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A MODEL OF SELF-REGULATION IN BANKING INDUSTRY

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Abstract

This article derives a model of self-regulation where banks issue insurance products to hedge their own leverage ratio. This approach is an alternative policy to Basel regulation for controlling systemic risk without increasing equity level. Then, we construct two insurability indicators informative about the attractiveness of these hedging instruments. Their implementation, on each of the 22 banks of 5 major countries from 2005 to 2012, reveals the cartography of fragility of several banks.

Keywords: Self-regulation, banking regulation, systemic risk, insurance.

JEL Classification: E44, E58, G01, G21, G28

1. Introduction

The cornerstone of the international regulatory agenda is the setting of higher requirements for banks' capital where the Modigliani-Miller (1958) theorem is seen as supportive of regulators' drive to require higher equity capital (e.g. Admati, DeMarzo, Hellwig and Peiderer (2011), Mehran and Thakor (2011), Admati and Hellwig (2013)). This Basel regulation's goal is to reduce idiosyncratic risks of individual banks (Gauthier, Lehar, and Souissi (2010)) and consequently lessen the risk of defaults cascading around the financial system. Indeed, capital requirement is defined as the amount of capital a bank has to hold to ensure that it can face losses from any investment to avoid a default risk. Notice that the sum of private and social costs represents the real cost of a bank failure. During these periods of financial stress, central banks act as lender of last resort while governments act as borrower of first resort (Chemla and Hennessy (2014)) to mitigate the social cost of failures. In any cases, excessive leverage of banks is widely believed to have contributed to bankruptcies. More important, a bank failure can cause the failure of other banks and firms, which will affect the real economy. This is due to systemic risk that has been widely studied in economic literature (e.g. Bandt and Hartmann (2000), Allen and Gale (2000), Karolyi (2003), Elsinger, Lehar and Summer (2006), Acharyaa (2009), Tarashev, Borio, and Tsatsaronis (2009), Acharya, Pedersen, Philippon and Richardsony (2010), Cont, Moussa and Santos (2010), Engle, Jondeau and Rockinger (2012)).

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The problem is that requiring a uniform minimum capital requirement is pointed out as the main solution by the Basel committee to contain systemic risk propagation. However, there are possible drawbacks of the regulation through Basel capital adequacy ratios.

First, the capital ratio may reduce the value of a bank as it was shown that the Modigliani and Miller (1958) seminal theorem is not relevant for the banking sector (Myerson (2013), DeAngelo and Stulz (2013)). The main reason is that debt contributes to the liquidity provider's role of banks (DeAngelo and Stulz (2013)). In the same vein, banks favor financing by debt, in presence of implicit government guarantee, as it increases their value (Aboura and Lépinette (2013)). Indeed, this guarantee can be seen as a free put option protecting the bank's debt/assets.

Second, the introduction of a capital ratio may foster the banks to set up large off-balance-sheet exposures, as it forces them to modify their asset allocation to face regulatory constraints. In fact the failure to capture major off-balance sheet risks may have been a key factor that amplified the crisis (see BIS report (2011)).

Third, the capital ratio may amplify the business cycles because a bank might reduce its lending during a recession to satisfy the Basel capital ratio requirement (Slovik and Cournede (2011)).

Four, we believe that the concept of risk-weighted assets, entering into the calculation of the capital adequacy ratio, is also not so clear. Indeed, it requires the computation of the risk level of the different banking activities like real estate, structured finance, mergers and acquisitions, retail etc. Unfortunately, the risk is not an observable variable and there are not available time series of historical volatility for these activities. Hence, it is not obvious that the volatility computations are representative of the real risk that characterizes the banking activity. Surprisingly, very few papers (e.g. Embrechts et al (2014)) have highlighted the weaknesses in the modeling of risk-weighted assets and its impact on the measurement of capital requirement.

Before processing to a further analysis, let us discuss more fundamentally why banking regulation exists. Surprisingly, there are few studies discussing this issue.[3] The more recent study is Marcinkowska (2013) who notes that existence of banking regulation is mainly justified in the literature by the reduction of systemic risk and the protection of depositors. We argue that the main rationale for banking regulation is only the protection of depositors. Indeed, commercial banks are primarily engaged in deposit and lending activities to private and corporate customers. A banking failure may directly affect the real economy through the channel of deposit activity and lending activity. In clear, what makes systemic risk a crucial issue in banking regulation is the potential transmission to real economy. Otherwise, a limited default among private institutions, as in other economic sectors, is by no means an important issue in a free-market economy.

Interestingly, this perspective is consistent with the *Irving Fisher (1936) 100% reserve proposal* for the banking system. Indeed, the 100% reserve proposal aims at insuring deposits by investing the checking accounts exclusively in safe monetary instruments such as Treasury bills. In that case, no government interventions to bailout banks would be expected since the deposits remain liquid and safe by nature. This full-reserve banking would consequently eliminate the systemic risks associated with bank runs and would probably reduce the costly regulatory

[3] Note that some private organizations deal with this issue like Cato Institute.

framework. This proposal was supported by the most prominent economists.[4] Therefore, there exists an alternative to requiring more equity as illustrated by the 100% reserve requirement. *It is related to self-regulation.* Self-regulation is generally opposed to government regulation (Omarova (2010)). In this literature, government regulation can be interpreted more generally as public regulation (i.e. from governments, central banks and the Basel committee). Self-regulation might be a good balance between deregulation and over-regulation. Deregulation is usually linked to free banking, which refers to a decentralized approach to money creation without any central bank or deposit insurance (see Selgin (1995)). Overregulation is related to government regulation, which sometimes induces secondary effects (distortions, regulatory dumping, etc.). Various authors (see e.g. Selgin (1994)) argue that self-regulation produces banking systems that are stable and sometimes crisis-free. Moreover, it is said to be more efficient, less costly and less complex than government regulation.

The motivation of this paper is to set up *a model of self-regulation.* Indeed, given the real cost of bank failures, it is legitimate to think that debt payments' risk should be charged to bank's shareholders and managers rather than depositors and other creditors. More specifically, the alternative to requiring more equity would be to legally force the banks to use "self-insurance" mechanism against debt payments' credit risk.[5] Concretely, this means that when a bank issues a bond, it sells at the very same time a hedging product. This insurance product might be a derivative contract with a non-standard pay-off with two components. The first component corresponds to the default case where the debt interests cannot be reimbursed by the bank. The second component corresponds to the case where the bank is able to pay the debt interests. This insurance product allows the bank to pay back interests without any default. This research is relevant because it treats banking regulation in terms of self-regulation far from the recent aforementioned papers that typically focus on Basel regulation. Indeed, the current setting requires complex regulation and supervision to avoid systemic risk. This can be interpreted as an implicit deal where banks accept the current (costly) regulatory framework in exchange of the governments (costly) protection.[6] In this spirit, our orthogonal setting would be to require the banks to hedge their own debt by issuing derivative contracts. This new setting is more suitable not only because the public regulation did not prevent banks from bankruptcies,[7] but also because it does not curb the amount of private debt at the banking sector level. The debt-to-equity ratio is very high in the banking sector probably due to the government protections (ex-ante safety net (deposit insurance[8] and implicit government guarantee) and ex-post bailout), which makes the debt optimal (DeAngelo and Stulz (2013), Aboura and Lepinette (2013)).

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4 Milton Friedman (1960, 1967), Maurice Allais (1947, 1999), James Tobin (1985) and Merton Miller (1985) etc.

5 Notice that our model is related to bankruptcy caused when debt is in excess to asset (see Merton (1974)).

6 Recently, the Customer Owned Banking Association, which represents credit unions and building societies, has lodged the submission that the Big Four banks of Australia be taxed for implicit government guarantee to the Financial System Inquiry.

7 See FDIC Failed Bank List of 500 banks since the Subprime crisis in the U.S.

8 Each depositor is insured, by the government, up to 250,000 USD (resp. 100,000 Euros) per bank in the U.S. (resp. Eurozone).

The contribution of this paper is to propose a model of banking self-regulation to hedge the leverage ratio. This approach is an alternative to the mainstream regulation view where rising equity is the unique approach to prevent systemic risk. To our best knowledge, no research paper has addressed, in so far, the issue of self-regulation in the banking sector by means of derivatives.

The article is organized as follows. Section 2 develops the model that characterized the self-insurance instrument. Section 3 discusses the model implementation on real banking data. Finally, Section 4 summarizes and concludes.

2. The Model

2.1. The model

Recall that a bank, and more generally a firm, is characterized by a quadruplet (*E, D, X, r*)at time *t* = 0, where *E* designates the common shares or equity and *D* is the debt. The interest rate of the debt is denoted by *r* and *X* is the random net income[9] received by the shareholders before deduction of the debt interest *rD.* We suppose that the random variables are defined on a probability space (**Ω**, $\mathtt{F}$, **P**). The expectation **E**[X]of any random variable *X* is considered under **P**. The symbol $\mathbf{I}_A$ designates the indicator function of the random event *A* of $\mathtt{F}$ and $X^+ = \max(X,0)$, $X^- = -\min(-X,0)$. We assume that the interest rate *r* for the debt *D*is risk-free because of the following model where the debt's risk is hedged. Indeed, we suppose that the bank sells at time *t = 0* a forward contract[10] whose payoff is defined at the end of the period, say *t = 1*, by:

$$Z = (X \wedge rD)\left(1 + \delta I_{X \geq rD(1+\delta)}\right) - rD = (X - rD)I_{X \leq rD} + rD\delta I_{X \geq rD(1+\delta)} \text{ .} \qquad \text{... (2.1)}$$

where the coefficient *δ*>0 may be interpreted as a risk premium. This choice of payoff implies that the bank obtains the wealth *rD* at time t = 1 in exchange of the payoff *Z* + *rD.* This allows paying the debt interests without any default. Observe that the investors only take risk in the case where *X* <*rD.* Notice that the net income received by the shareholders is given by:

$$Y = X - (Z + rD) = 0I_{X \leq rD} + (X - rD)I_{rD < X < rD(1+\delta)} + (X - rD(1+\delta))I_{X \geq rD(1+\delta)}. \qquad \text{... (2.2)}$$

This implies that the bank is prevented from bankruptcy. We seek for *δ*>0 such that the coefficient $\tau = \frac{\mathbf{E}[Z]}{rD}$ or equivalently **E**[Z]= *rDτ,* is positive. Indeed, this means that the forward contract delivers a positive expected terminal value. Notice that, by issuing an insurance contract, the bank reduces its shareholders' risk, but in the same time, their expected wealth. The coefficient *δ* reflects the idea that the bank only accepts, with a smaller probability, to provide a larger positive payoff to the insurer. Thus, the coefficient r may be interpreted as a discounting factor underlying the forward contract that makes the hedging instrument attractive to investors.

Let us denote the claims received by the investors at next times$t = i$, $i \geq 1$, by Z_i. Then, at a later time $t = n$, supposing that the associated random variables $(X_i)_{i=1}^n$are independent and identically distributed, we deduce by the law of large numbers that the following cumulated sum satisfies as n tends to ∞:

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[9] For each period of the infinite horizon setting, see the Modigliani-Miller model.

[10] Recall that, by definition, the price of a forward contract is zero when it is initiated.

$\sum_{i=1}^{n} Z_i = n\left(\frac{1}{n}\sum_{i=1}^{n} Z_i\right)) \simeq n\mathbf{E}[Z_1] \simeq rD\tau n.$ ... (2.3)

This means that, from an insurance point of view, it is interesting to invest in such a forward contract if *τ > 0*. We may also make the same reasoning if n represents the number of similar independent forward contracts an investor owns in one period.

Observe that

$\mathrm{E}[Z] = rD\left(\mathrm{P}\left(\frac{X-rD}{rD} \geq \delta\right) - \mathrm{E}\left[\frac{(X-rD)^-}{rD}\right]\right).$ ... (2.4)

It follows that **E**[*Z*]=*rDτ* is equivalent to:

$\delta\left(1 - \mathbf{F}_{\frac{X-rD}{rD}}(\delta)\right) = \tau + \mathrm{E}\left[\frac{(X-rD)^-}{rD}\right],$ ... (2.5)

where $\mathbf{F}_{\frac{X-rD}{rD}}$ designates the cumulative distribution function of $\frac{X-rD}{rD}$. A main question is whether there exists a coefficient *δ*>0 which satisfies the equation above. Indeed, this is a prerequisite for a bank to be insured against default as suggested. We can show that this is the case when $\frac{X-rD}{rD}$admits a Gaussiandistribution whose variance is large enough (see proof in Appendix).

Lemma 2.1.

Suppose that $\frac{X-rD}{rD} = m + \sigma G$ where*m, σ >0and G is a random variable of standard Gaussian distribution. Let ϕbe the cumulative distribution function and φ be the density function of G. Assume that*

$\sigma \geq \max\left(\frac{2m}{\sqrt{2\pi}}; \frac{\sqrt{2\pi}}{m^2}\left(\tau + \mathrm{E}\left[\frac{(X-rD)^-}{rD}\right]\right)\right).$ ... (2.6)

Then, Equation (2.5) admits two solutions μ_1, μ_2*such that*$1 \leq \mu_1 \leq 1 + m - \sigma\zeta \leq \mu_2$where $\zeta < \frac{m}{\sigma}$ *is the solution to the equation* $-\sigma\phi(x) + (m - \sigma x)\varphi(x) = 0.$

From Equation 2.5, we naturally deduce the following definition:

Definition 2.2. *We say that a bank is insurable if:*

$\mathrm{L}(X, D) \coloneqq \max_{\delta > 0}\left(\delta\left(1 - \mathbf{F}_{\frac{X-rD}{rD}}(\delta)\right) - \mathrm{E}\left[\frac{(X-rD)^-}{rD}\right]\right) > 0.$ ... (2.7)

In the case of the assumption given in Lemma 2.1, observe that

$\mathrm{L}(X, D) = \psi(\zeta) - \mathrm{E}\left[\frac{(X-rD)^-}{rD}\right],$ ... (2.8)

where*ζ*is the solution to the equation $\psi'(\zeta) = 0$and$\psi(x) \coloneqq (m - \sigma x)\phi(x)$.Condition (2.7) means that there exists *τ > 0* and *δ>0* such that inequality (2.5) holds. In other words, a bank satisfying Condition (2.7) may issue a forward contract whose expected terminal value is strictly positive, hence attractive for investors. The investors should accept a small multiplier τ only if $\mathrm{P}(X \leq rD)$is small but they should naturally prefer large *τ*. On the other hand, the shareholders of the bank should accept a large *δ*only because the probability $\mathrm{P}(X > rD(1+\delta))$ to pay $rD(1+\delta)$ *)* decreases when *δ*is larger. In conclusion, inequality (2.7) is optimal for the investors since *τ*=L(*X, D*)is the largest one. In particular, the larger L(*X, D*) is, the more attractive the bank's forward is. This may be regarded as if (2.7) provides a confidence indicator about bank's credit default. In other words, (2.7) is an indicator of insurability. In the spirit of the Sharpe ratio, we may also derive a second insurability indicator weighted by the default risk, we call normalized insurability indicator, given by

$$\bar{\bar{\mathrm{L}}}(X,D) := \frac{\mathrm{L}(X,D)}{\mathrm{P}(X \leq rD)}. \quad \text{... (2.9)}$$

Both indicators of insurability measure how far a bank's hedging contracts are attractive to investors. The bigger they are, the more their hedging instruments are attractive since the better the bank is prevented from credit default risk.

2.1. Insurance debtor versus insurance creditor

Our model reverses the traditional approach where the creditor is required to ensure itself with instruments like credit default swaps. In our setting, this is the debtor who is required to hedge itself with appropriate insurance products. The contract we propose allows the bank to benefit from a non-risky interest rate r. Otherwise, the bank benefits from an interest rate *r* +*s* where *s* >0 is the credit spread and **E**[*s*]is a risk premium given that the bank's debt is risky. It is interesting for the bank to sell the forward above only if **E**[*Z*] <*D***E**[*s*], i.e. *τ*<**E**[*s*]/*r.* Actually, when a market's equilibrium is reached, we should have **E**[*Z*] = *D***E**[*s*], i.e. *r*=**E**[*s*]/*τ.* To be fully efficient, this self-regulation system requires that every bank finds investors. Two cases may be considered. First, the banks sell the forward contracts to private investors. This is mainly possible for healthy banks so that the expected gain for private investors is positive. But, in this context, this self-regulation is not efficient, as it does not offer solutions to the most fragile banks. Moreover, investors need to price the forward contracts in a seemingly incomplete market, which is risky in a short term given the well-known difficulty to do it. Second, the banks could sell the forwards to a regulator such as a central bank. The central bank is, as a long term investor, rewarded in average by a positive gain, see (2.3), when considering the low frequency of banking crisis overall when self-regulation reduces bankruptcies. *A trade-off for the central bank would be to consider the expected value of self-regulation versus the expected value of Basel regulation.*

Let us examine the impact of the forward contract on the equity value. Before this insurance, the bank's equity is computed as:

$$E = \frac{(X-(r+s)D)}{R^E(s)}. \quad \text{... (2.10)}$$

When contracting a forward, this relation becomes:

$$E = \frac{(X-rD-Z)}{R^E(Z)} = \frac{(X-(r+s_Z)D)}{R^E(s_Z)}, \quad \text{... (2.11)}$$

where $s_Z := Z/D$ and $R^E(s)$, and $R^E(s_Z)$ are the expected equity returns given by the CAPM relation. When the debt becomes riskless, i.e. *s = 0*, there is a risk transfer from the debtholders to the shareholders. In clear, according to the CAPM model, the equity beta climbs as the debt's beta falls to zero. This implies that the expected equity return increases, which should push the stock price down to reflect the risk-return equilibrium. Similarly, when contracting a forward such that **E**[*Z*] <*D***E**[*s*], the stock price declines all the more when **E**[s_Z] <**E**[*s*]driving upward $R^E(s_Z)$because the debt is riskless in presence of the insurance, which increases the equity beta and therefore the equity expected return.

2.2. Policy implications

This article involves a trade-off between the current Basel regulatory setting and our model of self-regulation. In the current Basel III regime, the regulators ask the bank to increase its equity in presence of risky debt. The banks are allowed to have huge leverage as long as they compensate with supplementary core capital. The risk induced by the bank's leverage ratio is hedged by the bank's creditor with credit default swaps or more generally by diversification effect. The problem is fourfold. First, this Basel paradigm does not prevent bankruptcy, but reduces its likelihood with costly monitoring. Second, it does not reduce the level of debt at the whole economy level as it lets the creditors hedge themselves. Third, equity is an expensive source of financing given that banks do not obey to the Modigliani and Miller (1958) theorem. Four, it relies on the questionable RWA measure to compute the equity.

In our alternative, instead of requiring more equity, the regulator might require the banks to insure their own leverage ratio. *When considering the bank' shareholders private costs, the benefit of our model is a trade-off between the cost of additional equity required by Basel III and the cost of debt insurance.* However, from the regulator social cost viewpoint, it seems that the benefit of a self-regulation system is more appealing than the current system for various reasons. First, self-regulation might cost less than technocratic regulation which has never proven to be sufficiently robust against systemic risk given that it does not treat debt's riskiness, but only the ability of a bank to face the primary losses. In this paradigm, we notice that the public authorities have always been constrained to intervene ex-ante with safety net and ex-post with bailouts in order to safeguard the financial system. Second, there will be one main insurer of 'first resort', namely, the central bank even if private investors are still able to purchase hedging instruments. Indeed, as a lender of last resort, it has the moral authority and the financial credibility to support the system to become an insurance purchaser of first resort. For example, the European Central Bank is playing a central role in the Banking Union macro-prudential policy.

Note that typical problems of moral hazard involved with purchasing such insurance contracts might amplify the existing risk-seeking behavior of banks. However, it will be mitigated by the fact that self-insurance remains costly. In clear, risk-seeking behaviors should be reflected in the price of such insurance contracts. Note again that in the case that the number of Arrow-Debreu securities is less than the number of states of nature, a problem of market incompleteness may occur. Concretely speaking, the agents may be short of insurance products to hedge against future default risks. In our setting, banks are fostered to issue enough contracts to stabilize their own activity. Hence, we might believe that within self-regulation, banks will issue sufficient contract and central banks will purchase sufficient contracts for the sake of the financial stability.

Finally, remember that our model can be seen as a kind of generalization of the Irving Fischer 100% reserve proposal for the banking system. As the leading U.S. economist in the 30's, he recommended to his Government to force the banks to hedge their client's checking accounts in order to cover 100% of their nominal value. Instead of investing the checking accounts in Government's risk-free assets, it is equivalently possible, to legally force the banks to issue hedging contracts only on the checking accounts and not on the total outstanding amount of debt. Under this condition, our model matches the 100% reserve proposal, which aims at curbing the systemic risk transmission from the banking sector to the real economy with less regulation.

3. Model Implementation

Our conceptual model can also be applied to real data for risk management purposes. Indeed, as we mentioned, the higher the indicators $\mathtt{L}(X,D)$and $\bar{\bar{\mathtt{L}}}(X,D)$are, the better a bank should be prevented from a credit default. This is why we naturally propose to compute such indicators as an illustrative example.

3.1. Data

Bank data are obtained from a commercial database maintained by International Bank Credit analysis Ltd. (IBCA). The database provides information from the balance sheets. Given the application of the international account standards in major countries, the choice of these data makes sense as they should converge to market values. The database includes the major banks from the G5: USA, Japan, Germany, France and UK. The data spans 6 years from 2005 to 2012 for most of the banks. Market data are extracted from Data stream.

3.2. Illustration

We make the assumption that the random variable $(X - rD)/(rD)$ admits the Gaussian distribution $m + \sigma G$ where G is the standard Gaussian distribution of mean *0* and variance *1*. It follows that $\mathtt{L}(X,D)$is given by the formula (2.8). We approximate m by the average of the observed values and σ by the standard deviation. We then deduce an approximation of the solution $\zeta$to the equation $\psi'(x) = 0$(see (2.8)) using Excel solver. We then deduce $\mathtt{L}(X,D)$. From there, we compute $\bar{\bar{\mathtt{L}}}(X,D)$ given by (2.9). We only consider the following results as illustrative given that more data should be required to derive more accurate conclusions from them. Recall that the larger $\mathtt{L}(X,D)$ and $\bar{\bar{\mathtt{L}}}(X,D)$are, the better should be for the bank.

4. Conclusion

The regulators' current objective is to raise the banks' capital ratios to reach international minimum standards reducing systemic risk. This article derives a model of self-regulation where banks issue insurance products to hedge their leverage ratio. This model allows banks to issue insurance products to hedge their leverage ratio instead of increasing equity. It can be interpreted as an alternative policy for controlling systemic risk at the bank level, in particular when the insurer of first resort is a central bank. We apply the model and obtain indicators of insurability for each of the 22 banks of 5 major countries from 2005 to 2012.

Table 1. Results for indicators of insurability

Table I exposes the indicators of insurability $\mathtt{L}(X,D)$and $\bar{\bar{\mathtt{L}}}(X,D)$per bank and country. The data spans 6 years from 2005 to 2012 for most of the banks.

US	**JP Morgan**	**BoA**	**Citigroup**	**Wells Fargo**	**Goldman Sachs**		**Weighted average**
E/A	8.24%	9.68%	7.9%	9.42%	6.73%		8.52%
$\mathtt{L}$	12.24	0.23%	-0.01	2.84	2.62		2.62
$\bar{\bar{\mathtt{L}}}$	104.48	0.55%	-0.036	9.42	24.07		24.07
UK	**HSBC**	**Royal Bank of Scotland**	**Lloyds**	**Barclays**			
E/A	6.11%	4.72%	3.89%	3.36%			4.85%
$\mathtt{L}$	4.38	-2.1	-3.16	2.9			1.75
$\bar{\bar{\mathtt{L}}}$	31.8	-4.65	-6.08	11.25			14.48
Japan	**Mitsubishi UFJ Financial Group**	**Mizuho Financial Group**	**Resona Holdings Inc**				
E/A	5.28%	3.93%	4.92%				4.7%
$\mathtt{L}$	9.69	5.51	30.49				10.22
$\bar{\bar{\mathtt{L}}}$	42.23	20.55	244.5				54.9
Germany	**Deutsche Bank**	**Commerzba nk**	**Hypo Real Estate Holding AG**	**KFW Bank**	**Landesbank BW**	**Unicredit Bank AG**	
E/A	2.21%	3.08	1.71%	3.77%	2.32%	4.95%	2.77%
$\mathtt{L}$	1.61	-0.68	-9.22	-8.23	-6.17	0.25	-1.41
$\bar{\bar{\mathtt{L}}}$	6.55	-1.55	-14.66	-16.11	-8.92	0.63	-0.61
France	**BNP Paribas**	**Société Générale**	**Crédit Agricole**	**Natixis**			
E/A	3.76%	3.96%	4.33%	3.96%			4%
$\mathtt{L}$	7.48	2.86	4.33	3.93			5.11
$\bar{\bar{\mathtt{L}}}$	396.74	15	104	-4.59			180.23

Table I reveals a cartography of fragility as several banks have negative $\mathtt{L}(X,D)$and $\bar{\bar{\mathtt{L}}}(X,D)$. Recall that these average values are computed from 2005 to 2012. The banks that seem to be the most fragile are KFW Bank and Hypo Real Estate Holding. Although KFW is a government-owned bank typically seen as a solid institution, it has been exposed to losses in 2007-2008. They are followed by Landesbank, Lloyds, Royal Bank of Scotland, Natixis and Citigroup. Japan appears to have the strongest banking sector. BNP Paribas seems to be the strongest bank.

5. Appendix

Proof of Lemma 2.1.

Observe that (2.5) is equivalent to

$$\delta\phi\left(\frac{m-\delta}{\sigma}\right) = \tau + \mathbf{E}\left[\frac{(X-rD)^{-}}{rD}\right]. \quad \text{... (5.1)}$$

Setting $x = \frac{m-\delta}{\sigma} \leq \frac{m}{\sigma}$, (5.1) is equivalent to

$$(m - \sigma x)\phi(x) = \tau + \mathbf{E}\left[\frac{(X-rD)^{-}}{rD}\right]. \quad \text{... (5.2)}$$

We study the function $\psi(x) = (m - \sigma x)\phi(x)$. We find that $\psi'(x) = -\sigma\phi(x) + (m - \sigma x)\varphi(x)$ and finally $\psi''(x) = \varphi(x)(\sigma x^2 - mx - 2\sigma)$ .Let $x^1 < x^2$ bethe solutions to $\psi''(x) = 0$. A simple calculation gives $x^i = \frac{\left(m\pm\sqrt{m^2+8\sigma^2}\right)}{2\sigma}$, $i = 1,2$, hence $x^1 \leq 0 \leq \frac{m}{\sigma} \leq x^2$. From there, we deduce that ψ is increasing on $(-\infty, \zeta]$and decreasing on $\left[\zeta; \frac{m}{\sigma}\right]$where ζbelongs to$\left[x^1; \frac{m}{\sigma}\right]$as the solution to the equation $\psi'(x) = 0$. Notice that $\psi(-\infty) = \psi\left(\frac{m}{\sigma}\right) = 0$. It follows that ψ takes its values in $[0, \psi(\zeta)]$where

$$\psi(\zeta) = (m - \sigma\zeta)^2\varphi(\zeta)\sigma = \frac{\sigma\phi(\zeta)}{\varphi(\zeta)}. \quad \text{... (5.3)}$$

Moreover, by supposing that $\sigma \geq \frac{2m}{\sqrt{2\pi}}$, we deduce that $\psi'(\zeta) \leq 0$ hence $\zeta \leq 0$. We then study the function $g(x) = (m - \sigma x)^2\varphi(x)\sigma$. Its derivative is given by $g'(x) = \sigma(m - \sigma x)\psi''(x)$. We deduce that g is increasing on the interval $(-\infty, x^1]$ and decreasing on $\left[x^1; \frac{m}{\sigma}\right]$. As $\zeta \leq 0$, it follows that $g(\zeta) \geq g(0) = \frac{\sigma m^2}{\sqrt{2\pi}}$. Using the second inequality satisfied by σ, we deduce that $g(\zeta) \geq \tau + \mathbf{E}\left[\frac{(X-rD)^{-}}{rD}\right]$ and the conclusion follows.

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References

Aboura S., and E. Lepinette, (2013), "Do banks satisfy the Modigliani-Miller theorem?", Working paper, University of Paris-Dauphine.

Admati A.R., P.M. DeMarzo, M.F. Hellwig and P. Pfleiderer, (2011), "Fallacies, irrelevant facts, and myths in the discussion of capital regulation: Why bank equity is not expensive?", Working paper, Stanford University.

Admati A.R. and M. Hellwig, (2013), *The bankers' new clothes: What's wrong with banking and what to do about it*, Princeton University Press.

Acharya V., (2009), "A theory of systemic risk and design of prudential bank regulation", *Journal of Financial Stability*, 5, 224-255.

Acharya, V., L.H. Pedersen, T. Philippon and M. Richardsony, (2010), "Measuring systemic risk", working paper, New York University.

Allen F. and D. Gale, (2000), "Financial contagion", *Journal of Political Economy*, 108, 1-33.

Basel Committee on Banking Supervision, (2011), "Basel III: A global regulatory framework for more resilient banks and banking systems", BIS report.

Chemla G., and C. Hennessy, (2014), "Government as borrower of first resort", working paper, London Business School.

Cont R., A. Moussa and E.B. Santos, (2010), "Network structure and systemic risk in banking systems", working paper, Imperial College London.

DeAngelo H., and R. Stulz, (2013), "Why high leverage is optimal for banks", working paper, European Corporate Governance Institute.

De Bandt, O. and P. Hartmann, (2000), "Systemic risk: A survey", working paper, ECB.

Embrechts P., G. Puccetti, L. Rschendorf, R. Wang and A. Beleraj, (2014), "An Academic Response to Basel 3.5", *Risks*, 2, 25-48.

Engle, R.F., E. Jondeau and M. Rockinger, (2012), "Systemic risk in Europe", working paper, Swiss Finance Institute.

Fisher I.., (1936), *100% Money*, ed. New York: Adelphi Company.

Gauthier C, A. Lehar and M. Souissi, (2010), "Macroprudential capital requirements and systemic risk", working paper, Bank of Canada.

Karolyi, G.A., (2003), "Does international financial contagion really exist?", *International Finance*, Wiley Blackwell, 6, 179-99.

Marcinkowska M., (2013), "Regulation and self-regulation in banking: in search of optimum", *Bank iKredyt*, 44, 119-158.

Mehran H., and A. Thakor, (2011), "Bank Capital and Value in the Cross-Section", *Review of Financial Studies*, 24, 1019-1067.

Merton, R.C., (1974), "On the pricing of corporate debt: The risk structure of interest rates", *Journal of Finance*, 29, 449-470.

Modigliani F. and M. H. Miller, (1958), "The cost of capital, corporation finance, and the theory of investment", *American Economic Review*, 48, 261-297.

Myerson R.B., (2013), “Rethinking the principles of bank regulation: A review of Admati and Hellwig's bankers' new clothes”, working paper, University of Chicago.

Omarova, S.T., (2010), “Rethinking the future of self-regulation in the financial industry”, *Brooklyn Journal International Law*, 35, 665-698.

Selgin, G, (1994), “Are Banking Crises Free-Market Phenomena?”, *Critical Review*, 8, 591-608.

Selgin G., (1995), “Bank self-regulation: Comment on Bordo and Schwarz”, *Cato Journal*, 14, 481-492.

Slovik, P. and B. Cournede, (2011), “Macroeconomic impact of Basel III”, working paper, OECD Economics Department.

Tarashev N., C. Borio and K. Tsatsaronis, (2009), “The systemic importance of financial institutions”, *BIS Quarterly Review*, 75-87.

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