Bank of Finland Research Discussion Papers
3 • 2024

Diego Moreno – Tuomas Takalo

Stress test precision and bank competition

Bank of Finland
Research

Bank of Finland Research Discussion Papers
Editor-in-Chief Esa Jokivuolle

Bank of Finland Research Discussion Papers 3/2024
2 February 2024

Diego Moreno – Tuomas Takalo:
Stress test precision and bank competition

ISSN 1456-6184, online

Bank of Finland
Research Unit

PO Box 160
FIN-00101 Helsinki

Phone: +358 9 1831

Email: research@bof.fi
Website: www.suomenpankki.fi/en/research/research-unit/

Stress Test Precision and Bank Competition*

Diego Moreno† Tuomas Takalo‡

January 31, 2024

Abstract

We study a competitive banking sector in which banks choose the level of risk of their asset portfolios and, upon the public disclosure of stress test results, raise funding by promising investors a repayment. We show that competition forces banks to choose risky assets so as to promise investors high repayments, and to gamble on favorable stress test results. Increasing stress test precision increases banks' asset riskiness but also improves allocative efficiency. When risk taking is not too sensitive to the precision of information, maximal transparency maximizes both stability and surplus. In contrast, when banks exercise market power assets are less risky, while opacity maximizes banks' stability and, when the social cost of bank failure is sufficiently large, the surplus as well. Our results in overall highlight the need to take into account the structure of banking industry when designing stress tests.

Keywords: financial stability, stress tests, bank transparency, banking regulation, bank competition
JEL codes: G21, G28, D83

*We gratefully acknowledge the comments and suggestions of Ari Hyytinen, Esa Jokivuolle, and George Pennacchi. Moreno acknowledges the financial support of the Ministerio de Ciencia e Innovación (Spain), grants PID2022-142442OB-I00 and CEX2021-001181-M.

†Departamento de Economía, Universidad Carlos III de Madrid. diego.moreno@uc3m.es

‡Monetary Policy and Research Department, Bank of Finland, and Helsinki Graduate School of Economics. tuomas.takalo@bof.fi

1 Introduction

Stress testing has become a standard tool to promote financial stability, even though public information has complex effects on investors' confidence and banks' risk-taking incentives and costs of funds – see Goldstein and Sapra (2014). We show that bank competition may undermine financial stability in the presence of regulatory stress tests, inducing banks to choose risky assets so as to promise high returns to investors in exchange for liquidity, and to gamble on a favorable stress test result. The mechanism whereby competition undermines stability in our paper is thus reminiscent of Chuck Prince's (Citigroup CEO) infamous quote

> "When the music stops, in terms of liquidity, things will be complicated. But as long as the music is playing, you've got to get up and dance." (Charles O. Prince III, The Financial Times, July 9, 2007.)

In our setting banks choose their asset portfolios and, upon the public disclosure of stress test results, raise funding by promising investors a repayment. Stress tests provide binary signals of the likelihood that banks' assets will pay their returns – Goldstein and Leither (2018) and Pavan and Inostroza (2021) identify conditions for such simple information design to be optimal. Investors observe the banks' asset choices, repayment promises, and stress test results before they make their investment decisions.

The effects of increasing information disclosure are twofold: while it improves allocative efficiency by allowing investors to better tell apart strong and weak banks, thus reducing type I and II errors in the investors' liquidity provision, it strengthens banks' risk-taking incentives *ex ante*. We show that the stability maximizing stress test precision is minimal (maximal) if the banks' asset risk-taking is (is not) sufficiently sensitive to the stress test's precision. And while maximal precision maximizes the surplus as well when risk-taking is not too sensitive to the precision, lower levels of precision are called for when it is sufficiently sensitive. In that case, the optimal precision is the lower, the larger are the social costs of bank failures. Taken together, our results suggests that while stress tests may promote stability and welfare in a competitive banking sector, other regulatory interventions such as capital requirements may be needed to rein in banks' risk-taking behavior – cf. Orlov *et al.* (2023).

Using results of Moreno and Takalo (2023), we show that assets are riskier under perfect competition than they are in the presence of market power. Also, while asset riskiness monotonically increases with the precision of information in a competitive banking sector, in the presence of market power asset riskiness increases with the precision only for levels of precision above a certain threshold. Further, the conditions for maximal precision to be optimal are more stringent in the presence of market power than in a competitive banking sector.

While there is an extensive literature on the effects of competition and stress testing on bank stability and welfare, few papers study their joint effects. It is known that competition dissipates banks' charter value and therefore encourages risk-taking – see Keeley (1990) and Vives (2016). In our setting, however, banks gambling is purely the result of competitive pressure since their charter value is nil. Matutes and Vives (2000) and Hyytinen and Takalo (2002) study the effects of bank transparency on stability in oligopolistic banking markets. In their models, competition operates via the familiar charter value channel as well, and transparency affects retail depositors' choices. A more recent literature studies the effects of public information disclosures on roll-over risk, e.g., Chen and Hasan (2006 and 2008), Bouvard *et al.* (2015), Iachan and Nenov (2015), Moreno and Takalo (2016), Faria-e-Castro *et al.* (2017), Wei and Zhou (2021), from which we abstract away. Goldstein and Leitner (2020) survey the literature on optimal stress test design.

2 Model

Consider a banking sector with a positive measure of *banks,* which we index by the points of an interval I, and a unit measure of risk neutral *investors.* Each bank selects an *asset* from a collection of assets $\{R(\sigma),\ \sigma \in [\underline{\sigma}, \bar{\sigma}]\}$, where $0 < \underline{\sigma} < \bar{\sigma} < 1$. Assets have constant returns to scale: $R(\sigma)$ pays the return $r(\sigma)$ per unit of investment if it is successful, which happens with probability σ, and pays 0 otherwise. Thus, σ identifies the asset and serves as an inverse measure of its risk. We impose the following mild assumption on the return function r.

Assumption. The return function $r : [\underline{\sigma}, \bar{\sigma}] \to [0, \infty)$ is twice differentiable, strictly decreasing, and such that the expected return $\mathbb{E}[R(\sigma)] = \sigma r(\sigma)$ is strictly concave and reaches its maximum $\mathbb{E}[R(\mathring{\sigma})] > 1$ at $\mathring{\sigma} \in (\underline{\sigma}, \bar{\sigma})$.

Once a bank has selected an asset $\sigma \in [\underline{\sigma}, \bar{\sigma}]$, a quality review of the asset (e.g., a stress test) is conducted, which yields a binary signal $S(q) \in \{h, l\}$ of the likelihood that the asset will pay its return. Banks' signals $(S_i(q))_{i \in I}$ are independent and identically distributed. The parameter $q \in [1/2, 1]$ is the precision of the signal. Specifically, regardless of the asset $\sigma \in [\underline{\sigma}, \bar{\sigma}]$, $S(q) = h$ (respectively, $S(q) = l$) with probability q when the asset pays (does not pay) its return; i.e.,

$$\Pr[S(q) = h \mid R(\sigma) = r(\sigma)] = \Pr[S(q) = l \mid R(\sigma) = 0] = q.$$

Thus, the signal is correct with probability q, and is misleading with probability $1 - q$.

Upon the realization of the signals, which are truthfully disclosed, each bank raises funding by offering investors to *repay* $\rho \in [0, \infty)$ monetary units for each monetary unit invested in the asset. The profit per unit of investment of a bank that promises to repay ρ if its asset pays the return r is

$$\max\{r - \rho, 0\}.$$

That is, a bank pledges and is liable only up to its returns, and hence its profit is non-negative whatever contract it offers and whatever the signal and return realizations.

Each investor chooses whether to invest a monetary unit in a bank. The payoff of an investor who does not invest is 1, while the payoff of an investor that invests in a bank that promises to repay ρ if the return of the bank's asset is r is

$$\min\{\rho, r\}.$$

This formulation presumes that investors have priority amongst the bank's creditors. Upon observing the profile of contracts offered by the banks, $(\sigma_i, \rho_i(h), \rho_i(l))_{i\in I}$, and their signal realizations, $(s_i)_{i\in I}$, investors choose whether to invest in one of the banks. The expected payoff of an investor who invest in a bank that offers the contract $(\sigma, \rho(h), \rho(l))$ and signals $s \in \{h, l\}$ is

$$\mathbb{E}[\min\{\rho(S(q)), R(\sigma)\} \mid S(q) = s].$$

Since there are constant returns to scale to investments, a bank can satisfy any demand for its asset.

Our aim is to identify the contracts that are offered and raise funding in a competitive equilibrium, to determine the asset risk and the surplus, and to study how equilibrium is affected by variations of the signals' precision q. Since there are constant returns to scale to investments, in a competitive equilibrium banks' expected profit are zero. Moreover, competitive pressure will lead the banks to offer contracts that may attract investors with positive probability. A formal definition, much in line with the literature, e.g., Rothschild and Stiglitz (1976), follows.

Denote the set of all profiles of signal realizations by

$$\Omega := \{(s_i)_{i \in I} \mid s_i \in \{h, l\}, \forall i \in I\}.$$

Definition. A *competitive equilibrium (CE henceforth)* is a profile of contracts $(\sigma_i, \rho_i(h), \rho_i(l))_{i \in I}$ such that, when investors choose whether to invest in one of the banks aiming to maximize their expected payoff given the banks' signals, $(s_i)_{i \in I}$,

(i) banks' make zero expected profits, and

(ii) there is no alternative contract which, if offered by a bank, will increase investors' expected payoff; i.e., there is no contract $(\sigma, \rho(h), \rho(l))$, signal $s \in \{h, l\}$, and positive probability event $A \subset \Omega$ such that

$$\mathbb{E}[\min\{\rho(s), R(\sigma)\} \mid S(q) = s] > \max\{\mathbb{E}[\min\{\rho_i(S_i(q)), R(\sigma_i)\} \mid S_i(q) = s_i], 1\}$$

holds for all $i \in I$ and all $(s_i)_{i \in I} \in A$.

3 Results

We show that competitive pressure forces banks to offer the asset that maximizes investors' expected payoff conditional on $s = h$, i.e., to choose the asset

$$\sigma_c(q) := \arg \max_{\sigma \in [\underline{\sigma}, \bar{\sigma}]} \mathbb{E}[R(\sigma) \mid S(q) = h],$$

and to offer investors the full return, gambling on the asset signaling h. The following lemma establishes some useful results.

Lemma 1. *If $q \in (1/2, 1]$, then $\sigma_c(q) < \mathring{\sigma}$, and for all $\sigma \in [\underline{\sigma}, \bar{\sigma}] \backslash \{\sigma_c(q)\}$,*

$$\mathbb{E}[R(\sigma_c(q)) \mid S(q) = h] > \mathbb{E}[R(\sigma) \mid S(q) = h] > \mathbb{E}[R(\sigma)] > \mathbb{E}[R(\sigma) \mid S(q) = l].$$

Thus, $\mathbb{E}[R(\sigma_c(q)) \mid S(q) = h] > \mathbb{E}[R(\mathring{\sigma})] > 1$.

Proof. Let $q \in (1/2, 1]$. We may write

$$\mathbb{E}[R(\sigma) \mid S(q) = h] = \Pr[R(\sigma) = r(\sigma) \mid S(q) = h]\, r(\sigma) = qp(q,\sigma)\mathbb{E}[R(\sigma)], \tag{1}$$

where

$$p(q,\sigma) := \frac{1}{q\sigma + (1-q)(1-\sigma)} > 1.$$

Taking derivative in equation (1) we see that σ_c solves the equation

$$\frac{\partial \mathbb{E}[R(\sigma) \mid S(q) = h]}{\partial \sigma} = p(q,\sigma)q\left(\mathbb{E}'[R(\sigma)] - p(q,\sigma)(2q-1)\mathbb{E}[R(\sigma)]\right) = 0. \tag{2}$$

Since $\mathbb{E}[R(\sigma)]$ is strictly concave and is maximized at $\mathring{\sigma} \in (\underline{\sigma}, \bar{\sigma})$ by Assumption 1,

$$\mathbb{E}'[R(\sigma)] \gtreqless 0 \Leftrightarrow \sigma \lesseqgtr \mathring{\sigma}.$$

Hence, for all $\sigma \geq \mathring{\sigma}$,

$$\mathbb{E}'[R(\sigma)] - p(q,\sigma)(2q-1)\mathbb{E}[R(\sigma)] \leq -p(q,\sigma)(2q-1)\mathbb{E}[R(\sigma)] < 0,$$

and therefore equation (2) implies that $\sigma_c(q) < \mathring{\sigma}$.

The second claim of Lemma 1 follows from the inequalities

$$\Pr[R(\sigma) = r(\sigma) \mid S(q) = h] > \sigma > \Pr[R(\sigma) = r(\sigma) \mid S(q) = l],$$

which hold for all $\sigma \in [\underline{\sigma}, \bar{\sigma}]$ whenever $q > 1/2$. The last claim then follows from Assumption 1. $\square$

Next we identify the basic properties of competitive equilibria. We refer to the contracts $(\sigma, \rho(h), \rho(l))$ such that $(\sigma, \rho(h)) = (\sigma_c(q), r(\sigma_c(q)))$ as *competitive contracts.* For any profile of contracts $(\sigma_i, \rho_i(h), \rho_i(l))_{i \in I}$ we denote by I^* the set banks offering competitive contracts, and by A^* the event in which all banks offering competitive contracts signal l, i.e.,

$$A^* = \{(s_i)_{i\in I} \in \Omega \mid s_i = l, \, \forall i \in I^*\}.$$

Proposition 1 establishes that in a CE only the banks offering competitive contracts and signaling h may raise funding with positive probability.

Proposition 1. *A profile of contracts $(\sigma_i, \rho_i(h), \rho_i(l))_{i\in I}$ is a CE if and only if* $\Pr(A^*) = 0$. *Moreover, only the banks offering competitive contracts, $i \in I^*$, and signaling h may raise funding with positive probability.*

Proof. Let $(\sigma_i, \rho_i(h), \rho_i(l))_{i\in I}$ be a profile of contracts. If $\Pr(A^*) = 0$, then the probability that $s_i = h$ for some $i \in I^*$ is 1. Moreover, the expected payoff of an investor who chooses to invest in a bank $i \in I^*$ whose signal is $s_i = h$ satisfies for all $\sigma \in [\underline{\sigma}, \bar{\sigma}]\backslash\{\sigma_c\}$, $\rho \in [0, \infty)$ and $s \in \{h, l\}$,

$$\begin{aligned}
\mathbb{E}[\min\{\rho_i(s), R(\sigma_i)\} \mid S(q) = h] \quad &= \mathbb{E}[R\left(\sigma_c(q)\right) \mid S(q) = h] \\
&> \mathbb{E}[R\left(\sigma\right) \mid S(q) = s] \\
&\geq \mathbb{E}[\min\{\rho, R(\sigma)\} \mid S(q) = s]
\end{aligned}$$

where the inequality follows from Lemma 1. Moreover,

$$\mathbb{E}[\min\{\rho_i(s), R(\sigma_i)\} \mid S(q) = h] = \mathbb{E}[R\left(\sigma_c(q)\right) \mid S(q) = h] > \mathbb{E}[R\left(\mathring{\sigma}\right)] > 1$$

by Lemma 1 as well. Hence only banks $i \in I^*$ such that $s_i = h$ may raise funding with positive probability, and therefore banks' expected profits are zero. Moreover, there is no contract that if offered will increase investors' expected payoff. Therefore, the profile is a competitive equilibrium.

Contrariwise, assume that $\Pr(A^*) > 0$. Then I^* is proper subset of I for otherwise the Law of Large Numbers would imply that $\Pr(A^*) = 0$. Thus, if bank $j \in I\backslash I^*$ were to offer a contract such that $\sigma_j = \sigma_c(q)$ and

$\rho_j(h) = r(\sigma_c(q))$, then $\Pr[A^* \cap \{(s_i)_{i\in I} \in \Omega \mid s_j = h\}] > 0$, and

$$\begin{aligned}\mathbb{E}[\min\{\rho_i(s), R(\sigma_i)\} \mid S(q) = h] \quad &= \mathbb{E}[R\,(\sigma_c(q)) \mid S(q) = h] \\ &> \max\{\mathbb{E}[\min\{\rho_i(S_i(q)), R(\sigma_i)\} \mid S_i(q) = s_i], 1\}\end{aligned}$$

holds for all $i \in I$ and all $(s_i)_{i\in I} \in A^* \cap \{(s_i)_{i\in I} \in \Omega \mid s_j = h\}$, and therefore the given profile is not a competitive equilibrium. $\square$

We next show that asset risk increases with the precision of the signal.

Proposition 2. *For all* $q \in (1/2, 1]$ *such that* $\sigma_c(q) > \underline{\sigma}$, $\sigma_c'(q) < 0$.

Proof. Let $q \in (1/2, 1]$ and assume that $\sigma_c(q) > \underline{\sigma}$. Since $\sigma_c(q) < \mathring{\sigma}$ by Lemma 1, $\sigma_c(q) \in (\underline{\sigma}, \mathring{\sigma})$ is an interior solution, i.e.,

$$\frac{\partial \mathbb{E}[R\,(\sigma_c\,(q)) \mid S(q) = h]}{\partial \sigma} = 0 \tag{3}$$

and

$$\frac{\partial^2 \mathbb{E}[R\,(\sigma_c\,(q)) \mid S(q) = h]}{\partial \sigma^2} < 0.$$

Then, taking derivative in equation (2) and evaluating the resulting derivative at equilibrium $\sigma = \sigma_c(q)$ where equation (3) holds yield after some algebra

$$\frac{\partial^2 \mathbb{E}[R\,(\sigma_c(q)) \mid S(q) = h]}{\partial \sigma \partial q} = -p(q, \sigma_c(q))^3 q \mathbb{E}[R(\sigma_c(q))] < 0.$$

Thus, totally differentiating equation (3) we get

$$\sigma_c'(q) = -\frac{\partial^2 \mathbb{E}[R(\sigma_c\,(q)) \mid S(q) = h]}{\partial \sigma \partial q} \left(\frac{\partial^2 \mathbb{E}[R(\sigma_c\,(q)) \mid S(q) = h]}{\partial \sigma^2}\right)^{-1} < 0. \;\square$$

In a CE banks not offering competitive contracts or signaling l do not raise funding and fail. Let us assume that banks prefer not to fail, and hence that all banks offer competitive contracts, i.e., $I^* = I$. Then banks that signal h and pay return, i.e., the fraction $q\sigma_c\,(q)$, do not fail, while the remaining banks, i.e., the fraction $1 - q\sigma_c(q)$, fail. Thus, maximizing stability amounts to maximizing $q\sigma_c(q)$. Taking derivative gives

$$(q\sigma_c(q))' = \sigma_c(q)(1 + \varepsilon_c(q)), \tag{4}$$

where $\varepsilon_c(q) := q\sigma_c'(q)/\sigma_c(q)$ is the elasticity of asset risk-taking to the signal's precision. Since $\varepsilon_c(q)$ is negative by Proposition 2, equation (4) implies that if $\varepsilon_c(q) > -1$, then maximal transparency (i.e., $q = 1$) maximizes banks' stability. In contrast, if $\varepsilon_c(q) < -1$, then complete opacity (i.e., $q = 1/2$), leading banks to select the asset $\sigma_c(1/2) = \mathring{\sigma}$, maximizes banks' stability.

The social surplus is

$$W(C, q) := \mathbb{E}[R(\sigma_c(q)) \mid S(q) = h] - (1 - q\sigma_c(q))|I|C,$$

where $C > 0$ is the social costs of bank failure and $|I|$ is the measure of banks in the sector. The surplus thus consists of expected asset returns and expected costs of bank failures, captured by the first and second terms, respectively, in the definition of $W(C, q)$.

Using equation (1) we get

$$\frac{d\mathbb{E}[R(\sigma_c(q)) \mid S(q) = h]}{dq} = p(q, \sigma_c(q))^2(1 - \sigma_c(q))\mathbb{E}[R(\sigma_c(q))] > 0.$$

The effect of a more precise test on the expected return is positive, since it improves allocative efficiency by reducing investors' type I and II errors, i.e., reduces the probabilities that solvent banks fail due to illiquidity and that insolvent banks raise funding.

Also, increasing the stress tests precision has a decreasing *direct* effect on the expected social costs of bank failures (the direct effect of q on the term $(1 - q\sigma_c(q))|I|C$, in the definition of $W(C, q)$). However, a more precise stress test increases banks' risk-taking *ex ante* (since $\sigma_c' < 0$ by Proposition

2), which has an increasing *indirect* effect on the expected social costs of bank failures. Thus, the net effect of a more precise stress tests on the expected social costs of bank failures depends on the elasticity $\varepsilon_c(q)$: If $\varepsilon_c(q) \geq -1$, then the expected social costs of bank failures are decreasing with the signal's precision, and hence maximal transparency maximizes the surplus. If $\varepsilon_c(q) < -1$, however, maximizing the surplus requires an optimal balance of the (positive) effect of precision on the expected returns and its (negative) effect on the expected social costs of bank failures. Moreover, if the surplus maximizing precision is interior, then it decreases with the cost of bank failure C.

We state formally these results in Proposition 3.

Proposition 3. *If* $\varepsilon_c(q) \geq -1$, *then maximal transparency , i.e.,* $q = 1$, *maximizes stability and the social surplus, while if* $\varepsilon_c(q) < -1$, *then opacity, i.e.,* $q = 1/2$, *maximizes stability, and the maximum social surplus may be reached on* $(1/2, 1)$. *Moreover, when the maximum surplus reached on* $(1/2, 1)$, *then the precision that maximizes the surplus decreases with the cost of bank failure* C.

Proof. We proof the last claim of Proposition 3; the other claims summarize the analysis above the proposition. Assume that $W(C, \cdot)$ reaches its maximum at $q^W \in (1/2, 1)$. Then $\varepsilon_c(q^W) < -1$ (since otherwise $W(C, \cdot)$ is maximized at $q = 1$), and q^W solves the first-order condition $\partial W(C, q)/\partial q = 0$ and satisfies $\partial^2 W(C, q^W)/\partial q^2 < 0$. Differentiating this first-order condition yields

$$\frac{dq}{dC} = -(1 + \varepsilon_c(q^W))\sigma_c\left(q^W\right)\left(\frac{\partial^2 W(C, q^W)}{\partial q^2}\right)^{-1}|I| < 0. \square$$

Moreno and Takalo (2023) study in the same setting the equilibrium that arises when a bank exercises market power. Under alternative contracting scenarios they show that the equilibrium asset risk $\sigma^*(\cdot)$ and the effects of changes in the signal's precision q differ in transparent and opaque environments, which are identified by whether the signal's precision is above or below a threshold $q^* \in (1/2, 1)$. Specifically, they show that $\sigma^*(q) = \mathring{\sigma} > \sigma^*(q')$, whenever $q \in (1/2, q^*)$ and $q' \in (q^*, 1]$, and that $\sigma^*(\cdot)$ is a non-decreasing (decreasing) function in opaque (transparent) environments. Thus, Proposition 2 shows that $\sigma_c(\cdot)$ behaves as $\sigma^*(\cdot)$ in transparent environments, although the implicit incentives differ: The behavior of $\sigma_c(\cdot)$ is due to competitive pressure irrespective of the signal's precision. In contrast, a bank with market power must choose whether to select its assets aiming to raise funding regardless of the signal, or to give up raising funding upon the low signal. As raising funds upon the low signal becomes too costly when the signal is sufficiently precise (i.e., when $q \in (q^*, 1]$), the bank selects riskier assets gambling on a high signal somewhat as in the current competitive setting.

We establish that assets are riskier under perfect competition than they are when a bank exercises market power.

Proposition 4. *For all* $q \in (1/2, 1]$, $\sigma_c(q) < \sigma^*(q)$.

Proof. Since $\sigma_c(q) < \mathring{\sigma}$ by Lemma 1, and $\mathring{\sigma} = \sigma^*(q)$ when $q \in (1/2, q^*)$ by Proposition 1 in Moreno and Takalo (2023), then $\sigma_c(q) < \mathring{\sigma} = \sigma^*(q)$ for all $q \in (1/2, q^*)$.

Let $q \in (q^*, 1]$. Equations (1) and (2) imply

$$\mathbb{E}'[R(\sigma_c(q))] \geq (2q-1)\, p(q,\sigma)\mathbb{E}[R(\sigma_c(q)] = \frac{2q-1}{q}\mathbb{E}[R\left(\sigma_c(q)\right) \mid s = h],$$

and therefore, since $\mathbb{E}[R(\sigma_c(q)) \mid S = h] > 1$ by Lemma 1,

$$\mathbb{E}'[R(\sigma_c(q))] > 2 - \frac{1}{q} = \mathbb{E}'[R(\sigma^*(q))],$$

where the equality follows from equation (24) in Moreno and Takalo (2023) identifying the equilibrium asset $\sigma^*(q)$. Hence $\sigma_c(q) < \sigma^*(q)$ for all $q \in (q^*, 1]$ as well, since $\mathbb{E}[R(\sigma)]$ is strictly concave by Assumption 1. $\square$

This result is in line with most of the literature which, building on the insights in Keeley (1990), relates banks' willingness to take more risk to the dissipation of their charter value under competition – see Boyd and De Nicolò (2005) for a counterexample and Vives (2016) for a survey of the literature. In our setting, however, there is no charter value; instead, competition for liquidity forces banks to choose a risky asset to credibly offer a high repayment and to gamble on a high signal.

In the presence of market power, Moreno and Takalo (2023) show that if asset risk-taking is not too sensitive to changes in the signal's precision, then maximal transparency maximizes the surplus, much as in Proposition 3. However, this result holds only if the social cost of bank failure C is sufficiently small, while if C is large, then the maximum surplus is reached at or below q^* irrespective of the sensitivity of asset risk-taking to the signal's precision. As for the effect of precision on stability, Moreno and Takalo (2023) show that with a market power, maximal bank stability is reached at or below q^*, while as we show under perfect competition the stability maximizing precision depends on the sensitivity of asset risk-taking to the signal's precision.

4 Conclusion

In this paper we study the effect of stress test precision on stability and welfare in a competitive banking sector. We uncover a new mechanism whereby competition may increase banks' instability in the presence of regulatory stress tests: competition for liquidity forces the banks to offer high repayments, take risk, and gamble for a favorable signal in a stress test. We show that a more precise stress test increases banks' asset risk taking *ex ante*.

However, it also reduces investors' type I and II errors, thus improving the efficiency of liquidity provision into the banking system. Thus the stability maximizing stress test precision is minimal (maximal) if the banks' asset risk taking is (not) sensitive to the precision.

Since a more precise stress test reduces investors' type I and II erros, it increases their expected investment returns, besides having the two conflicting effects on stability. Therefore, a sufficient condition for maximal precision to be socially desirable is that the banks' asset risk taking is not too sensitive to changes in the precision. If, however, the asset risk taking is sufficiently sensitive, the concern for increased risk levels in the banking sector may force the regulatory authority running the stress test to choose an intermediate level of precision. In that case, the optimal precision is the lower, the higher are the social costs of bank failures.

Taken together, our results suggests that stress tests, while potentially both stability and welfare improving, are not an effective tool to rein in banks' asset risk taking in a competitive banking sector, warranting other regulatory interventions such as capital requirements. Orlov et al. (2023) study the optimal design of stress tests when it is jointly determined with capital requirements.

We also compare our results to Moreno and Takalo (2023) who study the effect of stress test precision when a bank has market power. We show that due to the gambling mechanism, asset risk levels are higher in a competitive bankings sector than in the presence of market power. While some results are similar with and without market power, our results in overall highlight the need to take into account the structure of banking industry when designing stress tests.

References

[1] Bouvard, M., Chaigneau, P., de Motta, A., 2015, Transparency in the Financial System: Rollover Risk and Crises. *J. Finance* 70, 1805-1837.

[2] Boyd, J. H., De Nicolò, G., 2005, The Theory of Bank Risk Taking and Competition Revisited. *J. Finance* 60, 1329-1343.

[3] Chen, Y., Hasan, I., 2006, "The Transparency of the Banking System and the Efficiency of Information-Based Bank Runs", *J. Financial Interm.* 15, 307-331.

[4] Chen, Y., Hasan, I., 2008, Why Do Bank Runs Look Like Panic? A New Explanation. *J. Money Credit Bank.* 40, 535-546.

[5] Faria-e-Castro, M., Martinez, J., Philippon, T., 2017, Runs versus Lemons: Information Disclosure and Fiscal Capacity, *Rev. Econ. Stud.* 84, 1683-1707.

[6] Goldstein, I., Leitner, Y., 2018, Stress Tests and Information Disclosure. *J. Econ. Theory* 177, 34-69.

[7] Goldstein, I., Leitner, Y., 2020, Stress Test Disclosure: Theory, Practice, and New Perspectives. In J. D. Farmer *et al.* (eds.) *Handbook of Financial Stress Testing*, 208-223. Cambridge University Press: Cambridge.

[8] Goldstein, I., Sapra, H., 2015, Should Bank's Stress Test Results to be Disclosed? An Analysis of Costs and Benefits. *Foundations and Trends in Finance* 8, 1-54.

[9] Hyytinen, A., Takalo, T., 2002, Enhancing Bank Transparency: A Re-Assessment. *Rev. Finance* 6, 429-445.

[10] Iachan, F., Plamen, N., 2015, Information Quality and Crises in Regime-Change Games, *J. Econ. Theory* 158, 739-768.

[11] Keeley, M., 1990, Deposit Insurance, Risk, and Market Power in Banking. *American Econ. Rev.* 80, 1183-1200.

[12] Matutes, C., Vives, X., 2000, "Imperfect Competition, Risk Taking, and Regulation in Banking, *European Econ. Rev.* 44, 1-34.

[13] Moreno, D., Takalo, T., 2016, Optimal Bank Transparency, *J. Money Credit Bank.* 48, 203-231.

[14] Moreno, D., Takalo, T., 2023, Precision of Public Information Disclosures, Banks' Stability and Welfare", *J. Money Credit Bank.,* forthcoming.

[15] Orlov, D., Zryumov, P., Skrzypacz A., 2023, The Design of Macroprudential Stress Tests. *Rev. Financial Stud.* 36, 4460-4501.

[16] Pavan, A., Inostroza, N., 2021, Persuasion in Global Games with Applications to Stress Testing. CEPR Discussion Papers No. 16484.

[17] Rothschild, M., Stiglitz, J., 1976, Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information, *Q. J. Econ.* 90, 629-649.

[18] Vives, X., 2016, *Competition and Stability in Banking: The Role of Regulation and Competition Policy.* Princeton University Press: Princeton, New Jersey.

[19] Wei, X., Zhou, Z., 2021, Dynamic Transparency and Rollover Risk, unpublished manuscript.

Bank of Finland Research Discussion Papers 2024

ISSN 1456-6184, online

1/2024	Gene Ambrocio – Iftekhar Hasan – Xiang Li **Global political ties and the global financial cycle**
2/2024	Michaela Elfsbacka-Schmöller – Nigel McClung **Price stability and debt sustainability under endogenous trend growth**
3/2024	Diego Moreno – Tuomas Takalo **Stress test precision and bank competition**