The Implied Bail-in Probability from the Contingent Convertible Securities Market

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Outline

1. Motivation and Contribution
2. CoCos 101
3. CoCos Pricing methods and bail-in probabilities estimation
4. Empirical analysis
5. Conclusion

1. 1 Motivation

- Recently the issuance of Contingent Convertible Securities (CoCos) has been increasing among large financial institutions.
- A CoCo absorbs the issuer's loss by converting it into stocks or reducing its principal when the issuer's capital ratio falls to a certain level (bail-in). Thus a CoCo's spread includes the bail-in risk as well as the default risk.
- In this paper, we develop a model to estimate implied bail-in probabilities from the market price of CoCos. The implied bail-in probability is considered to increase more sensitively than the implied default probability from the CDS market when credit events occur.
- We also pursue empirical studies of the bail-in probability for major CoCos issuers to demonstrate possible macro-prudential application as early warning indicators, not only for issuers but also for the financial system as a whole.

1.2 Contribution

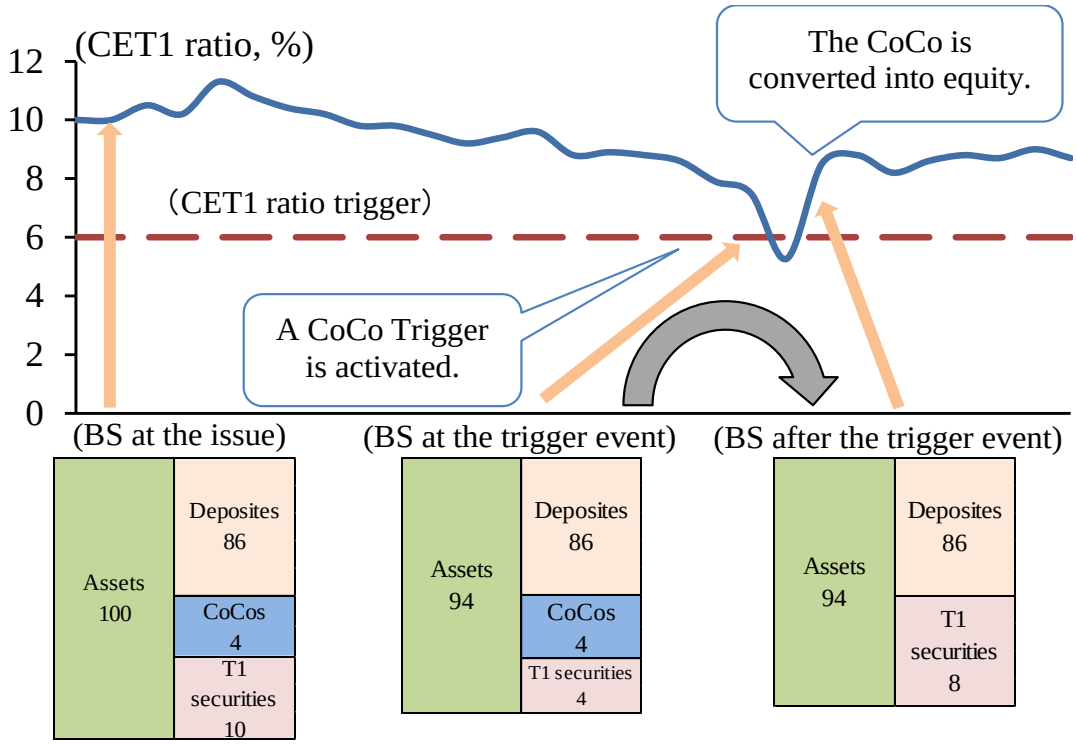
1. This study is the first comprehensive analysis of the bail-in probability of CoCos.
2. We confirm that implied bail-in probabilities increase more sensitively than the implied default probabilities from CDSs when credit events occur.
3. We also find that the market implied probability of default after bail-in tends to decrease as the issuance of CoCos increases.
4. From the principal component analysis by regions, we find that the implied probability in Japan is overwhelmingly lower than other areas.

2-1. CoCos 101

- CoCos are hybrid capital securities in Basel III's new capital requirements.
- Specifically, a CoCo issuer can write-down the CoCo or convert it into equity when a trigger event of the CoCo occurs to absorb the issuer's losses.
- Example of trigger events

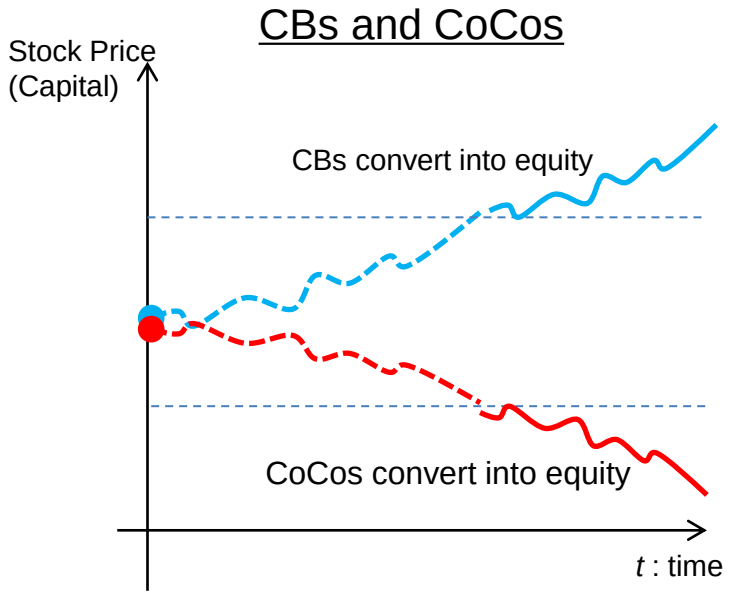
  Going Concern type: CET1 ratio falls below 5.125%

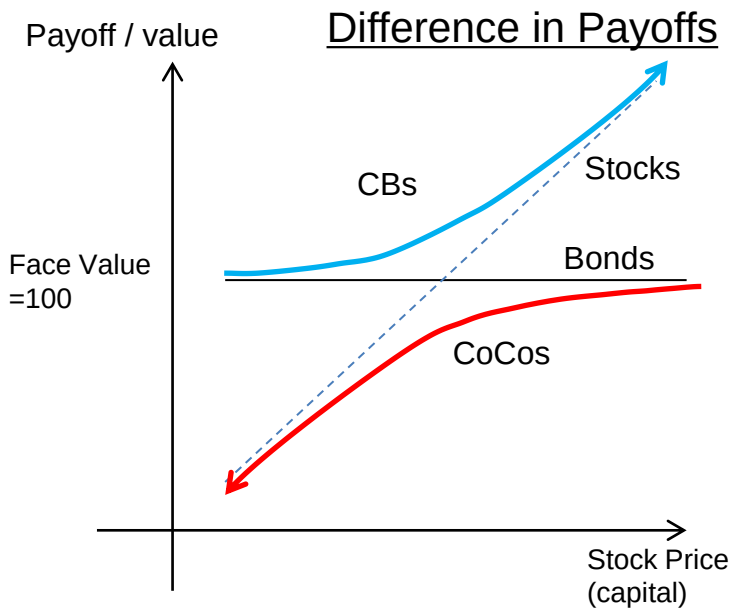
  Gone Concern type: Bankruptcy



2-1. CoCos 101：CoCos vs Convertible Bonds (CBs)

- CBs can be converted into equity by CB holders when the equity goes up
  - — CBs holders expect capital gain
  - — CB = Corporate bond + Long position of Call option
- CoCos are converted to equity when banks face financial distress
  - — **CoCos holders must be aware of down-side risk**
  - — CoCo ＝ Corporate bond ＋ Short position of knock-in option

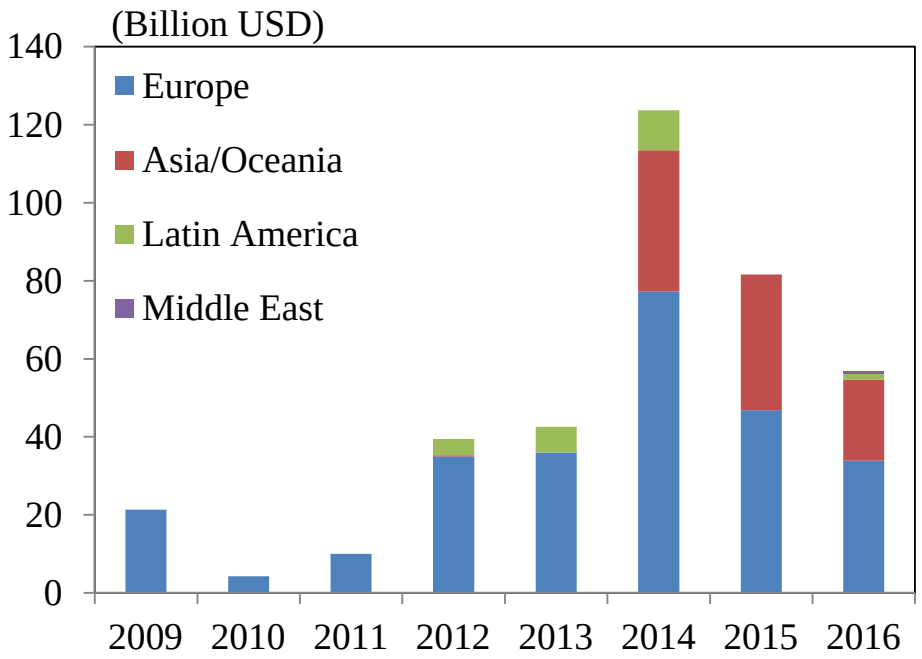




2-2. Overview of CoCos market

- The first CoCo was issued in 2009.
  - Issuance of CoCos is at a high level.
- Major CoCo issuers have been geographically concentrated in Europe.
  - Banks in other areas such as Asia and South America have also issued CoCos recently.
  - US banks have not issued CoCos. Some argue that this is due to uncertainty about tax treatment of CoCo coupons.

World-wide CoCo Issuance by year



Source: Bloomberg

# of CoCos by country and by currency（Top 5, to Apr. 2017）

Country	# of CoCos
BRITAIN	91
NORWAY	51
SWITZERLAND	37
CHINA	30
FRANCE	27

Currency	# of CoCos
US DOLLAR	155
EURO	96
NORWEGIAN KRONE	51
BRITISH POUND	46
SWISS FRANC	22

In Asia/Oceania（to Apr. 2017, excluding JP issuers）

Country	# of CoCos
CHINA	30
INDIA	17
AUSTRALIA	5
NEW ZEALAND	1
MALAYSIA	1
INDONESIA	1

Currency	# of CoCos
CHINA RENMINBI	21
INDIAN RUPEE	16
SINGAPORE DOLLAR	2
JAPANESE YEN	2
MALAYSIAN RINGGIT	1
NEW ZEALAND DOLLAR	1
INDONESIAN RUPIAH	1

(Source) Bloomberg

2-3. CoCo issuance among G-SIBs（2016）（21/30 banks）

Bucket	Banks	CoCo Issuers
4	Citigroup	×(US)
	JP Morgan Chase	×(US)
3	Bank of America	×(US)
	BNP Paribas	○
	Deutsche Bank	○
	HSBC	○
2	Barclays	○
	Credit Suisse	○
	Goldman Sachs	×(US)
	Industrial and Commercial Bank of China Limited	○
	Mitsubishi UFJ FG	○
	Wells Fargo	×(US)
1	Agricultural Bank of China	○
	Bank of China	○
	Bank of New York Mellon	×(US)
	China Construction Bank	○
	Groupe BPCE	×(France)
	Groupe Crédit Agricole	○
	ING Bank	○
	Mizuho FG	○
	Morgan Stanley	×(US)
	Nordea	○
	Royal Bank of Scotland	○
	Santander	○
	Société Générale	○
	Standard Chartered	○
	State Street	×(US)
	Sumitomo Mitsui FG	○
	UBS	○
	Unicredit Group	○

3-1. Pricing method of CoCos

1. Structural approach

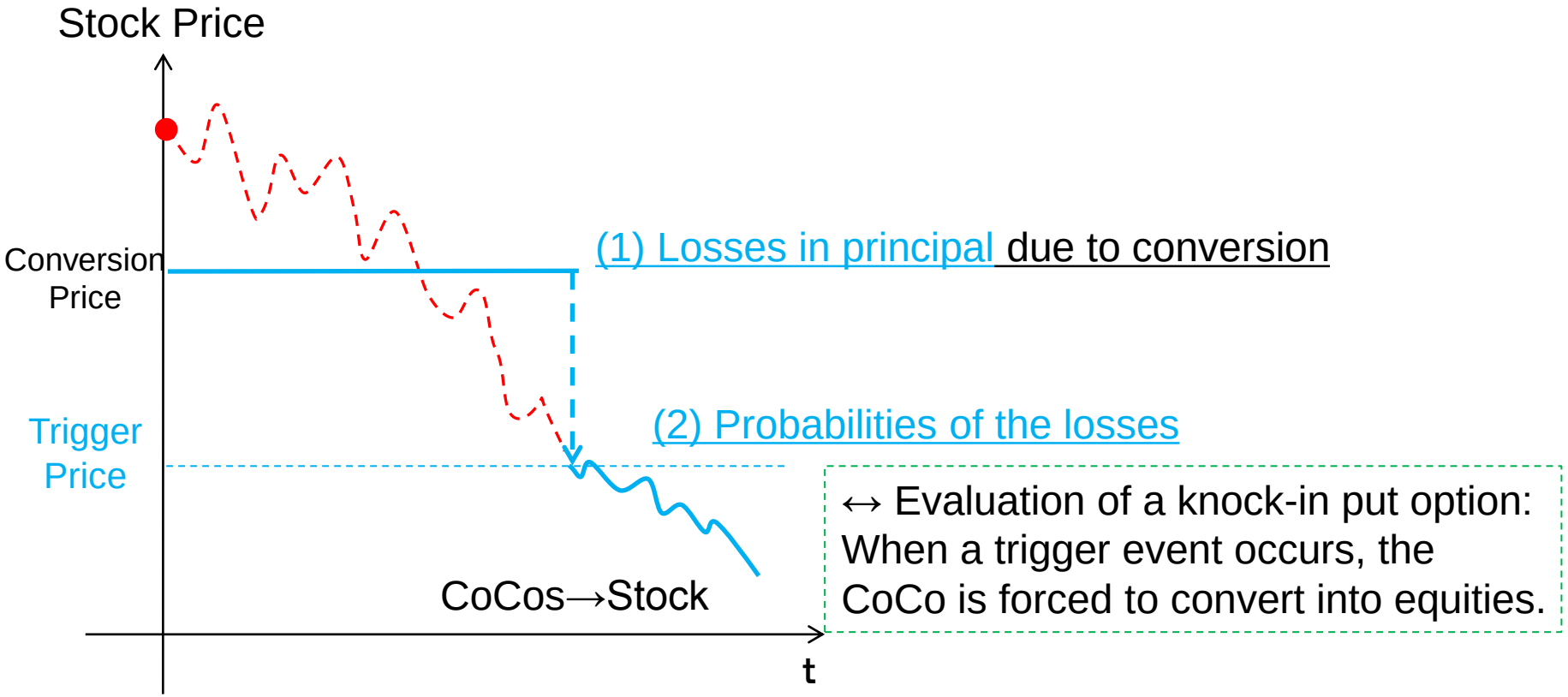
- Models the dynamics of asset price of financial institution and requires arbitrage free for all assets, equities and liabilities which include CoCos.
- A corporate finance approach. Used for analyzing the incentive structure of bank shareholders and creditors theoretically and the significance of issuing CoCos.
- Kamada (2010), Madan and Schoutens (2011), Pennacchi (2011), Albul *et al*. (2012), Glasserman and Nouri (2012), Cheridito and Xu (2013), Sundaresan and Wang (2015), Song and Yang (2016)

2. Derivative approach

- Focuses on the evaluation of CoCos' barrier options features.
- Used in empirical analysis because of the good fit with market data and the simplicity of estimation.
- De Spiegeleer and Schoutens (2012, 2014), Corcuera, De Spiegeleer, Ferreiro-Castilla, Kyprianou, Madan, and Schoutens (2012), Teneberg (2012), Serjantov (2011)

3-2. Derivative approach

Our approach is based on the credit derivative approach developed by De Spiegeleer and Schoutens (2012). The main assumption of the model is that the drop in a bank's capital ratio corresponds to the fall of the bank's share price.



3-2. Derivative approach

- A CoCo spread = Loss rate for equity conversion × Hazard rate

$$CS_{CoCo} = (1 - R_{CoCo}) \times \lambda_{Trigger} = Loss_{CoCo} \times \lambda_{Trigger}$$

  - The hazard rate shows the bail-in probability during a particular period.
- When the hazard rate is constant over time and low enough that its stochastic process is regarded as a Poisson process, the accumulative bail-in probability for upcoming T years is given by:

$$P_H = 1 - e^{-\lambda_{Trigger}\ T}$$

$$\Leftrightarrow\ \lambda_{Trigger} = -\frac{\ln(1 - P_H)}{T}$$

  - We call the accumulative bail-in probability as the bail-in probability.
- By combining the trigger share price *H*, which is the market value of a share at the time of bail-in, and a conversion share price C_p, which is the face value of a share the CoCo investors acquire, the loss rate is expressed as:

$$Loss_{CoCo} = \frac{C_P - H}{C_P} = 1 - \frac{H}{C_P}$$

3-3. Derivative approach

- With Black-Scholes formula for knock-in barrier option pricing, the bail-in probability P_H is equal to the probability that a stock price falls at the trigger share price:

$$P_H = N\left[\frac{\ln(H/S) - \mu T}{\sigma\sqrt{T}}\right] + \left(\frac{H}{S}\right)^{2\mu/\sigma^2} N\left(\frac{\ln(H/S) + \mu T}{\sigma\sqrt{T}}\right)$$

  - $N[\cdot]$: The normal cumulative distribution function.
- By combining all equations, the CoCo spread is equal to:

$$CS_{CoCo} = -\frac{\ln(1 - P_H)}{T} \times (1 - \frac{H}{C_P})$$

- By calibrating the equation above with market data, we obtain *H* and the implied bail-in probability P_H at maturity *T*.
  - We set the parameter *T* time to maturity or time to CoCo's first call as following market practice.

3-4. Relationships between P_H and its main parameters

$$P_H = N\left[\frac{\ln(H/S) - \mu T}{\sigma\sqrt{T}}\right] + \left(\frac{H}{S}\right)^{2\mu/\sigma^2} N\left(\frac{\ln(H/S) + \mu T}{\sigma\sqrt{T}}\right)$$

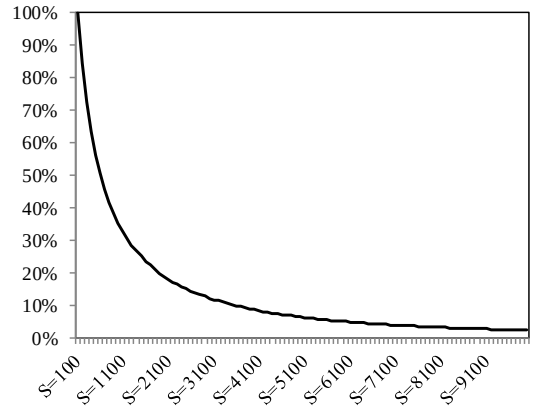
Parameters	P_H	Intuition
H (Trigger Stock price) ↑	Rises	Trigger stock price approaches today's stock price
S (Current Stock price) ↑	Falls	Today's stock price diverges from trigger stock price.
σ (Volatility) ↑	Rises	As volatility increases, P_H increases.
T (Duration) ↓	Falls	As duration becomes shorter, P_H becomes smaller.

- A bail-in probability by the time of redemption falls as duration becomes shorter.
- To exclude this effect, we fix T=5 after obtaining H by the previously-mentioned calibration procedure.

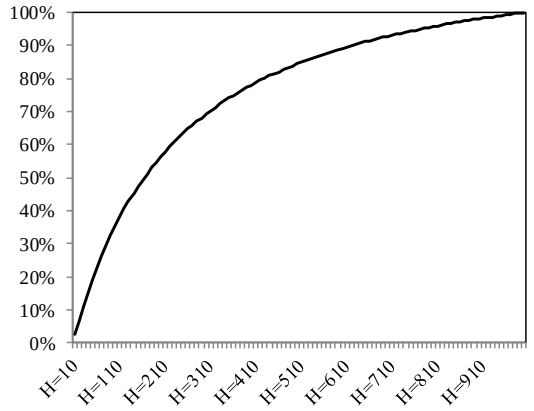
3-5. Relationships between P_H and its main parameters

[Base] S=1000, H=100, T=10, Rf=1%, Vol=50%, CS=4.36%

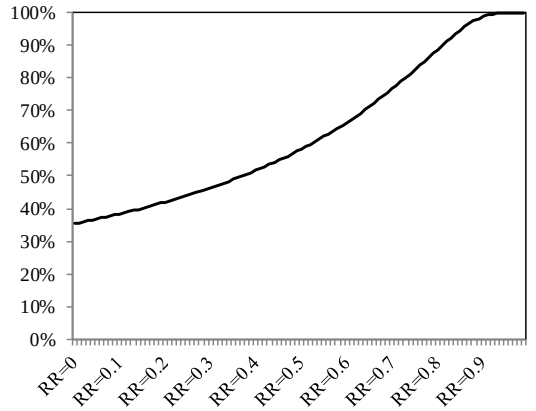
(1) Stock Price (100 to 1,000)



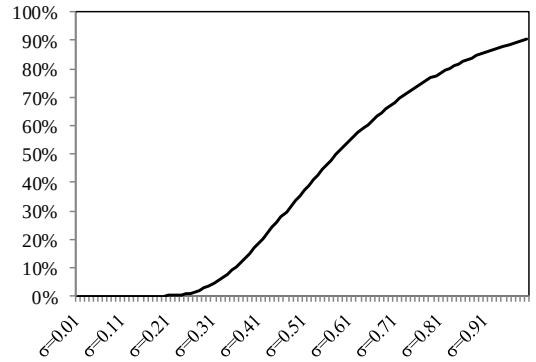
(2) Trigger Stock Price (10 to 1,000)



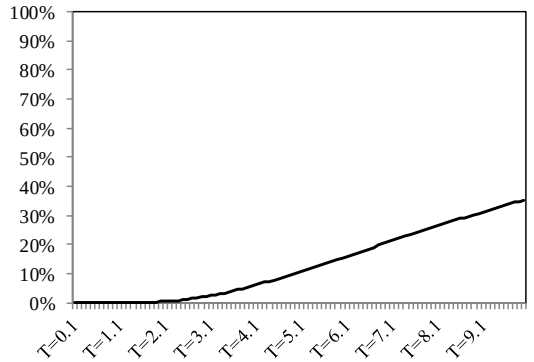
(3) Recovery rate (0% to 100%)



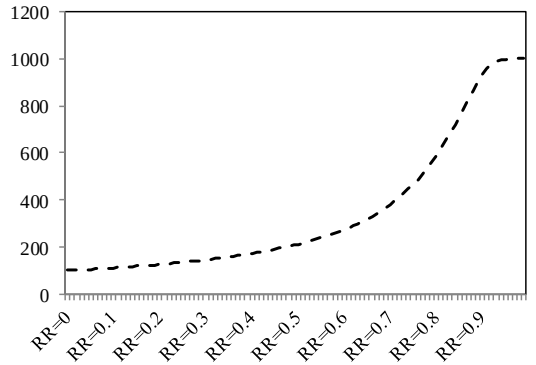
(3) Volatility (1% to 100%)



(4) Duration (0.1Y to 10Y)

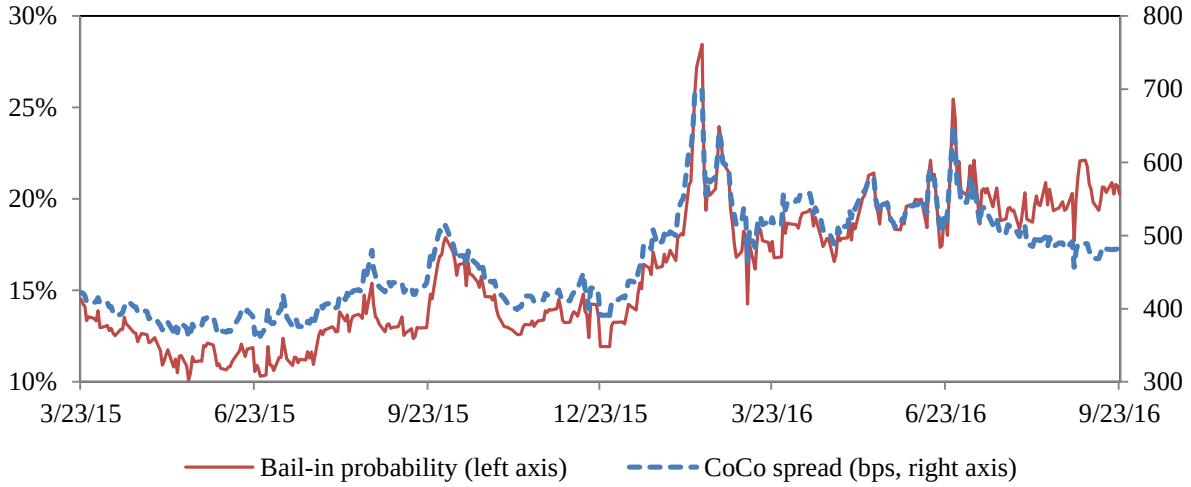


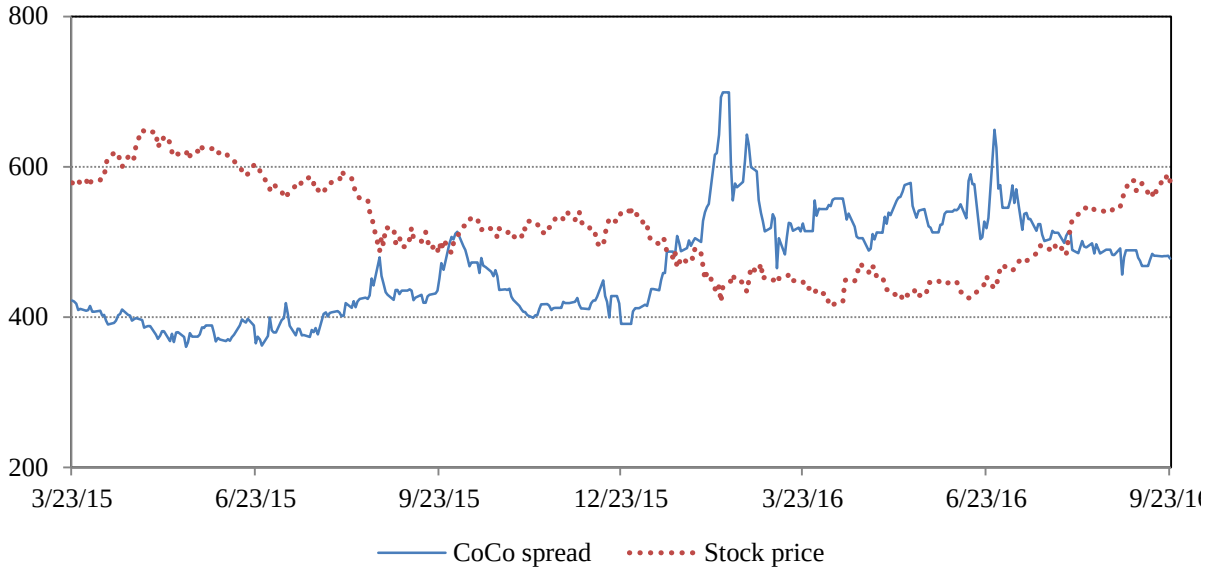
(Reference) Changes in Trigger stk price when recovery rate changes



3-6 Example of bail-in probability estimation

- The probability and the CoCo spread behave differently.



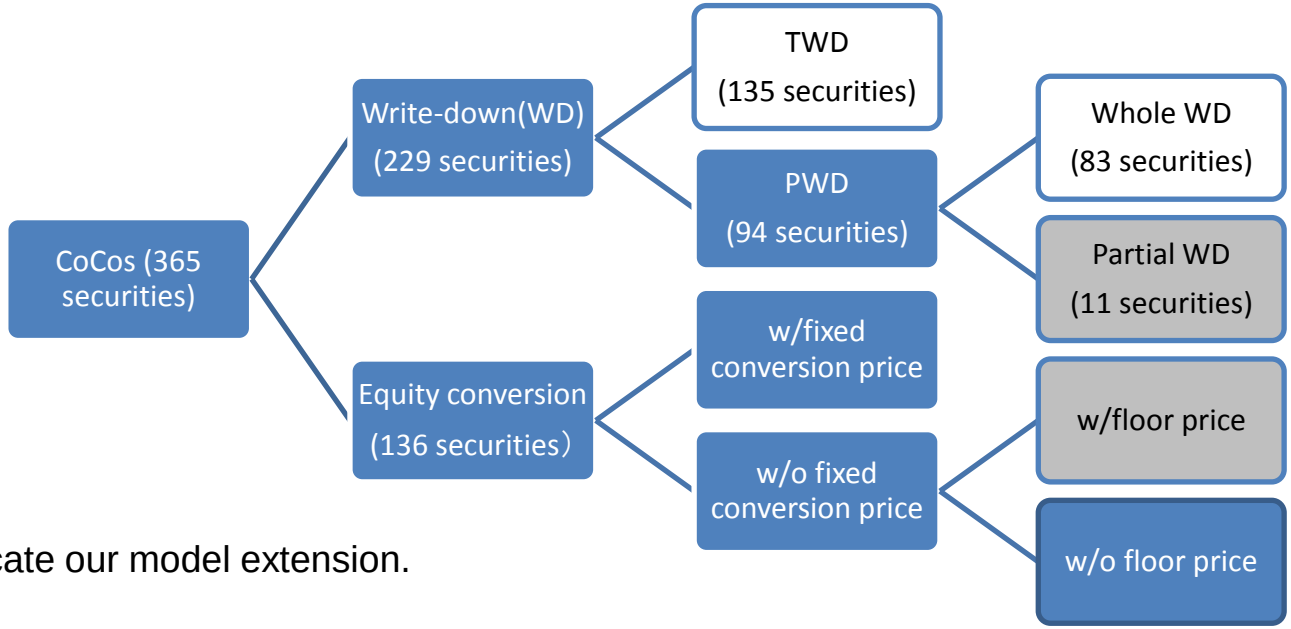


3-7. Diversity of CoCos

- CoCos are mainly classified into “equity conversion” types and “write-down” types (principal reduction)
- To deal with the various types of CoCos, we need to extend the existing model to more realistic settings, especially for CoCos with a write-down mechanism.

– We expand the model to the following types of CoCos.

1. Permanent write-down
2. Temporary write-down
3. Equity write-down with fixed conversion price
4. Equity write-down without fixed conversion price



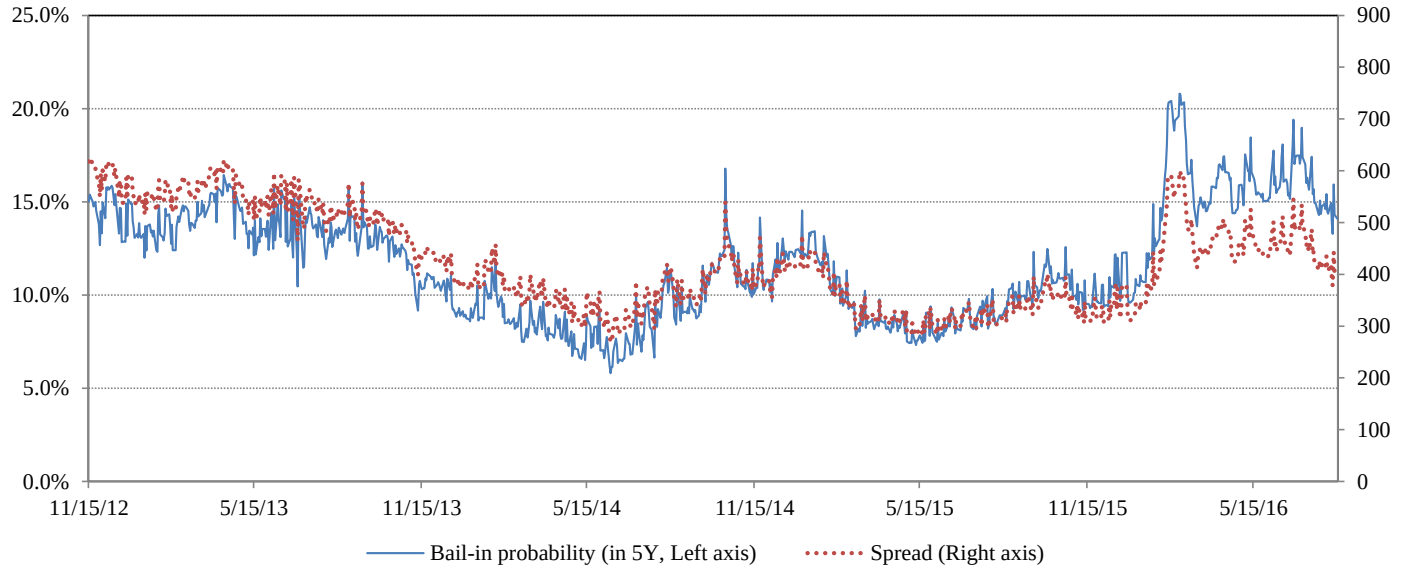
White Boxes indicate our model extension.
As of 2016/10/12

3-8. Permanent write-down (PWD)

- A CoCo principal becomes zero with no possibility of writing the principal up again.
- In this case, it means that the recovery rate is equal to zero (loss rate equals one) by definition

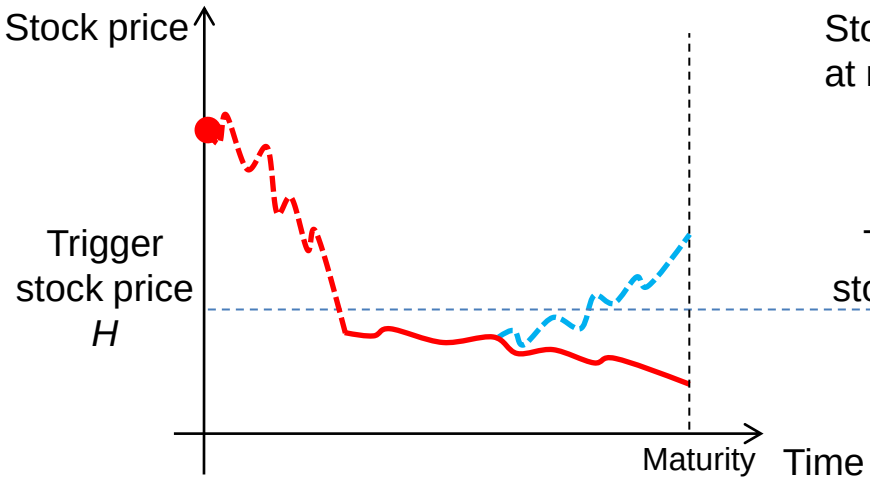
$$Loss_{CoCo} = 1 - \frac{H}{C_P} \rightarrow 1 \quad \Rightarrow \quad CS_{CoCo} \rightarrow \lambda_{CC} = -\frac{\ln(1 - P_H)}{T}$$

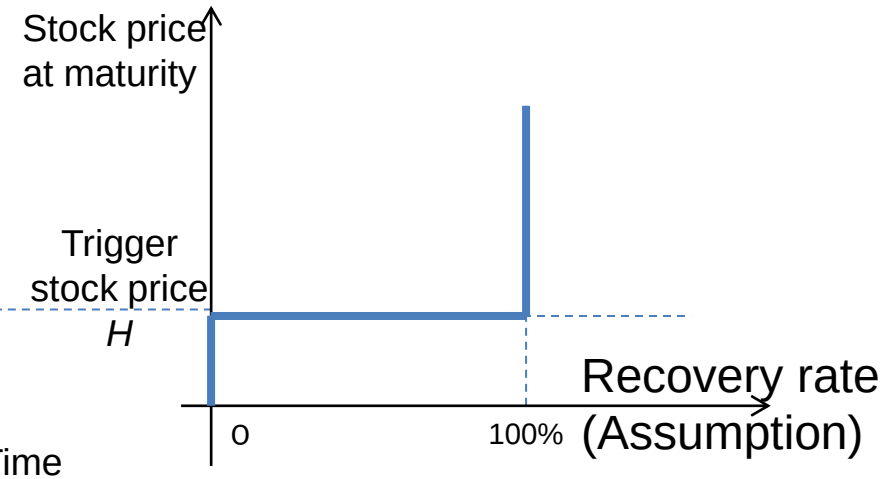
Example of PWD issued by a European G-SIB



3-9. Temporary write-down (TWD)

- A CoCo principal may be written up after write down, when the CoCo loss absorption mechanism is a temporary write down.
  - Due to its path dependent structure, an explicit and strict expansion of the model is difficult
- The coupon payments are assumed to be zero even after the write-up.
- This simplifies the problem of the TWD CoCo values depending only on the status of CoCos at maturity (whether or not their principals will be written down at maturity).
  - In our model, we need to consider whether or not the share price at the maturity will be higher than the trigger share price.





3-9. Temporary write-down (TWD)

- As a result, the CoCos spread is equal to a hazard rate when the stock price at the maturity is lower than the trigger stock price *H*:

$$CS^0_{CoCo}(H) \equiv -\frac{\ln\left(1 - P^0(H)\right)}{T},$$
$$P^0(H) = N\left[\frac{\ln(H/S) - \mu T}{\sigma\sqrt{T}}\right]$$

- Thus we can obtain the trigger share price by calibrating $CS^0_{CoCo}(H)$ with the market data. The bail-in probability is estimated by substituting *H* into the equation for the barrier option.

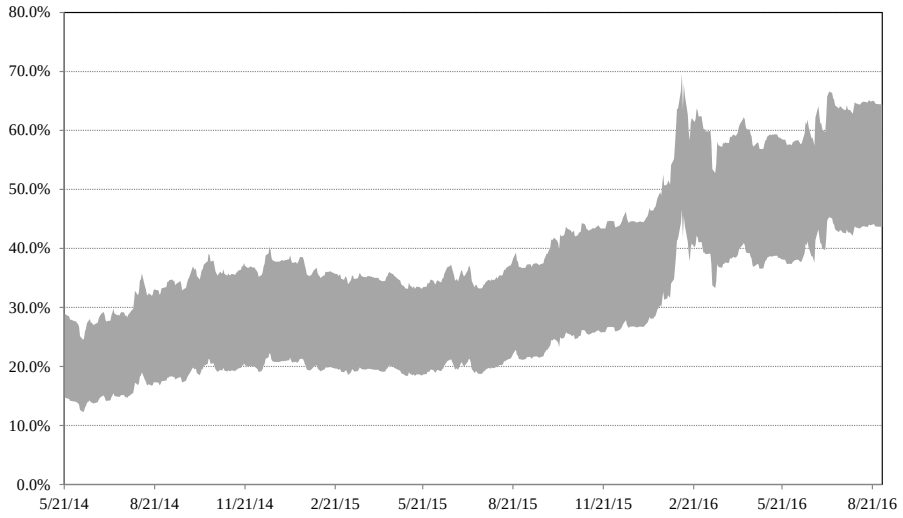
$$P_H = N\left[\frac{\ln(H/S) - \mu T}{\sigma\sqrt{T}}\right] + \left(\frac{H}{S}\right)^{2\mu/\sigma^2} N\left(\frac{\ln(H/S) + \mu T}{\sigma\sqrt{T}}\right)$$

3-9. Temporary write-down (TWD)

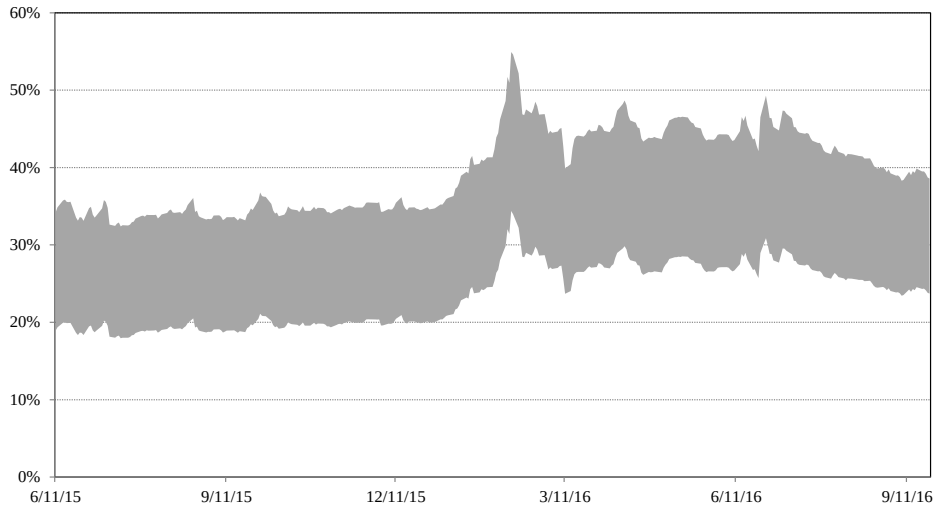
- However, our simplification might evaluate the value of the CoCos higher than actual.
- Then we express the bail-in probability as a range between (A) the simple result mentioned just above(a MOST desirable case for investors) and (B) the result from the PWD(a LEAST desirable case for investors):

$$P\left(H_{(B)}\right) \leq P(H) \leq P\left(H_{(A)}\right)$$

E bank



F bank

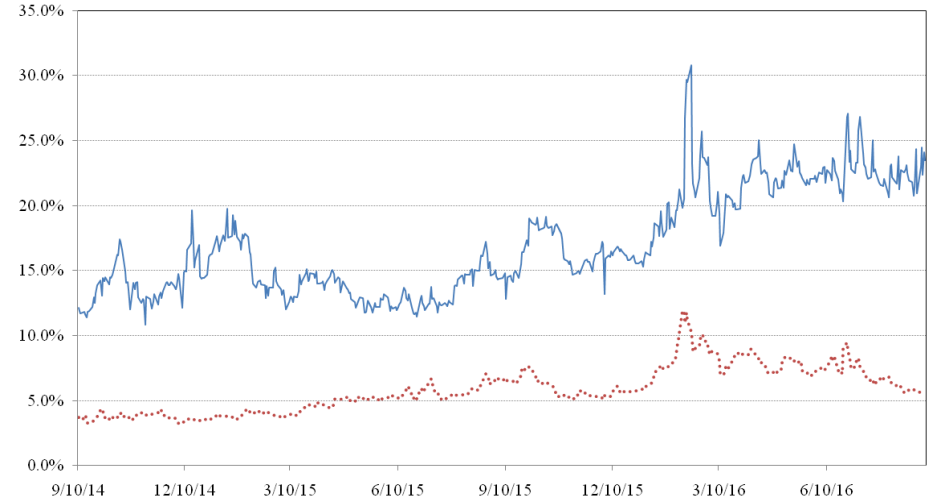


4. Empirical analysis

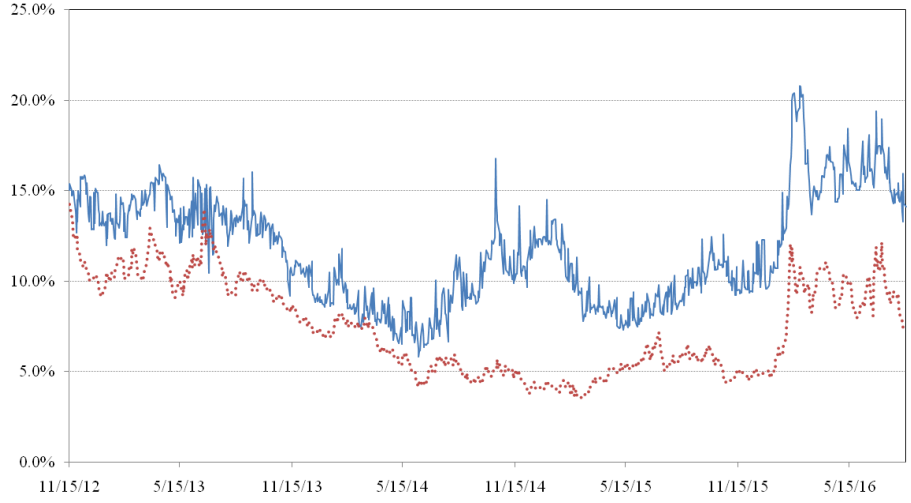
1. Comparison of bail-in probabilities (probs) and default probs
2. Probs of defaults after bail-ins of CoCos
3. Principal component analysis of bail-in probs by regions
4. Term structure of bail-in probs

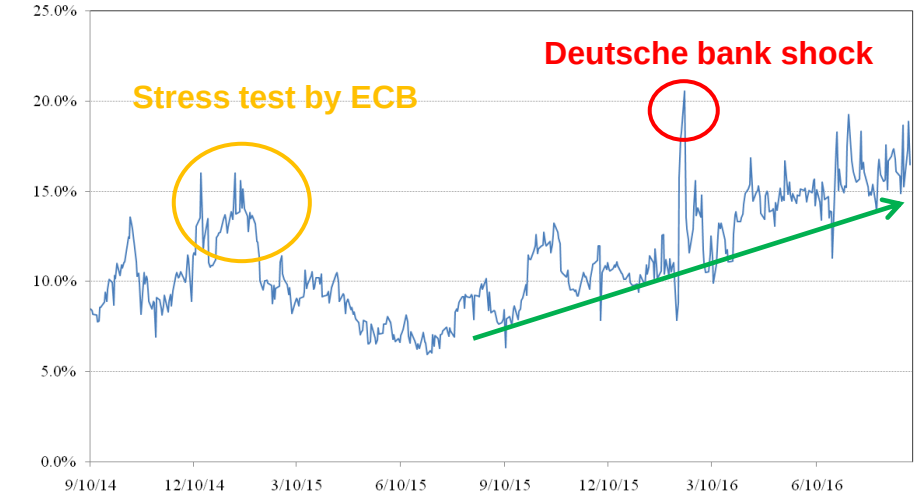
4-1. Comparison of Bail-in probs and default probs (1)

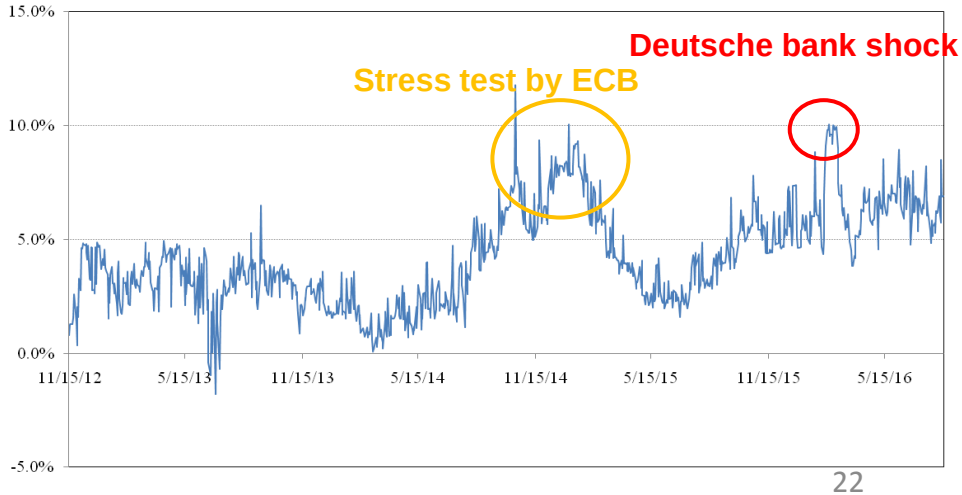
A bank (since 14/9; above : probs, below : Diffs)



B bank (since 12/11; above : probs, below : Diffs)

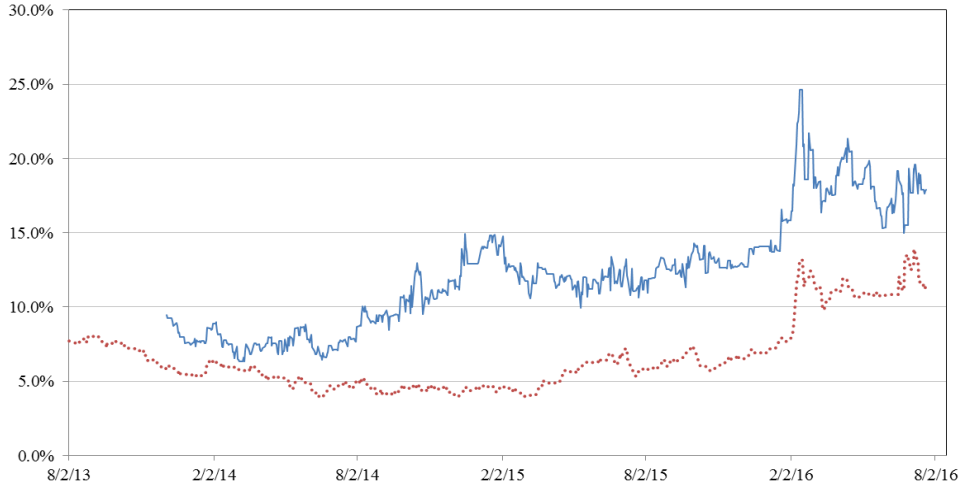




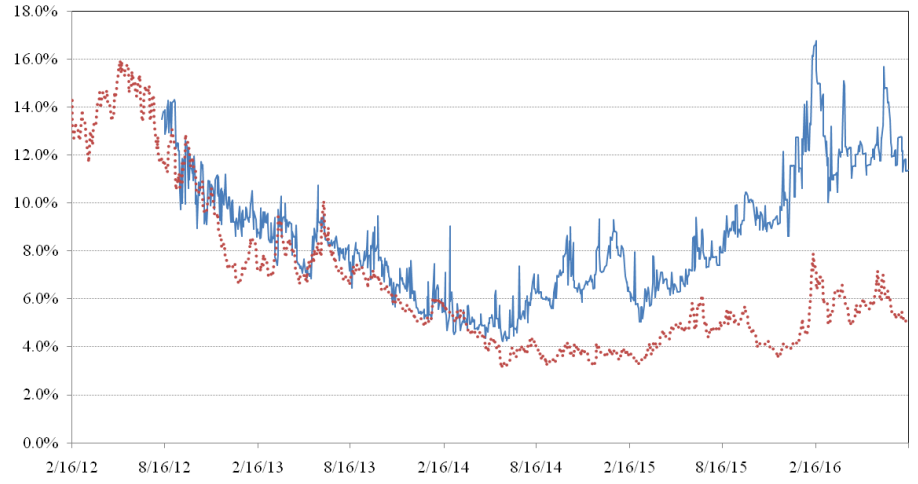


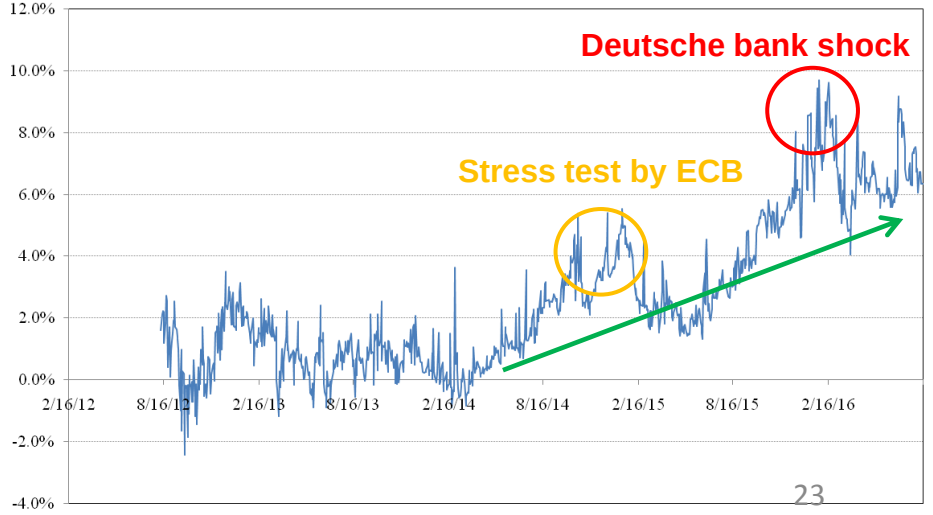
4-1. Comparison of Bail-in probs and default probs (2)

C bank (since 13/8; above : probs, below : Diffs)



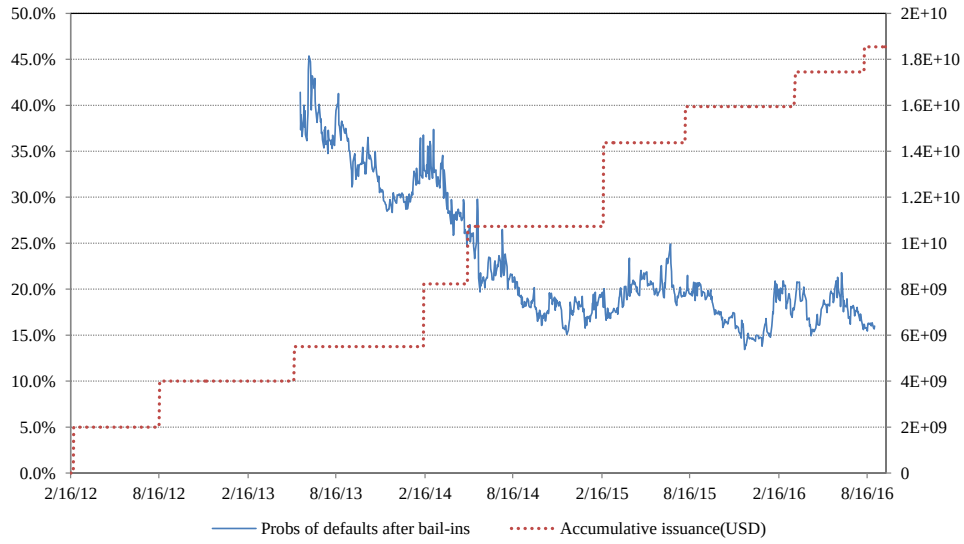
D bank (since 12/8; above : probs, below : Diffs)



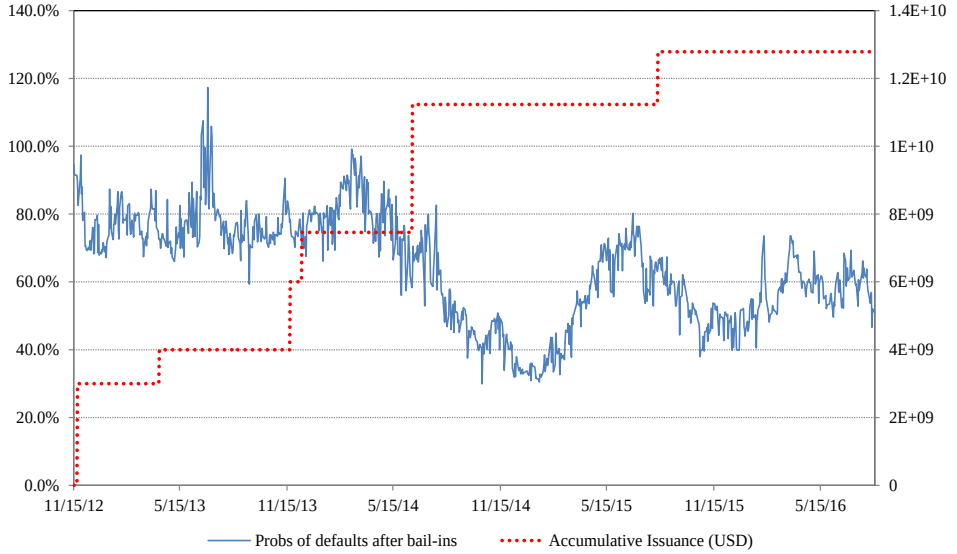


4-2. Probs of defaults after bail-ins of CoCos ($\frac{\text{P(Default)}}{\text{P(Bail in)}}$)

D bank (since 12/2)

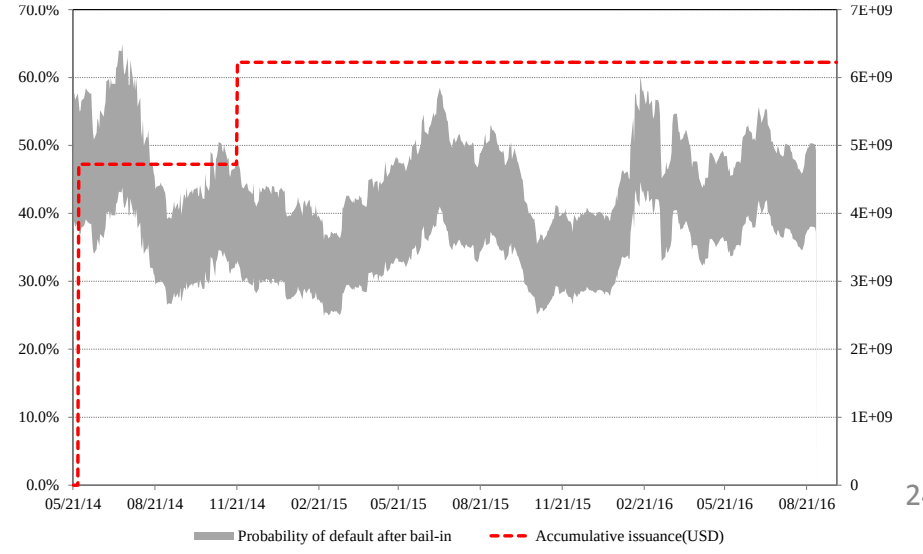


B bank (since 12/11)

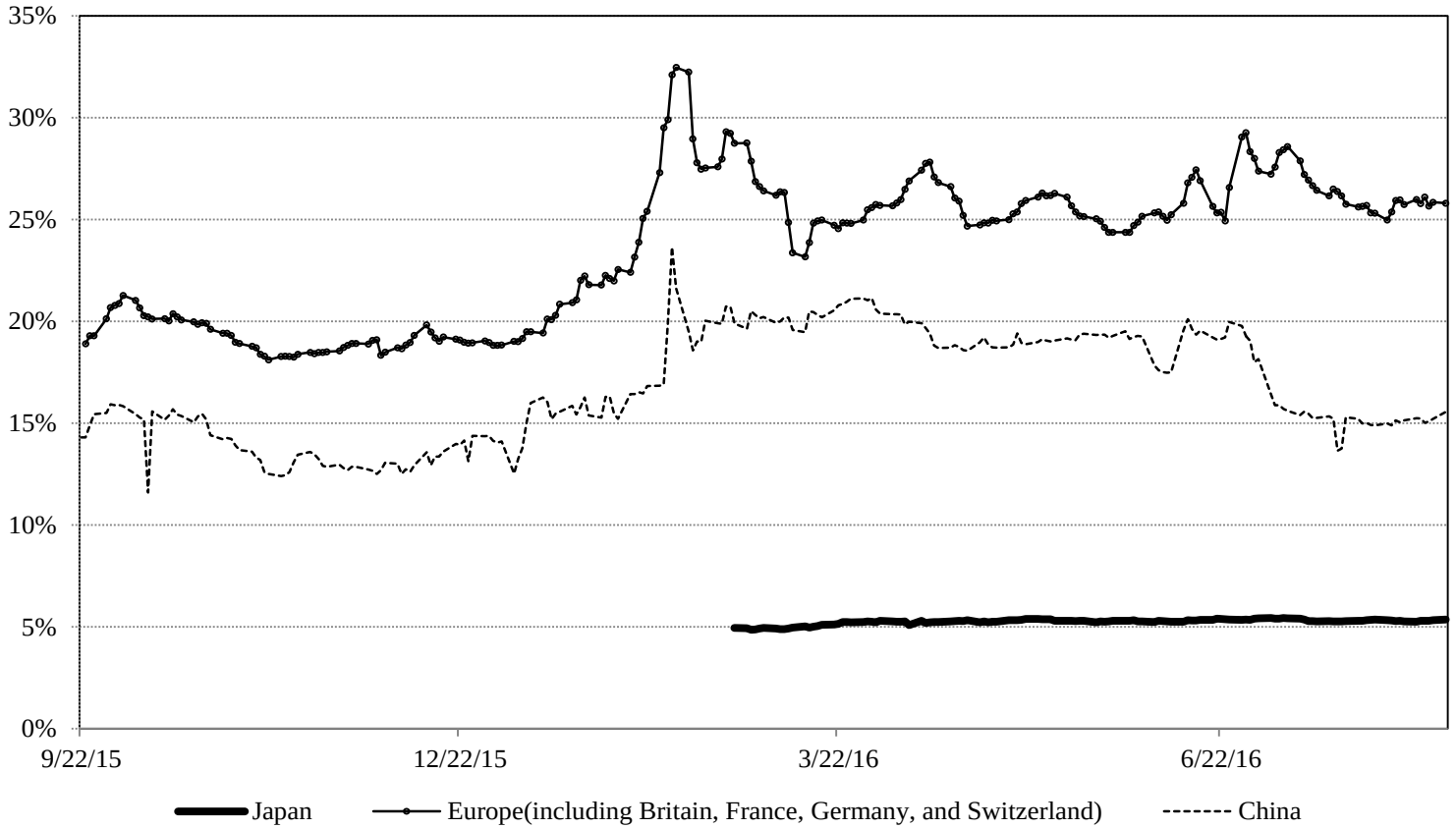


C bank (since 13/8)

E bank (since 14/5)



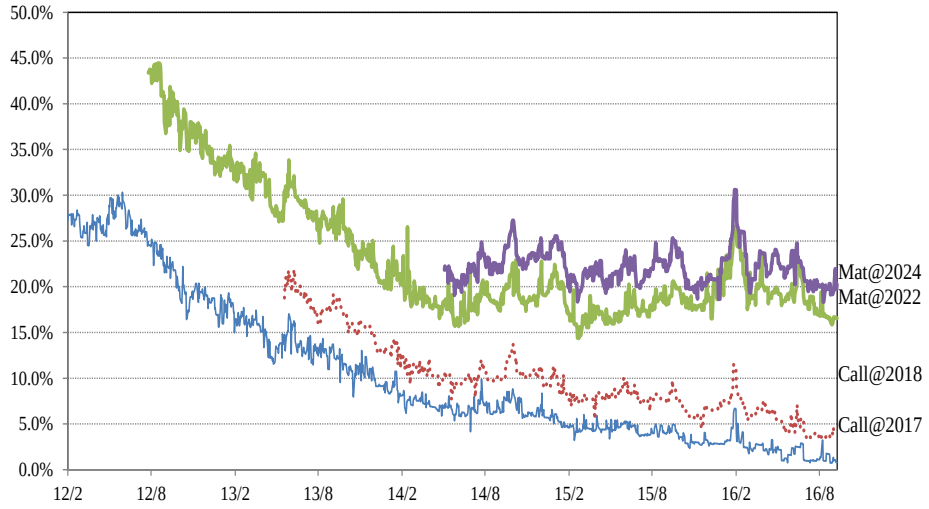
4-3. Principal component analysis of bail-in probs by regions



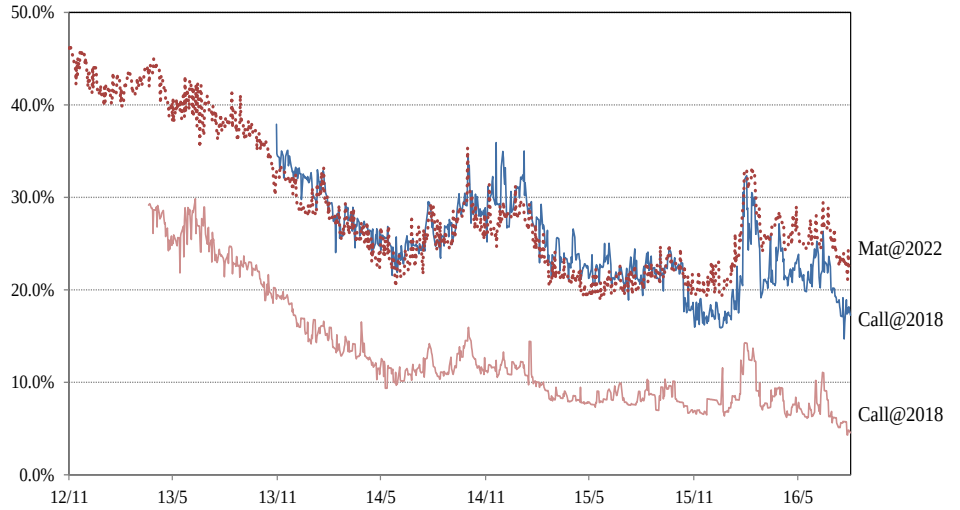
- PC analysis is performed with the first difference of log-transformed probabilities.
- The level of the probabilities of Japan is overwhelmingly low compared to the other region.
  - The result may reflect
    1. the soundness of major three Japanese banks are strong
    2. the strong movement of search-for-yield by Japanese investors.

4-4. Term structure of bail-in probs: Bail-in probs by redemptions

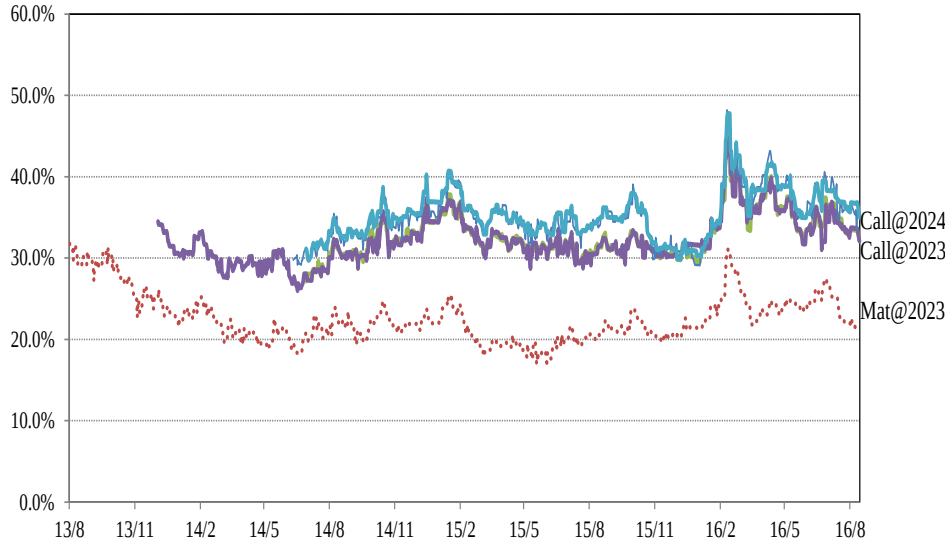
D bank (since 12/2)



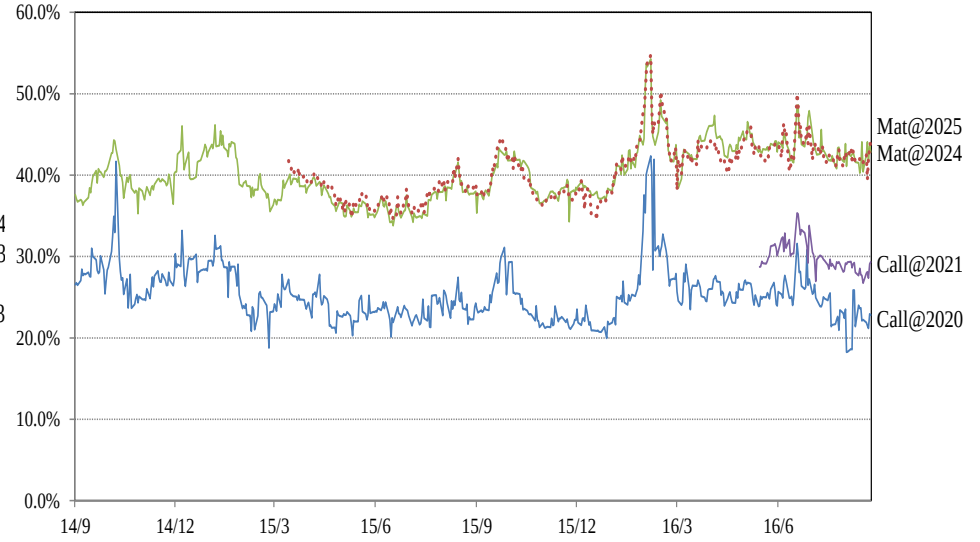
B bank (since 12/11)



C bank (since 13/8)

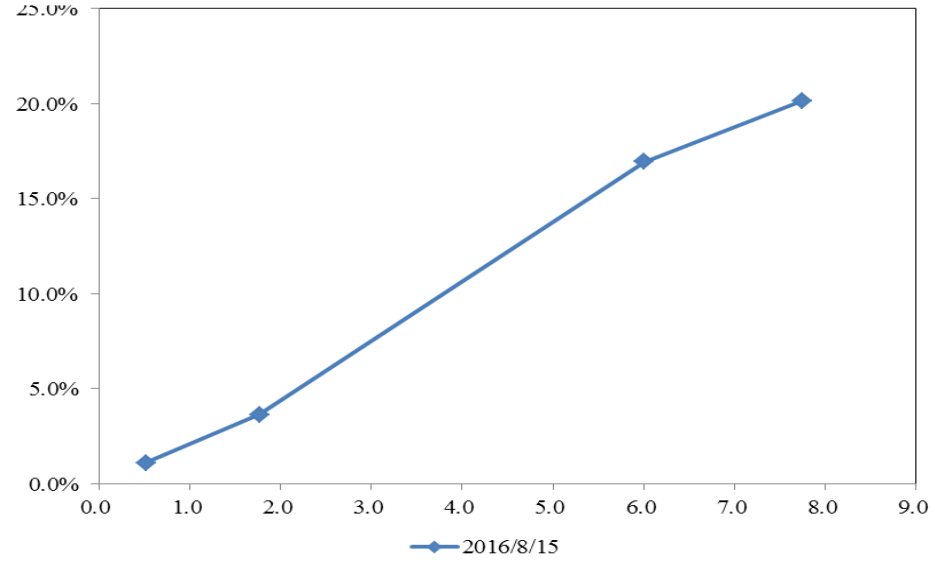


A bank (since 14/9)

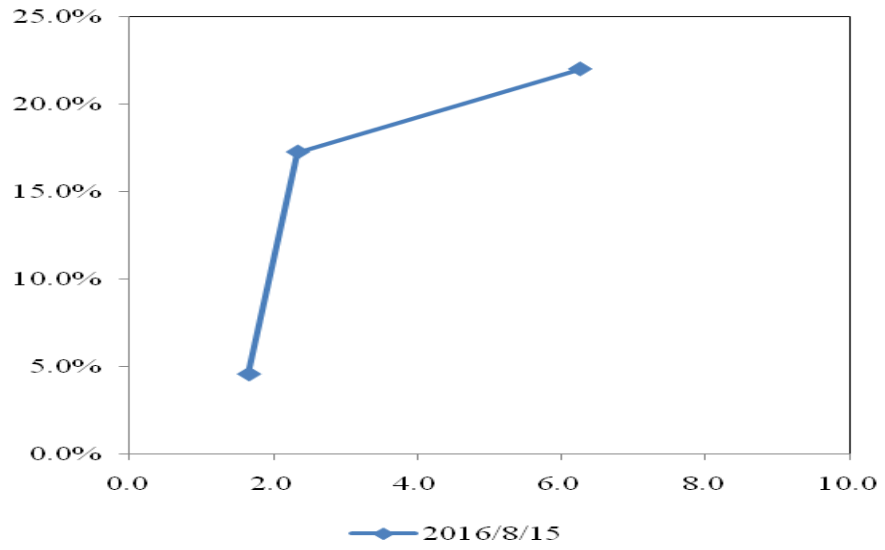


4-4. Term structure of bail-in probs: Cross-Section

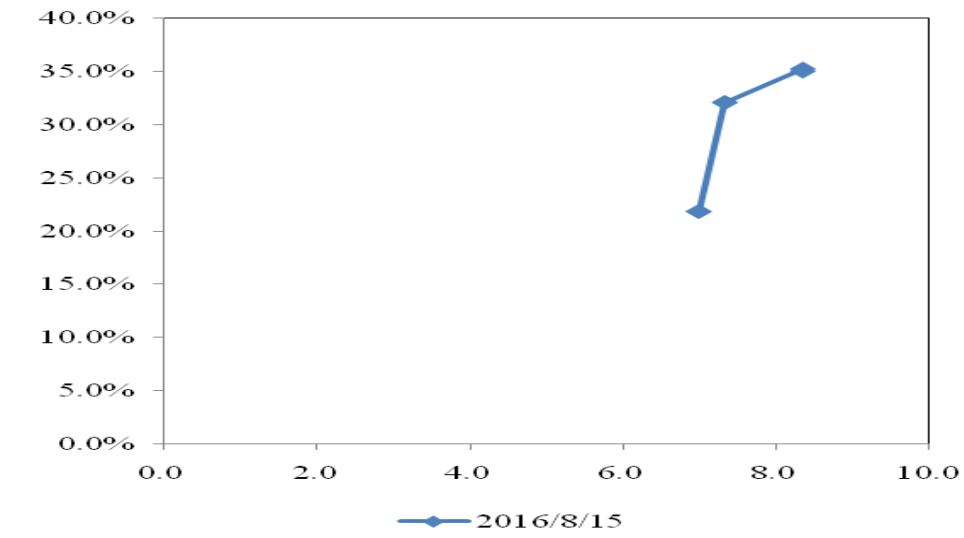
D bank



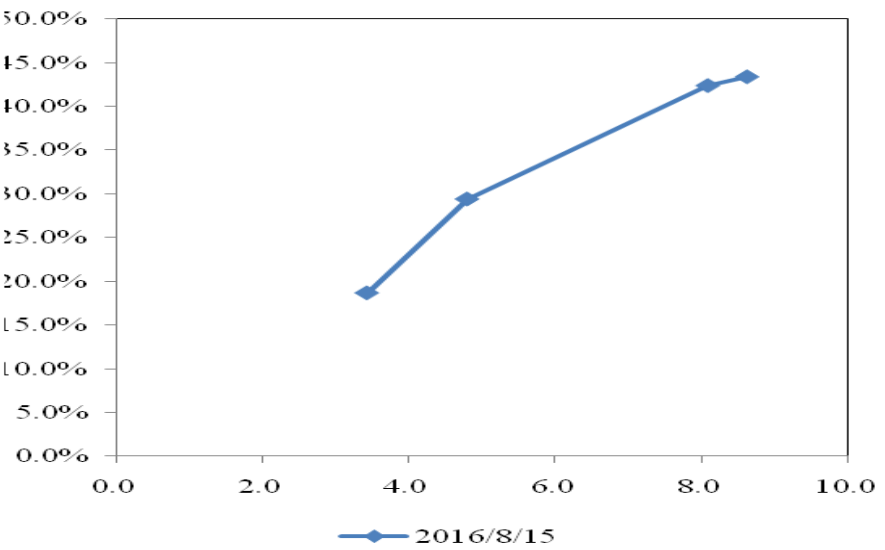
B bank



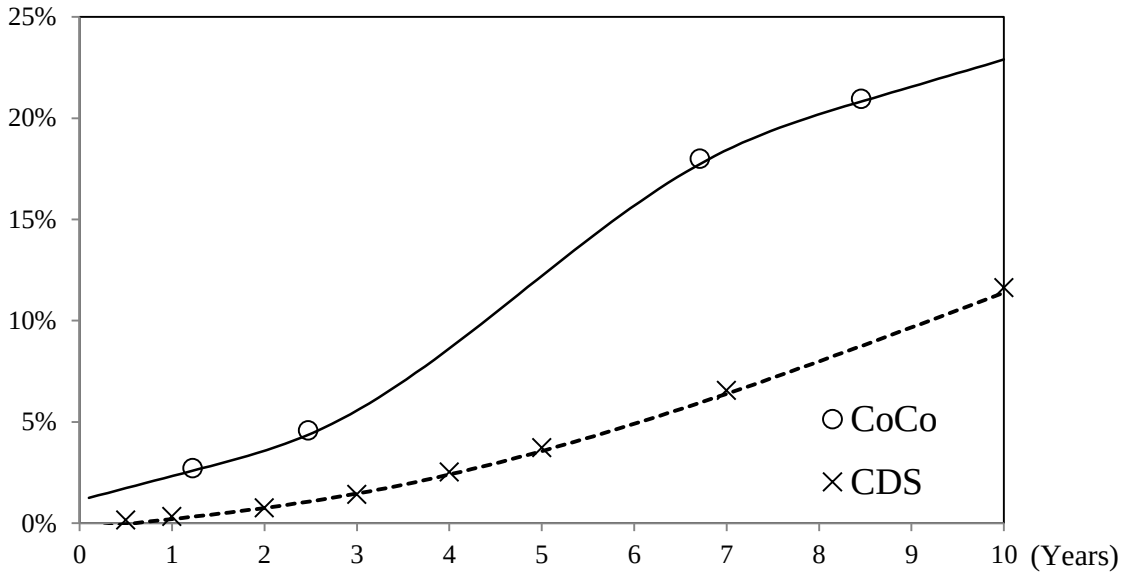
C bank

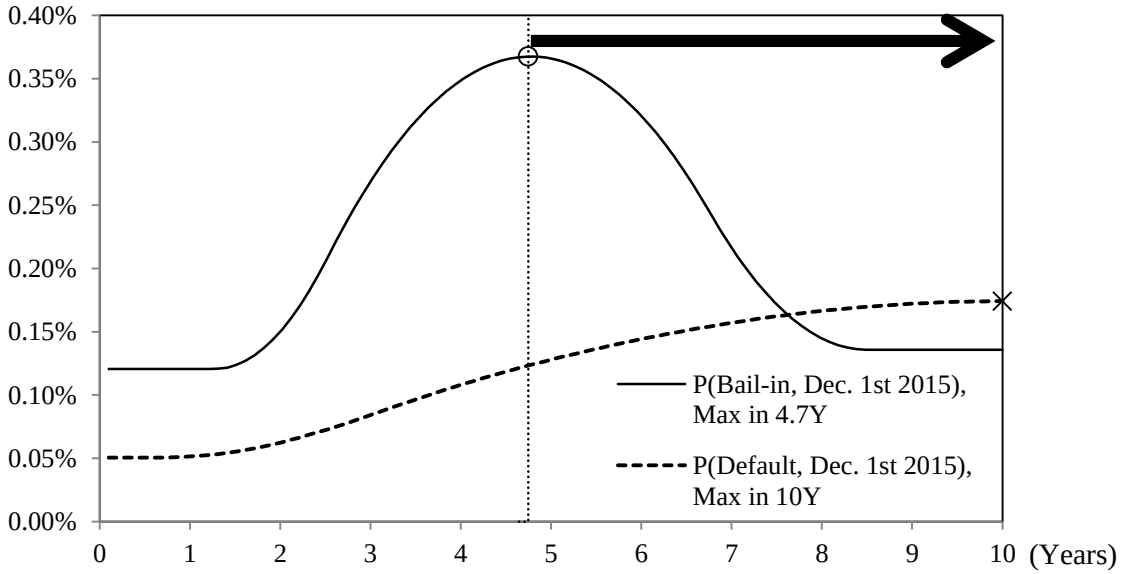


A bank

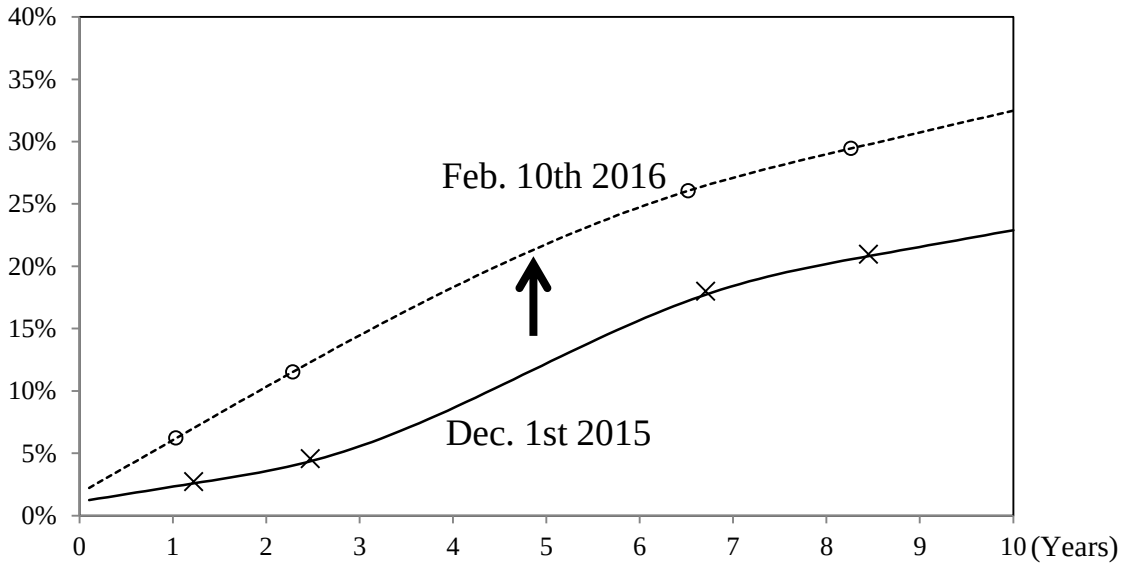


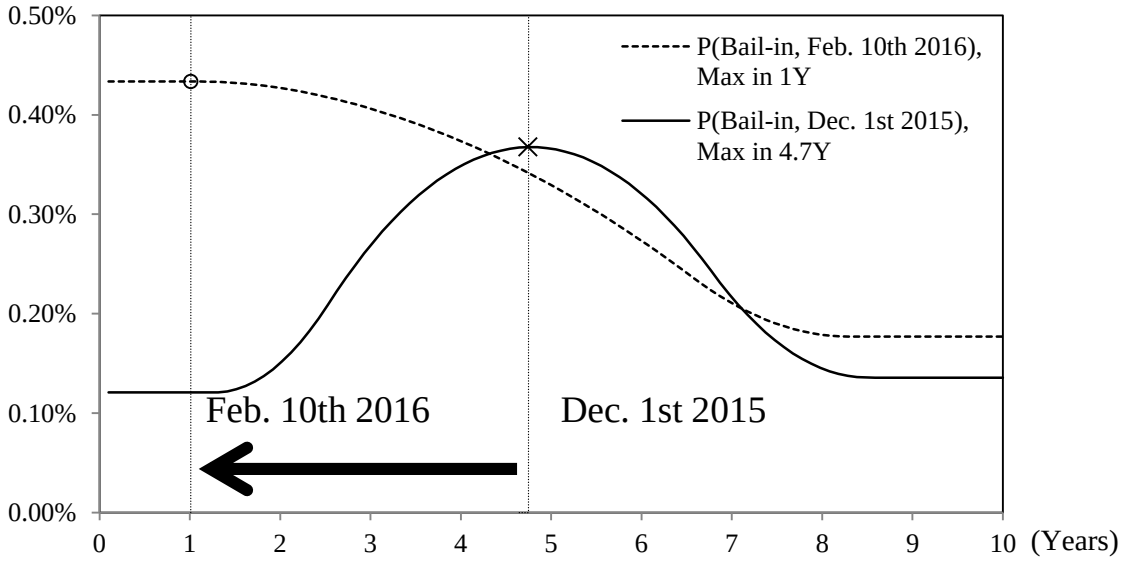
4-4. Term structure of bail-in probs and default probs: Implied bail-in/default time





4-4. Term structure of bail-in probs: Development of Implied bail-in time





5. Conclusion

1. This study is the first comprehensive analysis on bail-in probability of CoCos.
   - We also extend the credit derivative model to PWD and TWD.
2. We confirm that the implied bail-in probability increases when credit events occur more sensitively than the implied default probability from CDSs.
   - The bail-in probability would be a early warning indicator not only for an issuer but also for the financial system as a whole.
3. We also find that the market implied probability of default after bail-in tends to decrease as the issuance of CoCos increases.
   - It suggests that investors expect that the increase in the total amounts of loss absorption buffers for a bank prevents the institution from going into default
4. From the principal component analysis, we find that the implied bail-in probability of Japan is overwhelmingly lower than other areas.
   - Results from Japan would reflect the investors believe the capital structure of Japanese G-SIBS are safer than those in Europe. Moreover, it would also suggest that the movement of search for yield is relatively strong in Japan.

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