Firm Exit Through Bankruptcy – The Effect of Accounting Bias on Product Market Competition*

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Abstract

We analyze the effect of accounting reports on the competition and market structure of an industry in the presence of debt. Firms' debt covenants are based on accounting reports. A conservative accounting system increases the likelihood of debt covenant violations and firm liquidation. Interestingly, the increased likelihood of liquidation could ex-ante leave borrowing firms better off by inducing some firms to exit and leaving the surviving firms to catpure the entire market. In addition, conservative accounting bias transfers more rights to the creditors in the decision whether to liquidate or re-organize the firms' operations, thus reducing the possibility of "excessive liquidation" and thereby improving the creditors' expected payoffs. We contribute to the extant literature by showing that accounting conservatism can have real impact on competition, and reduce borrowing firms' interest rates.

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I. Introduction

Similar to entry deterrence, exit inducement softens the competition in a given market. One firm might induce a competitor to exit their market by adopting various predatory pricing (dumping) strategies as well as other predatory strategies.[1] Considered as an antitrust problem, exit inducement remains a concern to regulators of both domestic and international trade. Bolton and Scharfstein (1990) examine how indebtedness can be considered as a target of predation among firms. A more highly leveraged firm is vulnerable because it faces a higher likelihood of bankruptcy. Thus, a firm that is equity-financed (or less leveraged) could prey on its more highly leveraged rival to force it into bankruptcy. Chevalier (1995) uses data from the supermarket industry to test the effect of debt on the degree of competition and finds evidence supporting that increased leverage softens competition. In this paper, we demonstrate how accounting conservatism could encourage leveraged firms to exit from an industry because their debt covenants are based on accounting information.[2] Although our model does not directly involve one firm preying on its rival, the consequence is the same as in Bolton and Scharfstein (1990) in that competition is softened. Accounting conservatism simply facilitates more frequent exit.

This exit inducement effect arises primarily through creditors' liquidation decisions, which are based on the accounting signals reported by the borrowing firms. The accounting bias contained in each firm's report could cause the firm to be inappropriately liquidated (or continued), thus changing the competitive nature of the whole industry. Specifically, creditors' liquidation decisions can change a product market from, say, a duopoly into a monopoly, or even completely shut down the product market. Accounting reports are the information that creditors use to make such liquidation decisions. Depending on the direction of accounting bias and the demand function of the product market, accounting bias can

[1] For example, Kreps and Wilson (1982) and Milgrom and Roberts (1982) model how a predator firm could develop a reputation of always predating other firms to scare them off. Fudenberg and Tirole (1986) analyze a setting, in which the predator uses "signal-jamming" to mislead the prey into leaving the market.

[2] For example, Demerjian (2011) examines 100 randomly-selected private debt covenants, and found 96 use income statement-based information and 68 use balance sheet-based information.

lead to excessive liquidation (or excessive continuation) of the firms. However, the excessive liquidation does not necessarily make the creditors or the borrowing firms worse off. In fact, accounting bias can actually increase firms' total expected profitability to a higher level, relative to the benchmark of unbiased accounting. Thus, borrowing firms, subsequently competing in an oligopoly, and their creditors may prefer an accounting regime with deliberate bias[3].

Specifically, we analyze two firms that compete in an imperfect product market. Both firms borrow from banks to finance their operations. Both firms use the same accounting system that, for exogenous reasons, generates reports with a conservative or aggressive bias. That is, after the firms learn their true cost information, they must issue a public cost report following the requirements of the accounting system. The firms' debt covenants with the banks are also based on the public accounting reports. When the report is favorable, the firm's control rights remain in the hands of its initial owner/manager. When the report is unfavorable, the firm is taken over by the bank/creditor. Holding fixed the debt covenant, conservative accounting thus provides the creditor with more decision rights than under an aggressive accounting by triggering debt covenant violations more frequently. While the firm's owner/manager always prefers to continue the firm's operation and cannot reduce "false negative" error, the creditor can reduce "false positives" by not always terminating firms with unfavorable reports.[4]

We consider a setting with conservative accounting where the firms are forced to sometimes issue an unfavorable report when the true cost is indeed favorable. The consequence of such conservative accounting bias is excessive liquidation as the firms' debt covenants are more frequently violated. However, the firms may actually benefit from this increased

[3]Following prior literature, we acknowledge that any bias that is deterministic in magnitude can easily be unravelled by fully rational financial statement users. As a consequence, we follow analytical research and study bias that is random in magnitude. From an empirical perspective, this might best be labelled conditional conservatism.

[4]We consider the borrower's potential bankruptcy risk as the primary concern of the bank, thus false negative refers to the error when a firm is reported as good but is actually a bad type; while false positive refers to the error when a firm is reported as bad but is actually a good type.

frequency of covenant violation. In an imperfect product market, one firm being shut down means market share is transferred to the surviving rival. Thus, it is possible for the remaining firm to earn higher profit due to the change in the market structure. When the potential increase in firm profits due to the change in market structure outweighs the potential loss of profits due to excessive liquidation, we show the firms are actually better off ex-ante with conservative accounting.

Further, the banks assume control rights of the firms when a covenant violation is triggered by unfavorable cost reports. The banks then have the option of immediately liquidating the firms or, alternatively, letting the reorganized firms continue their operating activities.[5] If banks randomly liquidate firms with unfavorable cost reports, both firms would experience higher expected profitability. We follow the banking literature and assume that the banking market is perfectly competitive and that banks face a zero-profit constraint. Consequently, any gains from random liquidation would be passed on to the firms through lower borrowing rates thereby increasing firms' expected profits.

Under aggressive accounting, the firms' payoffs are generally lower than under unbiased accounting. With aggressive accounting bias in the cost report, the debt covenant is less likely to be violated, increasing the likelihood that firms are allowed to continue that should have been liquidated. Thus, the firms' expected profits are generally lower due to more intense product market competition.

The intuition behind accounting conservatism possibly leading to higher expected profits lies in the role of conservative bias in its effect of exit inducement. With conservative accounting, competing firms are sometimes forced to exit the product market due to liquidation initiated by banks. Any surviving firm(s) then gets to capture the entire market. The banks thus indirectly play an important role in softening product market competition among rival firms. Aggressive accounting has the opposite effect by inducing fiercer competition.

[5] In the U.S., a firm can choose to file Chapter 7 or Chapter 11 bankruptcy. With Chapter 7 bankruptcy, the firm is immediately liquidated; while with Chapter 11 bankrupcy, the firm is re-orgnized and allowed to continue its operations. The filing of an (involuntary) bankruptcy petition follows Section 303(b) of U.S. Title 11.

The firms' expected profits are therefore lower.

We also analyze the case where one single bank lends to two competing firms. As a single lender, this bank can decide which firm to liquidate and which firm is allowed to survive when both firms have unfavorable reports. The bank thus effectively turns the surviving firm into a monopolist, which then generates enough profits to pay back its debt in full. Since the bank only has decision rights when the report is unfavorable, accounting conservatism serves to facilitate the bank's control over the product market and reduces the risk faced by the creditor/bank. Again since the bank earns zero-profit, the additional gains from conservative accounting is passed on to the borrowing firms through lower borrowing rates.

As a benchmark, we examine the effect of accounting bias on the expected profits for debt-free firms who never face threat of liquidation. We again contrast the firms' profits under unbiased, conservatively-biased and aggressively-biased accounting systems. We find that accounting bias always decreases firms' expected profits: Compared to unbiased accounting, the firms' expected profits are strictly lower under both conservatively and aggressively biased accounting. Based on this analysis, the threat of liquidation is critical for conservative accounting to have a positive effect on firms' ex ante expected profitability.

The setup of our model is standard. Following Gigler et al. (2010) and Li (2012), we characterize accounting systems as exogenously given.[6] When accounting is *conservative*, a favorable report is perfectly informative while an unfavorable report is noisy. Conversely, when accounting is *aggressive*, an unfavorable report is perfectly informative while a favorable report is noisy. These definitions are consistent with the interpretation of conservatism by most empirical work such as Basu (1997).

We do not intend to endogenously derive the optimal level of accounting conservatism. Rather, we examine the impact of conservatism that is exogenously imposed. We also do not explain the existence of debt. The demand for debt is assumed rather than derived. Our goal in this paper is to demonstrate how the presence of debt affects the interaction

[6] There are other ways of defining conservative/aggressive accounting bias. For example, Chen et al. (2010) defines the accounting bias as an expected deviation of the reported signal from the true value.

between accounting conservatism and firms' operating decisions in an imperfect product market setting. Accounting conservatism provides creditors with additional opportunities for reducing the risk associated with asymmetric information regarding the borrower's type; thus improves lending efficiency and reduces interest rate.

As discussed above, we assume perfect competition in the banking market, thus our representative banks face a zero-profit constraint.[7] Finally, we assume that the nature of the product market competition is Cournot with perfectly substitutable products.[8]

Our paper relates to three areas of research. The first area is the impact on accounting disclosure of imperfect product market competition (without the presence of debt). Several studies present related research findings in different settings. Darrough and Stoughton (1990) show that the threat of entry may provide firms with incentives to voluntarily disclose information. Darrough (1993) examines firms' reporting behavior when engaged in Cournot or Bertrand competition. Wagenhoffer (1990) studies a firm's optimal voluntary disclosure strategy when facing a strategic market rival, and finds that these disclosures may increase the firm's product price while simultaneously imposing a proprietary cost on itself. Reis and Stocken (2007) contrast the informativeness of historical costing and fair value measurement in a strategic setting. Bagnoli and Watts (2010) also examine how two firms bias their accounting reports when competing in a Cournot product market and the effect of accounting bias on the firms' production decision. Corona and Nan (2011) find that firms competing with each other strategically over-report their planned future activities in pre-announcements. These studies either assume away the potential change in market structure, or examine entry deterrence only. Our study differs from these studies in that we focus on the exit inducement effect.

[7] The zero-profit constraint is not critical in obtaining our main results. Suppose the banks and the borrowing firms each have some bargaining powers in the allocation of the rent (extra payoff generated by the conservatively-biased accounting system). The banks then would not transfer all rent to the borrowing firms, but retain a portion of it instead. The banks and the borrowing firms would still demonstrate a strict preference to a conservative accounting system as both are better off. The only difference is the amount of rent is allocated between the bank and the firms, instead of being transferred to the firms only.

[8] See Appendix 1 for an analysis on why focusing on Cournot when products are perfect substitutes do not limit the generality of our results.

A second, related area of literature focuses on capital structure and imperfect product market competition. Brander and Lewis (1986) show a firm competing in an oligopolistic market behaves more aggressively when it is more highly leveraged, thus the whole industry settles on an equilibrium with the excessive debt in the firms' financial structure. Maksimovic (1988) examines leverage in a dynamic setting. Hughes and Kao (1998) and Hughes and Williams (2008) analyze how capital structure can be used as a commitment device in oligopolistic competition. Different from these studies that show leverage makes firm compete more aggressively, Bolton and Scharfstein (1990) examine how debt can lead to softened competition. On the one hand, firms' shareholders use debt to discipline managers; on the other hand, rival firms could prey on highly leveraged firms to force them into bankruptcy. Optimal leverage involves balancing agency problems against predation deterrence. Our setup differs from Brander and Lewis (1986), in which firms are never liquidated before production. The effect of debt in our study is instead more consistent with that of Bolton and Scharfstein (1990), in that debt makes firms more vulnerable by adding a threat of bankruptcy. Also, the banks in our model are strategic in their liquidation decisions. Upon receiving an unfavorable cost report, the banks take over the decision rights of the firm. Conditional on the reports received, the banks may choose to liquidate a firm, continue a firm, or even choose to randomly liquidate a firm.

A third area of research our paper relates to is accounting conservatism. Several recent studies examine the effect of accounting conservatism on debt contract efficiency.[9] Gigler et al. (2009) model accounting conservatism as a systematic bias to put more weight on unfavorable news and show that conservatism does not improve debt contracting efficiency. Li (2012) incorporates the possibility of debt renegotiation. She shows that conservatism may increase the borrower's profits when renegotiation is allowed. We put conservatism in

[9] Please note there are studies that explain accounting conservatism from perspectives other than debt contracting. For example, Bagnoli and Watts (2005) model accounting conservatism in a signalling model. Kwon (2005), Chen et al. (2007) and Raith (2009) justify conservatism as a mechanism to mitigate contracting problems in an agency setting. Kirschenheiter and Ramakrishnan (2010) regard conservatism as a natural consequence of managers' risk aversion and prudence.

the setting of an imperfect product market competition and study its effect on the market structure. In addition, by considering both types of bankruptcies (Chapter 7 and Chapter 11), we differ from Gigler et al. (2009), in which firms are always liquidated when unfavorable reports are given (Chapter 7). Further, we abstract from the challenging problems associated with renegotiation considered by Li (2012). The banks in our model may choose to not liquidate a firm with unfavorable cost reports, but the firms would always choose to continue production.

Our findings contribute in three ways. First, we show biased accounting can soften product market competition and induce changes in the market structure. That is, accounting regulation and accounting practice could have "real" effects on an economy and its productive activities. Note that this result generalizes to a setting without debt under two conditions. First, the investors require a minimum return to investment and the invested firms may be liquidated if such requirement is not met; Second, the intermediate disclosure about the investment can only be generated by an accounting system. For example, suppose firms competing in the product market are financed through equity. And, the shareholders may divest whenever the prospect of their investments is poor, e.g., unable to meet required return on investment. The only intermediate information that the shareholders receive from the invested firms is some accounting information. Under these conditions, the same "softening" effect of accounting conservatism on product market competition could occur.

Second, we show that accounting conservatism need not decrease a borrowing firm's expected profits. Prior analytical studies on conservatism demonstrate a negative effect on debt efficiency absent of market competition. In contrast, our results show that conservatism may be preferred by the banks (and borrowing firms) in the presence of imperfect product market competition. Accounting conservatism triggers liquidation more frequently, which then softens competition and improves the likelihood that borrowing firms can pay back the face value of their loans. Also, conservatism gives the banks more control and decision rights in the borrowing firms' operations. As a result, it reduces the banks' lending risk and the

firms' borrowing rates.

Third, we allow the banks the choice between immediate liquidation (Chapter 7 bankruptcy) and reorganization (Chapter 11 bankruptcy) of a borrowing firm. Prior literature typically does not consider Chapter 11 bankruptcy. Further, we allow the banks to employ a random strategy upon receiving an unfavorable cost report from the borrower.[10] We examine whether banks could improve their own payoffs (and therefore the borrowing firms' payoffs) by using a random strategy between liquidation and reorganization.

In addition, our findings may shed light on the results of several empirical studies that examine the relation between financial reporting behavior and market competition. For example, Dhaliwal et al. (2008) and Folsom (2010) both document a positive relation between accounting conservatism and the intensity of product market competition. Perhaps companies in a more competitive industry tend to lobby for more conservative accounting standards, which could serve as a coordination mechanism to increase industry-wide profit.

The rest of the paper is organized as follows: Section 2 sets up the model. Section 3 presents the analyses and results. Section 4 concludes the paper.

II. The Setup

We consider a setting with two firms, two creditors (or banks) and one representative consumer. We examine the interaction between these two firms i and j and their creditor(s). The firms first go to the two creditors for financing needs, and then each produces a product and sells to the representative consumer. As the focus of our paper is not on firms' optimal financial structure, we assume in our main analyses that their operations are fully debt-financed. For each firm, the bank loans an amount of initial cash, I, and the face value of the loan for each firm is D.

[10] An exception is Li (2012). She examines the renegotiation between a bank and a borrower. Both the bank and the borrower may initiate the renegotiation process in the interim stage. She does not include product market competition in the model, thus the bank's decision does not trigger any change in market structure as in our model.

Since the firms' products are perfect substitutes[11], the linear inverse demand function for the firms is $P = a - Q_i - Q_j$, where P is the unit price for the product; a is the intercept of market demand; Q_i and Q_j is the quantity produced and sold by each firm i and j, respectively. Each firm i's marginal cost C_i is its private information. We assume $C_i \in \{c_g, c_b\}$, with $c_b > c_g > 0$, where where c_b denotes unfavorable cost and c_g denotes favorable cost. We denote the probability of the firm having a low marginal cost as $\theta = \Pr\{C_i = c_g\}$, and the probability of the firm having a high marginal cost is $1 - \theta = \Pr\{C_i = c_b\}$. The marginal costs of firm 1 and 2 are independent. Each firm's operating profit is $\Pi_i = Q_i(P - C_i)$.

Upon privately observing its own cost, each firm simultaneously discloses a report of cost $\widehat{C}_i \in \{\widehat{c}_g, \widehat{c}_b\}$ to the public. The cost report is observed by everyone, including the creditors and the competitor. The report may be biased by containing a certain degree of accounting distortion. When both firms simultaneously decide their output quantities, firm i maximizes its profit conditional on (i) the realized value of its own true cost C_i, (ii) its own cost report $\widehat{C}_i$, and (iii) its competitor's cost report $\widehat{C}_j$. That is, the expected operating profit for firm i is

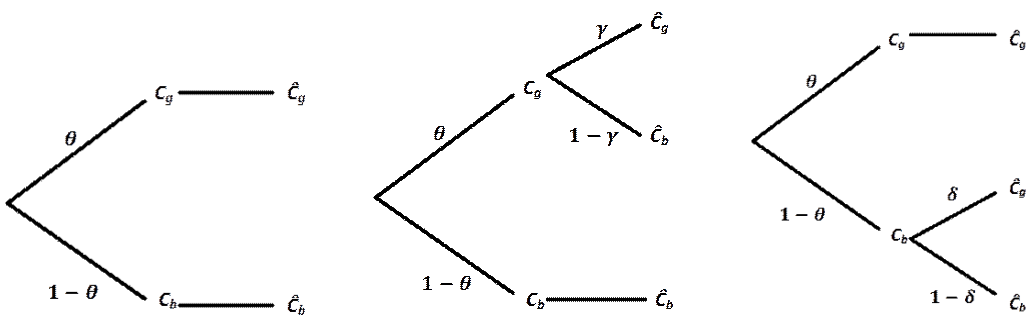
$$\Pi_i = \Pi_i\left(C_i, \widehat{C}_i, \widehat{C}_j\right) = E\left[(Q_i(a - Q_i - Q_j - C_i)|C_i, \widehat{C}_i, \widehat{C}_j\right]. \tag{1}$$

The creditor(s) and the firms use the cost signals for their debt covenants. If a firm's cost report is favorable, that is, $\widehat{C}_i = \widehat{c}_g$, the firm's manager retains the decision rights of the firm. If instead the reported cost is unfavorable, the creditor takes over control rights and can liquidate the firm if needed.

The reported cost is subject to the external accounting system. As is standard, we model the firm's accounting system through two variables δ and γ that represent the firms' reporting requirements, with $\delta \in [0, 1]$ and $\gamma \in [0, 1]$. Nature takes the first move, and decides whether firm i's true cost is c_g or c_b. A report is then produced by an exogenously

[11] We discuss the implication when this assumption is relaxed in Appendix A.

determined accounting system. There are three different accounting systems: unbiased, conservative and aggressive. First, the unbiased accounting system that we consider generates a truthful cost report with probability one. Second, a conservative accounting system is defined as generating an upwardly-biased cost report. Specifically, it generates an unfavorable cost report with probability one when the true cost is unfavorable; but generates a favorable cost report with probability γ (and an unfavorable cost report with probability $1-\gamma$) when the true cost is favorable. Third, an aggressive accounting system is the opposite of the conservative accounting system, generating a favorable cost report with probability one when the true cost is favorable, and a favorable cost report with probability δ (and an unfavorable cost report with probability $1-\delta$) when the true cost is unfavorable. For ease of presentation, we denote the posterior probabilities of true cost being consistent with the report as $Pr\left[c_g|\hat{c}_g\right]=\alpha$ and $Pr\left[c_b|\hat{c}_b\right]=\beta$.[12]



A. Unbiased system B. Conservative system C. aggressive system

Figure 1. Illustration of different accounting systems

Each accounting system in our model can only bias cost reports in one direction. That is, the conservative system only generates upwardly-biased cost report and the aggressive system only generates downwardly-biased cost report. The degree of bias is captured in the variables γ and δ. Specifically, the lower γ the more conservative the conservative system is, and the higher δ the more aggressive the aggressive system is.[13] The posterior probabilities

[12]Essentially, the setup is similar in spirit to that of Gigler et al. (2009) and Li (2012). While their definition of accounting bias can go both directions, we restrict the bias in our systems to be distinctively one way.

[13]Note that the case of an aggressive accounting system can be used to describe income-increasing ac-

under the three accounting systems are defined as:

Unbiased System:	$\alpha = 1$	$\beta = 1$
Conservative System:	$\alpha = 1$	$\beta = \frac{1-\theta}{(1-\theta)+\theta(1-\gamma)}$
Aggressive System:	$\alpha = \frac{\theta}{\theta+((1-\theta)\delta)}$	$\beta = 1$

The sequence of events is as follows. At time 0, each firm simultaneously borrows the needed cash from the bank(s). At time 1, nature reveals the firms' true marginal costs, which is privately observed by each firm. Each firm's accounting system generates a public cost report. These reports are observed by both the banks and the competitor. The firms' decision rights are controlled by the firm provided the reported cost is favorable, and controlled by the bank if the report is unfavorable. At time 2, the bank(s) make the decision to either continue or terminate the firm's operations upon an unfavorable cost report. When a bank chooses a Chapter 7 bankruptcy, the borrowing firm is immediately liquidated. When a bank chooses a Chapter 11 bankruptcy, the borrowing firm is reorganized and continues to run its operations under the bank's guidance. Thus at time 2, three outcomes are possible. First, if both firms survive, they face a Cournot duopoly competition. Second, if one firm's operations are terminated, the surviving firm becomes a monopolist in the product market. Third, if both firms are terminated, then there is no product market. At time 3, the firms make respective quantity decisions. At last, at time 4 payoffs are realized for all parties involved at the end. The structure of the model and its parameters are common knowledge. Figure 2 summarizes the timeline of these events.

counting rules. It may not be considered as uniformly prevalent in practice, we nevertheless examine it for the sake of completeness.

0	1	2	3	4
Firms borrow from banks.	Firms' cost revealed and cost report generated.	Banks decide to continue or terminate firms.	Firms make quantity decisions.	Payoffs realized for all.

Figure 2: Timeline of events.

In the subsequent sections, we analyze the role of the accounting system in several variations of the model described above. First, we examine the accounting effect when two firms each borrow from two independent banks. Third, we investigate when the two competing firms borrow from the *same* bank. In each of these variations, we contrast the results from an unbiased accounting system with that from a conservative system and from an aggressive accounting system. Finally, we also examine the impact of the accounting systems on firms' payoffs in a debt-free environment. That is, we consider when both firms are fully equity-financed and do not face any threat of potential termination due to bankruptcy.

III. Debt Financing

We first assume the two competing firms each must finance their production through a different creditor. At time 0, each of the two firms borrows debt with face value D from its creditor. The cash flow paid out to each firm by the creditor is I. The firms then disclose their costs generated by their reporting systems.

Absent renegotiation, it can easily be seen that the firm's initial owners will always prefer to continue the operations, since the payoff in case of termination is zero. However, the creditors will prefer to continue only when the payoff of continuing is higher than the

exogenous liquidation value, K, which represents the depreciated value of the firm's assets at time 2. Note the creditors always have incentive to continue the operations provided K is sufficiently small. Thus, we proceed assuming that K is sufficiently large to maintain a tension involving possible liquidation. When the cost report is favorable, decision rights reside with the firm's initial owners who will continue the firm's operations. When instead the cost report is unfavorable, the firm's decision rights transfer to the creditor who may - or may not - choose to liquidate. The payoffs for the banks and the borrowing firms are determined at the end of the timeline. Conditional on a favorable cost report, a firm does not violate its debt covenant, so the bank gets $\min\{D;\Pi\}$ and the initial owners get $\max\{0,\Pi-D\}$. Conditional on an unfavorable cost report, the creditors take control of the firm's operations and the initial owners get paid nothing. Upon a change in control, the creditors may take one of two actions. First, the bank gets paid the full liquidation value, K, if it decides to liquidate the firm. Alternatively, the bank gets all operating profits, Π, if instead it decides to continue the firm's operations.

A. Unbiased Accounting System

We first examine the firm payoffs under an unbiased accounting system. That is, both favorable cost and unfavorable cost are reported truthfully. In effect, the firms' true costs are public knowledge. With perfect information, we simply denote the firm's operating profit as a function of its own cost and the competitor's cost. For example, $\Pi_i\left(c_g,c_g\right)$ refers to firm i's operating profit when its own cost and its competitor's cost are both favorable. We assume the firms' liquidation value K is higher than the profit level of a firm with unfavorable cost that competes in the Cournot market. That is, $K>\Pi_d\left(c_b,c_b\right)>\Pi_d\left(c_b,c_g\right)$. (The subscript "$d$" denotes duopolistic competition.) Thus the bank will always choose to discontinue the firm's operations whenever the firm's reported cost is unfavorable.

An interesting consequence emerges when one firm issues a favorable report and the other issues an unfavorable report. The firm with an unfavorable report is liquidated, and

the remaining firm becomes a monopolist continuing to be operated by the original owners and earning a higher profit than when both firms have favorable cost. That is, $\Pi_m(c_g) > \Pi_d(c_g, c_g)$. (Here the subscript "$m$" denotes monopoly market.) A payoff table summarizing the possible payoffs for the banks and firms is shown below:

Bank 1 Bank 2 Firm 1 Firm 2	Prob. $= \theta$	Prob. $= 1 - \theta$
Prob. $= \theta$	D D $\Pi_c(c_f, c_f) - D$ $\Pi_c(c_f, c_f) - D$	D K $\Pi_m(c_f) - D$ 0
Prob. $= 1 - \theta$	K D 0 $\Pi_m(c_f) - D$	K K 0 0

Table 1. Payoffs of banks/firms under unbiased accounting system

Based on Table 1, each bank's expected payoff is

$$\theta^2 D + (1-\theta)^2 K + \theta(1-\theta)(D+K) = K - K\theta + \theta D. \tag{2}$$

From the bank's zero profit constraint, it follows that $K - K\theta + \theta D = I$, and thus $D = \frac{I-K}{\theta} + K$. Each firm's expected payoff is

$$\theta^2 (\Pi_d(c_g, c_g) - D) + \theta(1-\theta)(\Pi_m(c_g) - D), \tag{3}$$

where $\Pi_d(c_g, c_g) = \frac{(a-c_g)^2}{9}$ and $\Pi_m(c_g) = \frac{(a-c_g)^2}{4}$. Thus, each firm's expected profit is

$$\begin{aligned} E(\Pi_{unb.}) &= \theta^2\left(\frac{(a-c_g)^2}{9} - D\right) + \theta(1-\theta)\left(\frac{(a-c_g)^2}{4} - D\right) \\ &= \theta^2\frac{(a-c_g)^2}{9} + \theta(1-\theta)\frac{(a-c_g)^2}{4} - (I - K + \theta K) \end{aligned} \tag{4}$$

Bank's Decision.—The bank has three possible decision choices when receiving an unfavorable cost report: to always continue, to always liquidate, or liquidate randomly. First, if K is lower than the firm's profit level, then the bank would always choose to continue a firm with unfavorable cost. In that case, the bank's expected payoff would then be

$$\theta^2 D + (1-\theta)^2 \Pi_d(c_b, c_b) + \theta(1-\theta)(D + \Pi_d(c_b, c_g)). \tag{5}$$

Second, in the previous section, we assume the liquidation value K is strictly higher than the firm profit level when its cost is unfavorable. Thus the bank always liquidates a firm when the firm's cost report is unfavorable. Third, a complication arises when both firms' cost reports are unfavorable. If one bank chooses to let its borrowing firm continue, while the other bank liquidates the other borrowing firm, the remaining firm would turn into a monopolist and generates a profit $\Pi_m(c_b)$ that could be higher than K. When $\Pi_m(c_b) > K$, the banks could use a random strategy in liquidating the borrowing firms and improve the payoffs for all players.

Proposition 1. *Under an unbiased accounting system, when both firms report unfavorable cost, and when $\Pi_m(c_b) > K$, the banks may let their borrowing firms continue operating with probability $\frac{\Pi_m(c_b)-K}{\Pi_m(c_b)-\Pi_d(c_b,c_b)}$ to improve the total payoffs of the banks and borrowers.*

Proof. See Appendix.

Proposition 1 demonstrates the flexibility a competitive product market provides to the creditors of the firms competing in the market. Even when both firms are in financial

distress (i.e., both cost reports are unfavorable), the random termination of one firm softens competition, thus give the remaining firm a chance to be profitable again. The optimal probability of liquidation is simply the usual ratio between the difference in payoffs induced by different decisions. Assuming free entry, banks earn zero profit, so any gain from the random liquidation would be captured by the initial owners of the borrowing firms in the form of reduced interest rates on the loans. The random liquidation strategy thus provides a Pareto improvement to the payoffs of all players.[14]

Note that the effect demonstrated in Lemma 2 is independent of potential accounting influence, as there is no bias under unbiased accounting system. We show in the following section this effect could be amplified when the accounting system is biased. Also note the increase in number of firms in Cournot competition does not change the qualitative nature of the result. For simplicity, we include two competing firms in our model. As the number of firms competing in the same product market increases, the competition becomes more fierce. Nevertheless, the liquidation of one firm still softens the market competition and leaves the surviving firms better off.

B. Conservative Accounting System

Now we switch to the conservative accounting system. Under conservative accounting system, the firms must report unfavorable cost when the true cost is unfavorable. But when the true cost is favorable, the firm may report favorable cost with probability γ and report favorable cost with probability $1-\gamma$. A firm's profit is a function of its own cost, its reported cost and its competitor's reported cost. We denote a firm's profit and production quantity accordingly. For example, $\Pi\left(c_g,\widehat{c}_g,\widehat{c}_g\right)$ refers to the firm profit when its cost is favorable, its report is favorable, and its competitor's report is favorable. Following the same setup as under the unbiased accounting system, we first assume banks always liquidate the firms with

[14] We do not consider the potential welfare impact to consumers created by the change in product market structure. It is not immediately clear whether the consumer surplus would increase or decrease. For example, the random liquidation strategy could potentially improve consumer welfare since it prevents a complete market shutdown.

an unfavorable cost report. Thus, firms that have favorable cost but report unfavorable cost under the conservative accounting system would also be liquidated.

Bank 1 Bank 2 Firm 1 Firm 2	Prob. $= \theta\gamma$	Prob. $= \theta(1-\gamma)$	Prob. $= (1-\theta)$
Prob. $= \theta\gamma$	D D $\Pi_d(c_g, c_g) - D$ $\Pi_d(c_g, c_g) - D$	K D 0 $\Pi_m(c_g) - D$	K D 0 $\Pi_m(c_g) - D$
Prob. $= \theta(1-\gamma)$	D K $\Pi_m(c_g) - D$ 0	K K 0 0	K K 0 0
Prob. $= (1-\theta)$	D K $\Pi_m(c_g) - D$ 0	K K 0 0	K K 0 0

Table 2. Payoffs of banks/firms under conservative accounting system.

Examining the payoff table, we can see the conservative accounting system induces inappropriate termination of firms with favorable cost. The total expected payoff to the bank is the weighted average of above values:

$$\theta\gamma D + (1 - \theta\gamma) K \tag{6}$$

This payoff is lower than the bank payoff under the unbiased accounting system of $\theta D + (1-\theta) K$. With the bank facing the same zero profit constraint, we have

$$D = \frac{I - K + \theta\gamma K}{\theta\gamma}. \tag{7}$$

Firm i's expected profit is

$$E(\Pi_{con.}) = \theta^2\gamma^2 \frac{(a-c_g)^2}{9} + \theta\gamma(1-\theta\gamma)\frac{(a-c_g)^2}{4} - (I - K + \theta\gamma K). \tag{8}$$

Interestingly, under certain circumstances, the firms' expected profits under the conservative accounting system could even be higher than that under unbiased accounting system.

Proposition 2. *When* $(\theta+\theta\gamma)\left(\frac{(a-c_g)^2}{4} - \frac{(a-c_g)^2}{9}\right) > \left(\frac{(a-c_g)^2}{4} - K\right)$, *and* $\theta \neq 0$, $\gamma \neq 1$, *the firms' expected profits are higher under the conservative accounting system than that under the unbiased accounting system.*

Proof. See Appendix.

The above proposition demonstrates that accounting conservative bias induces two effects in the expected profits of the Cournot firms. One effect is the increased likelihood of a firm becoming a monopolist (as shown in Lemma 1). The second effect is the decreased chance of survival due to the creditors' excessive liquidation. When the first effect dominates the second, the firms' expected profits actually increase when there is an imposed conservative bias. Note that the second effect reduces the firm profit by the amount $\theta(1-\gamma)(\Pi_m(c_g) - K)$. This is because when a firm is liquidated, the creditor still gets liquidation value K. Since the creditors face zero-profit constraint, any extra value it gains will be still passed back to the firms through lower interest payments.

In addition, the firm's profit under the conservative accounting system depends on some parameter values.

Corollary 3. *Under the conservative accounting system, the firms' profits decrease with the degree of accounting conservatism when* $\Pi_m(c_g) - K > 2\theta\gamma(\Pi_d(c_g,c_g) - \Pi_m(c_g))$*; and increase with the degree of accounting conservatism when* $\Pi_m(c_g) - K > 2\theta\gamma(\Pi_d(c_g,c_g) - \Pi_m(c_g))$.

Proof. See Appendix.

The intuition behind the corollary 3 comes from the debts' role in changing the competitive nature of the industry. Although a conservative accounting system imposes excessive liquidation on firms that issue an unfavorable cost report, it turns the surviving firm into a monopolist that generates higher profit than a Cournot duopolist. When the difference between the monopolist profit and duopolist profit is higher than the difference between the monopolist profit and the liquidation value, higher degree of conservatism actually increases firm profit.

Combining the findings of Proposition 3 and Corollary 4, we know that the firms' profits under the conservative accounting system could be higher than that under the unbiased accounting system when $(\Pi_m(c_g) - K) < (\theta + \theta\gamma)(\Pi_m(c_g) - \Pi_d(c_g,c_g))$. Further, the firm profits increase as the degree of conservatism increases when $\Pi_m(c_g) - K < 2\theta\gamma(\Pi_m(c_g) - \Pi_d(c_g,c_g))$.This result is quite different from the prior literature on the effect of debt on conservatism, which typically shows conservatism decreases debt efficiency. The reason for the different result in our setting is due to the fact that accounting conservatism can indirectly change the industry structure through the firms' debt contracts.

Banks' Liquidation Decision.—Now we examine the creditors' decision to liquidate versus to let continue a firm that issues an unfavorable report. As under the unbiased accounting system, the liquidation decision largely depends on the value of K. If the banks never liquidate the firms with unfavorable cost reports, the bank's expected payoff is

$$\begin{aligned} &\theta\gamma D + \theta^2\gamma(1-\gamma)\Pi_d(c_g,\widehat{c}_b,\widehat{c}_g) + \theta(1-\gamma)(1-\theta\gamma)\Pi_d(c_g,\widehat{c}_b,\widehat{c}_b) \\ &+\theta\gamma(1-\theta)\Pi_d(c_b,\widehat{c}_b,\widehat{c}_g) + (1-\theta)(1-\theta\gamma)\Pi_d(c_b,\widehat{c}_b,\widehat{c}_b). \end{aligned} \tag{9}$$

Hence, the necessary condition for the bank to choose to *always* continue a firm with an unfavorable cost report is for the bank's payoff to be higher if this firm is continued. That is,

$$\begin{aligned} & \theta^2\gamma(1-\gamma)\Pi_d\left(c_g,\widehat{c}_b,\widehat{c}_g\right)+\theta(1-\gamma)\left(1-\theta\gamma\right)\Pi_d\left(c_g,\widehat{c}_b,\widehat{c}_b\right) \\ (10) \qquad & +\theta\gamma\left(1-\theta\right)\Pi_d\left(c_b,\widehat{c}_b,\widehat{c}_g\right)+\left(1-\theta\right)\left(1-\theta\gamma\right)\Pi_d\left(c_b,\widehat{c}_b,\widehat{c}_b\right) \\ > \quad & \left(1-\theta\gamma\right)K \end{aligned}$$

Obviously, the smaller the liquidation value K is, the more likely it is the above inequality will hold. Conversely, when the bank knows the cost report issued by the firm it lends to is unfavorable, and the cost report the rival firm sends out is favorable, the bank should always liquidate the firm if $(1-\beta)\,\Pi_d\left(c_g,\widehat{c}_b,\widehat{c}_g\right)+\beta\Pi_d\left(c_b,\widehat{c}_b,\widehat{c}_g\right)<K$.

Similar to Lemma 2, the bank could use a random strategy in the liquidation decision *if* $\Pi_m\left(c_b\right)>K$, when the cost reports sent out by both firms are unfavorable.

Proposition 4. *Under the conservative accounting system,when both firms report unfavorable cost, and when* $\Pi_m\left(c_b\right)>K$*, the banks let their borrowing firms continue operating with probability* $\frac{\beta\Pi_m(c_b)+(1-\beta)\Pi_m(c_g)-K}{\beta\Pi_m(c_b)+(1-\beta)\Pi_m(c_g)-\beta\Pi_d\left(c_b,\widehat{c}_b,\widehat{c}_b\right)+(1-\beta)\Pi_d\left(c_g,\widehat{c}_b,\widehat{c}_b\right)}$ *to improve the total payoffs of banks and borrowers.*

Proof. See Appendix.

The intuition of Proposition 4 is similar to that of Proposition 1, except that the conservative bias in the accounting system effectively increases the decision space for the banks. The banks hence have more flexibility in their liquidation decisions to improve the players' payoffs.

C. Aggressive accounting system

Now we analyze when there is an aggressive accounting distortion in the firms' reports. Recall that with an aggressive accounting system, the firms must report favorable cost when

the true cost is favorable; But when the true cost is unfavorable, the firm may report unfavorable cost with probability δ and report favorable cost with probability $1-\delta$. Again we first examine the payoff table of the banks and firms.

Bank 1 Bank 2 Firm 1 Firm 2	Prob. $=\theta$	Prob. $=$ $(1-\theta)\,\delta$	Prob. $=$ $(1-\theta)\,(1-\delta)$
Prob. $=\theta$	D D $\Pi_d\,(c_g,\widehat{c}_g,c_g)-D$ $\Pi_d\,(c_g,\widehat{c}_g,c_g)-D$	$\Pi_d(c_b,\widehat{c}_g,c_g)$ D 0 $\Pi_d\,(c_g,\widehat{c}_g,c_b)-D$	K D 0 $\Pi_m\,(c_g)-D$
Prob. $=$ $(1-\theta)\,\delta$	D $\Pi_d(c_b,\widehat{c}_g,c_g)$ $\Pi_d\,(c_g,\widehat{c}_g,c_b)-D$ 0	$\Pi_d\,(c_b,\widehat{c}_g,c_b)$ $\Pi_d\,(c_b,\widehat{c}_g,c_b)$ 0 0	K D 0 $\Pi_m\,(c_b)-D$
Prob. $=$ $(1-\theta)\,(1-\delta)$	D K $\Pi_m\,(c_g)-D$ 0	D K $\Pi_m\,(c_b)-D$ 0	K K 0 0

Table 3. Payoffs of banks and firms under aggressive accounting system

Examining the payoff table, it is clear the problem under aggressive accounting system is the inappropriate continuation of firms with unfavorable costs. The total expected payoff

to the bank is:

$$\begin{aligned}
&\left(\theta+(1-\theta)^2\delta(1-\delta)\right)D+\theta(1-\theta)\delta\Pi_d(c_b,\widehat{c}_g,c_g)\\
(11)\qquad &+(1-\theta)^2\delta^2\Pi_d(c_b,\widehat{c}_g,c_b)+(1-\theta)(1-\delta)K
\end{aligned}$$

Again, the banks' payoffs are smaller compared to the banks' payoffs under the unbiased accounting system of $\theta D+(1-\theta)K$, since $\Pi_d(c_b,\widehat{c}_g,c_g)<K$ and $\Pi_d(c_b,\widehat{c}_g,c_b)<K$. With the bank facing the same zero profit constraint, we set the bank's payoff equal to I and have

$$(12)\qquad D=\frac{\left(I-\theta(1-\theta)\delta\Pi_d(c_b,\widehat{c}_g,c_g)-(1-\theta)^2\delta^2\Pi_d(c_b,\widehat{c}_g,c_b)-(1-\theta)(1-\delta)K\right)}{\left(\theta+(1-\theta)^2\delta(1-\delta)\right)},$$

then we have firm i's expected profit

$$\begin{aligned}
E(\Pi_{agg.}) &= \theta^2\frac{\left(2(a-c_g)+(1-\frac{\theta}{\theta+((1-\theta)\delta)})(c_b-c_g)\right)^2}{36}\\
(13)\qquad &+\theta(1-\theta)\delta\frac{\left(2(a-c_g)+\left(1+\frac{\theta}{\theta+((1-\theta)\delta)}\right)(c_b-c_g)\right)^2}{36}\\
&+\theta(1-\theta)(1-\delta)\frac{(a-c_g)^2}{4}+(1-\theta)\delta(1-\delta)\frac{(a-c_b)^2}{4}\\
&-\begin{pmatrix} I-\theta(1-\theta)\delta\frac{\left(2(a-c_b)-\frac{\theta}{\theta+((1-\theta)\delta)}(c_b-c_g)\right)^2}{36}\\ -(1-\theta)^2\delta^2\frac{\left(2(a-c_b)+\frac{\theta}{\theta+((1-\theta)\delta)}(c_b-c_g)\right)^2}{36}-(1-\theta)(1-\delta)K\end{pmatrix}
\end{aligned}$$

Compared to the firm's payoff under the unbiased accounting system, the firm's payoff is almost always lower, except that $\Pi_d(c_g,\widehat{c}_g,c_g)>\Pi_d(c_g,c_g)$ with probability θ^2.[15]

Proposition 5. *When* $\theta^2(\Pi_d(c_g,\widehat{c}_g,c_g)-\Pi_d(c_g,c_g))>(\theta(1-\theta)\Pi_m(c_g)-(I-K+\theta K))-\begin{pmatrix}\theta(1-\theta)\delta\Pi_d(c_g,\widehat{c}_g,c_b)+\theta(1-\theta)(1-\delta)\Pi_m(c_g)+(1-\theta)\delta(1-\delta)\Pi_m(c_b)\\ -\left(I-\theta(1-\theta)\delta\Pi_d(c_b,\widehat{c}_g,c_g)-(1-\theta)^2\delta^2\Pi_d(c_b,\widehat{c}_g,c_b)-(1-\theta)(1-\delta)K\right)\end{pmatrix}$, *and* $\theta\neq$

[15] The profit levels of firms with good costs competing under the agressive accounting system is higher than under unbiased accounting system. The reason is that under an agressive accounting system, the firms take into consideration that the rivals' reported good cost may not be true. The competition is thus softened as both firms lower their production quantities accordingly.

0, $\delta \neq 1$, *the firms' expected profits are higher under aggressive accounting system than that under unbiased accounting system.*

Proof. The result is immediately clear from examining the expected firm profit levels under unbiased and aggressive accounting systems.

The above proposition shows that the chance for an aggressive accounting system to induce higher profit for the firms is very low. Observing the payoff table under aggressive accounting system, it is clear that all but one cell (upper left) contain bank payoff levels lower than under the unbiased system. For the condition specified in Proposition 5 to be true, the higher payoff in that single one cell must be high enough to compensate for the lower payoffs in all other eight cells. Compared to the results of Proposition 2, the possibility of an aggressive accounting system generating a higher payoff for the borrowing firms is much lower than that of a conservative accounting system.

Banks' decision.—Without renegotiation, the banks have no way to prevent the problem of inappropriate continuation of firms with unfavorable costs. The managers of the borrowing firms, on the other hand, have no incentive to terminate the firms by themselves. Thus there is no possible correction to the error induced by the aggressive accounting system.

IV. One Bank and Two Firms

Now we introduce another scenario where the competing firms borrow from the same creditor. The change from two creditors to one common creditor is non-trivial. The firms' cost realizations are independent of each other, and the common creditor in our model still cannot infer one firm's cost from the other. However, now the single creditor is able to manipulate the competitive nature of the market by strategic liquidation. The payoffs with one creditor are mostly the same as when there are two banks lending to two firms, but the bank maximizes its payoff from the whole industry rather than from each individual firm. Therefore, when both firms report unfavorable cost signals, the bank may be better off

letting one firm survive. Especially, when the profit of a monopolist with unfavorable cost $\Pi_m(c_b) > K$, the strategic liquidation provides a Pareto improvement on all players' payoffs.

A. Unbiased accounting system

We again first examine the payoffs under the unbiased accounting system. The payoff to the bank is essentially the sum of the two banks in the previous analyses. Examining the lower right cell of Table 1, in which both firms report unfavorable cost signals, the best the two banks can do is to use random strategy to liquidate the firms (as described in Lemma 1). However, when there is one bank lending to both firms, it is able to deterministically let one firm liquidate and the other continue as a monopolist. Its payoff is thus:

$$\theta^2 2D + (1-\theta)^2 (K + \Pi_m(c_b)) + 2\theta(1-\theta)(D+K). \tag{14}$$

Since the above must equal the total initial cash investment $2I$, we know

$$D = \frac{2I - (1-\theta)^2 \Pi_m(c_b) - (1-\theta)(1+\theta)K}{2\theta}, \tag{15}$$

which is strictly lower than $\frac{I-(1-\theta)K}{\theta}$ if the bank does not perform such random liquidation. Since the bank faces zero-profit constraint, all the extra profit is transferred to the firms through lower interest rate. Firm i's payoff is

$$\begin{aligned} &\theta^2 (\Pi_d(c_g, c_g) - D) + \theta(1-\theta)(\Pi_m(c_g) - D) \\ = \; &\theta^2 \Pi_d(c_g, c_g) + \theta(1-\theta)\Pi_m(c_g) - \frac{2I - (1-\theta)^2 \Pi_m(c_b) - (1-\theta)(1+\theta)K}{2}, \end{aligned} \tag{16}$$

which is strictly higher than $\theta^2 \Pi_d(c_g, c_g) + \theta(1-\theta)\Pi_m(c_g) - (I - K + K\theta)$, the payoff should such random liquidation not occur.

B. Conservative accounting system

Compared to the unbiased accounting system, the probability of both firms reporting an unfavorable cost is higher under the conservative accounting system. In fact, the four lower right cells in Table 2 all contain double liquidations. With one bank lending to both firms, one liquidation and one monopolist survivor would replace these cells instead. The bank's expected payoff would then be:

$$2\theta\gamma D + 2\theta\gamma\left(1-\theta\gamma\right)K + \theta\left(1-\gamma\right)\left(1-\theta\gamma\right)\Pi_m\left(c_g\right) + \left(1-\theta\right)\left(1-\theta\gamma\right)\Pi_m\left(c_b\right) \tag{17}$$

This payoff is greater than the bank payoff under strategic random liquidation. Again we compute the face value of the debt:

$$D = \frac{2I - 2\theta\gamma\left(1-\theta\gamma\right)K - \theta\left(1-\gamma\right)\left(1-\theta\gamma\right)\Pi_m\left(c_g\right) - \left(1-\theta\right)\left(1-\theta\gamma\right)\Pi_m\left(c_b\right)}{2\theta\gamma}, \tag{18}$$

which is smaller than if the bank does not perform the random liquidation.

The firm i's expected profit is thus

$$\begin{aligned} &\theta^2\gamma^2\Pi_d\left(c_g,c_g\right) + \theta\gamma\left(1-\theta\gamma\right)\Pi_m\left(c_g\right) - \\ &\frac{2I - 2\theta\gamma\left(1-\theta\gamma\right)K - \theta\left(1-\gamma\right)\left(1-\theta\gamma\right)\Pi_m\left(c_g\right) - \left(1-\theta\right)\left(1-\theta\gamma\right)\Pi_m\left(c_b\right)}{2} \end{aligned} \tag{19}$$

C. Aggressive Accounting System

As shown in Table 3, the aggressive accounting system also has one cell where both firms are liquidated. The single bank that lends to both firms could also replicate the same strategy to liquidate one firm and turn the surviving rival into a monopolist. However, the probability of both firms report unfavorable cost is much smaller than that under conservative system.

The above results are summarized in the following proposition.

Proposition 6. *Under all accounting systems, when two competing firms borrow from one*

common bank, the bank may improve the overall payoffs by turning one of the two firms that report an unfavorable cost into a surviving monopolist.

Proof. The result is immediately clear from examining the banks/firms payoffs.

V. Equity Financing

At the end, we also examine the scenario where the two competing firms are fully equity-financed. Since there is no debt, the banks' liquidation threat is muted at time 2. The absence of liquidation threat implies no change in the market structure regardless the firms' profit levels resulted from the competition, assuming there is no new entry. As shown in the analyses below, the results when firms are equity-financed are significantly different from when they are debt-financed.

A. Unbiased Accounting System

Suppose initially that accounting system report the firms' true costs without bias. There are four possible profit levels for firm i:

1. With probability θ^2, both firms have favorable cost realizations, and the firm profit from Cournot competition is $\Pi_i\left(c_g, c_g\right) = \frac{(a-c_g)^2}{9}$.

2. With probability $(1-\theta)^2$, both firms have unfavorable cost realizations, and the firm profit from Cournot competition is $\Pi_i\left(c_b, c_b\right) = \frac{(a-c_b)^2}{9}$.

3. With probability $\theta(1-\theta)$, firm i's own cost is favorable and the competitor's cost is unfavorable, and firm profit is $\Pi_i\left(c_g, c_b\right) = \frac{((a-c_g)+(c_b-c_g))^2}{9}$.

4. With probability $\theta(1-\theta)$, firm i's own cost is unfavorable and the competitor's cost is favorable, and firm profit is $\Pi_i\left(c_b, c_g\right) = \frac{((a-c_b)-(c_b-c_g))^2}{9}$.

The ex ante expected profit $\Pi_{unb.}$ for firm i is simply the weighted average of the above values.[16]

B. Conservative Accounting System

Now we examine the case when the two competing firms are subject to an accounting system with conservative bias. There are six possible levels of firm profit:

1. With probability $\theta^2\gamma^2$, firm i has favorable cost, reports favorable cost and its competitor also reports favorable cost. The firm's profit is $\Pi\left(c_g,\widehat{c}_g,\widehat{c}_g\right) = \frac{(a-c_g)^2}{9}$. This profit is the same as under the unbiased accounting system when both firms have favorable costs. This is because a favorable cost report from a conservative accounting system is fully revealing. Thus when both firms send out favorable cost signals, they both know their competitors' costs are truly favorable.

2. With probability $\theta^2\gamma(1-\gamma)$, firm i has favorable cost, reports unfavorable cost and its competitor reports favorable cost. The firm's profit is then $\Pi\left(c_g,\widehat{c}_b,\widehat{c}_g\right) = \frac{(2(a-c_g)-\beta(c_b-c_g))^2}{36}$, with $\beta = \frac{1-\theta}{(1-\theta)+\theta(1-\gamma)}$.

3. With probability $\theta\gamma(1-\theta)$, firm i has unfavorable cost, reports unfavorable cost and its competitor reports favorable cost. The firm's profit is then $\Pi\left(c_b,\widehat{c}_b,\widehat{c}_g\right) = \frac{(2(a-c_b)-(1+\beta)(c_b-c_g))^2}{36}$.

4. With probability $\theta\gamma\left(1-\theta\gamma\right)$, firm i has favorable cost, reports favorable cost and its competitor reports unfavorable cost. The firm's profit is then $\Pi\left(c_g,\widehat{c}_g,\widehat{c}_b\right) = \frac{(2(a-c_g)+2\beta(c_b-c_g))^2}{36}$.

5. With probability $\theta(1-\gamma)\left(1-\theta\gamma\right)$, firm i has favorable cost, reports unfavorable cost and its competitor reports unfavorable cost. The firm's profit is then $\Pi\left(c_g,\widehat{c}_b,\widehat{c}_b\right) = \frac{(2(a-c_g)+\beta(c_b-c_g))^2}{36}$.

[16] Note the total expected production quantities when there is perfect information and when there is symmetric imperfect information (when firms do not even know their own cost realization) are the same, but the total expected firm profits is higher when there is perfect information.

6. With probability $(1-\theta)(1-\theta\gamma)$, firm i has unfavorable cost, reports unfavorable cost and its competitor reports unfavorable cost. The firm's profit is then $\Pi(c_b, \widehat{c}_b, \widehat{c}_b) = \frac{(2(a-c_b)-(1-\beta)(c_b-c_g))^2}{36}$.

The ex ante expected firm profit $\Pi_{con.}$is the weighted-average of the above firm profits.

C. Aggressive Accounting System

There are also 6 possible levels of firm profit:

1. With probability $\theta(\theta+\delta-\theta\delta)$, firm i has favorable cost, reports favorable cost and its competitor also reports favorable cost. The firm's profit is $\Pi(c_g, \widehat{c}_g, \widehat{c}_g) = \frac{(2(a-c_g)+(1-\alpha)(c_b-c_g))^2}{36}$, with $\alpha = \frac{\theta}{\theta+((1-\theta)\delta)}$.

2. With probability $\theta(1-\theta)(1-\delta)$, firm i has favorable cost, reports favorable cost and its competitor reports unfavorable cost. The firm's profit is then $\Pi(c_g, \widehat{c}_g, \widehat{c}_b) = \frac{(2(a-c_g)+(1+\alpha)(c_b-c_g))^2}{36}$.

3. With probability $\delta(1-\theta)(\theta+\delta-\theta\delta)$, firm i has unfavorable cost, reports favorable cost and its competitor reports favorable cost. The firm's profit is then $\Pi(c_b, \widehat{c}_g, \widehat{c}_g) = \frac{(2(a-c_b)-\alpha(c_b-c_g))^2}{36}$.

4. With probability $(1-\theta)^2\delta(1-\delta)$, firm i has unfavorable cost, reports favorable cost and its competitor reports unfavorable cost. The firm's profit is then $\Pi(c_b, \widehat{c}_g, \widehat{c}_b) = \frac{(2(a-c_b)+\alpha(c_b-c_g))^2}{36}$.

5. With probability $(1-\theta)(1-\delta)(\theta+\delta-\theta\delta)$, firm i has unfavorable cost, reports unfavorable cost and its competitor reports favorable cost. The firm's profit is then $\Pi(c_b, \widehat{c}_b, \widehat{c}_g) = \frac{(2(a-c_b)-2\alpha(c_b-c_g))^2}{36}$.

6. With probability $(1-\theta)^2(1-\delta)^2$, firm i has unfavorable cost, reports unfavorable cost and its competitor reports unfavorable cost. The firm's profit is then $\Pi(c_b, \widehat{c}_b, \widehat{c}_b) =$

$\frac{(a-c_b)^2}{9}$.This profit is the same as that under the unbiased accounting system when both firms have unfavorable costs. This is because an unfavorable report is fully informative under aggressive accounting system. Thus when both firms send out unfavorable cost reports, they both know their competitors' costs are truly unfavorable.

Again, the ex ante expected firm profit $\Pi_{agg.}$ is simply the weighted average of the ex post profit values outlined above.

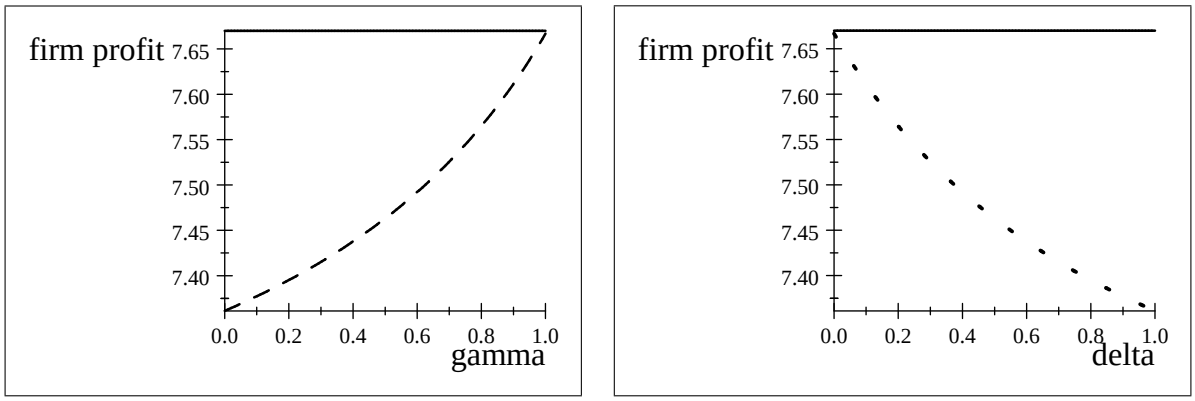
By examining the firms' payoffs, it is obvious that the firms would always prefer to report "favorable" low cost even when its true cost is "unfavorable". Thus under aggressive accounting system, the competing firms prefer to report aggressively.

Proposition 7. *When firms compete in Cournot fashion in a debt-free world, their profits under conservative/aggressive accounting systems are strictly lower than under unbiased accounting system, and their profits decreases with the level of conservatism/aggressiveness.*

Proof. See appendix.

Proposition 7 demonstrates that accounting bias decreases the amount of firm profit in a Cournot setting. The firms thus prefer a less biased accounting regime. The reason for the decreased profit is the efficiency loss caused by accounting distortion. Note there are two scenarios when the firm profit is higher under conservative accounting system than that under an unbiased accounting system: $\Pi\left(c_{g,}\widehat{c}_{g,}\widehat{c}_{b}\right)$ and $\Pi\left(c_{g,}\widehat{c}_{b,}\widehat{c}_{b}\right)$. However, the profits from the other four scenarios are all lower than that under unbiased accounting system. The losses thus outweigh the gains.

The following two figures visually demonstrate the efficiency loss due to accounting distortion.



A: Conservative bias B: Aggressive bias

— unbiased system; - - - conservative system; $\cdots$ aggressive system

Numerical values: θ=0.5, a=10, c_g=1, c_b=3.

Figure 3: Firm profit level as a function of accounting bias.

VI. Conclusion

We show that accounting bias decreases expected firm profits when debt-free firms compete in a Cournot product market. However, different results emerge when the firms' capital structure includes debt. Specifically, when debt covenants rely on interim accounting reports, accounting biases affect the likelihood of debt covenant violation and the banks' subsequent liquidation decision. When one of two firms is terminated, the other firm becomes a monopolist. The surviving firm is then able to capture the entire market, making a higher profit relative to when it faces competition from a rival firm. We then demonstrate that the firms' expected profits under conservative accounting can be higher than under unbiased accounting. In addition, conservative accounting provides creditors with more control by triggering debt covenant violation more frequently. The creditors can reduce "false positives" by not always terminating firms with unfavorable reports. Further, the creditors can choose to randomly allow one firm to survive when both firms' accounting reports are unfavorable. The remaining monopolist then generates sufficient profits to pay back its debt in full.

With the standard assumption of zero-profit constraints for the bank, the firms capture the additional gains from conservative accounting through decreased interest rates.

In summary, our study shows how accounting can have a real effect on firms' operating decisions through the presence of debt. Accounting bias is perceived to be merely a distortion of information, and devoid of any real impact on economic behavior. In our setting, however, accounting bias - such as accounting conservatism - can change the competitive nature of product markets, in which borrowing firms compete.

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Appendix

A Analysis on the Appropriateness of Cournot Competition with Perfect Substitutes

The two firms i and j produce two differentiated products. The prices and quantities of these two products are denoted as P_i, P_j, Q_i and Q_j. Following Vives (1984), the representative consumer's utility from the two favorables is $U(Q_i, Q_j) = a(Q_i + Q_j) - \frac{1}{2}\left(Q_i^2 + 2tQ_iQ_j + Q_j^2\right)$. The consumer's problem is thus

$$\text{(A1)} \qquad \max_{Q_i;Q_j} a(Q_i + Q_j) - \frac{1}{2}\left(Q_i^2 + 2tQ_iQ_j + Q_j^2\right) - P_iQ_i - P_jQ_j,$$

with $a > 0$, $|t| \leq 1$. Further, the two favorables are substitutes if $t > 0$ and complements if $t < 0$. When $t = 1$ or -1, the two favorables are *perfect* substitutes or complements. If $t = 0$, the two favorables are completely independent of each other, making the two firms monopolies in their own separate product markets. Solving the representative consumer's problem by taking the FOCs w.r.t Q_i and Q_j, we derive the inverse demand functions for the two products:

$$\text{(A2)} \qquad P_i = a - Q_i - tQ_j,$$

and

$$\text{(A3)} \qquad P_j = a - Q_j - tQ_i.$$

Suppose firm i's marginal cost is C_i and $C_i = C_j = c$. The firm i's profit function is $\Pi_i = Q_i(a - Q_i - tQ_j - c)$. Solving for the above Cournot game, we get the two firms'

production quantity decisions

$$Q_i = Q_j = \frac{a-c}{2+t}.$$

Substituting into the firms' profit functions, we have the firms' profits

$$\Pi_i = \Pi_j = \frac{(a-c)^2}{(t+2)^2}.$$

Substituting different values of t, we see $\Pi = \frac{(a-c)^2}{9}$ when $t = 1$; $\Pi = \frac{(a-c)^2}{4}$ when $t = 0$; and $\Pi = (a-c)^2$ when $t = -1$. Note that the two firms' profits when the two products are perfect complements ($t = -1$) are higher than when they are monopolies ($t = 0$). This is because the firm i's reaction function to firm j, $Q_i = \frac{a-c-tQ_j}{2}$, is upward sloping when $t < 0$. Firm i always produces more when firm j produces more. Thus, there is no real "competition" when the two products are perfect complements[17]. A firm is better off when another firm tproduces a complementary product to its own. In fact, we know the two firms' profits strictly decrease in the value of t, that is, $\frac{\partial}{\partial t}\frac{(a-c)^2}{(t+2)^2} = -2\frac{(a-c)^2}{(t+2)^3} < 0$.

From the inverse demand functions A2 and A3, we can also further solve for

$$Q_i = \frac{1}{1-t^2}\left(a\left(1-t\right) - P_i + tP_j\right) \tag{A4}$$

and

$$Q_j = \frac{1}{1-t^2}\left(a\left(1-t\right) - P_j + tP_i\right) \tag{A5}$$

for firm i and j respectively. Equations A4 and A5 represent demand functions used for Bertrand competition. Observing equations A2 and A4, we see the price of product i is inversely related to both its own and j's quantity, and the quantity of product i is inversely related to its own price and positively related to j's price. The same applies to the price and quantity of product j. As functions A2-A5 are derived from the same maximization problem

[17] An example of goods that are perfect complements is left shoes and right shoes.

of the representative consumer, we know the Cournot game using equations A2 and A3 is the "perfect dual" of the Bertrand game using equations A4 and A5 (Vives, 1984)[18].

Solving for the Bertrand game, we have

$$P_i = P_j = \frac{(a + c - at)}{2 - t},$$

and

$$\Pi_i = \Pi_j = \frac{(1 - t)(a - c)^2}{(t + 1)(t - 2)^2}.$$

Again, we can easily show that the firm profits decreases with t, since $\frac{\partial}{\partial t}\frac{(1-t)(a-c)^2}{(t+1)(t-2)^2} = \frac{\left(t^2-t+1\right)(a-c)^2}{(t+1)^2(t-2)^3} < 0$. The result is qualitatively consistent with that of the Cournot game.

The above analyses demonstrate the duality of Cournot and Bertrand games, conditioned on whether the two products are substitutes or complements. In the following sections of the paper, we limit our analyses to the case when being a monopolist has comparative benefits than being a duopolist. We shall focus on Cournot competition with favorables that are perfect substitutes ($t = 1$), and the case when the two favorables are complements thus does not apply.

B Computation of the firms' operating profits in Cournot setting

To compute the expected firm profit, we must compute the firm profits for each of the six scenarios under both conservative and aggressive systems.

A. With Conservative Bias

Scenario 1: When both firms report favorable signals.—When firm i has favorable cost, reports favorable cost and its competitor firm j also reports favorable cost, we

[18] Vives (1984) shows the strategic properties of Cournot competition with substitute (complement) products are very similar with Bertrand competition with complement (substitute) products.

know both firms must be reporting truthfully, since $\alpha = 1$. That is, both firms must have the same true cost and same reported cost. Thus the problem reduces to a standard Cournot game. Firm i' objective function is:

$$q_i\left(c_g,\widehat{c}_g,\widehat{c}_g\right)\left(a - q_i\left(c_g,\widehat{c}_g,\widehat{c}_g\right) - q_j\left(c_g,\widehat{c}_g,\widehat{c}_g\right) - c_g\right). \tag{B1}$$

Firm j' objective function is:

$$q_j\left(c_g,\widehat{c}_g,\widehat{c}_g\right)\left(a - q_j\left(c_g,\widehat{c}_g,\widehat{c}_g\right) - q_i\left(c_g,\widehat{c}_g,\widehat{c}_g\right) - c_g\right). \tag{B2}$$

Both firms maximize their profit functions over q. Setting the two FOCs equal to zero and solve for q_i and q_j , we have:

$$q_i\left(c_g,\widehat{c}_g,\widehat{c}_g\right) = q_j\left(c_g,\widehat{c}_g,\widehat{c}_g\right) = \frac{a - c_g}{3}. \tag{B3}$$

Substitute into the profit function, we have:

$$\Pi_d\left(c_g,\widehat{c}_g,\widehat{c}_g\right) = \frac{(a - c_g)^2}{9}. \tag{B4}$$

Scenarios 2, 3 and 4: When one firm issues a favorable report and the other firm issues an unfavorable report.—Suppose firm i issues a favorable report and firm j issues an unfavorable report. Firm i must have true favorable cost. Firm j could have either true unfavorable cost or have favorable cost but accounting conservatism results in an unfavorable report. The three FOCs are:

$$q_j\left(c_g,\widehat{c}_b,\widehat{c}_g\right) = \frac{a - c_g - q_i\left(c_g,\widehat{c}_g,\widehat{c}_b\right)}{2} \tag{B5}$$

$$q_j\left(c_b,\widehat{c}_b,\widehat{c}_g\right) = \frac{a - c_b - q_i\left(c_g,\widehat{c}_g,\widehat{c}_b\right)}{2} \tag{B6}$$

(B7) $$q_i\left(c_g,\widehat{c}_g,\widehat{c}_b\right)=\frac{a-c_g-\left(\beta q_j\left(c_b,\widehat{c}_b,\widehat{c}_g\right)+\left(1-\beta\right)q_j\left(c_g,\widehat{c}_b,\widehat{c}_g\right)\right)}{2}$$

Solving for the three unknowns and applying symmetry, we have:

(B8) $$q\left(c_g,\widehat{c}_g,\widehat{c}_b\right)=\frac{2\left(a-c_g\right)+2\beta\left(c_b-c_g\right)}{6}$$

(B9) $$q\left(c_g,\widehat{c}_b,\widehat{c}_g\right)=\frac{2(a-c_g)-\beta(c_b-c_g)}{6}$$

(B10) $$q\left(c_b,\widehat{c}_b,\widehat{c}_g\right)=\frac{2\left(a-c_b\right)-\left(1+\beta\right)\left(c_b-c_g\right)}{6}$$

The corresponding firm profits are:

(B11) $$\Pi\left(c_g,\widehat{c}_g,\widehat{c}_b\right)=\frac{\left(2\left(a-c_g\right)+2\beta\left(c_b-c_g\right)\right)^2}{36}$$

(B12) $$\Pi\left(c_g,\widehat{c}_b,\widehat{c}_g\right)=\frac{\left(2(a-c_g)-\beta(c_b-c_g)\right)^2}{36}$$

(B13) $$\Pi\left(c_b,\widehat{c}_b,\widehat{c}_g\right)=\frac{\left(2\left(a-c_b\right)-\left(1+\beta\right)\left(c_b-c_g\right)\right)^2}{36}$$

Scenarios 5 and 6: When both firms report unfavorable signals.—When two unfavorable signals are reported, the competing firms have symmetric imperfect information. Each firm must take into consideration that the competitor could have truly unfavorable cost, or have favorable cost but report unfavorable. Firm i maximizes its profit by choosing production quantity q_i so that $\frac{\partial}{\partial q_i}\left(q_i(a-q_i-E\left(q_j\right)-c_i\right)=0$, where $E(q_j)=\beta q_j\left(c_b,\widehat{c}_b,\widehat{c}_b\right)+\left(1-\beta\right)q_j\left(c_g,\widehat{c}_b,\widehat{c}_b\right)$. Firm j does the same. Applying symmetry, we have the following four

equations:

$$q_i\left(c_b,\widehat{c}_b,\widehat{c}_b\right)=\frac{1}{2}\left(a-c_b-\beta q_j\left(c_b,\widehat{c}_b,\widehat{c}_b\right)-(1-\beta)\,q_j\left(c_g,\widehat{c}_b,\widehat{c}_b\right)\right) \tag{B14}$$

$$q_i\left(c_g,\widehat{c}_b,\widehat{c}_b\right)=\frac{1}{2}\left(a-c_g-\beta q_j\left(c_b,\widehat{c}_b,\widehat{c}_b\right)-(1-\beta)\,q_j\left(c_g,\widehat{c}_b,\widehat{c}_b\right)\right) \tag{B15}$$

$$q_j\left(c_b,\widehat{c}_b,\widehat{c}_b\right)=\frac{1}{2}\left(a-c_b-\beta q_i\left(c_b,\widehat{c}_b,\widehat{c}_b\right)-(1-\beta)\,q_i\left(c_g,\widehat{c}_b,\widehat{c}_b\right)\right) \tag{B16}$$

$$q_j\left(c_g,\widehat{c}_b,\widehat{c}_b\right)=\frac{1}{2}\left(a-c_g-\beta q_i\left(c_b,\widehat{c}_b,\widehat{c}_b\right)-(1-\beta)\,q_i\left(c_g,\widehat{c}_b,\widehat{c}_b\right)\right) \tag{B17}$$

Solving the four equations and applying symmetry, we have:

$$q\left(c_g,\widehat{c}_b,\widehat{c}_b\right)=\frac{2\left(a-c_g\right)+\beta(c_b-c_g)}{6} \tag{B18}$$

$$q\left(c_b,\widehat{c}_b,\widehat{c}_b\right)=\frac{2\left(a-c_b\right)-(1-\beta)\left(c_b-c_g\right)}{6} \tag{B19}$$

Firm i's profit is:

$$\Pi\left(c_g,\widehat{c}_b,\widehat{c}_b\right)=\frac{\left(2(a-c_g)+\beta\left(c_b-c_g\right)\right)^2}{36} \tag{B20}$$

$$\Pi\left(c_b,\widehat{c}_b,\widehat{c}_b\right)=\frac{\left(2(a-c_b)-(1-\beta)\left(c_b-c_g\right)\right)^2}{36} \tag{B21}$$

B. With Aggressive Bias

Scenarios 1 and 2: when both firms report favorable signals.—When two favorable signals are reported, the firms could have truly favorable cost, or have unfavorable cost but report favorable. Thus, firm i's objective function is $q_i(a - q_i - E\left(q_j\right) - c_i$, where $E(q_j) = \alpha q_j\left(c_g,\widehat{c}_g,\widehat{c}_g\right) + (1-\alpha)\, q_j\left(c_b,\widehat{c}_g,\widehat{c}_g\right)$. Firm j does the same. Applying symmetry, we have 4 equations:

$$q_i\left(c_g,\widehat{c}_g,\widehat{c}_g\right) = \frac{1}{2}\left(a - c_g - \alpha q_j\left(c_g,\widehat{c}_g,\widehat{c}_g\right) - (1-\alpha)\, q_j\left(c_b,\widehat{c}_g,\widehat{c}_g\right)\right) \tag{B22}$$

$$q_i\left(c_b,\widehat{c}_g,\widehat{c}_g\right) = \frac{1}{2}\left(a - c_b - \alpha q_j\left(c_g,\widehat{c}_g,\widehat{c}_g\right) - (1-\alpha)\, q_j\left(c_b,\widehat{c}_g,\widehat{c}_g\right)\right) \tag{B23}$$

$$q_j\left(c_g,\widehat{c}_g,\widehat{c}_g\right) = \frac{1}{2}\left(a - c_g - \alpha q_i\left(c_g,\widehat{c}_g,\widehat{c}_g\right) - (1-\alpha)\, q_i\left(c_b,\widehat{c}_g,\widehat{c}_g\right)\right) \tag{B24}$$

$$q_j\left(c_b,\widehat{c}_g,\widehat{c}_g\right) = \frac{1}{2}\left(a - c_b - \alpha q_i\left(c_g,\widehat{c}_g,\widehat{c}_g\right) - (1-\alpha)\, q_i\left(c_b,\widehat{c}_g,\widehat{c}_g\right)\right) \tag{B25}$$

Solving the four equations and applying symmetry, we have:

$$q\left(c_g,\widehat{c}_g,\widehat{c}_g\right) = \frac{2\left(a - c_g\right) + (1-\alpha)\left(c_b - c_g\right)}{6} \tag{B26}$$

$$q\left(c_b,\widehat{c}_g,\widehat{c}_g\right) = \frac{2\left(a - c_b\right) - \alpha\left(c_b - c_g\right)}{6} \tag{B27}$$

Firm i's profit is:

$$\Pi\left(c_g,\widehat{c}_g,\widehat{c}_g\right)=\frac{\left(2\left(a-c_g\right)+\left(1-\alpha\right)\left(c_b-c_g\right)\right)^2}{36} \tag{B28}$$

$$\Pi\left(c_b,\widehat{c}_g,\widehat{c}_g\right)=\frac{\left(2\left(a-c_b\right)-\alpha\left(c_b-c_g\right)\right)^2}{36} \tag{B29}$$

Scenarios 3, 4 and 5: When one firm issues a favorable report and the other firm issues an unfavorable report.—Let firm i issues a favorable report and firm j issues an unfavorable report. Firm i could have true favorable cost or have unfavorable cost but the accounting report is favorable. Firm j must have true unfavorable cost. The three FOCs are:

$$q_i\left(c_g,\widehat{c}_g,\widehat{c}_b\right)=\frac{a-c_g-q_j\left(c_b,\widehat{c}_b,\widehat{c}_g\right)}{2} \tag{B30}$$

$$q_i\left(c_b,\widehat{c}_g,\widehat{c}_b\right)=\frac{a-c_b-q_j\left(c_b,\widehat{c}_b,\widehat{c}_g\right)}{2} \tag{B31}$$

$$q_j\left(c_b,\widehat{c}_b,\widehat{c}_g\right)=\frac{a-c_g-\left(\alpha q_i\left(c_g,\widehat{c}_g,\widehat{c}_b\right)+\left(1-\alpha\right)q_i\left(c_b,\widehat{c}_g,\widehat{c}_b\right)\right)}{2} \tag{B32}$$

Solving for the three unknowns and applying symmetry, we have:

$$q\left(c_g,\widehat{c}_g,\widehat{c}_b\right)=\frac{2\left(a-c_g\right)+\left(1+\alpha\right)\left(c_b-c_g\right)}{6} \tag{B33}$$

$$q\left(c_b,\widehat{c}_g,\widehat{c}_b\right)=\frac{2(a-c_b)+\alpha(c_b-c_g)}{6} \tag{B34}$$

$$q\left(c_b,\widehat{c}_b,\widehat{c}_g\right)=\frac{2\left(a-c_b\right)-2\alpha\left(c_b-c_g\right)}{6} \tag{B35}$$

And the corresponding firm profits are:

$$\Pi\left(c_g,\widehat{c}_g,\widehat{c}_b\right)=\frac{\left(2\left(a-c_g\right)+\left(1+\alpha\right)\left(c_b-c_g\right)\right)^2}{36} \tag{B36}$$

$$\Pi\left(c_b,\widehat{c}_g,\widehat{c}_b\right)=\frac{\left(2(a-c_b)+\alpha(c_b-c_g)\right)^2}{36} \tag{B37}$$

$$\Pi\left(c_b,\widehat{c}_b,\widehat{c}_g\right)=\frac{\left(2\left(a-c_b\right)-2\alpha\left(c_b-c_g\right)\right)^2}{36} \tag{B38}$$

Scenario 6: When both firms issue unfavorable reports.—Under aggressive accounting system, the firms must have truly unfavorable cost when they both issue unfavorable reports. Thus again the problem reduces to a standard Cournot game. Firm i's FOC is:

$$q_i\left(c_b,\widehat{c}_b,\widehat{c}_b\right)=q_j\left(c_b,\widehat{c}_b,\widehat{c}_b\right)=\frac{a-c_b}{3}. \tag{B39}$$

Substituting into the profit function, we have:

$$\Pi\left(c_b,\widehat{c}_b,\widehat{c}_b\right)=\frac{\left(a-c_b\right)^2}{9}. \tag{B40}$$

C Proof of Proposition 1

Suppose bank 1 let the borrowing firm continue with unfavorable cost report with probability x, and bank 2 does so with probability y. Then bank 1 should have the following program:

$$\max\ xy\Pi_d\left(c_b,c_b\right)+x\left(1-y\right)\Pi_m\left(c_b\right)+\left(1-x\right)K \tag{C1}$$

Taking the first order condition, we have:

$$\text{(C2)} \qquad \begin{aligned} & \frac{\partial}{\partial x}\left(xy\Pi_d\left(c_{b,}c_b\right)+x\left(1-y\right)\Pi_m\left(c_b\right)+\left(1-x\right)K\right) \\ = \; & \Pi_m\left(c_b\right)-K+y\Pi_d\left(c_b,c_b\right)-y\Pi_m\left(c_b\right)=0 \end{aligned}$$

Solving for y, we have:

$$\text{(C3)} \qquad y=\frac{\Pi_m\left(c_b\right)-K}{\Pi_m\left(c_b\right)-\Pi_d\left(c_b,c_b\right)}.$$

D Proof of Proposition 2

The firms' expected profits under unbiased accounting system are

$$\text{(D1)} \qquad \theta^2\Pi_d\left(c_{g,}c_g\right)+\theta(1-\theta)\Pi_m\left(c_g\right)-\left(I-K+\theta K\right).$$

The firms' expected profits under conservative accounting system are

$$\text{(D2)} \qquad \theta^2\gamma^2\Pi_d\left(c_{g,}c_g\right)+\theta\gamma\left(1-\theta\gamma\right)\Pi_m\left(c_g\right)-\left(I-K+\theta\gamma K\right).$$

Taking the difference between these two expected profits, we have

$$\text{(D3)} \qquad \begin{aligned} & \theta^2\gamma^2\Pi_d\left(c_{g,}c_g\right)+\theta\gamma\left(1-\theta\gamma\right)\Pi_m\left(c_g\right)-\left(I-K+\theta\gamma K\right) \\ & -\left(\theta^2\Pi_d\left(c_{g,}c_g\right)+\theta(1-\theta)\Pi_m\left(c_g\right)-\left(I-K+\theta K\right)\right) \\ = \; & \theta\left(1-\gamma\right)\left(\left(\theta+\theta\gamma\right)\left(\Pi_m\left(c_g\right)-\Pi_d\left(c_{g,}c_g\right)\right)-\left(\Pi_m\left(c_g\right)-K\right)\right). \end{aligned}$$

We know $\Pi_m\left(c_g\right)=\frac{(a-c_g)^2}{4}>\Pi_d\left(c_{g,}c_g\right)=\frac{(a-c_g)^2}{9}>K$. Thus the above value will be strictly positive when $\left(\theta+\theta\gamma\right)\left(\Pi_m\left(c_g\right)-\Pi_d\left(c_{g,}c_g\right)\right)>\left(\Pi_m\left(c_g\right)-K\right)$.

E Proof of Corollary 3

We examine the change of the firm's profit in γ. Taking the partial derivative, we have

$$\text{(E1)} \qquad \begin{aligned} & \frac{\partial}{\partial \gamma}\left(\theta^2\gamma^2\Pi_d\left(c_g,c_g\right)+\theta\gamma\left(1-\theta\gamma\right)\Pi_m\left(c_g\right)-\left(I-K+\theta\gamma K\right)\right) \\ = \; & \theta\left(\left(\Pi_m\left(c_g\right)-K\right)+2\theta\gamma\left(\Pi_d\left(c_g,c_g\right)-\Pi_m\left(c_g\right)\right)\right). \end{aligned}$$

Clearly the firms' profits will increase in γ if $\Pi_m\left(c_g\right)-K>2\theta\gamma\left(\Pi_m\left(c_g\right)-\Pi_d\left(c_g,c_g\right)\right)$, which means less conservatism leads to higher profit. However, if $\Pi_m\left(c_g\right)-K<2\theta\gamma\left(\Pi_m\left(c_g\right)-\Pi_d\left(c_g,c_g\right)\right)$, the firms' profits will decrease in γ, which means more conservatism leads to higher profit.

F Proof of Proposition 4

Suppose the bank let the borrowing firm continue with probability x. Then it will have the following program:

$$\text{(F1)} \qquad \begin{aligned} & \max_x \; xy\left(\beta\Pi_d\left(c_b,\widehat{c}_b,\widehat{c}_b\right)+\left(1-\beta\right)\Pi_d\left(c_g,\widehat{c}_b,\widehat{c}_b\right)\right) \\ & +x\left(1-y\right)\left(\beta\Pi_m\left(c_b\right)+\left(1-\beta\right)\Pi_m\left(c_g\right)\right)+\left(1-x\right)K \end{aligned}$$

Setting the FOC = 0 and solving for y, we obtain

$$\text{(F2)} \qquad y=\frac{\beta\Pi_m\left(c_b\right)+\left(1-\beta\right)\Pi_m\left(c_g\right)-K}{\beta\Pi_m\left(c_b\right)+\left(1-\beta\right)\Pi_m\left(c_g\right)-\beta\Pi_d\left(c_b,\widehat{c}_b,\widehat{c}_b\right)+\left(1-\beta\right)\Pi_d\left(c_g,\widehat{c}_b,\widehat{c}_b\right)}.$$

G Proof of Proposition 7

The expected payoffs of firm i in three different accounting systems are listed below.

Unbiased system:

$$
\begin{aligned}
E(\Pi_{unb.}) &= \theta^2 \frac{(a-c_g)^2}{9} + (1-\theta)^2 \frac{(a-c_b)^2}{9} \\
&\quad + \theta(1-\theta) \frac{((a-c_g)+(c_b-c_g))^2}{9} + (1-\theta)\theta \frac{((a-c_b)-(c_b-c_g))^2}{9}
\end{aligned}
$$

Conservative system:

$$
\begin{aligned}
E(\Pi_{con.}) &= \theta^2\gamma^2 \frac{(a-c_g)^2}{9} + \theta\gamma\left(\theta(1-\gamma)+(1-\theta)\right) \frac{\left(2\left(a-c_g\right)+2\frac{1-\theta}{(1-\theta)+\theta(1-\gamma)}\left(c_b-c_g\right)\right)^2}{36} \\
&\quad + \theta\gamma\theta(1-\gamma) \frac{\left(2(a-c_g)-\frac{1-\theta}{(1-\theta)+\theta(1-\gamma)}(c_b-c_g)\right)^2}{36} \\
&\quad + \theta(1-\gamma)\left(\theta(1-\gamma)+(1-\theta)\right) \frac{\left(2(a-c_g)+\frac{1-\theta}{(1-\theta)+\theta(1-\gamma)}\left(c_b-c_g\right)\right)^2}{36} \\
&\quad + \theta\gamma\left(1-\theta\right) \frac{\left(2\left(a-c_b\right)-\left(1+\frac{1-\theta}{(1-\theta)+\theta(1-\gamma)}\right)\left(c_b-c_g\right)\right)^2}{36} \\
&\quad + \left(1-\theta\right)\left(\theta(1-\gamma)+(1-\theta)\right) \frac{\left(2(a-c_b)-\left(1-\frac{1-\theta}{(1-\theta)+\theta(1-\gamma)}\right)\left(c_b-c_g\right)\right)^2}{36}
\end{aligned}
$$

Aggressive system:

$$
\begin{aligned}
E(\Pi_{agg.}) \quad = \quad & \left(\theta^2 + \theta\left(1-\theta\right)\delta\right) \frac{\left(2\left(a-c_g\right) + \left(1 - \frac{\theta}{\theta+((1-\theta)\delta)}\right)\left(c_b - c_g\right)\right)^2}{36} \\
& + \theta\left(1-\theta\right)\left(1-\delta\right) \frac{\left(2\left(a-c_g\right) + \left(1 + \frac{\theta}{\theta+((1-\theta)\delta)}\right)\left(c_b - c_g\right)\right)^2}{36} \\
& + \left(\theta(1-\theta)\delta + \left(1-\theta\right)^2\delta^2\right) \frac{\left(2\left(a-c_b\right) - \frac{\theta}{\theta+((1-\theta)\delta)}\left(c_b - c_g\right)\right)^2}{36} \\
& + \left(1-\theta\right)\delta\left(1-\theta\right)\left(1-\delta\right) \frac{\left(2(a-c_b) + \frac{\theta}{\theta+((1-\theta)\delta)}(c_b - c_g)\right)^2}{36} \\
& + \left(\theta\left(1-\theta\right)\left(1-\delta\right) + \left(1-\theta\right)\delta\left(1-\theta\right)\left(1-\delta\right)\right) \frac{\left(2\left(a-c_b\right) - 2\frac{\theta}{\theta+((1-\theta)\delta)}\left(c_b - c_g\right)\right)^2}{36} \\
& + \left(1-\theta\right)^2\left(1-\delta\right)^2 \frac{\left(a-c_b\right)^2}{9}
\end{aligned}
$$

To compute the difference in these profits, we deduct the conservative/aggressive profit from the unbiased profit.

$$
E(\Pi_{unb.}) - E(\Pi_{con.}) = \frac{11}{36}\theta\left(c_b - c_g\right)^2\left(1-\theta\right)\frac{1-\gamma}{1-\theta\gamma} > 0
$$

$$
E(\Pi_{unb.}) - E(\Pi_{agg.}) = \frac{11}{36}\theta\delta\left(c_b - c_g\right)^2\frac{1-\theta}{\theta+\delta-\theta\delta} > 0
$$

Thus we know the profit level under unbiased accounting system is always higher than that under conservative/aggressive accounting system.

To demonstrate the relationship between the firm profit and the level of conservative/aggressive bias, we take the first-order derivative of firm i's profit of γ/δ.

$$
\frac{\partial}{\partial\gamma}E(\Pi_{con.}) = \frac{11}{36}\theta\left(c_b - c_g\right)^2\frac{\left(\theta-1\right)^2}{\left(\theta\gamma-1\right)^2} > 0
$$

$$
\frac{\partial}{\partial\gamma}E(\Pi_{agg.}) = \frac{11}{36}\theta^2\left(c_b - c_g\right)^2\frac{\theta-1}{\left(\theta+\delta-\theta\delta\right)^2} < 0
$$

It is clear that the higher level of bias is, the lower the firm profit.