	-17.349***	-11.970***	-22.751***	-11.612***	-20.828***	-6.903***	-10.539***
HL15_20	-35.424***	-21.655***	-10.733***	-20.022***	-11.807***	-25.364***	-	-	-5.974***	-10.774***
HL20_30	-18.028***	-22.043***	-13.027***	-20.027***	-10.597***	-17.094***	-	-	-	-
BAS0_1	-6.484***	-19.173***	-3.203**	-29.855***	-1.593	-30.723***	-1.311	-34.827***	-1.072	-10.387***
BAS1_3	-4.529***	-23.951***	-3.387**	-28.052***	-3.854***	-21.419***	-1.674	-24.720***	-1.243	-20.006***
BAS3_5	-4.112***	-21.108***	-3.745***	-29.239***	-4.189***	-28.146***	-2.743*	-31.452***	-1.068	-9.605***
BAS5_7	-4.305***	-20.832***	-5.436***	-29.906***	-3.211***	-31.137***	-2.802*	-21.086***	-0.991	-20.795***
BAS7_10	-5.091***	-19.731***	-5.505***	-29.179***	-2.052***	-2.863***	-4.190***	-22.205***	-0.875	-18.056***

Table A.3
Unit Root Test (Continued)

Variable	Unit Root Test Indonesia		Unit Root Test Malaysia		Unit Root Test Thailand		Unit Root Test Hong Kong		Unit Root Test PLN	
	Level	1st Different	Level	1st Different	Level	1st Different	Level	1st Different	Level	1st Different
BAS10_15	-6.338***	-25.975***	-2.968***	-30.049***	-2.051	-20.336***	-3.793***	-22.513***	-1.061	-14.698***
BAS15_20	-5.925***	-38.769***	-4.405***	-21.309***	-3.002**	-3.434***	-	-	-	-
BAS20_30	-5.615***	-23.979***	-5.194***	-30.152***	-0.510	-47.395***	-	-	-	-
CDS1Y	-2.148	-23.780***	-3.349**	-41.956**	-2.554	-39.912***	-2.674*	-42.446***	-2.554	-18.632***
CDS2Y	-1.885	-22.908***	-2.104	-39.920***	-1.933	-39.457***	-	-	-2.834	-18.788***
CDS3Y	-1.806	-22.268***	-2.110	-39.997***	-1.716	-38.648***	-2.822*	-46.124***	-2.924	-19.415***
CDS4Y	-1.826	-22.098***	-1.683	-39.552***	-1.696	-38.214***	-	-	-2.689	-11.364***
CDS5Y	-1.843	-17.452***	-1.850	-16.999***	-1.355	-42.181***	-3.025**	-47.669***	-2.832	-14.494***
CDS7Y	-1.950	-21.232***	-1.663	-23.090***	-1.443	-31.507***	-3.206**	-46.535***	-2.562	-11.971***
CDS10Y	-2.090	-21.320***	-1.752	-40.064***	-1.438	-31.561***	-3.062**	-45.303***	-2.581*	-18.792***
PUAB	-1.974	-20.888***	0.573	-46.441***	-3.642***	-20.194***	-4.153***	-22.396***	-1.974	-20.888***
EXRATE	-2.539	-26.102***	-3.188**	-39.074***	-1.072	-39.060***	-1.781***	-38.594***	-2.539	-26.102***
VOLER	-3.663***	-11.313***	-2.736**	-11.275***	-4.186***	-12.371***	-4.501***	-9.0355***	-3.663***	-11.313***

Table A.4
Heteroscedasticity Test

This table shows the heteroscedasticity test of the GARCH model in Equation 3.

Heteroskedastic Test of Indonesian Securities							
Repo Maturity 1 Week	***F*-Statistic**	**Repo Maturity 2 Week**	**F-Statistic**	**Repo Maturity 1 Month**	***F*-Statistic**	**Repo Maturity 3 Month**	***F*-Statistic**
GARCH Model 1 (Maturity 0_1)	3.701***	GARCH Model 1 (Maturity 0_1)	3.135***	GARCH Model 1 (Maturity 0_1)	3.881***	GARCH Model 1 (Maturity 0_1)	1.634**
GARCH Model 2 (Maturity 1_3)	3.593***	GARCH Model 2 (Maturity 1_3)	5.968**	GARCH Model 2 (Maturity 1_3)	12.219***	GARCH Model 2 (Maturity 1_3)	3.488***
GARCH Model 3 (Maturity 3_5)	2.114**	GARCH Model 3 (Maturity 3_5)	11.498***	GARCH Model 3 (Maturity 3_5)	1.517**	GARCH Model 3 (Maturity 3_5)	1.599**
GARCH Model 4 (Maturity 5_7)	3.239***	GARCH Model 4 (Maturity 5_7)	1.758*	GARCH Model 4 (Maturity 5_7)	10.042***	GARCH Model 4 (Maturity 5_7)	1.489*
GARCH Model 5 (Maturity 7_10)	5.249***	GARCH Model 5 (Maturity 7_10)	4.742**	GARCH Model 5 (Maturity 7_10)	2.381***	GARCH Model 5 (Maturity 7_10)	3.376***
GARCH Model 6 (Maturity 10_15)	2.752***	GARCH Model 6 (Maturity 10_15)	3.839***	GARCH Model 6 (Maturity 10_15)	4.111***	GARCH Model 6 (Maturity 10_15)	0.777
GARCH Model 7 (Maturity 15_20)	5.774***	GARCH Model 7 (Maturity 15_20)	2.064*	GARCH Model 7 (Maturity 15_20)	7.460***	GARCH Model 7 (Maturity 15_20)	1.396*
GARCH Model 8 (Maturity 20_30)	1.854*	GARCH Model 8 (Maturity 20_30)	2.919***	GARCH Model 8 (Maturity 20_30)	2.799*	GARCH Model 8 (Maturity 20_30)	1.349

Table A.4
Heteroscedasticity Test (Continued)

Heteroskedastic Test of Indonesian Securities - High Risk							
Repo Maturity 1 Week	***F*-Statistic**	**Repo Maturity 2 Week**	**F-Statistic**	**Repo Maturity 1 Month**	***F*-Statistic**	**Repo Maturity 3 Month**	***F*-Statistic**
GARCH Model 1 (Maturity 0_1)	2.182***	GARCH Model 1 (Maturity 0_1)	2.784***	GARCH Model 1 (Maturity 0_1)	3.658***	GARCH Model 1 (Maturity 5_7)	1.485**
GARCH Model 2 (Maturity 1_3)	6.543***	GARCH Model 2 (Maturity 1_3)	6.243***	GARCH Model 2 (Maturity 1_3)	2.063***	GARCH Model 2 (Maturity 7_10)	2.024**
GARCH Model 3 (Maturity 3_5)	2.107**	GARCH Model 3 (Maturity 3_5)	11.546***	GARCH Model 3 (Maturity 3_5)	1.620**	GARCH Model 3 (Maturity 10_15)	1.398*
GARCH Model 4 (Maturity 5_7)	3.022***	GARCH Model 4 (Maturity 5_7)	2.944***	GARCH Model 4 (Maturity 5_7)	1.997***	GARCH Model 4 (Maturity 15_20)	1.896***
GARCH Model 5 (Maturity 7_10)	10.301***	GARCH Model 5 (Maturity 7_10)	4.765***	GARCH Model 5 (Maturity 7_10)	2.042***		
GARCH Model 6 (Maturity 10_15)	4.979***	GARCH Model 6 (Maturity 10_15)	12.497***	GARCH Model 6 (Maturity 20_30)	5.830***		
GARCH Model 7 (Maturity 15_20)	3.145***	GARCH Model 7 (Maturity 15_20)	1.835*				
GARCH Model 8 (Maturity 20_30)	2.008*	GARCH Model 8 (Maturity 20_30)	4.804***				

Table A.4
Heteroscedasticity Test (Continued)

Heteroskedastic Test of Malaysian Securities							
Repo Maturity 1 Week	***F*-Statistic**	**Repo Maturity 2 Week**	**F-Statistic**	**Repo Maturity 1 Month**	***F*-Statistic**	**Repo Maturity 3 Month**	***F*-Statistic**
GARCH Model 1 (Maturity 0_1)	1.880**	GARCH Model 1 (Maturity 0_1)	0.376	GARCH Model 1 (Maturity 0_1)	1.662**	GARCH Model 1 (Maturity 0_1)	7.072**
GARCH Model 2 (Maturity 1_3)	3.241***	GARCH Model 2 (Maturity 1_3)	20.446***	GARCH Model 2 (Maturity 1_3)	18.609***	GARCH Model 2 (Maturity 1_3)	0.297
GARCH Model 3 (Maturity 3_5)	3.487***	GARCH Model 3 (Maturity 3_5)	3.580***	GARCH Model 3 (Maturity 3_5)	11.130***	GARCH Model 3 (Maturity 3_5)	1.146
GARCH Model 4 (Maturity 5_7)	6.165***	GARCH Model 4 (Maturity 5_7)	21.406***	GARCH Model 4 (Maturity 5_7)	2.905***	GARCH Model 4 (Maturity 5_7)	1.461***
GARCH Model 5 (Maturity 7_10)	18.655***	GARCH Model 5 (Maturity 7_10)	35.346***	GARCH Model 5 (Maturity 7_10)	2.126***	GARCH Model 5 (Maturity 7_10)	6.345**
GARCH Model 6 (Maturity 10_15)	1.022	GARCH Model 6 (Maturity 10_15)	3.420**	GARCH Model 6 (Maturity 10_15)	7.814***	GARCH Model 6 (Maturity 10_15)	1.759*
GARCH Model 7 (Maturity 15_20)	6.565***	GARCH Model 7 (Maturity 15_20)	7.603***	GARCH Model 7 (Maturity 15_20)	1.696***	GARCH Model 7 (Maturity 15_20)	1.849***
GARCH Model 8 (Maturity 20_30)	3.221**	GARCH Model 8 (Maturity 20_30)	1.583**	GARCH Model 8 (Maturity 20_30)	1.366***	GARCH Model 8 (Maturity 20_30)	1.867***

Table A.4
Heteroscedasticity Test (Continued)

Heteroskedastic Test of Hong Kong Securities							
Repo Maturity 1 Week	***F*-Statistic**	**Repo Maturity 2 Week**	***F*-Statistic**	**Repo Maturity 1 Month**	***F*-Statistic**	**Repo Maturity 3 Month**	***F*-Statistic**
GARCH Model 1 (Maturity 0_1)	1.811*	GARCH Model 1 (Maturity 0_1)	2.069*	GARCH Model 1 (Maturity 0_1)	1.137	GARCH Model 1 (Maturity 0_1)	6.624***
GARCH Model 2 (Maturity 1_3)	6.016**	GARCH Model 2 (Maturity 1_3)	7.012***	GARCH Model 2 (Maturity 1_3)	1.605**	GARCH Model 2 (Maturity 1_3)	3.858***
GARCH Model 3 (Maturity 3_5)	6.991***	GARCH Model 3 (Maturity 3_5)	1.944*	GARCH Model 3 (Maturity 3_5)	2.375**	GARCH Model 3 (Maturity 3_5)	2.939*
GARCH Model 4 (Maturity 5_7)	4.013***	GARCH Model 4 (Maturity 5_7)	14.222*	GARCH Model 4 (Maturity 5_7)	3.564***	GARCH Model 4 (Maturity 5_7)	0.847
GARCH Model 5 (Maturity 7_10)	4.247***	GARCH Model 5 (Maturity 7_10)	11.660***	GARCH Model 5 (Maturity 7_10)	6.463**	GARCH Model 5 (Maturity 7_10)	3.027***
GARCH Model 6 (Maturity 10_15)	2.886***	GARCH Model 6 (Maturity 10_15)	2.269**	GARCH Model 6 (Maturity 10_15)	5.491***	GARCH Model 6 (Maturity 10_15)	2.203***
Heteroskedastic Test of PLN Indonesia Securities							
Repo Maturity 1 Week	***F*-Statistic**	**Repo Maturity 2 Week**	***F*-Statistic**	**Repo Maturity 1 Month**	**F-Statistic**	**Repo Maturity 3 Month**	***F*-Statistic**
OLS Model 1 (Maturity 1_3)	1.274	OLS Model 1 (Maturity 1_3)	1.449	OLS Model 1 (Maturity 1_3)	1.002	OLS Model 1 (Maturity 1_3)	1.305
GARCH Model 2 (Maturity 3_5)	1.029	GARCH Model 2 (Maturity 3_5)	0.515	OLS Model 2 (Maturity 3_5)	0.177	OLS Model 2 (Maturity 3_5)	1.595
GARCH Model 3 (Maturity 5_7)	0.636	OLS Model 3 (Maturity 5_7)	0.296	OLS Model 3 (Maturity 5_7)	0.583	OLS Model 3 (Maturity 5_7)	1.022
GARCH Model 4 (Maturity 7_10)	3.612***	GARCH Model 4 (Maturity 7_10)	2.869***	OLS Model 4 (Maturity 7_10)	1.201	OLS Model 4 (Maturity 7_10)	0.343
GARCH Model 5 (Maturity 10_15)	0.569	OLS Model 5 (Maturity 10_15)	0.968	OLS Model 5 (Maturity 10_15)	1.561	OLS Model 5 (Maturity 10_15)	0.277
GARCH Model 6 (Maturity 15_20)	0.341	GARCH Model 6 (Maturity 15_20)	0.517	OLS Model 6 (Maturity 15_20)	1.689	OLS Model 6 (Maturity 15_20)	1.693

Table A.5
Means and Standard Deviations of Haircut rate (Clean Price Growth) with Indonesia Government Bond and Corporate Bond (PLN Indonesia) Collaterals

The table displays the simulated haircut rate (clean price growth) of the Indonesia Government and PLN Corporate based-on securities' maturity buckets and repo maturities.

Maturity	Type of Collateral		Maturity Bucket							
			nR0_1	nR1_3	nR3_5	nR5_7	nR7_10	nR10_15	nR15_20	nR20_30
1 Week	Govt.	Mean	0.000712	0.000219	4.25E-05	-0.00026	-0.0003	-0.0005	-0.00053	-0.000597
		Stdev	0.001162	0.003028	0.005691	0.008424	0.010963	0.013247	0.014645	0.0140239
	Corp.	Mean		-0.00065	-0.00109	-0.00124	-0.00086	-0.00115	-0.00095	
		Stdev		0.003013	0.004811	0.007208	0.010829	0.017364	0.022019	
2 Weeks	Govt.	Mean	0.001526	0.000524	8.18E-05	-0.00045	-0.00059	-0.00101	-0.00108	-0.00115
		Stdev	0.001801	0.004716	0.008903	0.01303	0.016553	0.020095	0.022102	0.022169
	Corp.	Mean		-0.00141	-0.00234	-0.00264	-0.00239	-0.00335	-0.00228	
		Stdev		0.003948	0.006475	0.009885	0.015662	0.025485	0.031643	
1 Month	Govt.	Mean	0.002567	0.000979	0.000158	-0.00062	-0.00081	-0.00147	-0.00147	-0.00178
		Stdev	0.002528	0.006181	0.011842	0.017226	0.021583	0.026094	0.028543	0.029317
	Corp.	Mean		-0.00243	-0.00421	-0.00497	-0.00509	-0.00645	-0.00445	
		Stdev		0.005143	0.008253	0.012502	0.018934	0.033172	0.040864	
3 Months	Govt.	Mean	0.006882	0.003253	0.000564	-0.00123	-0.00173	-0.00317	-0.00297	-0.00501
		Stdev	0.005471	0.010266	0.020134	0.028391	0.034535	0.04136	0.046434	0.049603
	Corp.	Mean		-0.00653	-0.01195	-0.01418	-0.0177	-0.01965	-0.0138	
		Stdev		0.005827	0.009553	0.016302	0.023048	0.040388	0.055362	