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Should CAMELS ratings be publicly disclosed?

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Abstract

We explore the optimal disclosure of CAMELS ratings. We employ a Stackelberg leader-follower model to obtain net social welfare from disclosure. We extend the model by incorporating dynamic stochastic optimization, resulting in an optimal stopping problem that we solve using variational inequalities. Optimal disclosure is characterized by an explicit ratio of social benefit to social cost.

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1 Introduction

Financial institutions are rated by a system with the acronym CAMELS (**C**apital adequacy, **A**sset quality, **M**anagement, **E**arnings, **L**iquidity and risk **S**ensitivity). CAMELS ratings are disclosed only to an institution's top management. Social benefits to public disclosure include a reduction in adverse selection, moral hazard, contagion problems, and transactions costs. Disclosure may also reduce inappropriate behavior on the part of the institution. Conversely, disclosure of CAMELS ratings also identifies institutions on the "problem" institution list, potentially leading to panic and liquidity problems that endanger financial system stability. Understandably, institutions with high (low) ratings favor (oppose) disclosure.

Litner (2014) concludes that partial disclosure best serves society. Prescott (2008) finds that information disclosure may reduce institutional incentives to reveal information. Prescott and Slivinski (2009) argue that releasing results of annual bank examinations may impede supervisory ability to collect information. Curry, Fissel and Ramirez (2008) find that CAMELS ratings affect loan growth during 1985-1993, but not during 1994-2004. Deyoung, Flannery, Lang, and Sorescu (2001) find that nondisclosure of CAMELS ratings exacts social costs.[1]

We model the benefits, costs, and optimal timing of CAMELS ratings disclosure, and develop a metric to determine the socially optimal timing of disclosure. We first model disclosure as a Stackelberg leader-follower game between regulator (leader) and financial institution (follower) under complete information[2]. We obtain net social welfare from disclosure by integrating the institution's optimization decision with the regulator's evaluation system. The institution optimally reacts to disclosure rules enacted by the regulator. Strong institutions benefit from release, while weak institutions may impose costs on society through liquidity crises. The regulator optimally obtains societal benefits and costs from the institution's optimal response to regulation following disclosure. Our model enables regulators to quantify social benefits versus costs in a theoretically defensible manner when determining whether to disclose CAMELS ratings.

We then incorporate stochastically evolved societal cost and benefit processes arising from CAMELS ratings disclosure. The regulator's problem is to find the optimal disclosure (stopping) time that maximizes expected discounted net social benefit. We employ the technique of variational inequalities to solve the problem.

To our knowledge, this is the first paper to explore disclosure as a stochastic control problem. We find an analytical solution characterized by an explicit threshold defined by the optimal ratio of social benefit to social cost. An increase in uncertainty in social benefit and social cost processes discourage disclosure, while an increase in the correlation between the two processes encourages disclosure.

2 Model I – Stackelberg Leader-Follower Game Model

2.1 Background Information

We consider a regulator contemplating public CAMELS ratings disclosure. The regulator assigns each institution a CAMELS rating (a five level numerical score with "1" as the best and "5" as the worst), , e.g., x_i representing institution i's CAMELS rating with $x_i \in \{1, 2, 3, 4, 5\}$. Disclosure imposes social costs, so the regulator assigns each institution a profile characterized by its CAMELS rating and the loss it exacts on society should it fail (e.g., bank runs and business failures following disclosure, for

[1] Other studies examine release of bank stress testing and reporting frequency (Gigler, Kanodia, Sapra and Venugopalan (2016), Goldstein and Sapra (2014), Goldstein and Leitner (2013), Morrison and White (2013)).

[2] This assumption is valid in our framework since the policymaker has the information of all parameter values.

example, (x_i, c_i), where c_i represents institution i's cost to society with $c_i \in \mathbb{N}$.[3] CAMELS ratings disclosure also benefits society. Each institution is similarly assigned a profile characterized by its CAMELS rating and its societal benefit should it exist following disclosure, e.g., (x_i, y_i), where y_i represents institution i's benefit to society with $y_i \in \mathbb{N}$.[4] The random variables for the institution's CAMELS rating, X, cost to the society, C, and benefit to society, Y, are described by their probability distributions, which are characterized by corresponding probability mass functions, $f_X(x)$, $f_C(c)$, and $f_Y(y)$ respectively.

We proceed with the policymaker's evaluation of CAMELS ratings disclosure via the Stackelberg game. The institution's (follower's) strategy is defined as a set of $D = \{0, 1\}$ with 0 representing its opposition to disclosure, and 1 otherwise. We solve the problem backwards. The institution chooses its strategy, either for or against disclosure, by solving its utility maximization problem. The institution's utility maximization links directly to its value upon disclosure. The regulator (leader) then integrates the institution's decision (i.e., the best response function) into its valuation. Institutions favoring (opposing) disclosure are those that benefit (cost) society.

Given the institution's decision function, net social welfare from disclosure is the difference between the expected marginal benefit to society under joint probability mass function $f_{X,Y}(x, y)$, and the expected marginal cost to society under joint probability mass function $f_{X,C}(x, c)$.

2.2 The Financial Institution's (Follower's) Decision Function

An institution chooses its strategy, D, to maximize utility. We assume homogenous individual agents. We define an institution's utility function as:

$$U(x_i, D) = (2D - 1)\big(-a \times \frac{(x_i - \mu_X)}{\sigma_X} + r_p)\big)$$

where $D = \{0, 1\}$, μ_X and σ_X represent the mean and the standard deviation of X respectively, $a > 0$ is a constant[5], and $r_p > 0$ is the common value related to CAMELS rating information common to every institution. Obviously, rational institutions would choose $D = 1$ if $a \times \frac{x_i - \mu_X}{\sigma_X} < r_p$ and $D = 0$ otherwise, i.e., an institution's optimal strategy based on utility maximization relies on relations between the marginal value assigned to CAMELS rating disclosure, and the common value of rating information. We define such a rule as an institution's decision function given:

$$D(x_i) = \mathbb{1}_{x_i < \frac{r_p \times \sigma_X}{a} + \mu_X}.$$

An institution favors disclosure if its CAMELS rating represents better than average health. The additional assigned value from disclosure is determined by a weight, a (given in our model), of an institution's mean deviation standardized by volatility, $\frac{(x_i - \mu_X)}{\sigma_X}$. An institution in a competitive market assigns a value to disclosure based on the deviation of its rating from the average. A negative deviation represents an institution with a better than average rating, and vice versa.

[3] Other specifications exist. We omit the specification here since it is not our primary focus.

[4] As noted earlier, we omit the social benefit specification.

[5] The negative sign corresponds to CAMELS ratings in which a lower rating implies a healthier institution.

2.3 Policymaker's (Leader's) Valuation Function

To obtain the overall social welfare from disclosure, the regulator integrates the institution's utility maximization decision into its valuation function[6]:

$$V(x, y, c, D(x)) = \sum_{X}\sum_{Y} yD(x)f_{X,Y}(x, y) - \sum_{X}\sum_{C} c(1 - D(x))f_{X,C}(x, c). \tag{21}$$

where

$$\sum_{X}\sum_{Y} yD(x)f_{X,Y}(x, y) \tag{22}$$

is the overall expected social benefit from release of the CAMELS rating, and

$$\sum_{X}\sum_{C} c(1 - D(x))f_{X,C}(x, c) \tag{23}$$

is the overall expected social cost due to the disclosure. From (21), The Stackelberg model indicates that a rational regulator will not disclose if the resulting social welfare is negative by the time of disclosure, i.e., (22) $<$ (23). Disclosure occurs if and only if release yields non-negative social welfare. The policymaker is able to quantify social cost versus benefit, and gain the insight to the potential consequences of disclosure.

3 Model II - Stochastic Optimization in Continuous Time

3.1 Stochastic Processes

We use (22) and (23) as initial states which now evolve according to Geometric Brownian motion processes. The benefit process ($B(t)$) and the cost process ($K(t)$) evolves as:

$$dB(t) = \sigma_B B(t)dW(t),\ B(0) = b_0 \tag{31}$$

$$dK(t) = \sigma_K K(t)(\rho dW(t) + \sqrt{1 - \rho^2}dW^0(t)),\ K(0) = k_0 \tag{32}$$

where:

1. $W(t)$ and $W^0(t)$ are two independent standard Wiener process, and $0 < |\rho| < 1$ is the correlation coefficient between the benefit randomness and the cost randomness.

2. σ_B and σ_K are constants, representing the volatility (i.e., uncertainty) of the benefit and cost respectively.

3. b_0 and k_0 are obtained in (22) and (23) respectively.

[6]The specification implicitly assumes that an institution with a rating of $\frac{r_p \times \sigma_X}{a} + \mu_X$, will be indifferent between disclosure and nondisclosure.

3.2 Regulator's Optimal Stopping Problem

Given the evolution of benefit and cost defined by (31) and (32) respectively, the regulator's problem is to find the optimal time to disclose the CAMELS ratings (i.e., optimal stopping time) by maximizing the expected discounted net social welfare:

$$M(B,K) = \sup_{\tau \geq 0} \mathrm{E}\left[e^{-\alpha\tau}\left(B_{b_0}(\tau) - K_{k_0}(\tau)\right)\mathbb{1}_{\tau<\infty}\right], \tag{33}$$

where α is the discount rate.

3.3 Solution to Regulator's Optimal Stopping Problem

Assuming that the function $M(B,K)$ is sufficiently smooth, $M(B,K)$ solves the following variational inequality (V.I.) as a consequence of Dynamic Programming:

$$\begin{cases} \frac{1}{2}\left(\sigma_B^2 B^2 \partial_{BB} M(B,K) + 2\rho\sigma_B\sigma_K BK\partial_{BK} M(B,K) + \sigma_K^2 K^2 \partial_{KK} M(B,K)\right) \\ \qquad\qquad -\alpha M(B,K) \leq 0 \\ M(B,K) \geq \frac{B}{\alpha} - K \\ \left[M(B,K) - (\frac{B}{\alpha} - K)\right] \times \\ \quad \Big[\frac{1}{2}\left(\sigma_B^2 B^2 \partial_{BB} M(B,K) + 2\rho\sigma_B\sigma_K BK\partial_{BK} M(B,K) + \sigma_K^2 K^2 \partial_{KK} M(B,K)\right) \\ \qquad\qquad -\alpha M(B,K)\Big] = 0 \\ M(0,K) = 0;\ M(B,K) \geq 0;\ M(B,K) \quad \text{has linear growth at infinity.} \end{cases} \tag{34}$$

Theorem 3.1. *Assume* $\rho > \left(\frac{\sigma_K}{\sigma_B} - \frac{\alpha}{\sigma_B\sigma_K}\right)$.

$$M(B,K) = \begin{cases} \dfrac{B^*}{\alpha\beta}\left(\dfrac{\frac{B}{K}}{\frac{B^*}{K^*}}\right)^{\beta} & \frac{B}{K} \leq \frac{B^*}{K^*} \\ \frac{B}{\alpha} - K & \frac{B}{K} \geq \frac{B^*}{K^*} \end{cases}, \tag{35}$$

where $\beta > 1$ *is the positive root of the quadratic equation:*

$$\frac{1}{2}(\sigma_B^2 + \sigma_K^2 - 2\rho\sigma_B\sigma_K)\beta^2 - \frac{1}{2}(\sigma_B^2 - \sigma_K^2)\beta - \alpha = 0,$$

and $\frac{B^*}{K^*} = \frac{\alpha\beta}{\beta-1}$.

Proof. See Appendix A. □

From Theorem 3.1, the optimal time for the regulator to disclose CAMELS ratings (i.e., the optimal stopping time) that achieves the supremum in (33) is: $\tau^*(\frac{B}{K}) = \inf\left\{t | \frac{B_{b_0}(t)}{K_{k_0}(t)} \geq \frac{B^*}{K^*}\right\}$. That is, the policymaker makes the CAMELS ratings publicly available as soon as the benefit-cost ratio reaches the optimal threshold defined by $\frac{B^*}{K^*}$ from below.

Proposition 3.2. *The greater the uncertainty embedded either in the potential societal benefit or in the potential societal cost from CAMELS ratings disclosure, the higher the optimal benefit-cost ratio (i.e., the higher threshold) must be to disclose ratings, i.e., greater uncertainty discourages disclosure.*

Proof. From Theorem 3.1, taking the derivative of β with respect to σ_B or σ_K, an increase in σ_B or an increase in σ_K leads to a decrease in[7] β, thus causing the optimal benefit-cost ratio($\frac{B^*}{K^*} = \frac{\alpha\beta}{\beta-1}$) for

[7] We omit the contents of tedious calculations here, available from authors upon request.

disclosure to increase since the multiple $\frac{\beta}{\beta-1}$ increases. $\square$

Proposition 3.3. *The higher the covariance between changes in potential social benefit and potential social cost, the lower is the threshold optimal benefit-cost ratio for disclosure, i.e., greater covariance between benefit and cost uncertainty encourages disclosure.*

Proof. From Theorem 3.1, taking the derivative of β with respect to ρ, an increase in ρ leads to an increase[8] in β, thus causing the optimal benefit-cost ratio($\frac{B^*}{K^*} = \frac{\alpha\beta}{\beta-1}$) for disclosure to decrease since the multiple $\frac{\beta}{\beta-1}$ decreases. Holding variances of social benefit and social cost constant, the greater the ρ, the greater is the covariance between changes in the potential social benefit and the potential social cost, implying less uncertainty over the benefit-cost ratio. $\square$

4 Conclusion

We propose two models to study a regulator's optimal decision regarding CAMELS ratings public disclosure. A Stackelberg model quantifies marginal costs and benefits of disclosure. We obtain net social welfare by integrating the financial institution's optimization decision and the regulator's valuation system. A continuous time stochastic model yields the optimal threshold for public disclosure, i.e., an optimal time to disclose. An increase in uncertainty in either social benefit or social cost discourages regulatory disclosure. An increase in the correlation between the social benefit randomness and the social cost randomness encourages regulatory disclosure.

Our models provide regulators with a practical method for determining optimally whether and when to disclose CAMELS ratings.

A Appendix
Proof of Theorem 3.1

Proof. The solution (3.1) is $C^1(0,\infty)$ and piecewise C^2. It satisfies $M(B,K) \geq 0$ and $M(B,K)$ has linear growth at infinity. By continuation, it satisfies the complimentary slackness condition:

$$\left[M(B,K) - (\frac{B}{\alpha} - K)\right] \times \left[\frac{1}{2}(\sigma_B^2 B^2 \partial_{BB} M(B,K) + 2\rho\sigma_B\sigma_K BK\partial_{BK} M(B,K) + \sigma_K^2 K^2 \partial_{KK} M(B,K)) - \alpha M(B,K)\right] = 0$$

To complete the proof, we have to prove:

$$\frac{1}{2}\left(\sigma_B^2 B^2 \partial_{BB} M(B,K) + 2\rho\sigma_B\sigma_K BK\partial_{BK} M(B,K) + \sigma_K^2 K^2 \partial_{KK} M(B,K)\right) - \alpha M(B,K) \leq 0, \text{ if } \tfrac{B}{K} > \tfrac{B^*}{K^*}, \tag{A1}$$

and

$$M(B,K) \geq \frac{B}{\alpha} - K, \text{ if } \tfrac{B}{K} < \tfrac{B^*}{K^*}. \tag{A2}$$

[8] Calculations are available from authors upon request.

For (A1), it reduces to $-\alpha\left(\frac{B}{\alpha}-K\right)<0$, which is satisfied. To check (A2), set $G(B,K)=M(B,K)-\frac{B}{\alpha}+K$. We have $G(B,K)$ decreases on $(0,\frac{B^*}{K^*})$, $G(B^*,K^*)=0$, and $G(B,K)\geq 0$ on $(0,\frac{B^*}{K^*})$; therefore, (A2) is satisfied. This completes the proof. $\square$

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