A Macroeconomic Model with Firm Debt Financing, Bank Lending, and Banking Regulations

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Motivation

- The Basel committee on Banking Supervision (BCBS) is actively setting up regulatory requirements on banks.
- The BCBS has issued series of Basel Accords in part to strengthen the soundness and stability of the international banking system.
- Its current version of Basel III, published in 2010, raises:
  - **Capital requirement:**
    - Total capital ratio (Tier 1 plus Tier 2) must be at least 8 percent of risk-weighted assets
  - **Liquidity requirement:**
    - 1. Liquidity Coverage Ratio (LCR) requires that banks have sufficient high-quality liquid assets (at least 100 percent) to offset the net cash outflows over a short-term, ideally 30 days.
    - 2. Net Stable Funding Ratio (NSFR) asks for a minimum amount of stable sources of funding to the liquidity needs over a one-year horizon.

Motivation

- Current literature, for example De Nicolo et al. (2014), concentrates on the impacts of the Basel Accords particularly on the **bank lending**, and on the real economy.
- The majority of the literature reveals that tightening the capital requirements or implementing the liquidity requirements could reduce bank lending, and thus depressing output.
- **However**, the impacts on the **firm debt financing** is less documented.
- The **main** objective of this paper is to investigate how would the banking regulation, i.e. the Basel III, affect debt financing structure of firms, **the borrowers of banks**.

What I do

- I build up a quantitative general equilibrium model to investigate the impacts of the (capital and liquidity) requirements on:
  - **Bank lending**
  - **Firm debt financing**
  - **GDP**
  - **Macro-economy variables**, such as loan rates, bond rates, deposit rates.

Related literature

- **Evaluations of Basel-style (capital and liquidity) requirements:**
  De Nicolo et al. (2014), König (2015), Hugonnier and Morellec (2017) Van den Heuvel (2018), Carletti et al. (2018), Thakor (2018).
- **Methodologies on dynamic modelling:**
  Gertlerand and Karadi (2011), Gertler, Kiyotaki and Queralto (2012), Gertler and Kiyotaki (2015), Elenev et al. (2016), Elenev et al. (2018), Begenau and Landvoigt (2018).
- **Asset pricing:**
  He and Krishnamurthy (2013), Brunnermeier and Sannikov (2014), Drechsler et al. (2018).
- **Firm debt financing:**
  Franks and Pringle (1982), Campello (2014), Douglas, Fu and Tang (2014).

Contributions

The contributions of this paper are as follows:

- **Reveals a macro-prudential effect of the Basel-style requirements on the real economy**

  The evaluation extends to the production sector, not only on the banking sector.

- **Separation of risky assets**

  There are two risky assets: loans and corporate bonds, while current literature only consider loans.

- **Participation of savers in risky assets**

  Current literature, for example Elenev et al. (2018), assumes that savers only hold risk-free assets. This loses the generality as it is estimated that around 21 percent of savers'/households' wealth is in risky assets, such as corporate bonds and stocks.

Contributions

- **Model generalisations for asset pricing literature**
  - 1. Generates several results, such as credit spread, **loan spread**.
  - 2. Defaults of firms and banks are endogenously determined.
  - 3. Deposit (risk-free) rates are generated by Stochastic Discount Factor (SDF).

The model

- The model includes three agents and a government:
  - **Bankers**: Operate banks, lend long-term **loans** and hold **corporate bonds** to invest in firms. Buy **government bonds** from the government.
  - **Savers**: Supply their labour to firms for wages, deposit in banks, and by buy **corporate bonds** from firms.
  - **Entrepreneurs**: Operate firms, borrow **loans** from banks and sell **corporate bonds** to banks and savers.
  - **The government**: Sets up the requirements, issues **government bonds** to cover its expenditure, bail outs the defaulting banks, and insures the deposits.
- **Savers** and **Entrepreneurs** make up **Households**, while **Bankers** is **Non-Households**

The model

- There are four forms of assets:
  - **Loans**: At each time t, a portion of σ of existing loans matures. The loan rate is q_t^A.
  - **Corporate bonds**: At each time t, a portion of n of existing corporate bonds matures. The price of the bonds is p_t^B. $n < \sigma$ indicates that a corporate bond usually has a longer maturity than a loan. The **bonds** are less riskier than the **loans** due to a priority of claiming residuals from defaulting firms.
  - **Government bonds/deposits**: Risk-free, at the price of q_t^f.
  - **Capital**: Held by entrepreneurs/run by firms. Depreciate at the rate of δ_K

The model

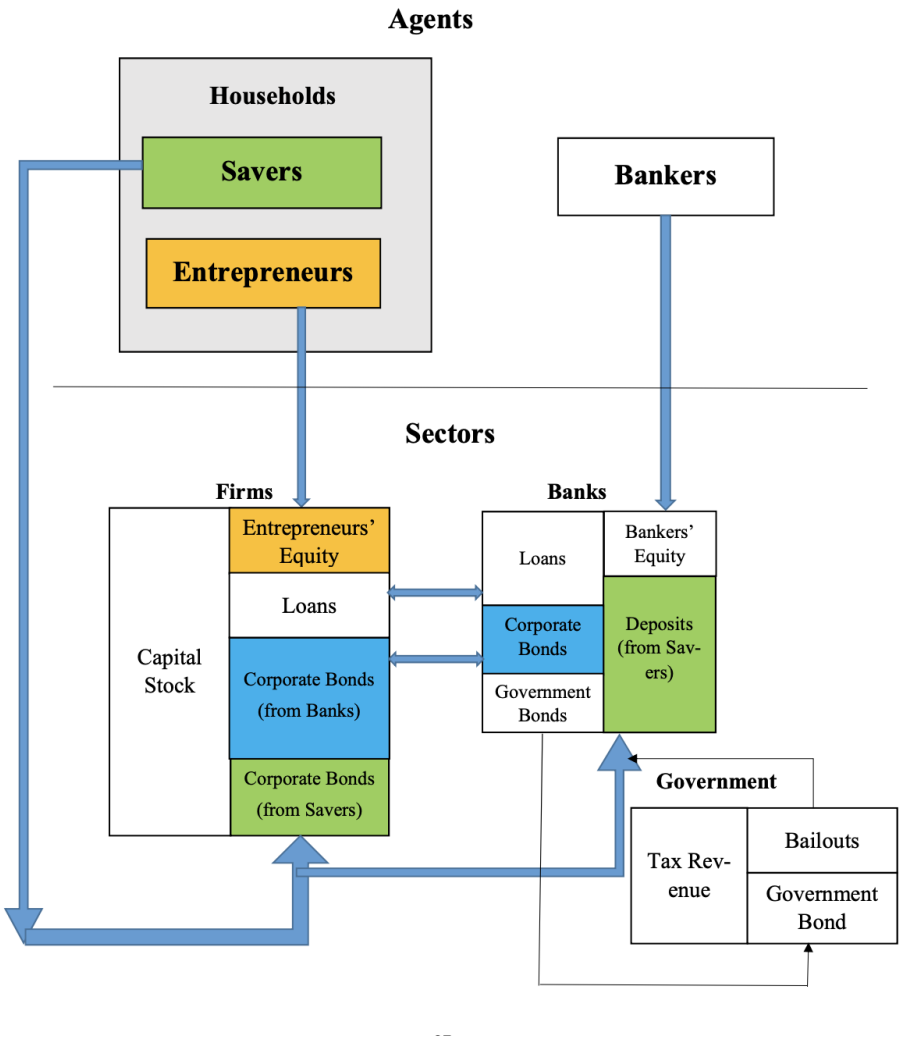

Figure: Overview of Balance Sheets of Model Agents

The model

- **Households**
  - At time t, households, **entrepreneurs** and **savers**, aim to maximise their respective utility function:

$$U_t^b = \left((1-\beta_b)(C_t^b)^{1-1/v_b} + \beta_b \left(E_t[(U_{t+1}^b)^{1-\sigma_b}] \right)^{\frac{1-1/v_b}{1-\sigma_b}} \right)^{\frac{1}{1-1/v_b}}$$

  - Households are subject to respective **budget constraints**. **Entrepreneurs** will be constrained with a **leverage constraint** to limit excess borrowing (Kiyotaki and Moore, 1997).
    - Notation b denotes the households, where $b = E$ represents **entrepreneurs** and $b = S$ represents **savers**.
    - C_t^b is current consumption (at time t)
    - v_b is inter-temporal elasticity of substitution
    - σ_b is risk aversion

The model

- **Households: Entrepreneurs**
  - Production Function
$$Y_{i,t} = \omega_{i,t} Z_t K_{i,t}^{1-\alpha} L_{i,t}^{\alpha}$$
    - $\omega_{i,t}$ is an idiosyncratic productivity shock, for individual firm i, and follows a Gamma distribution.
    - Z_t is total factor productivity (TFP)
    - $K_{i,t}$ is capital stock
    - $L_{i,t}$ is labour input, provided by entrepreneurs and savers.
  - An individual firm will fail if its idiosyncratic productivity shock falls below a threshold, $\omega_{i,t}^*$, which it cannot afford its liability.
  - The probability of default of firms is denoted by $\Omega_D(\omega_{i,t}^*)$.
  - At time t, surviving (aggregate) entrepreneurs optimally make **consumption** C_t^E, borrow **loans** A_{t+1}^F, sell **corporate bonds** B_{t+1}^F, choose **capital stock** K_t^F, **net capital investment** X_t, and hire **labour** L_t, where L_t is the sum of $L_{i,t}$ across the firms.
  - The entrepreneurs will operate to maximise their utility function.

The model

- **Households: Savers**
  - At time t, savers in-elastically supply their labour $\bar{L}_t$ for wages of $w_t \bar{L}_t$ and optimally make **consumption** C_t^S, choose **deposits** in the bank D_t^S and buy **corporate bonds** B_t^S.
  - Deposits are risk-free as honoured by the government in the form of deposit insurance, yielding return of $r_t^f = 1/q_t^f - 1$, where q_t^f is the price of government bonds.

The model

- **Bankers**
  - At time t, **bankers** aim to maximise their value function:

$$V^B(A_t^B, B_t^B, D_t^B, s_t) = d_t^B + E_t\left[\Lambda_{t,t+1}^B V^B(A_{t+1}^B, B_{t+1}^B, D_{t+1}^B, s_{t+1})\right]$$

  - Bankers are subject to their **budget constraints**, a **reserve constraint**, to limit over-leverage, and a representative **capital requirement** and **liquidity requirement**.
    - A_t^B is bank loans, B_t^B is banks' holding of corporate bonds, D_t^B is banks' debts in deposits, s_t is the state variables.
    - d_t^B is the dividend payment of banks
  - Bankers optimally make **dividend payout** d_t^B, **loans** A_{t+1}^B and **banks' holding of corporate bonds** B_{t+1}^B to maximise the above value function.

The model

- **The government**
  - At time t, the government pays for the **expenditure** G_t^w, such as bailing out defaulting banks, and incurs an exogenous **government spending** G_t.
  - To finance these expenses, the government receives **tax revenues** from all agents and sell **government bonds** to banks.

The model

- **Market clearing conditions**
  - **Loans**: $A^F_{t+1} = A^B_{t+1}$
  - **Corporate bonds**: $B^F_{t+1} = B^B_{t+1} + B^S_{t+1}$
  - **Capital**: $K^F_{t+1} = (1 - \delta_K)\Omega_D(\omega^*_{i,t})K^F_t + X_t$
  - **Labour**: $L^b_t = \bar{L}_t$ for $b = E, S$
  - **Deposits**: $D^B_{t+1} = D^S_{t+1} = \bar{D}$
  - **GDP**: $Y_t = C^E_t + C^B_t + d^B_t + G_t + G^w_t + InvestmentExpenses$

    InvestmentExpenses represents costs such as dividend payout cost, loan adjustment cost and capital investment expense.

Results

- **Model v.s. Data**

Variables	Notation	Data	Model
Risk-free rate	r^f	2.20	2.19
Standard deviation of risk-free rate	$\sigma(r^f)$	2.24	3.57
Loan rate	q^A	5.60	5.45
Corporate bond rate	$1/p^B - 1$	3.68	3.54
Credit spread	$1/p^B - 1 - r^f$	1.48	1.35
Capital Investment-GDP ratio	I^B/Y	21.44	26.11
Standard deviation of cap. In. GDP ratio	$\sigma(I^B/Y)$	1.52	1.68
Credit-GDP ratio	A^F/Y	65	65.8
Corporate bond-GDP ratio	B^F/Y	22	12.9
Standard deviation of dividend-GDP ratio	$\sigma(d^B/Y)$	0.14	13.1
Consumption-GDP ratio	C/Y	67	63.9
Firm leverage	$(A^F + B^F)/K$	40	30.7

Results

- **Agents**

	No Requirements		Capital Requirements		Capital & Liquidity Requirements	
	mean	std. dev.	mean	std. dev.	mean	std. dev.
			Entrepreneurs and Firms			
1. Capital	196.43	23.92	194.32	27.43	192.15	23.29
2. Cop. Bonds	**9.56**	8.66	**5.97**	3.41	**6.26**	3.71
3. Entre. Consp.	9.49	11.18	6.06	11.28	6.99	12.43
4. Default of firms	2.63	2.08	2.62	2.14	2.72	2.12
5. Loss in def.	4.03	3.12	3.96	3.22	4.13	3.20
6. Entrpre. value	134.63	21.92	138.23	18.51	138.43	26.72
			Bankers and Banks			
7. Bankruptcy	1.56	2.11	0.05	0.40	0.05	0.42
8. Loans	**49.32**	6.11	**48.94**	5.90	**47.12**	5.63
9. Bank Bond	8.14	9.23	4.88	3.67	5.11	4.25
10. Dividends	6.92	9.55	10.68	4.55	11.32	2.74
11. Bankers value	16.85	25.11	16.54	7.70	14.58	9.08
			Savers			
12. Savr. Consp.	17.62	1.39	17.65	1.51	17.82	0.99
13. Saver Bond	1.35	1.82	1.09	1.69	1.15	1.97
14. Savers value	31.92	2.62	32.11	1.93	32.59	2.14

- 1. **Probability of bankruptcy** reduces and **loans (bank credit)** reduces.
- 2. **Corporate bonds** do NOT rise after the implementation of the requirements.

Results

- **Agents**

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- 1. Standard deviations of **bankers and Banks** reduce, the reductions are not significant in **Entrepreneurs and Firms** and **Savers**.
- 2. This finding implies that the banking requirements are effective in stabilising the banking sector, while are not effective for other sectors.

Results

- **Agents**

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  - Wealth is redistributed from **bankers** to **savers** and **entrepreneurs**.

Results

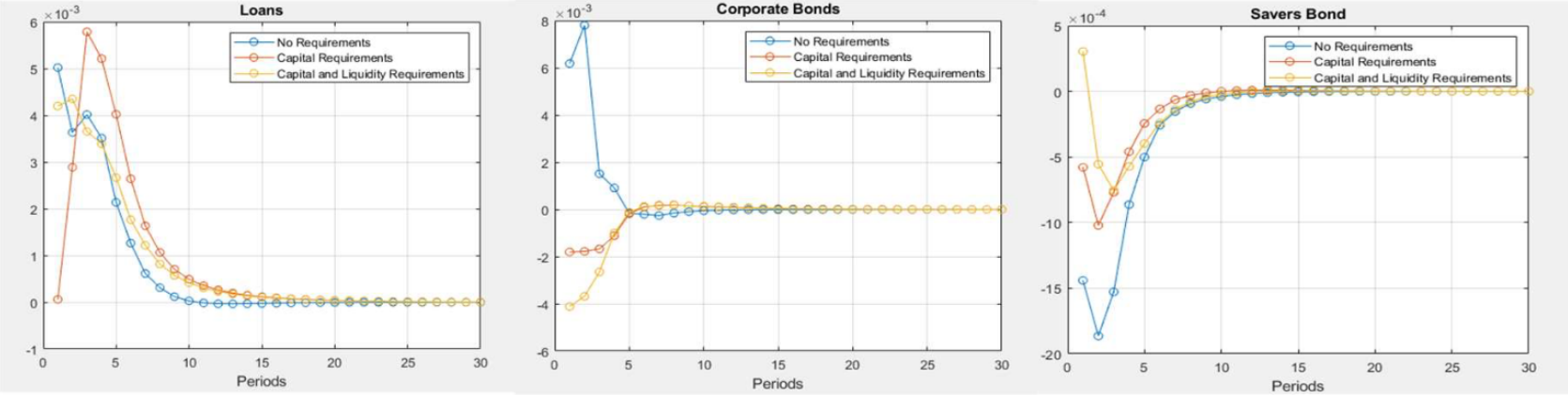
- **Macroeconomic Variables**

	No Requirements		Capital Requirements		Capital & Liquidity Requirements	
	mean	std. dev.	mean	std. dev.	mean	std. dev.
			Macro-economy and Prices			
15. GDP	**74.91**	3.36	**74.59**	3.79	**74.40**	3.19
16. Loan rate	**5.45**	1.86	**5.51**	1.24	**5.94**	1.59
17. Bond rate	**3.54**	1.98	**3.86**	1.75	**3.87**	2.26
18. Risk-free rate	**2.20**	3.57	**3.25**	2.66	**3.84**	3.99
19. Credit spread	1.35	3.73	0.61	2.61	0.03	3.55
20. Loan-bond spread	1.91	2.78	1.65	3.10	2.07	5.29

  - 1. GDP reduces after the implementation of the requirements, which is in line with the literature.
  - 2. **Loan rate**, **bond rate** and **deposit (risk-free) rate** raises, while **credit spread** reduces.

Results

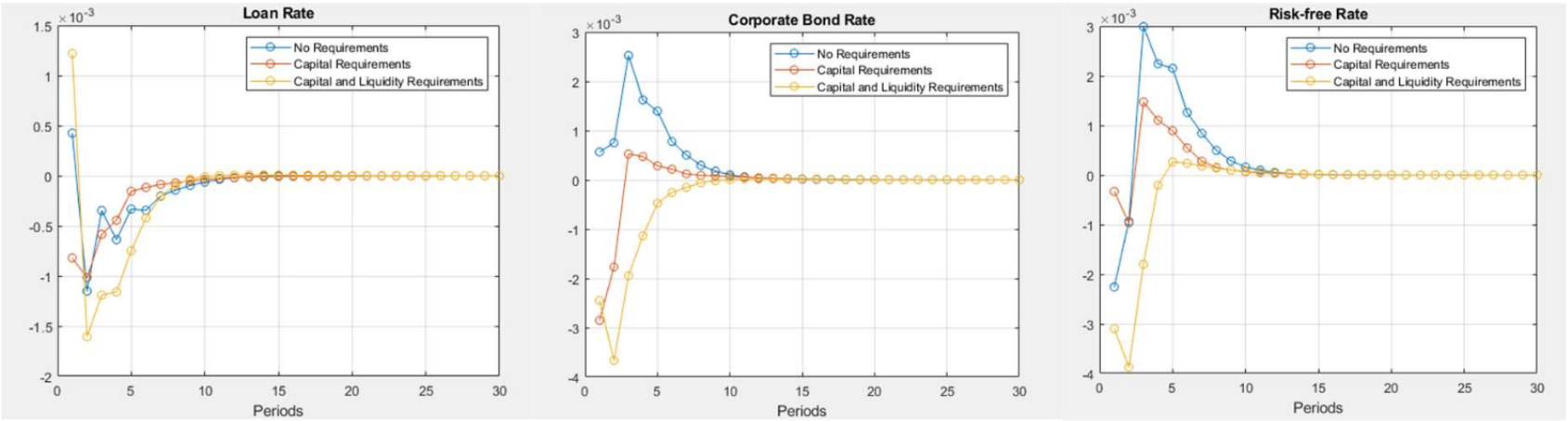
- **Impulse Response 1**



  - Corporate bonds recover more quickly (5 periods), while loans take longer time to recover (15 periods).
  - Requirements stabilises the **corporate bonds** (including **savers' bonds**), while are less effective in stabilising **loans**.

Results

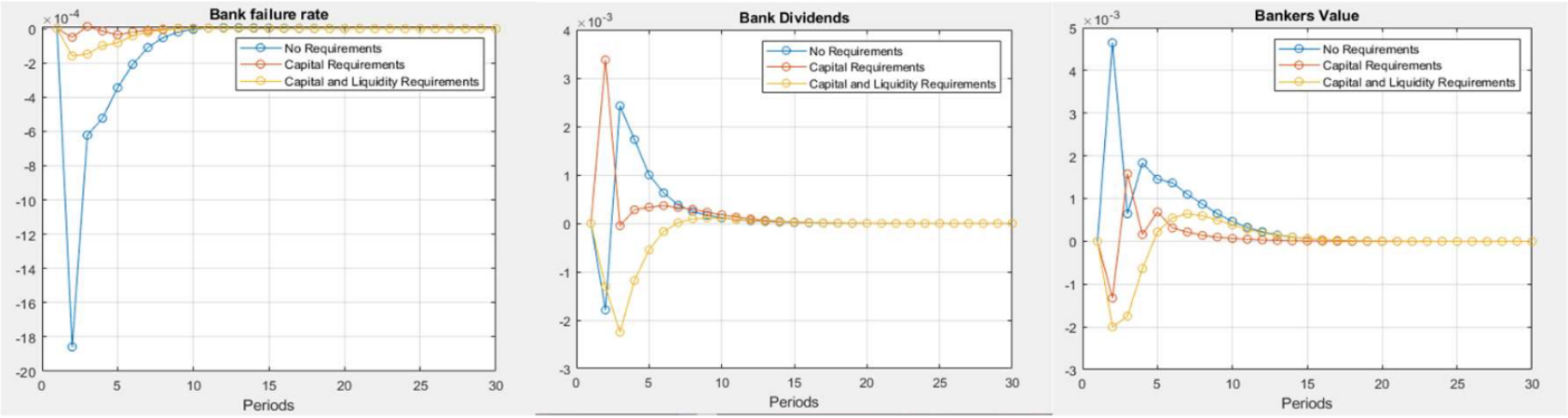
- **Impulse Response 2**



  - All variables take around 10 periods to recover.
  - Requirements are less effective in stabilising these variables.

Results

- **Impulse Response 3**



  - **Probability of bank failure** takes around 10 periods to recover, while others take longer times, around 15 periods.
  - Requirements are effective in stabilising these banking-related variables, especially in the **probability of bank failure**. This finding is in line with what I have revealed before.

Results

- **Computational Errors**

Equation	Percentile				
	Median	75th	95th	99th	Max
E1	0.0009	0.0022	0.0041	0.0056	0.0282
E2	0.0009	0.0018	0.0042	0.0074	0.0341
E3	0.0009	0.0012	0.0026	0.0031	0.0331
E4	0.0008	0.0041	0.0071	0.0107	0.0140
E5	0.0008	0.0035	0.0061	0.0102	0.0135
E6	0.0038	0.0058	0.0140	0.0178	0.0324
E7	0.0071	0.0084	0.0225	0.0290	0.0719
E8	0.0028	0.0037	0.0090	0.0098	0.0893
E9	0.0008	0.0023	0.0028	0.0043	0.0372
E10	0.0020	0.0037	0.0075	0.0102	0.0278
E11	0.0070	0.0080	0.0190	0.0201	0.0608
E12	0.0073	0.0101	0.0188	0.0206	0.0607
E13	0.0063	0.0091	0.0148	0.0186	0.0317
E14	0.0093	0.0201	0.0343	0.0362	0.0645
AE1 (1)	0.0082	0.0205	0.0514	0.0609	0.0707
AE1 (2)	0.0083	0.0205	0.0459	0.0579	0.0825
AE2 (1)	0.0083	0.0223	0.0388	0.0412	**0.1044**
AE2 (2)	0.0092	0.0280	0.0356	0.0393	0.0799

Conclusion

- Banking (capital and liquidity) requirements reduce the **probability of bank failure** and reduce the **volatility of the banking system**, i.e. enhance the **stability of the banking system**.
- However, the requirements would sacrifice (lead to a lower) loan lending, bank size and the output.
- Firms will not rely on the issuance of corporate bonds to compensate for the reduction in bank lending, due primarily to the **increase in the bond rate**.
- The requirements drive up **deposit (risk-free) rate**, **bond rate** and **loan rate** but narrow down **credit spread** and **loan spread**.

Thank you for your attention!