Macro-financial determinants of default probability using copula

A case study of Indonesian banks

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Outline

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Macro-financial linkages in financial stability

since aftermath GFC 2008.

- Financial and macroeconomic plays vital role in explaining business cycle.
- Shock in financial system is endogenous risk and potentially affect banks default probability.

Macro-financial linkages in financial stability.

By understanding the macro-financial linkages on financial stability...

- May help predict if a bank will default on its portfolio
- Help regulators to understand the drivers of default probability
- Determine the appropriate policy to promote financial stability

Outline

Previous Works.

Method to asses a bank's probability of default . . .

- Supervisory approach relies on firm-specific information.
  - Different from market-based approach (such as Merton).
  - Central bank proprietary data.
- Based on a multivariate distribution
  - Copula approach can capture non-linear relationships between variables with complex data structures (see also Brechmann et al. [2013]; Pourkhanali et al. [2016]; Zhang [2014]).
  - Reflects the likelihood that losses come from the marginal distribution (tail risk) - latent factor.

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Previous Works.

The drivers of default probability...

- Focus only a firm's intrinsic value or bank balance sheet or macroeconomic variables, but not using dependence modelling as copula does.[Weiß, Bostandzic, Neumann (2014), and Kleinow and Moreira (2016).]
- This paper analyze the interlinkage of bank-specific indicators and the macroeconomic variability to bank's default probability based on dependence modelling measurement (non-normal distribution).

Outline

Data(1)

We focus on Indonesian banks...

- Why Indonesia?
  - One of the large emerging economies in Asia.
  - Most suffered country among other peer countries in financial crises (Allen and Gale, 2000).
  - Serve as a benchmark due to the recent economic developments in emerging Asia
- Our data
  - 80 banks with 4800 observations from 2005–to 2019.
  - Coincides with the GFC 2008 and quantitative easing in 2013.
  - Included dummy periods of the pre-crisis, crisis and recovery periods of 2008
  - included dummy of bank owners: central state-owned, regional state-owned, and private commercial, also bank's region.

Data(2)

The determinants are:

- Bank-specific variables: CAR, CET 1 Ratio (CAP), NPL, LLP, IEF, OPM, LR, DEPOSIT, and LOAN
- Macro-economic variables: HHI, GDP, CPI, Unemployment (UNE), POLICYRATE, and exchange rate (RER)

Outline

Default Probability

Following (Sklar et al., 1959) theorem, the bank's balance sheet was mapped to the copula function $c(\cdot)$:

$$E_t = P(t,T) \iiint_0^{\infty} G_2\left(A_{C_T}, A_{L_T}, B_{C_T}, B_{L_T}; T\right) \cdot c\left(F_{A_C}, F_{A_L}, F_{B_C}, F_{B_L}\right) f_{A_C} f_{A_L} f_{B_C} f_{B_L} dA_{C_T} dA_{L_T} dB_{C_T} dB_{L_T} \quad (1)$$

where $c(\cdot)$ denotes the four-dimensional copula density function, $F(\cdot)$denotes the marginal cumulative distribution function, and $f(\cdot)$ denotes the marginal probability density function.

Using a Monte Carlo simulation, the values of a bank's equity can be estimated as follows:

$$\tilde{E}_t = P(t,T)\frac{1}{N}\sum_{k=1}^{N} G_2\left(\tilde{A}_{C_{Tk}}, \tilde{A}_{L_{Tk}}, \tilde{B}_{C_{Tk}}, \tilde{B}_{L_{Tk}}; T\right) \quad (2)$$

where N is the number of simulations, $E_t, \tilde{A}_{C_{Tk}}, \tilde{A}_{L_{Tk}}, \tilde{B}_{C_{Tk}}$, and $\tilde{B}_{L_{Tk}}$ are the simulated values of equity, current, and long-term assets and liabilities.

GMM Panel Model

We follow two-step system GMM estimator (Arellano - Bover, 1995; Blundell - Bond, 1998) using xtabond2 (Roodman,2009).

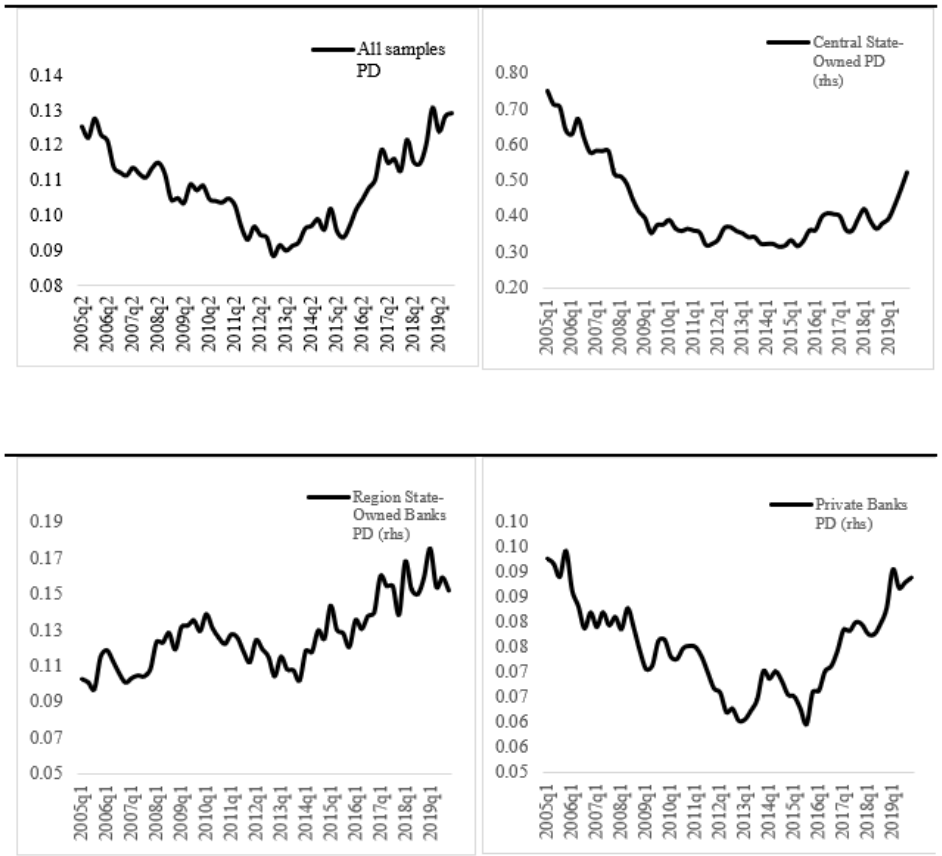
$$PD_{it} = \alpha + \delta \cdot PD_{i,t-1} + \beta \cdot V_{it} + \Sigma\varphi_i \cdot D_{it} + \varepsilon_{it} \quad (4)$$

where PD_{it} represents the probability of default of the bank i at year t; $PD_{i,t-1}$ denotes its lagged value, δ measure the speed of mean reversion, α is the constant term, V_{it} denotes the explanatory variables (banks-specific, structural, and macroeconomic variables). β is the vector of coefficient estimated, and $\Sigma\varphi_i \cdot D_{it}$ represents the time dummies for the period 2005q1 – 2019q4. Finally, ε_{it} is the disturbance term.

Outline

Evolution of Default Probability of Indonesian Banks

Figure 1. Evolution of probability of default of Indonesian banks



Source: Author calculation

Basic Model

	Probability of Default-PD (1)	Probability of Default-PD (2)
Lagged dependent	0.873***	0.862***
	(0.049)	(0.045)
Capital adequacy ratio	0	0
	(0)	(0)
CET 1 ratio	-0.0002**	-0.0003***
	(0.0001)	(0.0001)
Non-performing loan ratio	0	0.001**
	(0)	(0.001)
Loan loss provision	0	0
	(0)	(0)
Earnings ratio	0	0
	(0.001)	(0)
Inefficiency ratio	-0.00008*	-0.0002***
	(0)	(0)
Loan ratio	0	0
	(0)	(0)
Deposit ratio	0.00005**	0.00005**
	(0)	(0)
Liquidity ratio	0.003*	0
	(0.002)	(0.003)
Concentration ratio/HHI(1)		0.001
		(0.007)
Policy Rate(1)		-0.001***
		(0.0002)
Real exchange rate(1)		-0.0003***
		(0)
GDP growth(1)		-0.002***
		(0.001)
Inflation rate(1)		0
		(0.001)
Unemployment rate(1)		-0.049***
		(0.019)
Constant	0.014	0.082
	(0.011)	(0.054)
Time dummies	Yes	Yes
Observations	4720	4720
Sargan test (p-value)	609.05 (0.00)	651.01(0.00)
Hansen test (p-value)	14.17 (1.000)	73.41(0.132)
AB test AR (1) (p-value)	0.002	0.002
AB test AR (2) (p-value)	0.265	0.256

Basic Model

Our basic model says:. . .

- Increase in bank solvability improves a bank's ability to absorb sudden losses and reduces the PD.
- Banks with lower efficiency are less likely to experience distress - skimping hypothesis.
- DEPOSIT and LR positively impact default probability proves a "moral hazard effect".
- Other macroeconomic variables aligned with expectation except unemployment rate positively impacted the default probability.

Dummy crisis

	PD w/ Pre-crisis dummy	PD w/ Crisis dummy	PD w/ Post-crisis dummy
Lagged dependent	0.867***	0.861***	0.867***
	(0.042)	(0.045)	(0.041)
Capital adequacy ratio	0	0	0
	(0)	(0)	(0)
CET 1 ratio	-0.0004***	-0.0004***	-0.0004***
	(0)	(0)	(0)
Non-performing loan ratio	0.001**	0.001**	0.001**
	(0.001)	(0.001)	(0.001)
Loan loss provision	0	0	0
	(0)	(0)	(0)
Earnings ratio	0	0	0
	(0)	(0)	(0)
Inefficiency ratio	-0.0002***	-0.0002***	-0.0002***
	(0.0002)	(0)	(0)
Loan ratio	0	0	0
	(0)	(0)	(0)
Deposit ratio	0.00005**	0.00005**	0.00005**
	(0)	(0)	(0)
Liquidity ratio	0	-0.001	0
	(0.003)	(0.003)	(0.003)
Concentration ratio/HHI(1)	0.004	-0.001	0.003
	(0.008)	(0.007)	(0.007)
Policy Rate(1)	-0.001***	-0.001***	-0.001***
	(0)	(0)	(0)
Real exchange rate(1)	-0.0004***	-0.0004***	-0.0004***
	(0)	(0)	(0)
GDP growth(1)	-0.002**	-0.003***	-0.002**
	(0.001)	(0.001)	(0.001)
Inflation rate(1)	0	0.001	0.001
	(0.001)	(0)	(0)
Unemployment rate(1)	-0.057***	-0.053***	-0.068***
	(0.021)	(0.019)	(0.022)
Pre-crisis	-0.002		
	(0.002)		
Crisis		-0.002*	
		(0.001)	
Post-crisis			0.004**
			(0.002)
constant	.066	0.098*	0.077
	(.051)	(0.055)	(0.052)
Observations	4720	4720	4720
Sargan test *(p-value)*	654.97 (0.00)	648.91 (0.00)	651.99 (0.00)
Hansen test *(p-value)*	74.11 (0.121)	73.45 (0.132)	74.69 (0.112)
AB test AR (1) *(p-value)*	0.002	0.002	0.002
AB test AR (2) *(p-value)*	0.258	0.257	0.262

Dummy crisis

When we included dummy crisis. . .

- The positive value in the dummy crisis period indicates that Indonesian banks reduced their probability of default during the global financial crisis.
- A negative sign in recovery period demonstrates Indonesian banks increased their risk exposure , and as a result, PD was intensified.

Dummy Bank Ownership and Region.

	PD w/bank's owner dummy	PD w/ regional dummy
Lagged dependent	0.849***	0.863***
	(0.048)	(0.042)
Capital adequacy ratio	0	0
	(0)	(0)
CET 1 ratio	-0.0003***	-0.0003***
	(0.0001)	(0)
Non-performing loan ratio	0.001*	0.001**
	(0.0003)	(0.001)
Loan loss provision	0	0
	(0)	(0)
Earnings ratio	0	0
	(0)	(0)
Inefficiency ratio	-0.0001***	-0.0002***
	(0)	(0)
Loan ratio	0	-0.0002*
	(0)	(0)
Deposit ratio	0.00005**	0.00005**
	(0.00002)	(0)
Liquidity ratio	-0.001	0.001
	(0.003)	(0.002)
Concentration ratio/HHI(1)	0.004	-0.001
	(0.007)	(0.007)
Policy Rate(1)	-0.001***	-0.001***
	(0)	(0)
Real exchange rate(1)	-0.0003***	-0.0003***
	(0)	(0)
GDP growth(1)	-0.002***	-0.002**
	(0.001)	(0.001)
Inflation rate(1)	0	0
	(0.001)	(0.001)
Unemployment rate(1)	-0.051**	-0.047**
	(0.02)	(0.019)
Central State-Owned Banks	0.046***	
	(0.016)	
Regional state-owned banks	0.004	
	(0.006)	
Private Banks		
West region		0.012
		(0.014)
Central region		-0.01**
		(0.005)
East region		-0.002
		(0.007)
constant	0.056	0.099**
	(0.047)	(0.047)
Observations	4720	4720
Sargan test	628.13 (0.00)	649.69 (0.00)
Hansen test *(p-value)*	74.50 (0.115)	71.55 (0.167)
AB test AR (1) *(p-value)*	0.002	0.002
AB test AR (2) *(p-value)*	0.256	0.258

Dummy Bank Ownership and Region.

Impact of bank ownership and region...

- Central state-owned banks are at higher risk because their dominant and it affects the default probability as a whole.
- Regional state-owned banks in central region negatively associated with PD.

Summary

- CET 1 ratio, inefficiency ratio, and deposit substantially affect a bank's default probability.
- Skimping hypothesis linked to a bank's inefficiency indicator
- NPL appeared to be lagged indicator when we included macroeconomic variables.
- Policy rate, real exchange rate, economic growth, and unemployment rate reduce default probability.
- Recommendations
  - Regulatory should focus on capital regulatory and deposit management policy.
  - The policy rate effectively anticipated the banks' default risk.

QnA I

Questions?