Systemic Risk and Macroprudential Capital Requirements

An application on Romanian Banking System

Madalina Turlea

Supervised by Prof. PhD. Moisă Altăr

DOFIN

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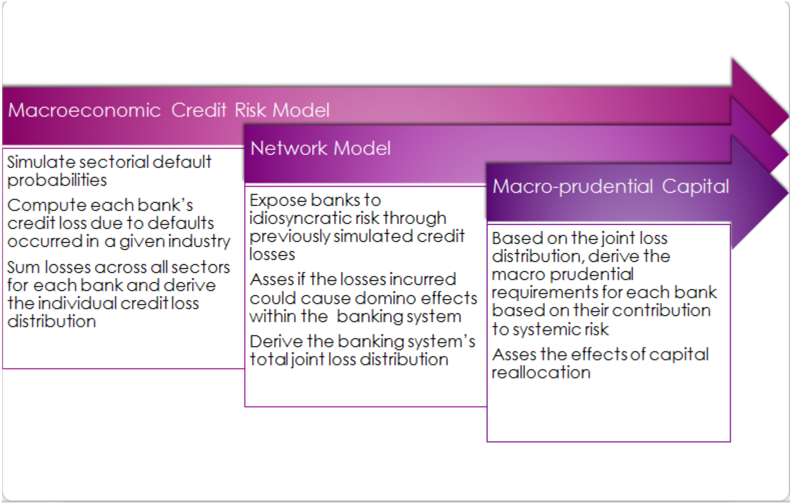
Motivation

- The recent financial turmoil and the high social cost it has incurred, both in terms of bail-outs and forgone potential economic output, have revealed major vulnerabilities of the financial system, specifically of its regulation.
- Judging by the government interventions on failed institutions it is safe to say that **systemic risk** is a real threat, as the failure of one bank could cause grater damage on the entire system than its individual default does.
- Bank regulation is currently aimed at the individual bank level, even though it has been argued for some time that bank regulation should be shifted from the micro to a macroprudential perspective.
- Macroprudential capital requirements should be installed as capital buffers that will ensure banks will be able to internalize the externalities created within the system.

Related Literature – Systemic Risk

- Sheldon and Maurer [1998] study the Swiss banking system.
- Upper and Andreas [2004] consider the German system.
- Boss et al. [2003] analyze the Austrian banking system
- Elsinger et al. [2006b] implement the model using UK banks data set
- Gauthier et al. [2011] take a look at the Canadian banking system

Overview of Methodology



Macro Credit Risk Model

- Default probability model is implemented as proposed by Misina and Dey [2006]
    - Sectoral default probabilities are a function of macroeconomic variables:

$$log\left(\frac{\pi_s}{1-\pi_s}\right) = X_{t-l}\beta^s + e_t^s, s = 1, ..., S \qquad (1)$$

- Generating credit losses
    - Generate a one year ahead path for the macroeconomic variables using a VAR model
    - Generate a vector of S random variables with the variance-covariance matrix given by $\hat{\Sigma}_e$
    - Substitute the results in the previous steps into equation 1
    - For each simulated default probability, the expected credit loss of the loan portfolio of each bank in the sum for $s = \overline{1, S}$:

$$El_t^s = \pi_t^s \times ex_t^s \times l_t^s \qquad (2)$$

Network Model

- The structure of a banking system is given by the matrix of interbank lending:

$$\pi_{ij} = \begin{cases} \frac{x_{ij}}{di} & \text{if } d_i > 0 \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

- The banking system is described by the tuple $(\Pi, E, \Lambda, D, d, P)$ for which a clearing vector is defined, given by X^*
    - A clearing vector is the aggregate payments of each bank to the interbank market - **fictitious sequential algorithm**
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$$x_i^* = min\left[d_i, max\left((p_ie_i + \lambda_i - \epsilon_i)(1 - \Phi_{[p_ie_i+\lambda_i-\epsilon_i+\sum_{j=1}^{N} x_j^* \pi_{ij} - D_i < d_i]}) + \sum_{j=1}^{N} x_j^* \pi_{ij} - D_i, 0\right)\right] \tag{4}$$

Network Model

- When credit losses incurred by a bank are large enough to wipe out the capital buffer, it may be forced to sell its assets in order to improve Tier 1 ratio:

$$\frac{p_i e_i + \lambda_i - \epsilon_i + \sum_{j=1}^{N} x_{ij} - x_i - L_i}{w_i p_i (e_i - s_i) - \epsilon_i} \geq r^* \tag{5}$$

- p_i, price of each bank's illiquid assets, is a decreasing function of their riskiness

$$p_i = min(1, p + (\bar{w} - w_i)k) \tag{6}$$

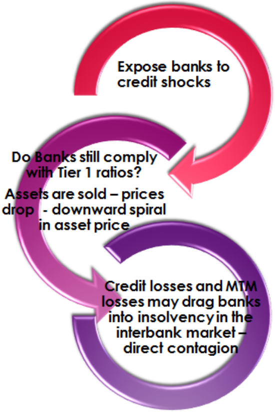
- The equilibrium price, p is given by the inverse demand function for the illiquid assets:

$$p = e^{-\alpha(\sum_i s_i)} \tag{7}$$

- α and k are calibrated in a manner that ensures an equilibrium price exists for all levels of aggregate supply

Contagion Channels

- When credit losses are large enough, banks will shrink their balance sheet to comply with regulation
- Assuming an inelastic demand curve of financial assets, prices will drop
  - MTM value of assets of selling bank drops
  - Affecting other banks that hold the same class of assets



- When credit and MTM losses are high enough, they may drag banks into insolvency
  - Banks become unable to pay their interbank obligations
  - Direct contagion for the other banks that have to write off the unreceived claims

Macroprudential Capital Requirements

- In banking regulation, capital allocation is a fixed-point problem

- Component VaR (Beta)

$$\beta_i = \frac{cov(l_i, l_p)}{\sigma_p^2} \quad (8)$$

- Incremental VaR

$$iVaR_i = VaR_p - VaR^{-i} \quad (9)$$

- MES

$$MES_i = E\left[l_i | l_p \leq VaR_p\right] \quad (10)$$

- Beta capital reallocation

$$C_i^{\beta} = \beta_i \sum_{i=1}^{n} C_i \quad (11)$$

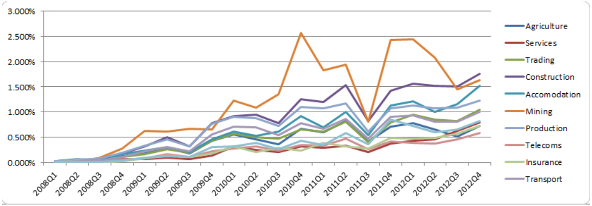
- iVaR capital reallocation

$$C_i^{iVaR} = \frac{iVaR_i}{\sum_i^n iVaR} \sum_i^n C_i \quad (12)$$

- MES capital reallocation

$$C_i^{MES} = \frac{MES_i}{\sum_i^n MES_i} C_i \quad (13)$$

Data for Credit Risk Model



- Insolvency rates are used as proxy variables for default rates
- Industry credit exposures of banks are obtained from financial reports
- Macroeconomic variables used: GDP, Unemployment Rate and EUR/RON exchange rate
- Macro economic scenario - based on historical values:
  - 4% decrease in GDP
  - 0.6 pp increase in unemployment rate
  - 10% depreciation of RON

Data for Network Model

- Banking system is assumed of comprising 7 Romanian banks
- Interbank matrix is estimated using **maximum entropy algorithm**
- Data on assets, liabilities and capital is obtained from 2012Q4 financial reports

Decomposition of Default Probabilities

- Default decomposition
  - Fundamental Default
  - AFS Default
  - Contagious Default

2012Q4	Fundamental	AFS	Contagious	Total
BCR	0.071	0.394	0.042	0.507
RB	0.05	0.022	0.447	0.519
VRB	0	0	0.299	0.299
BT	0.011	0	0.411	0.422
BRD	0	0.014	0	0.014
CEC	0	0.001	0	0.001
UTB	0.058	0.382	0.002	0.442

Table: Decomposition of default probabilities in % with $p_{min} = 0.90$ $\alpha = 0.8$ and $k = 0.05$

Probability of a financial crisis in Romania

- The dependency among banks is dictated by the interbank relationships and by similarities between asset portfolio composition

Default of bank i	Conditional on bank j						
	BCR	RB	VBR	BT	BRD	CEC	UTB
BCR	-	16.38	0.00	2.61	0.00	0.00	93.67
RB	16.77	-	83.28	90.76	0.00	0.00	12.90
VBR	0.00	47.98	-	68.25	0.00	0.00	0.00
BT	2.17	73.80	96.32	-	0.00	0.00	2.49
BRD	0.00	0.00	0.00	0.00	-	100.00	0.00
CEC	0.00	0.00	0.00	0.00	7.14	-	0.00
UTB	85.40	18.30	1.34	3.79	0.00	0.00	-

Table: Total Conditional Default Probabilities in %

Macroprudential Capital Requirements

- Results regrading the application of capital requirements, based on the three macroprudential risk measures, indicate that the Romanian banking system is well-capitalized, where

$$C_i^{Basel} = \frac{RWA_i}{\sum_i^n RWA_i} C_i \tag{14}$$

	Beta	iVaR	MES	C_i^{basel}	Current capital
BCR	755.72	922.98	782.55	629.68	712.33
RB	295.25	359.05	304.20	271.31	286.17
VRB	57.25	53.75	45.69	89.80	115.63
BT	255.59	293.47	245.64	226.72	277.94
BRD	395.40	459.87	379.47	496.58	552.35
CEC	71.01	82.38	67.34	133.01	201.26
UTB	279.97	343.91	285.30	263.08	270.43

Table: Capital allocations based on the three risk attribution rules, in 10 of mil RON

	Beta	iVaR	MES
BCR	6.09	31.00	9.86
RB	3.17	26.26	6.30
VRB	-50.49	-54.38	-60.49
BT	-8.04	4.89	-11.62
BRD	-28.41	-17.86	-31.30
CEC	-64.72	-60.60	-66.54
UTB	3.53	27.06	5.50

Table: Change in capital requirements for macroprudential capital allocation mechanisms in % of current capital

Default Probabilities under Macroprudential Capital

It is important to assess how default probabilities change if macroprudential capital requirements are applied.

Bank	Beta	iVaR	MES	C_i^{Basel}	Current Capital
BCR	0.08	0.027	0.044	0.403	0.507
RB	0.083	0.028	0.042	0.346	0.519
VRB	0.08	0.013	0.044	0.143	0.299
BT	0.08	0.023	0.045	0.366	0.422
BRD	0.046	0.002	0.03	0.027	0.014
CEC	0.04	0	0.024	0.006	0.001
UTB	0.089	0.025	0.052	0.358	0.442

Table: Banks' Individual Default Probabilities under Macroprudential Capital Requirements in %

Systemic Risk under Macroprudential Capital

In order to analyze how well will the banking system perform under macroprudential capital, table below presents the unconditional multiple default probabilities

No of Defaults	Beta	iVaR	MES	C_i^{Basel}	Current Capital
1	0.009	0.002	0.007	0.034	0.011
2	0.000	0.000	0.001	0.011	0.020
3	0.000	0.002	0.000	0.007	0.055
4	0.003	0.010	0.004	0.236	0.123
5	0.031	0.008	0.010	0.082	0.263
6	0.006	0.005	0.006	0.013	0.035
7	0.034	0.000	0.022	0.020	0.001
≥ 5	0.077	0.013	0.040	0.115	0.299
≥ 6	0.046	0.005	0.030	0.033	0.036

Table: Multiple Default Probabilities under Macroprudential Capital Requirements in %

External Shock and Systemic Risk

The relationship between the external shock and systemic risk for the Romanian banking system:

	Beta	iVaR	MES	C_i^{Basel}	Current Capital
BCR	1.674	1.673	1.674	1.674	1.676
RB	1.652	1.651	1.652	1.651	1.653
VRB	1.957	1.956	1.954	1.960	1.954
BT	1.748	1.748	1.747	1.750	1.748
BRD	1.821	1.818	1.817	1.821	1.819
CEC	1.746	1.745	1.744	1.746	1.745
UTB	1.723	1.723	1.721	1.724	1.724
Average	1.760	1.759	1.758	1.761	1.760

Table: Ratio of median total losses over credit losses (90% quantile): credit losses are the simulated non-bank loan losses, given by ϵ_i and derived through Credit Risk Model and total losses are derived through Network Model

Conclusions

- Results suggest that systemic risk and domino effects are likely to be rare
- Some banks are more prone to failure due to the price impact of selling into a falling market, while others are more sensitive to the stability of the interbank market
- Banks with large stocks of illiquid assets the assets fire sale mechanism could cause those banks large losses
- For banks with increased liquidity of their balance sheet but with large exposures in the interbank market, the risk of direct contagion rises
- One surprising finding is that 2 of the 7 analyzed banks seem unaffected of the soundness of the financial system
    - This result should not be viewed as if the 2 banks are risk free, but rather that the contagion channels investigated here are not major risk factors

Macroprudential Capital

- Financial stability in Romanian banking system could be improved if capital is reallocated among banks based on their individual contribution to systemic risk
- All three risk allocation rules significantly reduce both the individual banks and multiple banks default probabilities
- The expected LGD computed under the application of all three risk allocation mechanisms remain fairly constant in level with those simulated under the current observed capital
- The implementation of the macroprudential capital requirements slightly increase the individual default probabilities of two isolated banks
- Optimally regulatory framework should implement the macroprudential policy in combination with policies that address the other risk inherent in the banking system

Caution is necessary

- As with every application concerned with measuring risk the validity of the underlying assumptions has to be assessed
  - **Lack of detailed data** - interbank lending matrix is estimated using the maximization entropy algorithm, which minimizes the concentration of interbank exposures by assuming non-preferential interbank relationships.
  - **Incertitude framework** is implemented through the corporate loan shocks, and excluding the retail credit losses, which is also a significant source of credit risk that banks are facing
  - **Sensitivity to calibrated parameters** - α and k are calibrated so that offloading small portions of bank holdings affect prices significantly.
  - **Capital reallocation** - such distribution can have little use in real world application, but can offer significant insight into what type of risk measure is the most effective from a macroprudential perspective

Thank You!

Bank Balance Sheet Data

	Liquid Assets	Illiquid Assets	Interbank Claims	Interbank Debt	External Debt	Equity
BCR	26.39	73.23	0.38	2.11	87.79	10.10
RB	28.41	68.33	3.26	0.83	87.26	11.91
VBR	32.23	59.09	8.67	5.04	87.94	7.02
BT	40.20	55.07	4.73	0.64	89.88	9.35
BRD	29.84	70.08	0.08	0.66	87.82	11.53
CEC	56.33	43.61	0.06	1.47	91.05	7.48
UTB	33.42	66.38	0.21	2.28	86.93	10.79

Table: Individual bank data used in the network model in percentage of total assets

Interbank Lending Matrix

	Lending Bank							
	BCR	RB	VBR	BT	BRD	CEC	UTB	Total debt bank$i$
BCR	-	275,148.22	618,086.58	546,308.79	3,987.66	7,975.31	35,888.90	1,487,395
RB	143,555.59	-	35,888.90	20,337.04	-	-	-	199,781
VBR	99,691.38	243,246.98	-	438,642.09	35,888.90	-	11,962.97	829,432
BT	3,987.66	31,901.24	155,119.79	-	-	-	-	191,008
BRD	3,987.66	83,740.76	158,708.68	67,790.14	-	1,595.06	-	315,822
CEC	797.53	61,011.13	177,849.43	150,813.13	-	-	3,987.66	394,458
UTB	15,950.62	87,728.42	281,904.91	180,242.02	-	6,380.25	-	572,206

Table: Nominal Bilateral Interbank Exposures in RON thousands

Sensitivity Analysis

Table: Sensitivity analysis of the equilibrium price for different choices of α

Percentage assets sold	Hypothetical values of α				
	0.5	0.6	0.7	0.8	0.9
2%	0.9984	0.9981	0.9978	0.9975	0.9972
4%	0.9969	0.9962	0.9956	0.9950	0.9944
6%	0.9953	0.9944	0.9934	0.9925	0.9916
8%	0.9938	0.9925	0.9913	0.9900	0.9888
10%	0.9922	0.9906	0.9891	0.9875	0.9860

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