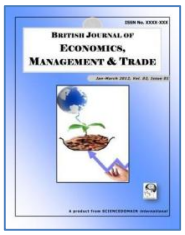

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Effects of Reputation and Economic Dependence on Auditor Strategic Interactions

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Authors' contributions

This work was carried out in collaboration between all authors. Author YCT designed the study, performed the analysis and wrote the first draft of the manuscript. Author RDC managed the literature searches, coordinated different views from the authors and wrote the responses to the reviewers' comments. Author HYL wrote the model protocol, extended the analysis of the model reasoning and helped the first draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To investigate the influence of reputation loss and economic dependence on auditor strategic interactions.
Study Design: We consider two risk neutral parties, an enterprise and an auditor, and sort the auditors as high-quality (Big 4) and low-quality (non-Big 4) to match actual situations. Then, a game model is established. We assemble the two new parameters of economic dependence and reputation loss into the model and wish to understand whether different types of auditors would adopt different stratagems if their concerns of economic dependence and reputation are different.
Methodology: A basic model for the backward induction of the Game Theory is established. We assume that an auditor is risk-neutral and that he seeks to maximize his profit. We set three

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decision points for an audit. First, we decide the input level of screening; second, we decide whether to accept the assignment; and third, we decide the level of audit effort. Four strategic interactions are derived and payoff of each strategic interaction is computed from the preliminary analysis. Finally, an equilibrium analysis between Big 4 firms and non-big 4 firms is performed.

Results: Big 4 firms would choose a strong-screening and low-audit-effort strategy to avoid high-risk clients because they risk larger reputation loss than non-Big 4 firms. However, non-Big 4 firms would choose a weak-screening and high-audit-effort strategy since economic dependence is a high priority for them.

Conclusion: Based on the results of the modeling, in the current environment, Big 4 firms face litigation risks after increased legal liabilities of audit failure, so they must bear the litigation cost and reputation loss and may even go out of business. Likewise, non-Big 4 firms not only face more litigation risks due to increased liabilities of audit failure but also are confronted by low-balling competition.

Keywords: Reputation effect; economic dependence; strategic interactions; client screening; audit effort.

1. INTRODUCTION

After the notorious Procomp scandal[1] occurred in Taiwan in 2004, the swift and heavy punishment against auditors imposed by the Financial Supervisory Commission (FSC[2] was unprecedented. An FSC statement in 2010 indicated that 68 auditors had been punished by the authority in the preceding 5 years. By making auditors' legal liabilities heavier, the FSC hoped to enhance audit quality. However, these efforts may lead auditors to re-examine the balance between reputation loss and the loss of economic dependence. Thus, the purpose of this study is to investigate auditors' strategic interactions regarding screening and audit effort and to examine the influence of auditor size on the considerations of reputation and economy.

Audit efforts can help reduce the damage of legal litigation, so legal liabilities and audit efforts have a positive relation [1,2,3]. However, [4] indicates that an inverse relation may exist when the discrepancy of the auditor's posterior beliefs about the risk of clients is sensitive to the quality of the client-risk screening. The impairment of reputation resulting from governmental disciplinary action leads to a reduction in audit fees, with the result that accounting firms face fee-related incentives to ensure the performance of audits at a level of quality consistent with their reputation [5,6]. Clients will even ask to replace auditors [7] once the auditors face litigation. A most famous example of such is the Enron fiasco, which led to the bankruptcy of Enron and forced Arthur Andersen to serve as the defendant and to suffer huge damage to its reputation and loss of clients [8,6]. This in turn has made the audit market share to reshuffle. [2] For this reason, auditors strive to maintain their reputations in order to hold on to their market share and attract new clients [9,10]. Furthermore, Big 4 firms have more clients than non-Big 4 firms, so litigation will result in more damage to the reputation of Big 4 firms. While auditors face the changes in market conditions and the legal environment, screening clients and nurturing employees are both important issues, auditors must find a balance between audit risk and 'client loss'.

This article contributes to the literature on the strategic interaction of auditors. We investigate an issue that has not been fully investigated in previous research: We probe the strategic interactions of different-sized auditors (Big 4 and non-Big 4) facing heavy litigation risk. Based on the management of litigation risk (screening) and the enhancement of audit quality (audit effort), we consider the reputation loss and economic dependence of different-sized auditors and then discuss how different-sized auditors have analyzed their strategic interactions regarding screening and audit efforts since the Procomp scandal in 2004.

The results indicate that Big 4 firms will adopt a strong-screening and low-audit-effort strategy because they must endure larger reputation losses than non-Big 4 firms and thus try to avoid high-risk clients. Because economic dependence is not a major issue for Big 4 firms, they strive to keep low-risk clients to avoid litigation risk.

[1] *The Procomp scandal is generally regarded as one of the major accounting scandals in Taiwan's history; it had a similar impact to that of the Enron fiasco in the US.*

[2] *Arthur Andersen went out of business after the Enron scandal, and the Big 5 international auditors in Taiwan were reduced to the Big 4.*

Correspondingly, non-Big 4 firms will choose a weak-screening and high-audit-effort strategy since economic dependence has high priority for them and they don't want to lose their market share.

The rest of this article is structured as follows. The next section reviews the prior literature. The third section presents the model. The fourth section analyzes the equilibrium of the model and provides the main results. The final section contains the conclusion.

2. LITERATURE REVIEW

There are many studies in the literature related to auditors' legal liability [11]. Indicated that risk of litigation is a very important factor for audit planning. They explored the relationship of business risk to determine the maximum level of audit risk acceptable to the auditors. Each audit should supply at least the level of audit assurance required by Generally Accepted Accounting Standards (GAAS), and each auditor's opinion should imply at least this level of assurance [12]. Found that several client and auditor characteristics are associated with lawsuits against auditors. The accounting profession is witnessing an increase in both the number of lawsuits against auditors and the settlements associated with those suits. The additional cost to firms associated with litigation is reflected in the rise of malpractice insurance rates.

Prior research has found that the relation between liability of legislation and the behavior of auditors would influence investor's behavior [13]. Presented an analytical model that explores the impact of auditor legal liability on audit quality and investment. The model is particularly focused on the impact of damage measures on investments. The threat of liability payments creates an incentive for the auditor to work hard; however, the potential liability payments can provide "insurance" for investors in the event the state of nature is bad. Similarly, [14] found that increasing the legal liability enhances audit quality but high audit quality does not inevitably raise the value of the business as a whole [15]. Explored the impact of increased legal liability for auditors on investment and found that higher legal liability leads to conservative behavior by auditors and thus reduces investors' investment frequency [16]. Found that increased litigation is likely to result in a demand displacement from high-quality to low-quality auditors. This result is consistent with the notion that even Big 4 firms that have "deep pockets" would reject high-risk clients when the risk and cost of litigation are increased.

[17] Established a model to discuss the dynamic interactions among the firm's owner, auditors and managers. They claimed the multi-agent moral hazard problem is the essence of concern for auditor independence. They also indicated that a "low-balling" compensation scheme and the auditors' legal liability represent an efficient dynamic contracting mechanism for hierarchical agency. They found that low balling may serve as a surrogate for legal liabilities for maintaining auditor independence and could truly enhance auditor independence [1]. Considered how auditors assess the risk of fraudulent financial reporting and plan their audit when a possibly fraudulent auditee expects the assessment and planning process. The auditor uses the auditee's (possibly fraudulent) earnings report to revise his beliefs about the likelihood of fraud when preparing an audit plan. In contrast, the auditor is no better off using the auditee's report for audit planning. Inherent risk, detection risk and overall audit risk could increase when an auditor uses the auditee's report. Thus, due to the active interaction between the auditor and auditee, procedures that help in assessing audit risk may not reduce that risk or result in more efficient audits [2]. Examined the potential impact of the "new" legal environment described by the SEC and found that changes in the litigation environment recently are associated with the issuance of fewer going-concern-modified opinions to stressed companies. This finding is consistent with the SEC's claim that auditors' behavior in recent years has been influenced by reduced litigation pressures.

As high-quality external auditing is a core component of a healthy capital market, auditors have reputational incentives to avoid audit failures because audit quality is precious to clients and so priced in the market for audit service [6]. Using the data in Japan as an event study, [6] found evidence on the importance of an auditor's reputation for quality. They found that clients defect to other auditors when an audit firm's reputation for quality deteriorates, similar to what happened in the US as Enron scandal took place.

It is a longstanding viewpoint that auditor independence is threatened by the economic dependence of an auditor on client fees. Prior

literature provides evidence that client fees impair perceived auditor independence but it is unclear whether particular types of fees result in impairment [e.g.,18,19]. [19] Examined the relationship between perceived auditor independence and audit litigation and how non-audit service fees play a role in the above relationship. Since the fees obtained through the provision of non-audit services increase an auditor's dependence on a client, they are easy to be perceived as a threat to auditor independence [19]. Found that audit litigants act as if they believe non-audit service fees would strengthen the case against the auditor, and thus affect the court resolution if the lawsuit is taken to verdict [10]. Examined auditor commitment to clients and how it affects the level of value-added audit service provided to the clients. A positive relationship between the above two variables is found and higher-quality relationship leads to higher levels of service that go beyond the basic requirements of the audit itself.

Theory suggests that higher audit effort increases the chance of detected errors and reduces the chance of undetected errors [20,21]. [22] Tested the theoretical prediction by examining whether the likelihood of financial report misstatements decreases as audit efforts increase. They found the above prediction applies only to audited annual reports and not to un-audited reports. Thus, audit effort does have a robust negative relation with annual report restatement.

Several empirical studies in Taiwan have demonstrated the relation between the litigation environment and auditors' behavior [23]. Examined the influence of the change of auditors' level of qualification and legal liability on the audit market. She found that if the legal liability is fixed, audit fees will increase when the level of qualification of auditors is enhanced. The benefits of clients will be reduced, and the level of quality of auditors will be increased, but the overall market quality will not be enhanced as expected. Furthermore, if the legal liability decreases and the level of qualification of auditors is fixed, audit fees will decrease. The benefits of clients will increase, but overall market quality will not decrease. [4] examined an audit setting in which an auditor sequentially determines the client-risk screening investment and his effort level. He also investigated the impact of auditors' litigation costs on audit efforts when the auditor screens the client risks before the acceptance of an audit engagement. After incorporating the auditor's screening decision, he suggested that the argument in the existing literature that there is a positive relation between auditor litigation and audit effort might need to be reassessed.

To summarize, prior research has yielded mixed results on the issue of reputation loss and economic dependence. For instance, in order to manage potential litigation risk effectively, auditors will probably increase audit hours [24]. And the legal liability of auditors is positively associated with audit efforts [25,26,3]. However, there is a lack of evidence regarding the strategic interactions of different-sized auditors when they face heavy litigation risk. Thus, the purpose of this study is to find an alternative strategic interaction of Big 4 firms and non-Big 4 firms while considering the issues of reputation loss and economic dependence.

3. THE MODEL

3.1 Establish the Basic Model

We first assume that an auditor is risk-neutral and that he seeks to maximize his profit. The process of an audit is as follows: (1) establish the screening system, (2) estimate the audit risk, and (3) confirm the level of audit effort. Therefore, we set three decision points for an audit. First, we decide the input level of screening; second, we decide whether to accept the assignment; and third, we decide the level of audit effort.

First, nature decides if the client is in the high-risk group (H) or the low-risk group (L). Auditors cannot be sure which group clients belong to, but they know that the percentages are 1-λ (H) and λ (L), the probability of prior belief about clients.

3.1.1 The input-level of screening

We assume that auditors will assess the financial situation of clients before accepting an audit engagement. This screening can be categorized as strong screening and weak screening. A strong-screening investment is greater than a weak-screening one; that is, $F^S > F^W > 0$. In addition, the level of screening influences the probability that clients are classified correctly to the high-risk group or the low-risk group. In other words, a strong screening can infer the risk type of clients more accurately than a weak screening; that is, $1 > \alpha^s > \alpha^w > 0$.

Screening can revise the probability of prior belief about clients. The probability of a strong-screening investment is α^s; thus, we could obtain the probability of the prior belief about the low-risk client as follows:

$$b^s = \frac{\lambda}{\lambda + (1-\lambda) \times (1-\alpha^s)} \quad (1)$$

Conversely, the probability of a weak-screening investment is α^w; we could obtain the probability of the prior belief about the low-risk client as follows:

$$b^w = \frac{\lambda}{\lambda + (1-\lambda) \times (1-\alpha^w)} \quad (2)$$

Moreover, we derive $1 > b^s > b^w > 0$ because $1 > \alpha^s > \alpha^w > 0$. Namely, while other conditions are invariable, a strong screening could enhance the probability of the prior belief about the low-risk group in comparison with a weak-screening.

3.1.2 Whether to accept the engagement

Screening could revise the probability that clients are classified to the high-risk group or the low-risk group. According to the probability, auditors could decide if they should accept the engagement.

3.1.3 The level of audit effort

We assume that auditors could decide the level of audit effort (high, e^H, or low, e^L) after they accept the audit engagement and that the audit-cost is C^H or C^L, respectively. The audit fees are the fixed value of K.

Moreover, if auditors accept the assignment of a high-risk client, the probability is β that the client faces a financial crisis. In case of a financial crisis, investors would bring a lawsuit against the auditors. The auditors must bear the litigation-cost (LA) as well as the legal liability of an audit failure. The probability of losing a lawsuit is a function of the audit effort, as is the probability of winning a lawsuit. Furthermore, the probability of winning a lawsuit through high audit effort (p^H) is larger than the probability of winning through low audit effort (p^L); that is, $1 > p^H > p^L > 0$. Yet, once auditors lose the lawsuits, they must bear a compensation of D and a reputation loss of R.

Following the analysis of the basic model, we derive the event chart and the corresponding payoff for each audit process. Please refer to Appendix 1.

3.2 Preliminary Analysis

Based on the analysis of the basic model, we list the four strategic interactions as follows: weak screening with low audit effort, weak screening with high audit effort, strong screening with low audit effort, and strong screening with high audit effort. Please refer to Table 1 for the payoff of each strategic interaction and to Appendix 2 for the details of the calculation.

We assume that the payoff of each strategic interaction is greater than 0 in order to ensure that auditors have economical and rational behavior when they accept the engagement. In other words, when screening -investment of F^i ($i \in \{W \text{ or } S\}$) matches audit effort of e^j ($j \in \{L \text{ or } H\}$), we obtain payoffs that are greater than zero:

$$K - F^i - C^j - (1-b^i) \times \beta \times LA - (1-b^i) \times \beta (1-p^j) \times (D+R) > 0 \quad (3)$$

Therefore, we could calculate the difference in expected payoffs between the high audit effort and the low audit effort, whether auditors choose the strong-screening or the weak-screening strategy:

$$\Pi (e^L|F^i) - \Pi (e^H|F^i) = C^H - C^L - (1-b^i) \times \beta (p^H - p^L) \times (D+R) \quad (4)$$

Table 1. The payoff of each strategic interaction

	Weak screening	Strong screening
Low audit effort	$K - F^w - C^L - (1-b^w) \times \beta \times LA - (1-b^w) \times \beta (1-p^L) \times (D+R)$	$K - F^S - C^L - (1-b^S) \times \beta \times LA - (1-b^S) \times \beta (1-p^L) \times (D+R)$
High audit effort	$K - F^w - C^H - (1-b^w) \times \beta \times LA - (1-b^w) \times \beta (1-p^H) \times (D+R)$	$K - F^S - C^H - (1-b^S) \times \beta \times LA - (1-b^S) \times \beta (1-p^H) \times (D+R)$

We then analyze Equation 4 and find that results of all the screening strategies are the same. When auditors choose the weak-screening strategy, we find that they make low audit efforts when $C^H - C^L - (1- b^w) \times \beta (p^H- p^L) \times (D+R) > 0$; that is, when the expected payoff of low audit effort is larger than the expected payoff of high audit effort. Conversely, we find that auditors would make high audit efforts when $C^H - C^L - (1- b^w) \times \beta (p^H- p^L) \times (D+R) < 0$, or when the expected payoff of low audit effort is smaller than the expected payoff of high audit effort. Finally, if $C^H - C^L - (1- b^w) \times \beta (p^H- p^L) \times (D+R)$ is equal to zero, the expected payoff of low audit effort is the same as the expected payoff of high audit effort.

Similarly, when auditors follow the strong-screening strategy, we find that they make low audit efforts when $C^H - C^L - (1- b^S) \times \beta (p^H- p^L) \times (D+R) > 0$, or when the expected payoff of low audit effort is larger than the expected payoff of high audit effort. Conversely, we find that auditors make high audit efforts when $C^H - C^L - (1- b^S) \times \beta (p^H- p^L) \times (D+R) < 0$; that is, when the expected payoff of low audit effort is smaller than the expected payoff of high audit effort. Finally, if $C^H - C^L - (1- b^S) \times \beta (p^H- p^L) \times (D+R)$ is equal to zero, the expected payoff of low audit effort is the same as the expected payoff of high audit effort.

The above can be simplified as the following:

$$\Delta\Pi (e|F^i) = C^H - C^L - (1-b^i) \times \beta (p^H- p^L) \times (D+R)$$

Further,

$$\partial [\Delta\Pi(e|F^i)]/\partial (C^H- C^L) > 0,\ \partial [\Delta\Pi(e|F^i)]/\partial (\beta) < 0,\ \partial [\Delta\Pi(e|F^i)]/\partial (p^H- p^L) < 0,$$
$$\partial [\Delta\Pi(e|F^i)]/\partial (D) < 0,\ \partial [\Delta\Pi(e|F^i)]/\partial (R) < 0$$

Through the above analysis of partial differentials, we find that whether auditors choose the strong-screening or the weak-screening strategy, they tend to make low audit efforts if the difference between the cost of the high audit efforts and the low audit efforts ($C^H - C^L$) is higher, the probability of clients' bankruptcy (β) is lower, the difference in probability that auditors win lawsuits between the high audit efforts and the low audit efforts ($p^H- p^L$) is lower, the compensation of a lawsuit (D) is lower, and the reputation loss (R) is lower.

4. EQUILIBRIUM ANALYSIS BETWEEN Big 4 FIRMS AND NON-Big 4 FIRMS

We extend our analysis to the firm level, and we divide auditors into Big 4 firms and non-Big 4 firms. After considering the size of the firm, we add a variable for "reduced client quantity" ($CQ(F^i)$) which is a function of client selection. Auditors are influenced by screening in two ways. First, we could infer an inverse association between reputation loss and the level of screening. Please refer to the relation of reputation loss (R) and the level of screening (F) in Fig. 1. Fig. 1 indicates that the level of screening impacts Big 4 firms more seriously because Big 4 firms could suffer larger reputation losses than non-Big 4 firms.

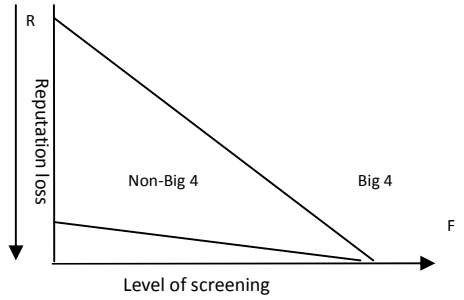

Fig. 1. The relation of reputation loss (R) and the level of screening (F)

Second, we infer an inverse association between reduced client quantity and the level of screening. Please refer to the relation of reduced client quantity (CQ) and the level of screening (F) in Fig. 2. In addition, we think that non-Big 4 firms have a higher ratio of reduced client quantity than Big 4 firms at the same level of screening.

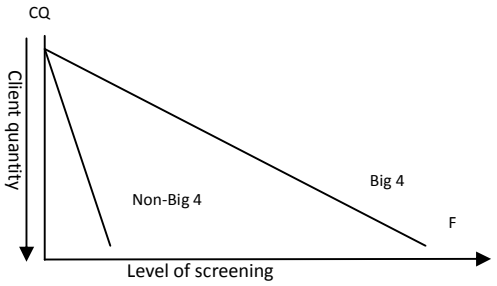

Fig. 2. The relation of reduced client quantity (CQ) and the level of screening (F)

Based on the above analysis, we obtain the payoff of each strategic interaction for Big 4 firms and non-Big 4 firms in Table 2 and Table 3, respectively.

We calculate the difference between the strong-screening payoff and the weak-screening payoff

when Big 4 firms make high audit efforts at (1) of Appendix 3, and we show the result in Equation 5. In addition, we calculate the difference between the strong-screening payoff and the weak-screening payoff when Big 4 firms make low audit efforts at (2) of Appendix 3, and we show the result in Equation 6.

$$\begin{aligned}&\Delta\Pi^{B}(\Delta F|e^{H})\\&=\Pi^{B}(F^{S}|\,e^{H})-\Pi^{B}(F^{W}|\,e^{H})\\&=(b^{S}-b^{w})\times\beta\times[LA+(1-p^{H})\times(D+R^{B})]-K[CQ^{B}(F^{S})-CQ^{B}(F^{W})]-(F^{S}-F^{W})\end{aligned}\quad(5)$$

$$\begin{aligned}&\Delta\Pi^{B}(\Delta F|e^{L})\\&=\Pi^{B}(F^{S}|\,e^{L})-\Pi^{B}(F^{W}|\,e^{L})\\&=(b^{S}-b^{w})\times\beta\times[LA+(1-p^{L})\times(D+R^{B})]-K[CQ^{B}(F^{S})-CQ^{B}(F^{W})]-(F^{S}-F^{W})\end{aligned}\quad(6)$$

Lemma 1. Because Big 4 firms have more clients and a higher slope on the relation between reputation loss and the level of screening, they tend to select a strong-screening strategy whatever they make high audit efforts or low audit efforts.

Lemma 2. Because Big 4 firms have more clients and a lower slope on the relation between reduced client quantity and the level of screening, they tend to select a strong-screening strategy whether they make high audit efforts or low audit efforts.

We analyze Equations 5 and 6 and find that Big 4 firms choose the strong-screening strategy because their potential reputation loss is larger than the potential loss of clients. In other words, whether they make high audit efforts or low audit efforts, Big 4 firms would select a strong-screening strategy as long as the expected payoff of the strong screening is larger than the expected payoff of the weak screening; that is, if Equation 5 > 0 and Equation 6 > 0.

Also,

$$\partial[\Delta\Pi^{B}(\Delta F^{i}|e^{j})]/\partial K[CQ^{B}(F^{S})-CQ^{B}(F^{W})]<0,$$
$$\partial[\Delta\Pi^{B}(\Delta F^{i}|e^{j}))]/\partial(F^{S}-F^{W})<0,\ \partial[\Delta\Pi^{B}(\Delta F^{i}|e^{j}))]/\partial(b^{S}-b^{w})>0,\ \partial[\Delta\Pi^{B}(\Delta F^{i}|ej)]/\partial(\beta)>0,\ \partial[\Delta\Pi^{B}(\Delta F^{i}|e^{j}))]/\partial(LA)>0,$$
$$\partial[\Delta\Pi^{B}(\Delta F^{i}|e^{j}))]/\partial(1-p^{j})>0,$$
$$\partial[\Delta\Pi^{B}(\Delta F^{i}|e^{j}))]/\partial(D)>0,$$
$$\partial[\Delta\Pi^{B}(\Delta F^{i}|e^{j}))]/\partial(R^{B})>0.$$

According to Figs. 1 and 2 and the above analysis of partial differentials, we find that regardless of whether audit effort is high or low, Big 4 firms would select the strong-screening strategy if the difference of reduced client quantity between strong screening and weak screening ($K[CQ^{B}(F^{S})-CQ^{B}(F^{W})]$) is smaller, the difference of cost between strong screening and weak screening ($F^{S}-F^{W}$) is smaller, the difference of probability between strong screening and weak screening when auditors meet the low-risk client group ($b^{S}-b^{w}$) is higher, the probability of client bankruptcy (β) is higher; lawsuit cost (LA) is higher, the probability of lawsuit failure ($1-p^{j}$) is higher, the compensation of lawsuit (D) is higher, and the reputation loss (R^{B}) is higher.

Lemma 3. Because non-Big 4 firms have fewer clients and a smaller slope on the relation between reputation loss and the level of screening, they tend to select the weak-screening strategy whether they make high audit efforts or low audit efforts.

Lemma 4. Because non-Big 4 firms have fewer clients and a higher slope on the relation between reduced client quantity and the level of screening, they tend to select the weak-screening strategy whether they make high audit efforts or low audit efforts.

Table 2. The payoff of Big 4 firms

	High audit effort	Low audit effort
Strong screening	$K\times[Q^{B}-CQ^{B}(F^{S})]-F^{S}-C^{H}-(1-b^{S})\times\beta\times LA-(1-b^{S})\times\beta(1-p^{H})\times(D+R^{B})$	$K\times[Q^{B}-CQ^{B}(F^{S})]-F^{S}-C^{L}-(1-b^{S})\times\beta\times LA-(1-b^{S})\times\beta(1-p^{L})\times(D+R^{B})$
Weak screening	$K\times[Q^{B}-CQ^{B}(F^{w})]-F^{w}-C^{H}-(1-b^{w})\times\beta\times LA-(1-b^{w})\times\beta(1-p^{H})\times+R^{B})$	$K\times[Q^{B}-CQ^{B}(F^{w})]-F^{w}-C^{L}-(1-b^{w})\times\beta\times LA-(1-b^{w})\times\beta(1-p^{L})\times(D+R^{B})$

Table 3. The payoff of non-big 4 firms

	High audit effort	Low audit effort
Strong screening	$K\times[Q^{nB}-CQ^{nB}(F^{S})]-F^{S}-C^{H}-(1-b^{S})\times\beta\times LA-(1-b^{S})\times\beta(1-p^{H})\times(D+R^{nB})$	$K\times[Q^{nB}-CQ^{nB}(F^{S})]-F^{S}-C^{L}-(1-b^{S})\times\beta\times LA-(1-b^{S})\times\beta(1-p^{L})\times D+R^{nB})$
Weak screening	$K\times[Q^{nB}-CQ^{nB}(F^{W})]-F^{W}-C^{H}-(1-b^{W})\times\beta\times LA-(1-b^{W})\times\beta(1-p^{H})\times(D+R^{nB})$	$K\times[Q^{nB}-CQ^{nB}(F^{W})]-F^{W}-C^{L}-(1-b^{W})\times\beta\times LA-(1-b^{W})\times\beta(1-p^{L})\times D+R^{nB})$

We calculate the difference between the weak-screening payoff and the strong-screening payoff when non-Big 4 firms make high audit efforts at (3) of Appendix 3, and we present the result in Equation 7. In addition, we calculate the difference between the weak-screening payoff and the strong-screening payoff when non-Big 4 firms make low audit efforts at (4) of Appendix 3, and we present the result in Equation 8.

$$\begin{aligned}&\Delta\Pi^{nB}(\Delta F|e^{H})\\&=\Pi^{nB}(F^{W}|e^{H})-\Pi^{nB}(F^{S}|e^{H})\\&=K[CQ^{nB}(F^{S})-CQ^{nB}(F^{w})]+(F^{S}-F^{w})-(b^{S}-b^{w})\times\beta\times[LA+(1-p^{H})\times(D+R^{nB})]\end{aligned}\quad(7)$$

$$\begin{aligned}&\Delta\Pi^{nB}(\Delta F|e^{L})\\&=\Pi^{nB}(F^{W}|e^{L})-\Pi^{nB}(F^{S}|e^{L})\\&=K[CQ^{nB}(F^{S})-CQ^{nB}(F^{w})]+(F^{S}-F^{w})-(b^{S}-b^{w})\times\beta\times[LA+(1-p^{L})\times(D+R^{nB})]\end{aligned}\quad(8)$$

After analyzing Equations 7 and 8, we find that non-Big 4 firms choose the weak-screening strategy because their client loss (if they take the strong–screening strategy) is larger than their reputation loss due to audit failure. In other words, whether they make high audit efforts or low audit efforts, non-Big 4 firms would choose the weak-screening strategy when the expected payoff of the weak screening is larger than the expected payoff of the strong screening; that is, when Equation 7 > 0 and Equation 8 > 0.

Moreover,

$$\begin{aligned}&\partial[\Delta\Pi^{nB}(\Delta F^{i}|e^{j})]/\partial K[CQ^{nB}(F^{S})-CQ^{nB}(F^{w})]>0,\\&\partial[\Delta\Pi^{nB}(\Delta F^{i}|e^{j}))]/\partial(F^{S}-F^{w})>0,\\&\partial[\Delta\Pi^{nB}(\Delta F^{i}|e^{j}))]/\partial(b^{S}-b^{w})<0,\\&\partial[\Delta\Pi^{nB}(\Delta F^{i}|e^{j})]/\partial(\beta)<0,\partial[\Delta\Pi^{B}(\Delta F^{i}|e^{j}))]/\\&\partial(LA)<0,\ \partial[\Delta\Pi^{B}(\Delta F^{i}|e^{j}))]/\partial(1-p^{j})<0,\\&\partial[\Delta\Pi^{nB}(\Delta F^{i}|e^{j}))]/\partial(D)<0,\ \partial[\Delta\Pi^{nB}(\Delta F^{i}|e^{j}))]\\&/\partial(R^{nB})<0.\end{aligned}$$

Based on the above analysis of partial differentials and Figs. 1 and 2, we find that whether the audit effort is high or low, non-Big 4 firms tend to select the weak-screening strategy if the difference of reduced client quantity between the strong screening and the weak screening ($K[CQ^{B}(F^{S})-CQ^{B}(F^{W})]$) is larger, the difference of cost between strong screening and weak screening ($F^{S}-F^{W}$) is larger, the difference of probability between strong screening and weak screening when auditors meet the low-risk client group ($b^{S}-b^{w}$) is lower, the probability of client bankruptcy (β) is lower, the lawsuit cost (LA) is lower, the probability of lawsuit failure ($1-p^{j}$) is lower, the compensation of lawsuit (D) is lower, and the reputation loss (R^{B}) is lower. Thus, Proposition 1 is presented as follows.

Proposition 1. After considering reputation loss and economic dependence issues, Big 4 firms tend to select the strong-screening strategy and non-Big 4 firms tend to select the weak-screening strategy.

Through the above analysis, we found that whether auditors make high audit efforts or low audit efforts, Big 4 firms tend to select the strong-screening strategy, while non-Big 4 firms tend to select the weak-screening strategy.

Next, we analyze the audit efforts of Big 4 firms and non-Big 4 firms separately, for the cases where auditors choose the strong-screening or the weak-screening strategy.

Lemma 5. Whether Big 4 firms choose the weak-screening or strong-screening strategy, if $(C^{H}-C^{L})-[(1-b^{w})\times\beta\times(p^{H}-p^{L})\times(D+R^{B})]>0$, then they tend to make low audit efforts. Otherwise, they tend to make high audit efforts.

We calculate the difference between the low-audit-effort payoff and the high-audit-effort payoff in the cases where Big 4 firms choose the weak-screening or the strong-screening strategy. Please refer to the calculation details at (5) and (6) of Appendix 3. The results are presented in Equations 9 and 10 as well.

$$\begin{aligned}&\Delta\Pi^{B}(\Delta e|F^{w})\\&=\Pi^{B}(e^{L}|F^{w})-\Pi^{B}(e^{H}|F^{w})\\&=(C^{H}-C^{L})-[(1-b^{w})\times\beta\times(p^{H}-p^{L})\times(D+R^{B})]\end{aligned}\quad(9)$$

$$\begin{aligned}&\Delta\Pi^{B}(\Delta e|F^{S})\\&=\Pi^{B}(e^{L}|F^{S})-\Pi^{B}(e^{H}|F^{S})\\&=(C^{H}-C^{L})-[(1-b^{S})\times\beta\times(p^{H}-p^{L})\times(D+R^{B})]\end{aligned}\quad(10)$$

After analyzing Equations 9 and 10, we find that Big 4 firms tend to make low audit efforts when they take the weak screening strategy and Equation 9 > 0. In addition, Big 4 firms also make low audit efforts when they take the strong screening strategy and Equation 10 > 0 since $1>b^{s}>b^{w}>0$. Thus, $(C^{H}-C^{L})-[(1-b^{S})\times\beta\times(p^{H}-p^{L})\times(D+R^{B})]>0$. In summary, Big 4 firms tend to make low audit efforts based on the above conditions or else they make high audit efforts.

Lemma 6. Whatever non-Big 4 firms choose the weak-screening or the strong-screening strategy, and $(C^{H}-C^{L})-[(1-b^{w})\times\beta\times(p^{H}-p^{L})\times(D+R^{nB})]>0$, then they tend to make low audit efforts; otherwise, they make high audit efforts.

We calculate the difference between the low-audit-effort payoff and the high-audit-effort payoff whether non-Big 4 firms select the weak-screening or strong-screening strategy at (7) and (8) of Appendix 3, and the results are presented in Equations 11 and 12.

$$\Delta\Pi^{nB}(\Delta e|F^{w}) = \Pi^{nB}(e^{L}|F^{w}) - \Pi^{nB}(e^{H}|F^{w}) = (C^{H}-C^{L}) - [(1-b^{w})\times\beta\times(p^{H}-p^{L})\times(D+R^{nB})] \quad (11)$$

$$\Delta\Pi^{nB}(\Delta e|F^{S}) = \Pi^{nB}(e^{L}|F^{S}) - \Pi^{nB}(e^{H}|F^{S}) = (C^{H}-C^{L}) - [(1-b^{S})\times\beta\times(p^{H}-p^{L})\times(D+R^{nB})] \quad (12)$$

From analyzing Equations 11 and 12, we find that non-Big 4 firms would make low audit efforts when they choose the weak-screening strategy and Equation 11 > 0. Furthermore, non-Big 4 firms would also make low audit efforts when they choose the strong-screening strategy and Equation 12 > 0 because $1 > b^{s} > b^{w} > 0$. So, $(C^{H}-C^{L}) - [(1-b^{S})\times\beta\times(p^{H}-p^{L})\times(D+R^{nB})] > 0$. In summary, non-Big 4 firms would make low audit efforts based on the above conditions or else they would make high audit efforts. Thus, Proposition 2 is presented as follows.

Proposition 2. After considering legal liability and audit cost issues, Big 4 firms tend to make low audit efforts and non-Big 4 firms tend to make high audit efforts.

For both Big 4 firms and non-Big 4 firms, if $(C^{H}-C^{L})-[(1-b^{w})\times\beta\times(p^{H}-p^{L})\times(D+R^{i})] > 0$, auditors would make low audit efforts. Next, from Condition 1 of Fig. 3, we find that Big 4 firms are more suitable than non-Big 4 firms under this condition. In Condition 1**,** auditors take the weak-screening strategy, and they could distinguish between the low-risk group and the high-risk group. Therefore, auditors need only make low audit efforts to manage the risk of litigation.

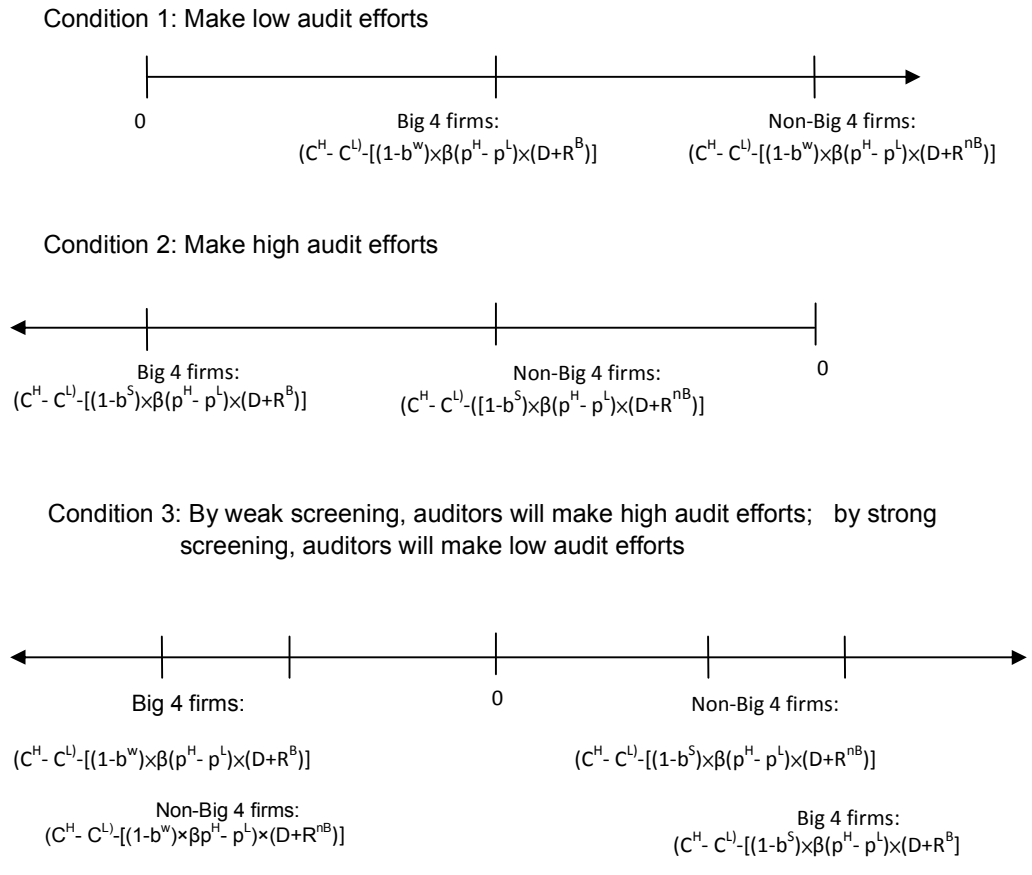

Fig. 3. The conditions of strategic interactions of big 4 firms versus non-big 4 firms

Further, for both Big 4 firms and non-Big 4 firms, if $(C^H-C^L)-[(1-b^S)\times\beta\times(p^H-p^L)\times(D+R^i)] < 0$, auditors tend to make high audit efforts. Next, from Condition 2 of Fig. 3, we find that non-Big 4 firms are more suitable than Big 4 firms under this condition. In Condition 2, auditors take the strong-screening strategy, but they still could not distinguish between the low-risk group and the high-risk group by the weak-screening strategy. In that case, auditors need to make high audit efforts to manage the risk of litigation.

Finally, in Condition 3, if $(C^H-C^L)-[(1-b^w)\times\beta\times(p^H-p^L)\times(D+R^i)] < 0 < (C^H-C^L)-[(1-b^S)\times\beta\times(p^H-p^L)\times(D+R^i)]$, auditors would make high audit efforts when they select the weak-screening strategy and auditors would make low audit efforts when they select the strong-screening approach. In other words, auditors choose the weak-screening strategy, but they still could not distinguish between the low-risk group and the high-risk group under this condition. Thus, auditors need to make high audit efforts to manage the risk of litigation. Furthermore, auditors choose the strong-screening strategy and could distinguish between the low-risk group and the high-risk group in this case, so auditors only need to make low audit efforts to manage the risk of litigation. However, from Condition 3 of Fig. 3 we find that Big 4 firms are more suitable than non-Big 4 firms under this condition.

From the above analysis, we find that Big 4 firms and non-Big 4 firms tend to select the strategic interaction of Result 1. This result is consistent with our expectation, namely that Big 4 firms would choose the strong-screening strategy and make low audit efforts in order to avoid huge reputation losses and to reduce audit cost; while non-Big 4 firms would choose the weak-screening strategy and make high audit efforts in order to protect their economic dependence and avoid lawsuits.

Result 1. After considering reputation loss, economic dependence, legal liability and audit cost, Big 4 firms tend to choose the strong-screening strategy and make low audit efforts, while non-Big 4 firms tend to choose the weak-screening strategy and make high audit efforts.

5. CONCLUSION

The Procomp scandal has already changed Taiwan's audit environment. Based on the change in the audit market, we consider reputation loss and economic dependence for Big 4 firms and non-Big 4 firms, and we apply a model to analyze their strategic interactions (screening and audit effort). We want to understand the effects of reputation and economic dependence on Big 4 firms and non-Big 4 firms.

Our results indicate that Big 4 firms tend to choose the strong-screening strategy and make low audit efforts, while non-Big 4 firms tend to choose the weak-screening strategy and make high audit efforts. We also obtain the following findings. First, when $(C^H-C^L)-[(1-b^w)\times\beta\times(p^H-p^L)\times(D+R^i)] > 0$, auditors would make low audit efforts. However, as Condition 1 of Fig. 3 indicates**,** auditors would choose the weak-screening strategy and could distinguish between the low-risk group and the high-risk group, so they make only low audit efforts to manage the risk of litigation. Further, if $(C^H-C^L)-[(1-b^S)\times\beta\times(p^H-p^L)\times(D+R^i)] < 0$, auditors would make high audit efforts. Yet, Condition 2 of Fig. 3 suggests that auditors choose the strong-screening strategy and still cannot distinguish between the low-risk group and the high-risk group, so they need to make high audit efforts to manage the risk of litigation. Finally, as in Condition 3, if $(C^H-C^L)-[(1-b^w)\times\beta\times(p^H-p^L)\times(D+R^i)] < 0 < (C^H-C^L)-[(1-b^S)\times\beta\times(p^H-p^L)\times(D+R^i)]$, auditors tend to make high audit efforts when they follow the weak-screening strategy, and they tend to make low audit efforts when they follow the strong-screening strategy. In other words, Condition 3 of Fig. 3 shows that auditors choose the weak-screening strategy and still could not distinguish between the low-risk group and the high-risk group, so they need to make high audit efforts to manage the risk of litigation. However, auditors select the strong-screening strategy and could distinguish between the low-risk group and the high-risk group under Condition 3, so they only need to make low audit efforts to manage the risk of litigation.

In addition, once we consider reputation loss in our model, we find that Big 4 firms would choose the strong-screening strategy to measure audit risk. But due to the cost issue, Big 4 firms only make low audit efforts to manage litigation risk. Conversely, non-Big 4 firms would choose the weak-screening strategy because they have lower reputation loss than Big 4 firms and because they must take the economic dependence issue into consideration. However, non-Big 4 firms also need to avoid litigation risk, so they tend to make high audit efforts.

This study has one major limitation. We assume that audit fees are constant for every client in our model since the audit fee data are not available in Taiwan. However, in real case, audit fees may change according to audit risk. In other words, auditors would ask high-risk clients for high audit fees [1]. Further research may wish to include audit fees in their models because these may affect auditors' strategic interactions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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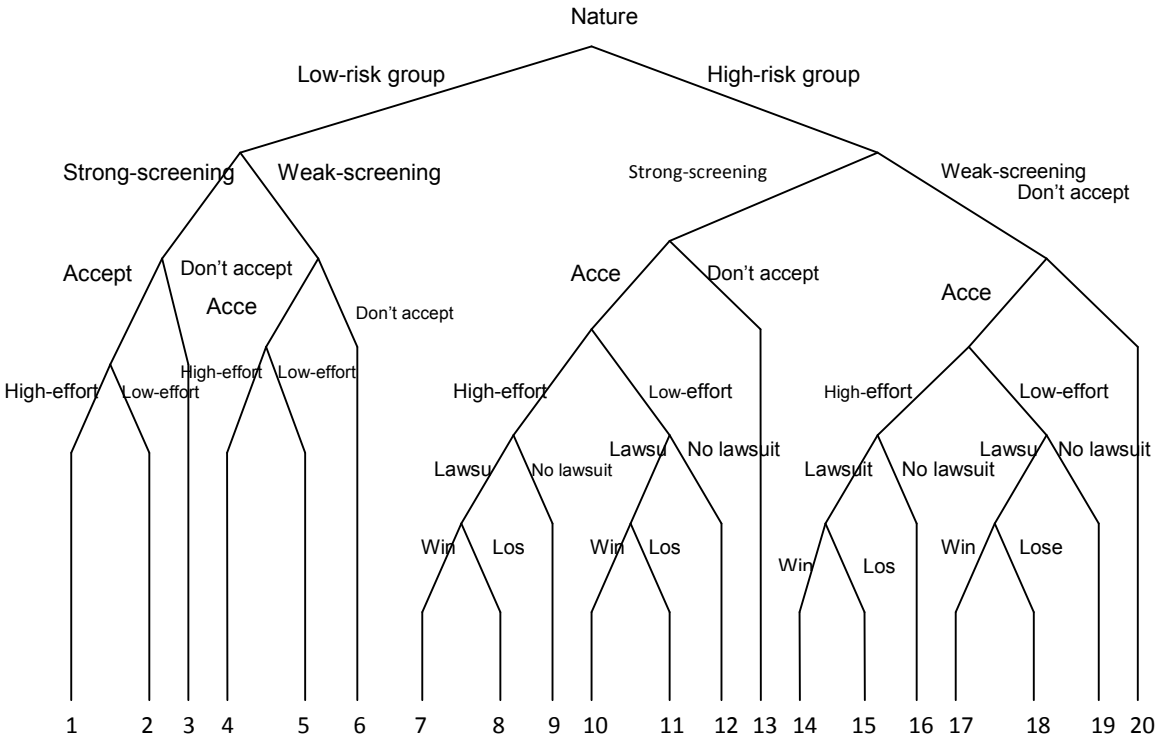
APPENDIX 1

Event Chart of Every Audit Process



The payoff of every audit process: (1): K-F^S-C^H; (2): K-F^S-C^L; (3): -F^S; (4): K-F^W-C^H; (5): K-F^W-C^L; (6): -F^W;(7): K-F^S-C^H-LA; (8): K-F^S-C^H-LA-D-R; (9): K-F^S-C^H; (10): K-F^S-C^L-LA; (11): K-F^S-C^L-LA-D-R; (12): K-F^S-C^L; (13): -F^S; (14): K-F^W-C^H-LA; (15): K-F^W-C^H-LA-D-R; (16): K-F^W-C^H; (17): K-F^W-C^L-LA;(18): K-F^W-C^L-LA-D-R; (19): K-F^W-C^L; (20): -F^W。

APPENDIX 2

1. If auditors select the weak-screening and low-audit-effort, we can get the expected payoff as follows:

$$\Pi(e^L|F^w)$$
$$= b^w \times (K-F^W-C^L) + (1-b^w) \times \beta \times p^L \times (K-F^W-C^L-LA) + (1-b^w) \times \beta \times (1-p^L) \times (K-F^W-C^L-LA-D-R) + (1-b^w) \times (1-\beta) \times (K-F^W-C^L)$$
$$= K - F^W - C^L - (1-b^w) \times \beta \times LA - (1-b^w) \times \beta (1-p^L) \times (D+R)$$

2. If auditors select the weak-screening and high-audit-effort, we can get the expected payoff as follows:

$$\Pi(e^H|F^w)$$
$$= b^w \times (K-F^W-C^H) + (1-b^w) \times \beta \times p^H \times (K-F^W-C^H-LA) + (1-b^w) \times \beta \times (1-p^H) \times (K-F^W-C^H-LA-D-R) + (1-b^w) \times (1-\beta) \times (K-F^W-C^H)$$
$$= K - F^W - C^H - (1-b^w) \times \beta \times LA - (1-b^w) \times \beta (1-p^H) \times (D+R)$$

3. If auditors select the strong-screening and low-audit-effort, we can get the expected payoff as follows:

$$\Pi(e^L|F^S)$$
$$= b^S \times (K-F^S-C^L) + (1-b^S) \times \beta \times p^L \times (K-F^S-C^L-LA) + (1-b^S) \times \beta \times (1-p^L) \times (K-F^S-C^L-LA-D-R) + (1-b^S) \times (1-\beta) \times (K-F^S-C^L)$$
$$= K - F^S - C^L - (1-b^S) \times \beta \times LA - (1-b^S) \times \beta (1-p^L) \times (D+R)$$

4. If auditors select the strong-screening and high-audit-effort, we can get the expected payoff as follows:

$$\Pi(e^H|F^S)$$
$$= b^S \times (K-F^S-C^H) + (1-b^S) \times \beta \times p^H \times (K-F^S-C^H-LA) + (1-b^S) \times \beta \times (1-p^H) \times (K-F^S-C^H-LA-D-R) + (1-b^S) \times (1-\beta) \times (K-F^S-C^H)$$
$$= K - F^S - C^H - (1-b^S) \times \beta \times LA - (1-b^S) \times \beta (1-p^H) \times (D+R)$$

APPENDIX 3

1. While Big 4 firms make high-audit efforts, we can get the difference between strong-screening payoff and weak-screening payoff as follows:

$$\Pi^{B}(F^{S}|e^{H})-\Pi^{B}(F^{w}|e^{H})$$
$$=\{K\times[Q-CQ(F^{S})]-F^{S}-C^{H}-(1-b^{S})\times\beta\times LA-(1-b^{S})\times\beta(1-p^{H})\times(D+R^{B})\}-\{K\times[Q-CQ(F^{w})]-F^{w}-C^{H}-(1-b^{w})\times\beta\times LA-(1-b^{w})\times\beta(1-p^{H})\times D+R^{B})\}$$
$$=(b^{S}-b^{w})\times\beta\times LA+[(b^{S}-b^{w})\times\beta\times(1-p^{H})\times(D+R^{B})]-K[CQ^{B}(F^{S})-CQ^{B}(F^{w})]-(F^{S}-F^{w})$$
$$=(b^{S}-b^{w})\times\beta\times[LA+(1-p^{H})\times(D+R^{B})]-K[CQ^{B}(F^{S})-CQ^{B}(F^{w})]-(F^{S}-F^{w})$$

2. While Big 4 firms make low-audit efforts, we can get the difference between strong-screening payoff and weak-screening payoff as follows:

$$\Pi^{B}(F^{S}\mid e^{L})-\Pi^{B}(F^{w}|e^{L})$$
$$=\{K\times[Q-CQ(F^{S})]-F^{S}-C^{L}-(1-b^{S})\times\beta\times LA-(1-b^{S})\times\beta(1-p^{L})\times(D+R^{B})\}-\{K\times[Q-CQ(F^{w})]-F^{w}-C^{L}-(1-b^{w})\times\beta\times LA-(1-b^{w})\times\beta(1-p^{L})\times(D+R^{B})\}$$
$$=(b^{S}-b^{w})\times\beta\times LA+[(b^{S}-b^{w})\times\beta\times(1-p^{L})\times(D+R^{B})]-K[CQ^{B}(F^{S})-CQ^{B}(F^{w})]-(F^{S}-F^{w})$$
$$=(b^{S}-b^{w})\times\beta\times[LA+(1-p^{L})\times(D+R^{B})]-K[CQ^{B}(F^{S})-CQ^{B}(F^{w})]-(F^{S}-F^{w})$$

3. While non-Big 4 firms make high-audit efforts, we can get the difference between weak-screening payoff and strong-screening payoff as follows:

$$\Pi^{nB}(F^{S}|e^{H})-\Pi^{nB}(F^{w}|e^{H})$$
$$=\{K\times[Q^{nB}-CQ^{nB}(F^{W})]-F^{W}-C^{H}-(1-b^{w})\times\beta\times LA-(1-b^{w})\times\beta(1-p^{H})\times(D+R^{nB})\}-\{K\times[Q^{nB}-CQ^{Nb}(F^{S})]-F^{S}-C^{H}-(1-b^{S})\times\beta\times LA-(1-b^{S})\times\beta(1-p^{H})\times(D+R^{nB})\}$$
$$=K[CQ^{nB}(F^{S})-CQ^{nB}(F^{w})]+(F^{S}-F^{w})-(b^{S}-b^{w})\times\beta\times LA+[(b^{w}-b^{S})\times\beta\times(1-p^{H})\times(D+R^{nB})]$$
$$=K[CQ^{nB}(F^{S})-CQ^{nB}(F^{w})]+(F^{S}-F^{w})-(b^{S}-b^{w})\times\beta\times[LA+(1-p^{H})\times(D+R^{nB})]$$

4. While non-Big 4 firms make low-audit efforts, we can get the difference between weak-screening payoff and strong-screening payoff as follows:

$$\Pi^{nB}(F^{S}|e^{L})-\Pi^{nB}(F^{w}|e^{L})$$
$$=\{K\times[Q^{nB}-CQ^{nB}(F^{W})]-F^{W}-C^{L}-(1-b^{w})\times\beta\times LA-(1-b^{w})\times\beta(1-p^{L})\times(D+R^{nB})\}-\{K\times[Q^{nB}-CQ^{nB}(F^{S})]-F^{S}-C^{L}-(1-b^{S})\times\beta\times LA-(1-b^{S})\times\beta(1-p^{L})\times(D+R^{nB})\}$$
$$=K[CQ^{nB}(F^{S})-CQ^{nB}(F^{w})]+(F^{S}-F^{w})-(b^{S}-b^{w})\times\beta\times LA+[(b^{w}-b^{S})\times\beta\times(1-p^{L})\times(D+R^{nB})]$$
$$=K[CQ^{nB}(F^{S})-CQ^{nB}(F^{w})]+(F^{S}-F^{w})-(b^{S}-b^{w})\times\beta\times[LA+(1-p^{L})\times(D+R^{nB})]$$

5. While Big 4 firms take weak-screening strategy, we can get the difference between low-audit-effort payoff and high-audit-effort payoff as follows:

$$\Pi^{B}(e^{L}|F^{w})-\Pi^{B}(e^{H}|F^{w})$$
$$=\{K\times[Q^{B}-CQ^{B}(F^{w})]-F^{w}-C^{L}-(1-b^{w})\times\beta\times LA-(1-b^{w})\times\beta(1-p^{L})\times(D+R^{B})\}-\{K\times[Q^{B}-CQ^{B}(F^{w})]-F^{w}-C^{H}-(1-b^{w})\times\beta\times LA-(1-b^{w})\times\beta(1-p^{H})\times(D+R^{B})\}$$
$$=(C^{H}-C^{L})-[(1-b^{w})\times\beta\times(p^{H}-p^{L})\times(D+R^{B})]$$

6. While Big 4 firms take strong-screening strategy, we can get the difference between low-audit-effort payoff and high-audit-effort payoff as follows:

$$\Pi^{B}(e^{L}|F^{S})-\Pi^{B}(e^{H}|F^{S})$$
$$=\{K\times[Q^{B}-CQ^{B}(F^{S})]-F^{S}-C^{L}-(1-b^{S})\times\beta\times LA-(1-b^{S})\times\beta(1-p^{L})\times(D+R^{B})\}-\{K\times[Q^{B}-CQ^{B}(F^{S})]-F^{S}-C^{H}-(1-b^{S})\times\beta\times LA-(1-b^{S})\times\beta(1-p^{H})\times(D+R^{B})\}$$
$$=(C^{H}-C^{L})-[(1-b^{S})\times\beta\times(p^{H}-p^{L})\times(D+R^{B})]$$

7. While non-Big 4 firms take weak-screening, we can get the difference between low-audit-effort payoff and high-audit-effort payoff as follows:

$$\Pi^{nB}(e^{L}|F^{w}) - \Pi^{nB}(e^{H}|F^{w})$$
$$= \{K\times[Q^{nB} - CQ^{nB}(F^{w})] - F^{w} - C^{L} - (1-b^{w})\times\beta\times LA - (1-b^{w})\times\beta(1-p^{L})\times(D+R^{nB})\} -$$
$$\{K\times[Q^{nB} - CQ^{nB}(F^{w})] - F^{w} - C^{H} - (1-b^{w})\times\beta\times LA - (1-b^{w})\times\beta(1-p^{H})\times(D+R^{nB})\}$$
$$= (C^{H} - C^{L}) - [(1-b^{w})\times\beta\times(p^{H} - p^{L})\times(D+R^{nB})]$$

8. While non-Big 4 firms take strong-screening, we can get the difference between low-audit-effort payoff and high-audit-effort payoff as follows:

$$\Pi^{nB}(e^{L}|F^{S}) - \Pi^{nB}(e^{H}|F^{S})$$
$$= \{K\times[Q^{nB} - CQ^{nB}(F^{S})] - F^{S} - C^{L} - (1-b^{S})\times\beta\times LA - (1-b^{S})\times\beta(1-p^{L})\times(D+R^{nB})\} -$$
$$\{K\times[Q^{nB} - CQ^{nB}(F^{S})] - F^{S} - C^{H} - (1-b^{S})\times\beta\times LA - (1-b^{S})\times\beta(1-p^{H})\times(D+R^{nB})\}$$
$$= (C^{H} - C^{L}) - [(1-b^{S})\times\beta\times(p^{H} - p^{L})\times(D+R^{nB})]$$

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