Stress Tests and Information Disclosure

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\(^1\)The views expressed here are those of the authors and do not necessarily reflect those of the Federal Reserve Bank of Philadelphia or of the Federal Reserve System.
The paper is about whether a regulator should disclose information about banks.

Very controversial. For example, with regards to disclosure of stress tests results:

- Fed Governor Tarullo expresses support for wide disclosure as it “allows investors and other counterparties to better understand the profiles of each institution.”
- But the Clearing House Association is concerned of “unanticipated and potentially unwarranted and negative consequences to covered companies and U.S. financial markets.” (WSJ, 2012)
This paper

- A new theory of (optimal) disclosure, focusing on the following tradeoff:
  - Disclosure harms risk sharing arrangements among banks. (Relates to Hirshleifer effect.)
  - But some disclosure may be necessary to prevent a market breakdown.

- We find that:
  - During normal times, no disclosure is optimal.
  - During bad times, some disclosure is necessary. We characterize its optimal form; e.g., under what conditions a simple cutoff rule is optimal.
In our model, risk sharing takes a simple form:

- A bank has an asset that yields a random cashflow.
- The bank can replace the random cash flow with a deterministic cashflow by selling the asset in a competitive market.

The sale price – and hence the bank’s ability to share risk – depends on the regulator’s disclosure policy.

The regulator does not inject money in our model. (We discuss extensions.)
Bayesian persuasion games (e.g., Kamenica & Gentzkow, 2011)

Disclosure

- by regulator (e.g., Morris & Shin, 2002; Angeletos & Pavan, 2007; Prescott, 2008; Leitner, 2012; Bond & Goldstein, 2012; Bouvard, Chaigneau & de Motta, 2013; Shapiro & Skeie, 2013; Goldstein & Sapra, 2014; Gick and Pausch, 2014; Andolfatto, Berentsen, and Waller, 2014)
- by firm (e.g., Diamond, 1985; Fishman & Hagerty, 1990, 2003; Adamati & Pflederer, 2000)
- by credit rating agencies (e.g., Lizzeri, 1999; Kartasheva & Yilmaz, 2012; Goel and Thakor, 2015)

Market incompleteness based on Hirshleifer effect vs. adverse selection (Marin & Rahi, 2000)

Financial networks (e.g., Allen & Gale, 2000; Leitner, 2005)
The model

- There is a bank, a regulator (planner), and a perfectly competitive market.
- The bank has an asset that yields \( \tilde{\theta} + \tilde{\varepsilon} \). \( \tilde{\theta} \perp \tilde{\varepsilon} \), \( E(\tilde{\varepsilon}) = 0 \)
- The bank can sell its asset in the market for an amount \( x \) (derived endogenously).
- Everyone is risk neutral, and the risk-free rate is 0%.
- Hence, \( x = E[\tilde{\theta} + \tilde{\varepsilon} \mid \text{market information}] \).
- Bank’s final cash holding: \( z = \begin{cases} x & \text{if bank sells asset} \\ \tilde{\theta} + \tilde{\varepsilon} & \text{if bank keeps asset} \end{cases} \)
Bank’s final payoff is

\[ R(z) = \begin{cases} 
  z & \text{if } z < 1 \\
  z + r & \text{if } z \geq 1
\end{cases} \quad (r > 0) \]

Several motivations: project, debt liability, bank run

Bank maximizes \( E[ R(z) \mid \text{bank's information}] \).
The model (cont’d)

- \( \tilde{\theta} \) is drawn from a finite set \( \Theta \subset \mathbb{R} \) according to \( p(\theta) = \Pr(\tilde{\theta} = \theta) \).
- \( \tilde{\epsilon} \) is drawn from a continuous cumulative distribution function \( F \).
- Probability structure (i.e., functions \( p \) and \( F \)) is common knowledge.
- Assume: \( \theta_{\text{max}} \geq 1, F(1 - \theta_{\text{min}}) < 1, F(1 - \theta_{\text{max}}) > 0 \).
The model (cont’d)

- Planner observes the realization of $\tilde{\theta}$ (denoted by $\theta$).
- Market does not observe $\theta$.
- As for the bank, we focus on 2 cases:
  1. Bank does not observe $\theta$.
  2. Bank observes $\theta$.
- In both cases, no one observes the realization of $\tilde{\varepsilon}$. 

Goldstein & Leitner () Stress Tests and Information Disclosure September 2015 9 / 28
Disclosure rules

- Before observing \( \theta \), the planner chooses (and publicly announces) a disclosure rule.
- A disclosure rule is a set of “scores” \( S \), and a function that maps each type to a distribution over scores. (Without loss, \( S \) is finite.)
- Denote

\[
g(s|\theta) = \Pr(\tilde{s} = s|\tilde{\theta} = \theta)
\]

\[
\mu(s) = E[\tilde{\theta} + \tilde{\varepsilon}|\tilde{s} = s] = \frac{\sum_{\theta \in \Theta} \theta p(\theta) g(s|\theta)}{\sum_{\theta \in \Theta} p(\theta) g(s|\theta)}
\]
The planner can commit to the chosen disclosure rule.

Planner’s objective: maximize expected total surplus.

Same as maximizing bank’s expected payoff across all types.
1. The planner chooses a disclosure rule and publicly announces it.
2. The bank’s type $\theta$ is realized and observed by the planner. (In case 2, $\theta$ is also observed by the bank.)
3. The planner assigns the bank a score $s$ and publicly announces it.
4. The market offers to purchase the asset at a price $x(s)$.
5. The bank chooses whether to keep its asset or sell it for a price $x(s)$.
6. The residual noise $\varepsilon$ is realized. So, $z$ and $R(z)$ are determined.

Essentially, a score is a price recommendation to the market.
Case 1: Bank does not observe its type

- Bank’s action depends only on $s$, and so does not convey additional information to the market.
- Hence, the market sets a price $x(s) = \mu(s)$.
- Hence, in equilibrium the bank sells if and only if $\mu(s) \geq 1$. (Explain.)
Case 1: Bank does not observe its type

- Expected payoff for type $\theta$, given disclosure rule $(S, g)$:

$$u(\theta) = \sum_{s: \mu(s) < 1} [\theta + r \Pr(\tilde{\epsilon} \geq 1 - \theta)] g(s | \theta) + \sum_{s: \mu(s) \geq 1} [\mu(s) + r] g(s | \theta)$$

  
  - bank keeps asset
  
  - bank sells

- The planner chooses $(S, g)$ to maximize $\sum_{\theta \in \Theta} p(\theta) u(\theta)$.
- Same as maximizing

$$\sum_{\theta \in \Theta} p(\theta) \Pr(\tilde{\epsilon} < 1 - \theta) \sum_{s: \mu(s) \geq 1} g(s | \theta).$$
Case 1: Bank does not observe its type

- We can focus (without loss) on disclosure rules that assign at most two scores, $s_1$ and $s_0$, such that $\mu(s_1) \geq 1$ and $\mu(s_0) < 1$.

- $h(\theta)$: probability of obtaining the “high” score $s_1$. 
Planner’s problem

Lemma

The planner’s problem reduces to choosing \( h : \Theta \rightarrow [0, 1] \) to maximize

\[
\sum_{\theta \in \Theta} p(\theta) \Pr(\tilde{\epsilon} < 1 - \theta) h(\theta),
\]

subject to

\[
\sum_{\theta \in \Theta} p(\theta)(\theta - 1) h(\theta) \geq 0.
\]

- Constraint follows since \( \mu(s_1) \geq 1. \)
Solution to planner’s problem

- If $E(\tilde{\theta}) \geq 1$, set $h(\theta) = 1$ for every $\theta \in \Theta$. (“normal” times)

- If $E(\tilde{\theta}) < 1$ (“bad” times), the solution depends on the gain-to-cost ratio:

  $$G(\theta) \equiv \frac{\Pr(\tilde{\epsilon} < 1 - \theta)}{1 - \theta}.$$

  - For $\theta \geq 1$: set $h(\theta) = 1$
  - For $\theta < 1$: set $h(\theta) = 1$ to types with high $G(\theta)$, and $h(\theta) = 0$ to types with low $G(\theta)$
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- Types that obtain the low score are not necessarily the lowest.
Implementation

- If $E(\tilde{\theta}) \geq 1$, the planner can give every type the same score (i.e., no disclosure)
  - It is also possible to give multiple scores, such that $\mu(s) \geq 1$ for every score.
  - If $\theta_{\text{min}} \geq 1$, we can even have full disclosure.

- If $E(\tilde{\theta}) < 1$, the planner must assign at least two scores. Yet, full disclosure is suboptimal.
Example 1 ("normal" times)

- $\tilde{\theta} \in \{0.8, \ 1.0, \ 1.2\}$, equal probabilities.
- With no disclosure, every type sells (for $1$) $\rightarrow$ optimal.
- With full disclosure, only types 1 and 1.2 sell $\rightarrow$ suboptimal.
Example 2 ("bad" times)

- \( \tilde{\theta} \in \{0.6, 0.8, 1.0, 1.2\} \), equal probabilities.
- With no disclosure, no one sells (since average is 0.9).
- With full disclosure, only types 1 and 1.2 sell.

Partial disclosure can do better (since more types sell).
- \( G(\theta) \) increasing \( \rightarrow \) high score to 0.8 1.0 1.2
- \( G(\theta) \) decreasing \( \rightarrow \) high score to 0.6 (with probability 0.5) 1.0 1.2
Case 2: Bank observes its type

- The solution so far (when bank does not observe its type) is close to Kamenica & Gentzkow (2011); but since we put more structure on the planner’s objective, we can say more.

- The case in which the bank observes its type is harder (and new).
  - Now each type has its own “reservation price,” i.e., a minimum price at which it is willing to sell.

- The planner may need to assign more than 2 scores to distinguish among types with different reservation prices.
Optimal disclosure rules

- $\rho_1$: reservation price of highest type
- If $E(\tilde{\theta}) \geq \rho_1$, no disclosure achieves the optimal outcome.
- If $E(\tilde{\theta}) < \rho_1$, some disclosure is necessary.

Next, we focus on the case in which resources are scarce

- I.e., it is impossible to implement an outcome in which every type sells with probability 1.

In this case, if the highest type that obtains score $s$ is $\theta_i \geq 1$, then $x(s) = \rho(\theta_i)$
Optimal disclosure rules (an example)

- Consider 2 types above 1 ($\theta_1 > \theta_2 > 1$) with different reservation prices ($\rho_1 > \rho_2 \geq 1$).

- First result: $\theta_1$ and $\theta_2$ must obtain different scores.
  
  “Proof”:
  - If $\theta_1$ and $\theta_2$ obtain the same score, type $\theta_2$ ends up with $\rho_1$.
  - This is a waste of resources, but without any gain.
  - Better to give type $\theta_2$ its own score, so that it ends up with only $\rho_2$.

- Second result: Among the types below 1 that are pooled with types above 1, the lowest types below 1 are pooled with the highest types above 1.
Optimal disclosure rules (an example)

<table>
<thead>
<tr>
<th>type</th>
<th>0.5</th>
<th>0.7</th>
<th>0.8</th>
<th>1.4</th>
<th>1.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sale price</td>
<td>n/a</td>
<td>1.2</td>
<td>1.2</td>
<td>1.1</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Intuition:

- As before, the planner uses a gain-to-cost ratio to assign scores, but now the cost depends on the assigned score.

\[
G_i(\theta) \equiv \frac{\text{Pr}(\tilde{\epsilon} < 1 - \theta)}{\rho_i - \theta}.
\]

- Nonmonotonicity follows because it is relatively more costly to assign a high score to a high type. (That is, when \( \rho_1 > \rho_2 \), \( \frac{\rho_1 - \theta}{\rho_2 - \theta} \) is increasing in \( \theta \).)
Will nonmonotonicity prevail if we enrich our model?

- Add a constraint that higher types must end up with higher expected equilibrium payoff
  - E.g., banks can freely dispose assets (Innes, 1990).

- If planner *can* randomize:
  - Lower types may continue to sell for higher prices, but they sell with probability that is less than 1.
  - Types above 1 may sell above their reservation prices.

- If planner *cannot* randomize:
  - Optimal rule becomes monotone and generally involves two cutoffs.
  - For some parameter values, full disclosure is uniquely optimal.
Risk sharing can take a more complicated form.
Model can capture externalities imposed by banks on the rest of society. (Hence, regulation is necessary.)
In many cases, regulator’s commitment would arise endogenously.
Model can be used as benchmark to think of credit rating agencies.
An interesting extension: regulator can provide funds to banks.
  Such an extension would suggest that in some cases, it is optimal to inject money not only to weak banks but also to strong banks.
The results could be applied to other settings of Bayesian persuasion.
Conclusion/ Implications

- If $E(\theta)$ is sufficiently high, no disclosure is necessary.
- Otherwise, some disclosure is needed to enable trade.
  - True even if banks do not have private information.
- In many cases, the weakest banks receive the lowest possible score and are out of the market. But more generally, use “gain-to-cost” ratio.
- When banks observe their types, more disclosure is needed.
- Low types receiving high scores can emerge as a socially optimal outcome.
Thank you!