A multi-period model of the auditor's valuation and fraud detection activities

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A multi-period model of the auditor's valuation and fraud detection activities: Implications for mandatory auditor rotation

ABSTRACT

We examine a multi-period model of auditing to investigate two related issues. The first issue is how routine valuation activities and fraud detection activities interact in the conduct of an audit. We assert that the preponderance of audit activity relates to expert valuation of uncertain future amounts in the form of accruals. These values are frequently determined through discussion and negotiation between the auditor and client management. Simultaneously, the auditor is also responsible for taking reasonable steps to identify fraud if it is perpetrated. These two types of activity are at odds with each other because valuation activities reflect cooperation in the resolution of uncertainty, but fraud detection relates to information asymmetry between the client manager and the auditor To understand the nature of audit pricing, we must examine a multi-period model that integrates both audit issues. In the U.S. market, the status quo does not require mandatory auditor rotation (MR), but we find that MR mitigates the multi-period benefits to the auditor and therefore induces more conservative reporting of accruals. This result is affected by the fraud detection activity. More costly fraud detection activities dampen the relative reporting and fee differences related to mandatory rotation.

Keywords: Audit tasks; Fraud detection; Mandatory Auditor Rotation; Audit Fees.

1. INTRODUCTION

In the U.S. capital markets the Public Company Accounting Oversight Board (PCAOB) mandates auditors engage in a complex portfolio of tasks that work together to validate the veracity and accuracy of a client's financial statements. PCAOB AS 2501, *Auditing Accounting Estimates Including Fair Value Measurements*, mandates auditors manage the inherent imprecision in valuation estimates in the reporting of accruals. Because reported cash flows do not involve uncertainty, financial statement informativeness relies on the estimation of accruals. In contrast, PCAOB AS 2401, *Consideration of Fraud*, mandates auditors actively engage in detecting intentional misreporting and fraud. The PCAOB mandates both activities because the reporting environment involves both uncertainty and the potential for dishonest reporting.

To understand how the auditor integrates these tasks in the conduct of an audit, we examine a comprehensive economic model that includes both valuation and fraud detection activities. We examine this model over multiple periods to determine how these audit tasks, or components, are affected by auditor tenure. We apply our multi-period model to the issue of mandatory auditor rotation (MR) to characterize how exogenous limits on auditor tenure affect financial reporting (accruals), audit fees, and the auditor-client relationship.

Our model addresses both the auditor's valuation activities that focus on accurate reporting and the auditor's fraud detection activities that relate to identifying intentional misstatement by client management. We solve these components simultaneously for each period of the audit. In the valuation component, we assume uncertainty but no information asymmetry.[1] The auditor and client share uncertainty about the future value of accruals and must agree upon a

[1] We assume the underlying distribution of accruals is known by both the auditor and management with no private information. But the model would be unaffected if the auditor openly shares her knowledge about the underlying distribution of the representative accrual, based on her past experience, with the manager who is less knowledgeable about the preferred treatments of these reporting issues.

value to report.[2] In the fraud-detection component, the auditor is concerned that the client manager *may be* dishonest and *might* have an opportunity to report fraudulently. The auditor can assess the likelihood that a misreporting opportunity will arise, but does not know whether or not the manager will misreport. Therefore, because the possibility that misreporting (fraud) exists, the auditor must commit audit resources to detect and deter intentional misreporting.

We assert that in the valuation component, the auditor can earn economic rents through routine and expert activity. But because the fraud-detection component addresses intentional misstatement by the audit client, no economic rents are possible for this activity. Because the audit client pays for the audit, the client would never choose to pay "extra" for the auditor's efforts to detect fraud – even if the client did not commit fraud. This component of the audit is therefore similar to a public good and why PCAOB AS 2401 holds the auditor accountable for reasonable efforts to detect and deter fraud.

For our multi-period pricing model, we follow DeAngelo (1981), Magee and Tseng (1990), and Zhang (1999) that assume auditors bid to earn zero discounted economic profits over the expected tenure of the audit relationship. In the initial period, the non-incumbent auditor will lowball the bid to earn the engagement and then earn expected economic profits in future periods. This model therefore has implications for mandatory auditor rotation (MR).

For our valuation component, we assume that the auditor and client negotiate the value to report for accrued expenses. The true value is uncertain, but the distribution of the true value is common knowledge. The negotiation incorporates the client manager's preference to report

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[2] We focus on accruals because reported earnings are comprised of a cash component and an accrual component (Dechow 1994). Uncertainty exists, of course, only in the accrual component because cash is verifiable in the course of the audit.

lower accrued expenses and the auditor's preference for accuracy. Uncertainty provides room for the two parties to negotiate a value that is acceptable to both.[3]

For our fraud-detection component, we assume that the manager is dishonest with an opportunity to commit fraud with a fixed probability. The manager either does or does not commit fraud. The auditor only knows the probability that fraud might be perpetrated and the amount of the possible fraud. The auditor will commit resources to fraud detection and will, if fraud is committed, detect the fraud stochastically. This component of the model is a simple example of strategic auditing as in Smith, Tiras, and Vichitlekarn (2000).

The fraud-detection component affects the overall model by driving the probability that the engagement tenure survives to the next period. We assume that if the auditor detects fraud, then either the auditor will drop the client or the client will fire the auditor. Thus, the greater the probability that fraud is perpetrated and detected in a given period, the greater the probability that the engagement tenure will *end* in the current period. The greater the probability that the engagement tenure ends in the current period, the smaller will be the probability that the engagement will survive to the next period.

The probability that the engagement survives to the next period affects the valuation component. Because the valuation component is driven by the expected discounted future profits at each point in time, the discount factor is a combined metric that takes into account the time value of money *and* the probability that the engagement survives to the next period. That probability is endogenous to our model. Using this discount factor, we derive equilibrium reporting and equilibrium fees across two settings. The first setting is what we refer to as a status-quo (SQ) setting where no exogenous end to the engagement tenure exists. This is

[3] We introduce a parameter for the auditor's level of conservatism that reflects the auditor's risk tolerance.

modeled, similar to DeAngelo (1981) and Zhang (1999), as an infinite-horizon game that is discounted with the comprehensive discount factor. The second setting is a mandatory rotation setting that must end no more than N periods in the future.

We find that in the MR setting, negotiated accruals are always more conservative and are increasingly more conservative over time relative to accruals in the SQ setting. Negotiated accruals are expected to be biased more towards client-manager preferences when the opportunity cost of losing the client is greater. Because each period in the SQ setting is the same in perpetuity, the opportunity cost is constant across periods in this setting. The constant opportunity costs across periods in the SQ setting, in turn, result in a constant level of conservatism across periods. But in the MR setting where the engagement horizon is finite, the opportunity cost of losing the client decreases each period and results in increasingly conservative negotiated accruals each subsequent period.

Surprisingly, we find that the impact of mandatory auditor rotation on audit fees changes over time. In contrast, reputation costs remain constant over time in the SQ setting. Initially in the SQ setting, we find that audit fees are lower than in the MR setting due to lowballing. But in the MR setting, reputation costs decrease over time because reporting becomes more conservative. Because reputation costs are priced into the audit, the fees in the MR setting will decrease over time and, at some point, fall below the fees in the SQ setting. The conditions for and characterizations of this occurrence are derived in our analysis.

Next, we examine how the fraud component of auditing, characterized by information asymmetry, affects lowballing, bias, and audit fees through the endogenous discount factor. We find that more costly fraud detection drives down the comprehensive discount factor. As a result, lowballing decreases and decreases more in the SQ setting than in the MR setting. Reporting bias also decreases with more costly fraud detection in both settings and again the decrease in bias is greater for the SQ setting than for the MR setting.[4] We cannot sign the change in fees for changes in fraud detection costs, because the direct effect of fraud detection activities increase audit fees, but increased detection costs decrease the discount factor which serves to decrease fees. Numerical examples imply that increased fraud detection costs increase fees in both settings, but they increase fees less in the SQ setting than in the MR setting.

Our study contributes to the literature by identifying how the auditor's valuation and fraud-detection activities affect the quality of reported accruals. DeFond and Zhang (2014) highlight the importance of this link, even though the auditing literature to-date has not examined how these activities interact to affect accrual quality. Audited accruals result from the client management first preparing the financial reports, and the auditor then attesting to the fair presentation of the firm's financial results. The uncertainty inherent in the accrual estimation provides room for negotiating the report and the possibility of reporting bias, where the reported accrual is lower than the auditor's best estimate, but within the range of the auditor's estimate of possible outcomes. Salterio (2012) provides empirical evidence that the auditor's attestation of the reports often involves negotiation between the auditor and the client management. Francis (2022) points out that for the auditor to form an opinion, the audit is a blend of investigative activities, valuation activities, aggregation activities, and judgment. Francis (2022) describes some basic characteristics of the financial statements considered by the auditor.

> Accounting numbers are a combination of relatively straightforward factual data such as the cash flows from the purchase and sale of inventory, and more complex forecasts and estimations of other items which are called "accruals."
>
> Accrual-based earnings are a better measure of an organization's operating performance than operating cash flows, and are more informative to investors

[4] Bias, in this manuscript, refers to the difference between a reported value and the auditor's best estimate of the value. Both values are within the range of reasonable outcomes, so bias in our setting relates to the uncertainty in an estimate and not to intentional misstatement.

> (Dechow, 1994). However, accruals also introduce uncertainty that can potentially reduce the quality of accounting earnings. There are no black and white standards for accruals and accrual adjustments. Instead, they are the subjective judgment and estimate of managers who can have personal incentives to use these accrual estimates to “distort” or “manage” earnings numbers…(T)he careful audit and review of accruals is where the audit can potentially have the greatest effect on the quality of audited accounting information, by providing a check on the reasonableness of managerial discretion with respect to accruals.

The Francis (2022) characterization informs the valuation component of our model, which reflects the reporting issues identified in AS 2501 (Paragraph 25):

> If the auditor's independent expectation consists of a range rather than a point estimate, the auditor should determine that the range encompasses only reasonable outcomes, in conformity with the applicable financial reporting framework, and is supported by sufficient appropriate evidence.

Consistent with AS 2501, we assume that the Nash Bargaining Solution (Nash 1950) provides the reported value that results from the negotiation. While descriptive of the Salterio (2012) characterization of auditor-client-manager (ACM) negotiation, this assumption achieves two key purposes for this study. First, we believe that it provides the most reasonable outcome for our assumed setting. Second, it allows us to address how reporting bias differs across the MR and SQ settings using a simple reporting problem.

Negotiation has been investigated empirically and theoretically in the accounting literature. Gibbins, Salterio, and Webb (2001) surveyed 93 public accountants to assess the elements most important in auditor-client negotiation. Our modeling approach is supported by several of their findings, including a strong plurality that indicated there was a “range of mutually satisfactory outcomes,” and that there existed a “difference in auditor-client preferences.” The most frequent negotiated outcome was the “agreement on a position between the original positions of the auditor and client management.” These basic results are echoed in other empirical studies on ACM (see Salterio 2012).

The extant theoretical literature in audit negotiation began with two foundational studies by Antle and Nalebuff (1991) and Zhang (1999) that focus on how information asymmetry affects the auditor's bargaining decision. The client is better informed about the ultimate true value, and the auditor is endowed with distribution information about the true value. The auditor in these papers has an incentive to provide limited accommodation the reporting preferences of the client. Our study differs from these two studies in two fundamental ways. First, we consider negotiation as opposed to a one-shot bargaining strategy. Negotiation allows for recursive offers and counter-offers. Second, we focus on a full-information bargaining problem and assume the Nash Bargaining Solution as the resolution to the problem. Note that neither Antle and Nalebuff (1991) or Zhang (1999) can accommodate recursive negotiation because the client would not wish to yield the information advantage.

DeFond and Zhang (2014) notes, "(a) critical area of the audit process that has been virtually ignored in the archival literature is the auditor's assessment of audit risk and audit procedures for detecting fraud." DeFond and Zhang (2014) asserts that this fact is primarily due to data limitations. The literature on fraud detection, therefore, consists mainly of modeling papers, which Ye (2023) summarizes. A consistent approach taken in these papers is to consider a two- or three-player game with the auditor and client as strategic players. The client, if dishonest, chooses whether or not to perpetrate fraud (or an amount of fraud to perpetrate) and the auditor chooses an amount of costly effort to commit to fraud detection. Detection is typically stochastic and perfect assurance is assumed to be cost-prohibitive. The objective of our fraud component is to yield an integrated multi-period model of the audit that considers the interaction across fraud detection and other, more routine, audit activities.

Several studies in the empirical audit literature address the issue of mandatory auditor rotation that is extensively reviewed in Florio (2024). One of the major take-aways from this review is that there are significant differences across the empirical literature regarding proxies for mandatory rotation. Many empirical studies do not restrict the term to regulatory requirements that a client firm change auditors at some point. One notable exception is Cameran, Prencipe, and Trombetta (2016) that examines the Italian regulatory regime that mandates auditors rotate after no more than nine years. Our results in the MR setting provide theoretic support for the Cameran, Prencipe, and Trombetta (2016) findings that auditors are increasingly conservative in the valuation of accruals over the tenure of the relationship.

Early models by Acemoglu and Gietzmann (1997) and Gietzmann and Sen (2002) consider the endogenous demand for auditing with and without mandatory rotation to provide incentive alignment in owner-manager contracting. Ye (2023) notes that proponents of MR assert that "a long-term relationship with a client creates familiarity threats and makes auditors complacent," and that MR serves to mitigate that threat. Lu and Sivaramakrihsnan (2009), Lu, Ruan, and Sivaramakrishnan (2025), and Dordzhieva (2022) all examine models of mandatory rotation. The models of Lu and Sivaramakrihsnan (2009) and Lu, Ruan, and Sivaramakrishnan (2025) are one-period models. While they examine the auditor/client interactions in the mandatory rotation setting, they do not explicitly address the multi-period nature of the auditor-client relationship. Dordzhieva (2022) compares a two-period model to an infinite horizon setting. The two-period model cannot address the decay in auditor incentives over time that we observe in our mandatory rotation setting. Bleibtreu and Stefani (2018) proposes an intricate model that examines MR when auditors have firm-specific expertise. Because their model does not *explicitly* include a tenure or MR multi-period timeline, their model is not directly tied to the issues we examine in this paper.

The remainder of the paper is organized as follows. Section 2 provides the models of negotiation and fraud detection that we assume in our SQ and MR settings and derives the form of reported accruals that we will compare across these settings and the equilibrium outcomes for the fraud component. Section 3 analyzes our SQ setting that does not assume any fixed end to the auditor-client relationship. Section 4 analyzes our MR setting and compares those results to results in the SQ setting. Section 5 provides a numerical example and examines the robustness of our model and results. Finally, section 6 provides a discussion of our results and our conclusions.

2. MODEL OF AUDITING

To compare auditing in the SQ setting and the MR setting, our paper examines a comprehensive model of auditing in each period that includes both the valuation and reporting of accrued expenses as well as the detection and deterrence of potential fraudulent misstatements, which are two essential components of every financial statement audit. In the first component, the auditor and client manager negotiate accrued expenses from a shared signal that reflects uncertainty. The auditor reviews and approves the client's assumptions, methods, and computations for routine valuation activities such as the appropriate computation of depreciation.[5] While this dimension of audit activity involves differences in preference over reported amounts, it generally reflects cooperative interaction between the two parties and comprises the larger portion of most audits. Because the client manager may be dishonest and realize an opportunity to engage in fraud (moral hazard), the second component of our audit

[5] We condense the routine valuation and reporting activities into a single choice of reported accruals under uncertainty. We believe this simplification faithfully represents the routine activities in the conduct of an audit.

model consists of fraud-detection activities. The possibility of the manager being dishonest and engaging in fraud occurs *stochastically*. The auditor is responsible for detecting fraud if it exists.

We analyze these two components separately and integrate the characterizations of the equilibrium negotiations from the first component and the equilibrium fraud costs and probabilities from the second component in our analysis of the SQ model without mandatory auditor rotation and in our MR model that assumes mandatory auditor rotation. In section 2.1, we model the auditor's valuation activities and the negotiation of accrued expenses between the auditor and client manager. In section 2.2, we add information asymmetry to the model and examine the auditor's responsibility for fraud detection if fraud is perpetrated. Discovered fraud is non-negotiable and the auditor must always report fraud if it is detected.[6] Finally, in section 2.3, we integrate the two components into a single comprehensive structure for the audit and for our analyses of the SQ and MR settings.

2.1 Negotiated accrued expenses

For this component of the auditor-client interaction, we assume that an unknowable true value x_i exists for accrued expenses, but that a conservative signal $y_i = x_i + e_i$ is common knowledge. e_i is not observable but is exponentially distributed $f(e_i) = \frac{1}{\mu} Exp\left[-\frac{e_i}{\mu}\right]$ in period i.[7] The signal is conservative relative to x_i since e_i is distributed over the positive real numbers with a mean of μ and a variance of μ^2. We refer to μ as the uncertainty parameter.

The idea underlying this valuation problem is that the auditor investigates and determines the value constructs and stochastic characteristics of these unknown future values. The auditor

[6] PCAOB AS 2401 / AU 316 (Consideration of Fraud in a Financial Statement Audit) mandates that if the auditor finds evidence of fraud, they must inform the appropriate level of management and the audit committee, regardless of materiality.
[7] This assumption simplifies our analysis and is commonly assumed in auditing models including Newman, Patterson, and Smith (2001) and Patterson, Smith, and Tiras (2022).

communicates her expert knowledge about these values to the client management. For simplicity, we label these values as accrued expenses.[8] The auditor and the client negotiate the report a_i to represent x_i. An unbiased estimate of x_i is computed as $y_i - \mu$.[9] We assume that the client manager prefers lower (less conservative) reported accruals. We model the negative of the accrual as a payoff to the client manager of $-\gamma a_i$ for reported accrued expenses of a_i and we assume that if the auditor and client manager are unable to agree upon a reported value, the client manager incurs an exogenous disagreement cost of $-q$ and the client will change auditors. In that event, the auditor will also incur an endogenous opportunity cost related to losing the client.[10] γ is a multiplier that characterizes the importance of the reported accrual relative to the "fixed" negative payoff if the two parties fail to agree. The payoff $-q$ could be characterized as a modified audit opinion or another consequence of a breakdown in negotiations.

Similar to Zhang (1999) and Antle and Nalebuff (1991), the auditor will incur a reputation cost proportionate to the squared difference between x_i and a_i, $r_i = \omega(x_i - a_i)^2 = \omega(y_i - e_i - a_i)^2$ where ω is a reputation cost multiplier that scales the auditor's reputation cost for each unit of error in the report.[11] Because we assume complete information for this component subgame, all players can compute the expected value of the auditor's reputation cost r_i in terms of the reported accruals a_i:[12]

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[8] We could consider accrued revenues or other valuations that are characterized by uncertainty. This restriction does not limit the applicability of our model to other types of accruals. We ignore, for this paper, financial assets because those assets have much more easily verified values.

[9] This fact is shown below in the solution to equation (4) if negotiation is not considered.

[10] The endogenous opportunity cost in period i will be denoted in this section as OC_i. This cost will differ across the two settings and will be further characterized in sections 3 and 4.

[11] Following Zhang (1999) and Antle and Nalebuff (1991), we refer to this cost generically as a reputation cost. Because the strategic incentives for the client-manager are uni-directional, this cost could also be interpreted as a litigation cost borne by the auditor with no loss of generality. Recall that the true value of x_i is estimated and is unknowable at the time of negotiation.

[12] Since e_i is identically distributed in each period with a constant parameter μ and since y_i is observable to all players, we suppress the subscript on y_i and e_i without loss of generality. a_i might *not* be the same each period, so we retain the subscript on that choice variable.

$$r_i = \int_o^\infty \omega(y - e - a_i)^2 f(e)de = \omega((y - a_i)^2 - 2(y - a_i)\mu + 2\mu^2). \quad (1)$$

If the auditor agrees to a_i, she avoids the opportunity cost of losing the client. This opportunity cost differs across our two settings and possibly across time. To compute the negotiated report, we denote the opportunity cost in the SQ setting in period i as OC_i^{SQ} and in the MR setting in period i as OC_i^{MR}. We specify the opportunity cost for each setting in future sections.

Because we do not restrict the nature of negotiation, we assume that the resolution of the negotiation is achieved consistently with the Nash Bargaining Solution (Nash 1950). Nash (1950) proves that a bargaining problem in which two parties must agree upon an outcome $n \in \mathbb{R}$ has one solution that satisfies the four axioms of (1) scale invariance, (2) symmetry, (3) Pareto optimality, and (4) independence from irrelevant alternatives. The driving axiom is that of Pareto optimality, which holds no alternative solution can make one party better off without harming the other party. The other three axioms relate to basic reasonableness issues. Note that the Nash Bargaining Solution only applies to bargaining problems with complete information, but Myerson (1984) and others have extended the concept to a broader set of problems.

The Nash Bargaining Solution will result in a reported value that maximizes the joint difference between agreement and disagreement payoffs for both parties. If the parties agree to a negotiated amount a_i in period i, the auditor has an expected payoff in (1) if the parties agree and the expected opportunity cost of OC_i if they disagree. Therefore, combining the auditor's and client-manager's expected payoffs, the Nash Bargaining Solution maximizes the following product with the choice of a_i:

$$E[AudMgr_i] = \left(OC_i - \omega((a_i - y)^2 + 2\mu(a_i - y) + 2\mu^2)\right)(q - \gamma a_i). \quad (2)$$

The value of a_i that maximizes (2) yields the equilibrium reported accrual amount provided in Proposition 1:[13]

Proposition 1:
The equilibrium reported accruals in each period i will be:

$$a_i^* = \frac{q}{3\gamma} + \frac{2(y-\mu)}{3} - \sqrt{\frac{OC_i}{3\omega} + \left(\frac{q}{3\gamma}\right)^2 + \frac{2q(\mu-y)}{9\gamma} + \frac{y^2-2y\mu-2\mu^2}{9}}. \tag{3}$$

(All proofs in appendix)

To evaluate how negotiation affects the reported accruals, we first compute the reported accruals without negotiation. In this case, the auditor's optimal report is that amount that minimizes the expected reputation costs in equation (1) in the absence of negotiation. The first-order condition of expected reputation costs in (1) with respect to reported accruals is:

$$\frac{dr_i}{da_i} = \frac{d\left(\omega\left((a_i-y)^2+2(a_i-y)\mu+2\mu^2\right)\right)}{da_i} = 2\omega(a_i - y + \mu) = 0. \tag{4}$$

The second-order condition is positive, so the value $a_i = y - \mu$ minimizes the expected reputation cost. We define the negotiated bias in period i as the difference between the negotiated report and the optimal report or $b_i = y - \mu - a_i$. Subtracting a_i from $y - \mu$ yields the reporting bias.

Corollary 1:
The bias in reported accruals in period i is the difference between the report computed in (3) and the report without negotiation.

$$b_i = -\frac{q}{3\gamma} + \frac{y-\mu}{3} + \frac{\sqrt{\omega\left(q^2\omega+2q\omega\gamma(-y+\mu)+\gamma^2\left(3OC_i+\omega(y^2-2y\mu-2\mu^2)\right)\right)}}{3\gamma\omega}. \tag{5}$$

The reported accruals affect audit fees through the expected reputation cost in each period r_i. We compute the expected reputation cost as a function of μ and b_i in Corollary 2.

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[13] As with most quadratics, there are two solutions to the first-order condition of the expression in (2) but only that in (3) satisfies the second-order condition.

Corollary 2:
The expected reputation cost related to reported accruals in period i is computed as:
$$r_i = \omega(\mu^2 + b_i^2). \tag{6}$$

Section 2.2 presents our model of fraud detection.

2.2 Fraud and fraud detection.

In this section, we add an asymmetric information component to our model.[14] We assume that, in addition to negotiating on the uncertainty of accruals in section 2.1, the auditor is expected to deter and detect fraudulent reporting by client management. To that end, we analyze a simple model of fraud that stochastically provides the client the opportunity and incentives to commit fraud and the auditor the technology and responsibility to detect fraud. In equilibrium, the client manager will perpetrate fraud as a mixed strategy. We construct this model to fit with the model of negotiation in section 2.1.

The point of the fraud-detection component of our model is that this branch of audit work is distinct in activity and in purpose from valuation uncertainty that can be negotiated. Fraud is non-negotiable and must be reported if detected. In that case, the audit engagement *does not* survive to the subsequent period.[15] We assume that the two key decisions made are whether to commit fraud (on the part of the client-manager) and what resources the auditor should direct toward fraud detection.

We assume that the client manager is dishonest and realizes an opportunity to commit fraud each period with probability θ.[16] We assume a fixed fraud amount f that will be

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[14] Information asymmetry can relate to hidden information or a hidden action. With binary information asymmetry, these are strategically equivalent. This relates to fraud detection because fraud is not technically the act of asset diversion. Fraud is the dishonest disclosure of the act.
[15] This assumption is consistent with Patterson, Smith, and Tiras (2019).
[16] While it is possible that this probability might *decrease* over time due to the auditor better understanding fraud risks, it is also possible, as was the case with ENRON, that the probability is low in early periods but then increases in later periods. Consistent with Patterson, Smith, and Tiras (2024), we consider this probability the risk of material misstatement arising from fraud.

committed by the manager with decision probability φ.[17] As a result, the expected fraud in a period is computed as $\theta\varphi f$ where $\varphi \in (0,1)$ is the mixed-strategy probability that the client-manager commits fraud. The auditor is assumed to have an exponential detection technology, similar to Smith, Tiras, and Vichitlekarn (2000) and Patterson, Smith, and Tiras (2019) given by $d[x] = 1 - e^{-x}$ at a cost of kx to the auditor.

The client manager benefits a fixed amount f for fraud that is perpetrated and not detected by the auditor. If perpetrated fraud is detected, the client manager incurs a penalty of q_f. If fraud is perpetrated and the auditor fails to detect it, she incurs a penalty of $\omega_f f$.[18] We assume that if fraud is not detected in a period, the penalty accrues but that the fraud and the accrued penalty are not publicly observable at the time.[19]

All periods are assumed identical in the fraud component of the model. Therefore, period designations are unnecessary. The auditor's fraud-related cost in each period is given by equation (7) below:

$$A_f^e = e^{-x} f \omega_f \theta \varphi + kx. \tag{7}$$

The first component of equation (7) is the auditor's expected penalty for undetected fraud. That is the probability $\theta\varphi$ that fraud is perpetrated times the disutility to the auditor (penalty) for undetected fraud $f\omega_f$ times the probability e^{-x} that fraud goes undetected. The

[17] Similar to Smith, Tiras, and Vichitlekarn (2000), we assume that the client choice of fraud is a stochastic choice of a fixed amount rather than a continuous amount. This assumption allows the fraud detection component of the model to be commensurate with the negotiation of uncertain accruals and avoids the issue of immaterial frauds.
[18] We distinguish between the auditor's penalty multiplier ω in the audit component in section 2.1 and ω_f in this section and the client-manager penalties q and q_f because these values affect equilibrium differently. Equilibrium reported accruals depend directly on ω and q, but depend on ω_f and q_f only through their effects on δ. Finally, we do not compute squared-error losses for the fraud component. This simplification is without loss of generality in the fraud component because the amount of fraud f is a fixed amount.
[19] This assumption is necessary because otherwise undetected fraud would signal that fraud *was perpetrated*. We believe this assumption is reasonable because frequently significant frauds go on for several periods before they are ultimately detected. Once a penalty is realized, the fraud is publicly observable and the engagement ends.

manager's fraud-related payoff in each period, which arises with the risk of material misstatement due to fraud θ is given by equation (8):[20]

$$M = \varphi\left(e^{-x}f - (1 - e^{-x})q_f\right). \tag{8}$$

Equation (8) is the probability that the manager perpetrates fraud φ times the expected benefit from undetected fraud $e^{-x}f$ less the expected penalty for detected fraud $(1 - e^{-x})q_f$.

The first-order condition for the auditor with respect to x is computed in (9):

$$\frac{dA_f^e}{dx} = -e^{-x}f\omega_f\theta\varphi + k = 0, \tag{9}$$

and the manager's expected payoff must be zero for him to choose any $\varphi \in (0,1)$.

The equilibrium choices for the auditor and the client manager for the fraud component of the model are provided in Proposition 2.

Proposition 2:
The manager's mixed-strategy choice of fraud (the probability that fraud is perpetrated) and the auditor's equilibrium choice of detection effort in the fraud component of the model in each period *i* are:

$$\varphi^* = \frac{k(q_f+f)}{\theta f q_f \omega_f} \text{ and} \tag{10}$$

$$x^* = \text{Log}\left(1 + \frac{f}{q_f}\right). \tag{11}$$

From our equilibrium, we provide two corollaries. The first is the expected equilibrium cost in each period *i* to the auditor of the fraud detection component of the audit. This expected equilibrium cost will be added to the auditor's costs in audit pricing.

Corollary 3:
The expected equilibrium cost to the auditor related to fraud in each period i is computed as:

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[20] See Patterson, Smith, and Tiras (2024) for a discussion of the risk of material misstatement due to fraud that characterizes this probability as the inherent risk that the client manager is dishonest multiplied by the probability that a fraud opportunity exists within the internal control structure of the firm.

$$A_f^e = k\left(1 + \text{Log}[1 + \frac{f}{q_f}]\right). \tag{12}$$

This cost includes the cost of audit effort kx plus the equilibrium cost of non-detection. This equilibrium cost to the auditor of the fraud component of the model combines the cost of audit effort $k\text{Log}[1 + \frac{f}{q_f}]$ with the equilibrium cost of fraud *nondetection*:

$\theta\varphi^*\omega_f f(1 - d[x^*]) = \frac{k(q_f+f)}{q_f}\left(\frac{q_f}{q_f+f}\right) = k$. The expected cost in (12) can be computed by all parties and can thus be included in the audit pricing for each period as the net cost of providing fraud detection services.

The second important computation is the probability that the sequence of audits will end abruptly with the detection of fraud. This probability is computed as the risk of material misstatement θ multiplied by the probability that the manager commits fraud in his mixed strategy choice φ and multiplied by the probability that the auditor detects fraud in her equilibrium choice of $d[x^*] = \frac{f}{q_f+f}$. Combining these probabilities, we obtain Corollary 4.

Corollary 4:
The expected equilibrium probability that fraud will be detected in a given period is computed as:

$$\Pr(DF) = \theta\varphi^* d[x^*] = \theta\frac{k(q_f+f)}{\theta f q_f \omega_f}\left(\frac{f}{q_f+f}\right) = \frac{k}{q_f\omega_f}. \tag{13}$$

This probability will serve as an input to the *ex-ante* probability that the engagement sequence will *not* survive to the subsequent period. One interesting point to note from Corollaries 3 and 4 is that neither the expected audit cost nor the equilibrium probability of detection depend on the risk of material misstatement θ. That is because the manager incorporates that probability in determining φ^* in (10) such that the effect of that risk is canceled. The probability in (13) will be used in discounting the series of expected profits from the continuing audit engagement in the SQ and MR settings.

Section 2.3 integrates the results of section 2.1 and section 2.2 into a comprehensive audit structure for both the negotiated accruals and fraud components that we employ for the remainder of the analysis.

2.3 Combined costs and probabilities from the two components of audit activity.

Proposition 1 provides the equilibrium audited accruals in each period as a function of the opportunity costs facing the auditor if the client terminates the audit. In section 2.1, that outcome never occurs. Because the focus is the negotiation of reported accruals using the Nash Bargaining Solution, agreement is always achieved. Of course, there is always a *possibility* that agreement is not achieved. That possibility is addressed in this section.

To construct multi-period models (either the SQ or the MR model), we must first define a discount factor. For expositional simplicity, we denote this factor as δ and it incorporates both time-value of money (TVM) considerations and the probability that the engagement survives the current period into an additional period. Denote ρ as the one-period time-value of money factor and χ_i as the probability that the engagement survives to period $i+1$. So, for period i, $\delta_i = \rho\chi_i$.

The probability that the engagement survives is the probability that the engagement survives the negotiation of accruals multiplied by the equilibrium probability that the auditor *does not* detect fraud. Because the negotiation of accruals using the Nash Bargaining Solution always results in an agreement, we assume that the probability of survival relative to the negotiation component is a constant (exogenous) value ξ. Using the probability of detected fraud in a period computed in Corollary 4, we can compute the value $\chi = \xi\left(1 - \frac{k}{q_f\omega_f}\right)$ which implies:

$$\delta = \rho\xi\left(1 - \frac{k}{q_f\omega_f}\right), \tag{14}$$

that is constant from period to period.[21]

The audit fees in a given period will include all costs incurred by the auditor, including audit effort and expected reputation costs for the negotiated accrual component of the audit that will be derived in sections 3 and 4. They will also include the net audit costs in equation (12). Corollary 5 provides some useful intermediate comparative static results.

Corollary 5:
The following table characterizes the changes in ρ, ξ, k, f, q_f, ω_f, and θ on the equilibrium values of x^*, φ^*, δ and A_f^e.

	Change in equilibrium value of:			
Increases in parameter	Equilibrium audit effort x^*	Equilibrium manager choice of fraud φ^*	Endogenous discount factor δ	Equilibrium fraud auditing costs A_f^e
ρ	0	0	+	0
ξ	0	0	+	0
k	0	+	-	+
f	+	-	0	+
q_f	-	-	+	-
ω_f	0	-	+	0
θ	0	-	0	0

While these comparative statics are straightforward implications of our equilibrium outcomes in equations (10), (11), (12), (13), and (14), the most important result, that we will

[21] Note that we can suppress the subscript i in (14) because each period is independent and identical.

exploit in our next two sections, is that increases in the unit cost of audit effort k induces decreases in the comprehensive discount factor δ. This result implies that an increased cost of fraud detection decreases the expected future benefits in multi-period audit engagements. We next consider the SQ setting without mandatory auditor rotation in section 3.[22]

3. STATUS QUO (SQ) SETTING WITHOUT MANDATORY AUDITOR ROTATION

In the SQ setting, we employ an infinite-horizon model of one-period auditor-client engagements.[23] The model begins with the price competition of non-incumbent auditors vying for the engagement with the client firm at $t = 0$. As in DeAngelo (1981), Magee and Tseng (1990), and Zhang (1999), we assume that the auditor proposes a fee at time $t = 0$, F_0^{SQ} with the anticipation that if she obtains the engagement, she can earn excess profits in subsequent periods. The market for audit services is competitive, and the non-incumbent auditor bids a fee to break even in discounted expected present value. The incumbent auditor bids the maximum F_i^{SQ} in future periods so that a potential entrant cannot under-bid the incumbent.

The variable δ characterized in (14) is a constant period-to-period discount factor that incorporates both time value of money considerations and the probability that the relationship will end with the current period, including the probability that fraud is perpetrated and detected in the period. At each point in time i the expected future profits for an incumbent auditor will be

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[22] We will use superscripts SQ for status-quo and MR for mandatory auditor rotation to identify the setting when comparing these metrics in future sections. These superscripts will be employed whenever a parameter or variable might differ across the two settings.

[23] Zhang (1999) also embeds the bargaining game in an infinite series of plays such that, in each period, there is a non-zero fixed probability that the game ends. But our model differs significantly from Zhang (1999) because Zhang (1999) assumes that there is no strategic end to the series of plays. Rather, Zhang (1999) assumes implicitly that the game continues indefinitely if the parties disagree but that the auditor is penalized for disagreement. The importance of this distinction is that our model explicitly integrates separate audit issues related to the negotiation of uncertainty and the detection of fraud (information asymmetry). The Zhang (1999) model, which examines bargaining over information asymmetry cannot be applied to our view of the audit.

the infinite sum of the audit fees for the period less the costs in that period, discounted perpetually with the discount factor δ.[24]

In each period i, the auditor incurs a valuation cost for accruals of v, an expected cost of the fraud component of A_f^e, and a reputation cost r_i related to the equilibrium understatement of accrued expenses. In addition, we assume that in the first period of the engagement, the auditor incurs a learning cost ℓ. Finally, we assume that if the client chooses, for whatever reason, to switch auditors, the client will incur auditor switching costs of c. The costs v, ℓ, and c are exogenous and are assumed to be constant over time. Similar costs are assumed in Magee and Tseng (1990) and in Zhang (1999). The expected fraud-component auditing cost of A_f^e is endogenous but because the structure of the fraud detection component is identical each period, this value is also constant over time. The reputation cost in period i is period-dependent and results from the period-specific negotiation of accrued expenses. Combining these costs, we denote the costs in period i as:

$$C_1^{SQ} = v + \ell + A_f^e + r_1^{SQ} \text{ for } i = 1 \text{ and}$$
$$C_i^{SQ} = v + A_f^e + r_i^{SQ} \text{ for } i > 1. \qquad (15)$$

Because we assume complete information for the valuation component, all expected costs C_i^{SQ} are priced into the audit fee bid each period.[25]

Audit fees in the SQ *setting.*

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[24] Recall that $\delta = \rho\xi\left(1 - \frac{k}{q_f\omega_f}\right)$ from (14). This comprehensive discount factor incorporates the equilibrium probability that fraud is *not* detected in the current period.

[25] The client firm that hires the auditor (the audit committee) is distinct from the client manager in purview and in preferences. The client manager will prefer lower reported accruals as we model in section 2 and these reported accruals involve negotiation between the auditor and the client manager. We assume that the audit committee does not interact with the auditor on this level. The audit committee in our model is an automaton that hires the auditor based upon audit fees. We assume that all audit costs, including the auditor's expected reputation costs, are priced into the audit fee.

We now explain the details of the dynamic pricing model. We will denote the audit fees in period i by F_{i-1}^{SQ} because the auditor must bid for the engagement *prior* to the beginning of the period. At the beginning of the time horizon, there is no incumbent auditor. All auditors will bid: $F_0^{SQ} = F_1^{SQ} - c$ so that:

$$F_0^{SQ} - C_1^{SQ} - S^{SQ} = 0. \tag{16}$$

S^{SQ} is the discounted expected future profits from being an incumbent auditor at $t = 2$ and, similar to Magee and Tseng (1990) and Zhang (1999), represents the amount of lowballing in the initial audit period. S^{SQ} is computed as:

$$S^{SQ} = \sum_{i=2}^{\infty} \delta^{i-1}\left(F_i^{SQ} - C_i^{SQ}\right). \tag{17}$$

We combine (15), (16) and (17) to obtain (18):[26]

$$F_0^{SQ} = v + \ell + A_f^e + r_1^{SQ} - S^{SQ}$$

and, for $i \geq 1$,

$$F_i^{SQ} = v + \ell + c + A_f^e + r_{i+1}^{SQ} - S^{SQ}. \tag{18}$$

The expected auditor profit in the SQ setting in period i is:

$$\Pi_1^{SQ} = F_0^{SQ} - C_1^{SQ} = v + \ell + A_f^e + r_1^{SQ} - S^{SQ} - \left(v + \ell + A_f^e + r_1^{SQ}\right) = -S^{SQ} < 0$$

for $i = 1$ and

$$\Pi_i^{SQ} = F_{i-1}^{SQ} - C_i^{SQ} = v + \ell + A_f^e + c + r_i^{SQ} - S^{SQ} - \left(v + A_f^e + r_i^{SQ}\right) = (\ell + c - S^{SQ}) > 0$$

for $i > 1$. (19)

The sum of discounted expected profits from $i = 2$ to infinity is:

$$S^{SQ} = \sum_{k=2}^{\infty} \delta^k \Pi_k^{SQ} = \sum_{k=2}^{\infty} \delta^k (\ell + c - S^{SQ}) = \delta(\ell + c). \tag{20}$$

[26] S^{SQ} is the infinite sum of discounted expected profits if potential entrants always bid F_0^{SQ} and incumbents always bid the potential entrant bid plus the switching cost c. We assume that the current reputation cost is always included in the bid and the agreed upon fee since the component interaction has complete information.

This is the expected future benefit that the auditor stands to lose if the client switches to another auditor at time $t = 2$. Since the horizon is always infinite in the SQ setting, we know that the opportunity cost in the SQ setting, which we denote OC_i^{SQ} will always be equal to $S^{SQ} = \delta(\ell + c)$ over all periods. Also note, that $\Pi_1^{SQ} + OC_1^{SQ} = \Pi_1^{SQ} + S^{SQ} = 0$ which is the condition expressed in (16).

Substituting OC_i^{SQ} into (3) and (5), we obtain:

$$a_i^{SQ} = \frac{q}{3\gamma} + \frac{2(y-\mu)}{3} - \sqrt{\frac{\delta(\ell+c)}{3\omega} + \left(\frac{q}{3\gamma}\right)^2 + \frac{2q(\mu-y)}{9\gamma} + \frac{y^2-2y\mu-2\mu^2}{9}} \tag{21}$$

and

$$b_i^{SQ} = -\frac{q}{3\gamma} + \frac{y-\mu}{3} + \frac{\sqrt{\omega\left(q^2\omega+2q\omega\gamma(-y+\mu)+\gamma^2\left(\delta(\ell+c)+\omega(y^2-2y\mu-2\mu^2)\right)\right)}}{3\gamma\omega}. \tag{22}$$

Note that a_i^{SQ} and b_i^{SQ} in (21) and (22) are independent of the period i. These values are the same over the entire horizon. Before examining the characteristics of the setting, we combine (18) with equation (6) from Corollary 2, to obtain:

$$F_0^{SQ} = v + A_f^e + (1-\delta)\ell - \delta c + \omega\mu^2 + \omega\left(b_1^{SQ}\right)^2 = v + A_f^e + \ell + \omega\mu^2 + \omega\left(b_1^{SQ}\right)^2 - S^{SQ} \tag{23}$$

and

$$F_i^{SQ} = v + A_f^e + (1-\delta)(\ell + c) + \omega\mu^2 + \omega\left(b_i^{SQ}\right)^2 \text{ for } i > 0. \tag{24}$$

We now characterize some comparative static analyses for the SQ setting in Proposition 3.

Proposition 3:
The following comparative static results are derived for bias and audit fees in the SQ setting. These results relate only to parameters in the valuation component of the analysis. Results related to parameters in the fraud component of the analysis are provided in Corollary 6 below.

1. Bias b_i^{SQ} in the SQ setting:
    a. decreases in the auditor's reputation multiplier ω, the manager's disagreement cost q, and the uncertainty parameter μ;
    b. increases in the auditor's learning cost ℓ, the client's switching cost c, the client's preference parameter for lower reported accruals γ, the probability of survival relative to the negotiation component ξ and the discount factor ρ.
2. Audit fees F_i^{SQ} in the SQ setting:

a. increase in the auditor's learning cost ℓ, the client's switching cost c, and the client's preference parameter for lower reported accruals γ;
b. decrease in the manager's disagreement cost q, the probability of survival relative to the negotiation component ξ and the discount factor ρ;
c. may increase *or* decrease in the auditor's reputation multiplier ω and the uncertainty parameter μ;
d. are initially less in period 1, before the client faces switching costs for the relationship but increase by the switching costs c in period 2 and remain constant for the remainder of the auditor's tenure.

The auditor's learning cost ℓ, the client's switching cost c, and the client's preference parameter for lower reported accruals γ all provide more incentives for increased bias. The auditor's opportunity cost for losing the client increases in ℓ and c. So, these parameters drive the auditor to negotiate lower reported accruals. Increases in these two parameters induce direct increases in audit fees and further induce increases in audit fees because they increase expected reputation costs. Increases in the client's preference for lower reported accruals γ have no direct effect on audit fees. But increases in γ increase bias and the expected reputation cost. That increase in expected reputation costs then increases audit fees.

The manager's parameter q for failing to reach agreement unambiguously decreases bias. And audit fees unambiguously increase in the amount of bias, so increases in q decrease audit fees.

The parameters ω and μ affect the auditor's reputation cost directly but have no direct effect on audit fees. The effect of increases in these two parameters on audit fees is driven only by the effect on reputation costs. Because increases in these two parameters increase the cost related to negotiated bias, they both induce decreases in negotiated bias which would decrease expected reputation costs. But the indirect effect of a decrease in negotiated bias on expected reputation costs and audit fees is offset by the direct effect that increases in ω and μ have on reputation costs related to reported accruals: $r_i^{SQ} = \omega(\mu^2 + (b_i^{SQ})^2)$. As a result, the overall effect is indeterminate and must be evaluated empirically. We discuss this issue in more depth in our numerical analysis in section 5.

Finally, when viewed as a parameter, increases in the discount parameter δ have a decreasing direct effect on audit fees and an increasing indirect effect on reputation costs through the effect on bias. But we can sign this derivative. As long as b_i^{SQ} is positive, the direct effect of $\frac{\partial F_i^{SQ}}{\partial \delta} < 0$ overwhelms the indirect effect of $\frac{\partial F_i^{SQ}}{\partial b_i^{SQ}}\left(\frac{\partial b_i^{SQ}}{\partial \delta}\right) > 0$ so that $\frac{dF_i^{SQ}}{d\delta} < 0$.[27] In the negotiation component of the model, δ increases in the time-value of money parameter ρ and the exogenous (non-strategic) probability that the engagement survives from period to period ξ. So, increases in ρ and ξ increase b_i^{SQ} and decrease F_i^{SQ}.

But, δ also increases in the probability that *no fraud* is detected in the current period. We can evaluate changes in b_i^{SQ} resulting from changes in parameters in the fraud component using the chain rule. The effects of changes in the parameters in the fraud component of the audit then affect bias through their effects on δ as characterized in Corollary 5. Audit fees will be affected directly by changes in A_f^e and indirectly by changes in δ. The effects of changes in audit component parameters on bias and audit fees are provided in Corollary 6.

Corollary 6:
Bias $\left(b_i^{SQ}\right)$ and audit fees $\left(F_i^{SQ}\right)$ in the SQ setting are affected by parameters in the fraud component of the model as follows:

- b_i^{SQ} increases in f, q_f, and ω_f and decreases in *k*.
- F_i^{SQ} increases in k and f, and decreases in q_f and ω_f.

Bias is not affected by audit fees but increases in δ. So effects on bias from the fraud component parameters will be the same as the effect on δ in Corollary 5. F_i^{SQ} increases in A_f^e and

[27] If $q > \gamma(y - \mu)$, then $b_i > 0$ unless $\omega\mu^2 > \delta(\ell + c)$. We discuss the robustness of our results in section 5.

decreases in δ. Increases in k increase A_f^e and decrease δ. Both effects increase F_i^{SQ}. Conversely, increases in q_f decrease A_f^e and increase δ and both effects decrease F_i^{SQ}. Increases in ω_f increase δ but do not affect A_f^e. So, increases in ω_f decrease F_i^{SQ}. Increases in f do not affect δ but increase A_f^e. As a result, increases in f also increase F_i^{SQ}.

Section 4 examines a modification of the model in section 3 with mandatory rotation. The fundamental difference in section 4 is that the multi-period interaction between an incumbent auditor and the client must not exceed N periods, where N is a finite number.

4. SETTING WITH MANDATORY AUDITOR ROTATION (MR)

For our mandatory auditor rotation (MR) setting, the infinite horizon model no longer applies because the auditor-client tenure can last at most *N* periods with mandatory rotation. And while the dynamic programming model of Magee and Tseng (1990) employs a finite end of the auditor's tenure on or before the end of N periods, Magee and Tseng (1990) also assumes that the client's business ends after *N* periods. To model mandatory rotation, we must assume that the client's business is a going concern and continues indefinitely, but that the tenure relationship is at most *N* periods. We modify our model using these constructs.

We assume a finite N-period horizon of one-period engagements, beginning with the price competition of non-incumbent auditors vying for the engagement with the client firm at $t = 0$. The auditor again earns zero profits over the N-period horizon and the period-to-period discount rate of δ continues to incorporate both time value of money considerations and the exogenous probability that the tenure ends unexpectedly in the current period. A non-incumbent auditor may bid in any period to break even in expected discounted profits over an N-period horizon.

In section 3, the auditor chooses the same bias each period and, as a result, incurs the same expected reputation cost, $r_i^{SQ} = \omega\left(\mu^2 + \left(b_i^{SQ}\right)^2\right)$ where b_i^{SQ} is computed in (22) and is the same each period. Because b_i^{MR} is not the same each period, r_i^{MR} will also differ across periods.[28]

The equilibrium pricing condition in (16) for the SQ setting is, for the MR setting:

$$F_0^{MR} - C_1^{MR} + S^{MR} = 0.^{29} \tag{25}$$

The zero-profit condition in the MR setting is:

$$Bid^e - (v + \ell + A_F^e) + S^{MR} - r_1^{MR} = 0. \tag{26}$$

Equation (26) implies the following:

$$F_0^{MR} = Bid^e = v + \ell + A_F^e - S^{MR} + r_1^{\mathrm{MR}} \text{ and} \tag{27}$$
$$F_i^{MR} = v + \ell + A_F^e + c - S^{MR} + r_{i+1}^{MR} \text{ for } i \geq 1, \tag{28}$$
where
$$S^{MR} = (\ell + c)\frac{(\delta - \delta^N)}{(1 - \delta^N)}. \tag{29}$$

Using (27), (28), and (29), we compute the profit in period *i* as:

$$\Pi_1^{\mathrm{MR}} = -S^{MR} = -(\ell + c)\frac{(\delta - \delta^N)}{(1 - \delta^N)} \text{ for } i = 1 \text{ and} \tag{30}$$
$$\Pi_i^{\mathrm{MR}} = (\ell + c) - S^{MR} = (\ell + c)\frac{(1 - \delta)}{(1 - \delta^N)} \text{ for } i \in \{2, N\}. \tag{31}$$

We now turn to the opportunity cost for the MR setting. The opportunity cost at time *i* is the sum of discounted expected profits from time $i \geq 2$ to N or:

$$OC_i^{\mathrm{MR}} = \sum_{k=1}^{N-i} \delta^k (\ell + c)\frac{(1 - \delta)}{(1 - \delta^N)} = (\ell + c)\frac{(\delta - \delta^{N+1-i})}{(1 - \delta^N)}. \tag{32}$$

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[28] We make a simplifying assumption for the fees in the MR setting for tractability reasons. We assume that the reputation costs r_i^{MR} incurred in periods $i > 1$ are priced into the audit fees rather than the reputation costs that would be priced-in for a potential entrant. Without this assumption, closed-form solutions do not exist in the MR setting. We have examined the audit pricing issue in the MR setting without this simplification and find that the results are generally unaffected but require substantially more complex exposition. Details are available from the authors.

[29] Similar to S^{SQ} in section 3, S^{MR} refers to the discounted expected future profits in the MR setting at $t = 2$.

Because $\frac{(\delta-\delta^{N+1-i})}{(1-\delta^N)}$ is less than δ, we know that $OC_i^{MR} < OC_i^{SQ}$ for all $i \geq 1$. And after the first period, OC_i^{MR} decreases each period and then, in period N, $OC_N^{\mathrm{MR}} = 0$.[30]

Negotiation in the MR setting is the same as in the SQ setting except that the opportunity cost changes from $\delta(\ell + c)$ in the SQ setting to $\frac{(\delta-\delta^{N+1-i})}{(1-\delta^N)}(\ell + c)$ in the MR setting for periods $i \in \{1, N-1\}$.

Substituting (32) into (3) and (5) we obtain:

$$a_i^{MR} = \frac{q}{3\gamma} + \frac{2(y-\mu)}{3} - \sqrt{\frac{q^2}{9\gamma^2} - \frac{2q(y-\mu)}{9\gamma} + \frac{(y^2-2y\mu-2\mu^2)}{9} + \frac{(\ell+c)(\delta-\delta^{N+1-i})}{3\omega(1-\delta^N)}} \quad (33)$$

and

$$b_i^{MR} = \frac{y-\mu}{3} - \frac{q}{3\gamma} + \sqrt{\frac{q^2}{9\gamma^2} - \frac{2q(y-\mu)}{9\gamma} + \frac{(y^2-2y\mu-2\mu^2)}{9} + \frac{(\ell+c)(\delta-\delta^{N+1-i})}{3\omega(1-\delta^N)}}. \quad (34)$$

Because $\delta < 1$, $\frac{(\delta-\delta^{N+1-i})}{(1-\delta^N)}(\ell + c) < \delta(\ell + c)$ and $\frac{(\delta-\delta^{N-i})}{(1-\delta^N)}(\ell + c) < \frac{(\delta-\delta^{N+1-i})}{(1-\delta^N)}(\ell + c)$. So, the opportunity cost in the MR setting in periods $i \in \{2, N-1\}$ is less than the corresponding opportunity cost in the SQ setting and the opportunity cost in the MR setting decreases each subsequent period in the MR setting. This implies that the negotiated bias $b_i^{MR} < b_i^{SQ}$ for all $i > 1$. The implications of these facts are formalized in Proposition 4.

Proposition 4:

(1) Negotiated bias b_i^{MR} in the MR setting:
  a. is less than in the SQ setting for every period;
  b. is always less in period $i+1$ than in period i; and
  c. will be zero on or before period *N* and when it becomes zero before period *N*, and negotiated bias will remain zero through period *N*.

(2) Audit fees F_i^{MR} in the MR setting are initially higher in period 1 in the MR setting than in the SQ setting but decrease from period 2 through N only in the MR setting.

[30] It is possible that b_i^{MR} decreases to zero *before* period N. We discuss this possibility in section 5.

The results (1)a and (1)b are straight-forward implications of the fact that $OC_i^{MR} < \delta(\ell + c)$ and OC_i^{MR} decreases in i. (1)c results from the fact that there is zero opportunity cost in period *N*. Because the opportunity costs are decreasing in *i*, it is likely that reporting bias, b_i^{MR}, will decrease to zero *before* period *N*.

Result (2) reflects the fact that the initial opportunity cost is higher in the SQ setting than in the MR setting because $\delta > \frac{\delta-\delta^N}{1-\delta^N}$ and that the difference in initial opportunity cost is greater than the difference in reputation costs: $r_1^{SQ} > r_1^{MR}$. The difference in initial bids in the MR setting relative to the SQ setting is equal to the difference in opportunity costs: $OC_1^{SQ} - OC_1^{MR} > 0$.

Our next result extends Proposition 4 to consider the structural difference of the two settings in Proposition 5. These results depend on the number of periods N prior to mandatory rotation. The comparative-static effects of fraud component variables are identical in sign for b_i^{MR} and F_i^{MR} as they were for b_i^{SQ} and F_i^{SQ}, but of course, the magnitudes of the derivatives are different. We will extend our discussion of these differences in Corollary 7 after Proposition 5.

Proposition 5:
(1) The initial fees and first-period bias in the MR setting converge to the initial fees and first-period bias in the SQ setting as N approaches infinity.
(2) After the initial period, as N approaches infinity, both bias and audit fees in the MR setting diverge from bias and audit fees, respectively, in the SQ setting.
(3) There exist values $N^* > 1$ and $i_N < N$ such that the fees in the MR setting are greater than the fees in the SQ setting for $i \leq i_N$ and the fees in the MR setting are less than the fees in the SQ setting for $i > i_N$ if and only if $N \geq N^*$. The critical value of N^* is:

$$N^* = Log\left[\frac{\left(b_i^{SQ}\right)^2}{\left(b_i^{SQ}\right)^2 + (c+\ell)(1-\delta)}\right] / Log[\delta].$$

As N approaches infinity, the opportunity cost in period 1 (S^{MR}) in the MR setting converges to the opportunity cost in the SQ setting (S^{SQ}). So the initial fees will converge and the first-period bias will converge. However, because the bias and fees will always decrease over time in the MR setting but not in the SQ setting, the bias and fees do not converge in larger values of *N* in subsequent periods.

Let N refer to the number of periods prior to mandatory rotation in the MR setting. Result (3) implies that the fee curves cross and fees in the MR setting are less than fees in the SQ setting for all periods $i > i_N$. The cutoff i_N depends on N and the cutoff only exists if N is sufficiently large (greater than N^*).

To understand how the fraud component affects the relationship between the SQ and MR setting outcome metrics, we will rely on the effect of a single parameter k on those metrics. The parameter k has the benefit of characterizing the fraud-detection technology and the probability that fraud is committed and detected in a period. As k increases, fraud detection becomes more expensive and the equilibrium probability that fraud is detected decreases.[31] The probability that the engagement survives to the subsequent period δ is computed in (14) as $\rho\xi(1 - \Pr(DF))$ where $\Pr(DF)$ is characterized in (13). The equilibrium probability that fraud is perpetrated and detected in our fraud component affects our outcomes *only* through δ. The auditor cost A_f^e does not affect these metrics because it is computable by all parties and is priced into the audit fees. $\Pr(DF)$ increases unambiguously in k and Corollary 5 provides that $\frac{d\delta}{dk} < 0$. So δ decreases in k. We provide the differential comparative-static implications of the fraud component of the model in Corollary 7.

Corollary 7:
The relationship between the comparative-static implications of changes in k on the relationships between S^{SQ} and S^{MR}, b_i^{SQ} and b_i^{MR}, and F_i^{SQ} and F_i^{MR} are:

1. The lowballing factors S^{SQ} and S^{MR} both decrease as the fraud detection coefficient k increases. The decrease in S^{SQ} as k increases is greater than that in S^{MR}: $-\frac{dS^{SQ}}{dk} + \frac{dS^{MR}}{dk} > 0$.

[31] We could instead use q_f or ω_f as our focus parameter. All derivatives with respect to f would have the same sign as those with respect to k and all derivatives with respect to q_f or ω_f would have the opposite sign.

2. Negotiated bias (and, therefore expected reputation costs from negotiation) decrease in k in both settings. The decrease in bias as k increases is greater in the SQ setting than in the MR setting: $-\frac{db_i^{SQ}}{dk}+\frac{db_i^{MR}}{dk}>0$. And because b_i^{SQ} is constant over i and b_i^{MR} decreases over i, the difference increases over i *and* k.
3. The differential effect of changes in k on audit fees F_i^{SQ} and F_i^{MR} cannot be signed. The lowballing effect induces greater fee decreases in F_i^{SQ} than in F_i^{MR} and the increase in fees due to the reputation effect of negotiation bias, driven by $\omega\left(b_i^{SQ}\right)^2$ and $\omega(b_i^{MR})^2$, is greater in the SQ setting. One effect decreases relative fees and the other increases.

Part 1 results because the differences in derivatives of the lowballing factors $\frac{d(S^{SQ}-S^{MR})}{d\delta}$ reflect the derivatives of the opportunity costs in the first period of losing future economic rents in the SQ and MR settings characterized in (20) and (29). The opportunity cost in the SQ setting is always greater and is constant with respect to δ. The opportunity cost in the MR setting is lower and is decreasing in δ. The comparative static results in part 2 relate to the equilibrium bias in the two settings. Again, the differences in the bias results arises from the difference in the opportunity costs and the effect of δ on these costs. And the effect of k on these metrics results from the result in Corollary 5 that $\frac{d\delta}{dk}<0$.

The fee effects cannot be signed because the fee subtracts the lowballing factor each period and adds ω times the square of the equilibrium bias. These effects work in opposite directions and are not computationally additive, so we cannot sign the resulting changes. We make some observations about fees in our numerical examples that may be helpful to future experimental or archival research on audit fees.

In the next section, we examine some robustness issues related to negotiation, and we provide a numerical example to illustrate our results.

5. NUMERICAL EXAMPLE AND ROBUSTNESS ISSUES.

In this section, we examine a numerical example to illustrate the characteristics of our models. We first examine the SQ setting and then compare it to the MR setting to illustrate the different structures of the two settings. We also examine robustness issues of our modeling.

We begin our numerical example ignoring the fraud component of the model. Because the fraud component only affects the interaction by changing the comprehensive discount factor δ that depends on the probability that the engagement survives to the subsequent period. We initially ignore the fraud component by fixing $\delta = .9$.

Consider first the SQ setting with no mandatory auditor rotation. For our numerical example, we assume the following parameter values for the negotiation of reported accruals:

ω	q	y	ℓ	c	μ	γ	δ	v	N for MR setting
1	500	225	4,000	4,000	40	2	.9	2,000	15

For these parameters, in the SQ setting, the bias in accruals $b_i^{SQ} = 26.67$ in every period and, for each period after the first, the audit fee is $\mathrm{F}_{\mathrm{i}}^{\mathrm{SQ}} = v + (\ell + c)(1-\delta) + \omega\left(\mu^2 + \left(b_i^{SQ}\right)^2\right) = 5111.11$ and the fee in the first period is $F_0^{SQ} = \mathrm{F}_{\mathrm{i}}^{\mathrm{SQ}} - c = 1111.11$. The auditor's profit in the first period of the SQ setting is $\Pi_1^{SQ} = -\delta(\ell + c) = -7200 < 0$ because she lowballs the initial bid in order to obtain the initial engagement. Her discounted expected profit is $(\ell + c)(1 - \delta) = 800$ each period after the first. The discounted present value of this series of cash flows is $S^{SQ} = \sum_{k=1}^{\infty} \delta^k (\ell + c)(1-\delta) = \delta(\ell + c) = 7200$ which satisfies the zero-profit constraint in (16).

In the MR setting, the reported bias depends upon the period. In period 1, the expected bias is $b_1^{MR} = 25.95$ which is less than $b_1^{SQ} = 26.67$ because the period 1 opportunity cost of the SQ setting (7200) is greater than that of the MR setting $S_1^{MR} = (\ell + c)\frac{\delta - \delta^N}{1-\delta^N} = 6992.58$. The initial audit fees for our example are 1111.11 for the SQ setting and 1280.62 for the MR setting. The difference ($F_0^{MR} - F_0^{SQ} = 169.51 = S^{SQ} - S^{MR} - (r^{SQ} - r_1^{MR}) = 7200 - 6992.58 - (2311.11 - 2273.2)$. In period 2, the audit fees in both settings increase by the switching costs of 4000, but the increase in the MR setting is mitigated by the decrease in reputation costs in the MR setting of $r_1^{MR} - r_2^{MR} = 41.56$. So, the difference in audit fees decreases in the second period to 127.94. Bias in the MR setting decreases from 25.95 in period 1 to 25.13 in period 2.

Bias in the SQ setting remains constant at 26.67 for all periods but decreases in each period in the MR setting. Because the opportunity cost in period *N* is always zero in the MR setting, $b_N^{MR} = 0$. In proposition 3, we show analytically that the audit fees are greater in the MR setting than in the SQ setting in period 1 and that in period N, the audit fees are greater in the SQ setting (for sufficiently large *N*). It is possible that the bias is zero in some period $i < N$ and that the audit fees in the MR setting are constant from that period until period N since the reputation cost is constant. For our example, this result obtains for periods 14 and 15. In period 13, $b_{13}^{MR} = .92$ and $r_{13}^{MR} = 1600.85$. So $F_{12}^{MR} = c + \ell + v - S + r_{13}^{MR} = 4646.21$. For periods 14 and 15, $b_{14}^{MR} = b_{15}^{MR} = 0$. So, $r_{14}^{MR} = r_{15}^{MR} = \omega\mu^2 = 1600$ and $F_{14}^{MR} = F_{15}^{MR} = 4607.42$. The fees in the MR setting decrease monotonically in *i* and the MR setting in our example has a fee lower than in the SQ setting for all periods from 5 to 15. In period 5, the fee in the MR setting is $F_4^{MR} =$

$5090.31 = \ell + c + v - S + r_5^{MR}$.[32] The comparisons of the biases and the fees are illustrated in Figure 1. We find $b_i^{SQ} > b_i^{MR}$ for all periods and that $b_{i+1}^{MR} \leq b_i^{MR}$ for all $i < N$.

****
Insert Figure 1 about here
****

The audit fees in our example increase in ω and they increase in μ after a small initial decrease.[33] This is because audit fees are only affected by changes in ω and in μ through the change in expected reputation costs, r^{SQ} and r_i^{MR}. The effect of changes in ω and μ on audit fees are illustrated in Panels A and B of Figure 2.

****
Insert Figure 2 about here
****

Panel A of Figure 2 shows the fees in the SQ setting (the solid curve) and in the MR setting (the dashed curve) while holding ω constant at $\omega = 1.0$ over the range of $\mu \in [5,40]$. We compare the fees in the MR setting to the fees in the SQ setting across two different periods (period 1 and period 7).[34] The fees in the first period of the MR setting are greater than the fees in the SQ setting for all values of μ in Panel A and the fees in period 7 of the MR setting are less. Panel B of Figure 2 shows the fees in the SQ setting (the solid curve) and in the MR setting (the dashed curve) while holding μ constant at $\mu = 40$ over the range of $\omega \in [.6,1.8]$. Fees and expected reputation costs increase as ω increases and again we find $F_1^{MR} > F^{SQ} > F_7^{MR}$. Fees

[32] Proposition 5 (point 3) states that this result requires a sufficiently long rotation horizon ($N = 15$ in this example). If $N = 7$, for example, this result would not obtain and $F_i^{MR} > F_i^{SQ}$ for all i.

[33] As a function of μ, the fees initially decrease for smaller values of μ but then increase. The reason for this effect is that expected reputation costs are quadratic (parabolic) in μ and b. They initially decrease in μ because b decreases in μ and for smaller values of μ this effect dominates. But for larger values of μ, the direct effect of $\omega\mu^2$ dominates.

[34] We choose period 7 because (1) fees cross *before* period 7 in our example and (2) it approximates the mid-point of the auditor's MR rotation period.

and expected reputation costs follow the same pattern because fees only differ from expected reputation costs by a constant.

Before examining the impact of the fraud component, we examine the robustness of our negotiation equilibrium across the two settings. The parametric plot in Figure 3 shows how the constraint of $\delta(\ell + c) > \omega\mu^2$ in the SQ setting and $\frac{\delta-\delta^{N-i+1}}{1-\delta^N}(\ell + c) > \omega\mu^2$ in the MR setting relate across values of μ, ω, and i.

****
Insert Figure 3 about here
****

The figure illustrates five regions. The top-right region (labeled SQ) represents the values of μ and ω for which no negotiation will occur in either setting. The opportunity cost in this region is insufficiently large to motivate the auditor and client to negotiate. Every $\{\mu, \omega\}$ pair below this boundary yields negotiation in the SQ setting but not necessarily in the MR setting. The small region just below the SQ boundary represents the region for which there is negotiation in period 1 in the MR setting. That region is only slightly more restrictive than the SQ setting boundary. But the negotiation region gets smaller and smaller each period in the MR setting and at some point, on or before the last period, negotiation will not occur.

We now consider the fraud component of the model. We assume the following parameter values for the analysis in section 2.2:

ξ	q_f	f	ρ	θ	k
.98	500	1,000	.95	.2	2 or 5

We consider two distinct values for k so that we can examine the effect of the fraud game on negotiation and mandatory rotation. Assume first that $k = 2$. The fraud detection equilibrium

(Proposition 2) would be evaluated as follows. The manager is inclined toward fraud and recognizes an opportunity to commit fraud with joint probability $\theta = .2$.[35] In equilibrium, the manager commits fraud with probability $\phi^* = \frac{k(q_f+f)}{\theta f q_f \omega_f} = \frac{2(500+1{,}000)}{.2*500*1{,}000*1} = .03$ and the auditor chooses $x = Log[3] = 1.09861$ and detects fraud with probability $1 - e^{-x} = 2/3$. The equilibrium probability that a fraud occurs and is detected is, then .2*2/3*.03 = .004. The engagement will survive the current period with probability $\delta = .98 * .95 * (1 - .004) =$ 0.92727. If we use $k = 5$, the probability is $\delta = 0.92169$. Note that δ decreases in k. While the audit cost from the fraud component is added in determining the fees, it does not differ between the SQ and MR settings. This cost is $A_f^e = k\left(1 + Log\left[1 + \frac{f}{q_f}\right]\right) = 4.1972$ for $k = 2$ and 10.49306 for $k = 5$.

The following table illustrates the effects of the fraud game on S^{SQ}, S^{MR}, b_i^{SQ}, b_i^{MR}, F_i^{SQ}, and F_i^{MR} for $k = 2$ and $k = 5$.

	Low cost $k = 2$	High cost $k = 5$
$\delta = \rho\xi\left(1 - \frac{k}{q_f \omega_f}\right)$	0.92728	0.92169
S^{SQ}	7418	7374
S^{MR}	7142	7112
$S^{SQ} - S^{MR}$	276	261
b^{SQ}	27.41	27.26
b_1^{MR}	26.46	26.36
$b^{SQ} - b_1^{MR}$	0.9483	0.8982
F_i^{SQ}	4937.48	4980.12

[35] Patterson, Smith, and Tiras (2024) interprets this probability as the risk of material misstatement RMM. The RMM is the inherent risk (IR) multiplied by the control risk (CR). In equilibrium, the RMM ($\theta = .2$ in this example) is irrelevant because this factor cancels in the auditor's and manager's equilibrium choices.

F_i^{MR}	5051.51	5087.10
$F_2^{SQ} - F_2^{MR}$	-114.03	-106.94

Corollary 7, part 1 states that $S^{SQ} > S^{MR}$ but that the difference decreases in k. We observe this assertion in the table. For $k = 2$, the difference $S^{SQ} - S^{MR} = 276$, but for $k = 5$, the difference $S^{SQ} - S^{MR} = 261$. Also, part 2 states that b_i^{SQ} (which is constant in i) is greater than b_1^{MR} (and b_i^{MR} decreases in i), but that this difference decreases in k. Again, we observe the assertion in the table. For $k = 2$, the difference $b_i^{SQ} - b_1^{MR} = .9483$, but for $k = 5$, the difference $b_i^{SQ} - b_1^{MR} = .8982$. Finally, for this example, F_2^{MR} is greater than F_2^{SQ} by 114.03 if $k = 2$, but only by 106.94 if $k = 5$. This observation is not generalizable, though since $F_4^{SQ} - F_4^{MR} = 9.51$ if $k = 2$ but $F_4^{SQ} - F_4^{MR} = 12.38$ if $k = 5$.

We note that while the auditor's cost for the fraud detection component A_f^e is priced in to the audit fees F_i^{SQ} and F_i^{MR}, the amount is identical across the two settings, so the fraud detection component of auditing only affects audit fees through the equilibrium probability that fraud is detected in each period, which then affects the probability that the engagement survives from period to period.

6. DISCUSSION AND CONCLUSION

In this section, we interpret our model and results. Our model provides a perspective on the nature of auditing in a multi-period audit environment. The PCAOB mandated in AS 2501 that auditors manage the inherent imprecision in valuation estimates in reporting acccruals, and in AS 2401 they mandated that that auditors actively engage in detecting intentional misreporting and fraud. Based uon these mandates, we examine audit activities related both to routine valuation and to fraud detection and deterrence. Because the reporting of accruals is an estimate of an uncertain future value, we assume that the reported value is negotiated between the auditor and client management. Switching costs provide potential economic rents from incumbency in our multi-period model and provide incentives for negotiation.

With the auditor's role in the detection of fraud if it has been perpetrated, the detection of perpetrated material fraud can be catastrophic for the client and will almost certainly end the auditor's tenure with the firm. As a result, fraud detection efforts are included in audit fees, but provide no economic rents. The joint probability that the client manager is dishonest, that there is an opportunity to commit fraud, that fraud is committed, and that the auditor detects the fraud in a given period provides the probability that the auditor's tenure ends in the current period due to fraud detection. This endogenous probability is incorporated into the periodic discount rate and that affects the audit as a whole. This interaction demonstrates one way in which fraud detection activities impact valuation activities and ultimately the auditor's economic rents.

There is a likelihood that information generated in one component informs decision-making in the other component. For example, some valuation activities might provide red-flag information that is relevant for the fraud detection component. For simplicity, we ignore those possibilities in this paper. Our perspective is that any material, private information withheld from the auditor by client management represents fraud and would be incorporated in the fraud component of our model. Future research can further examine the impact of information obtained in the course of valuation activities on the auditor's assessment of fraud risk.

Our approach is to modify the audit fee models from DeAngelo (1981), Magee and Tseng (1990), and Zhang (1999) to compare an infinite-horizon pricing environment with no exogenous ending point that represents the status quo in the U.S. audit environment to an environment with mandatory rotation that has, at most, a finite N-period horizon. In both models, the auditor's tenure can end stochastically in any period due to the exogenous probability that the client decides to switch auditor or if the auditor detects and reports material fraud. The probability that the auditor's tenure ends due to fraud detection is endogenously computed in our fraud component and decreases in the auditor's fraud detection costs. In this way, increased fraud-detection costs mitigate the reporting impact of switching to mandatory rotation.

In the status-quo model without an exogenous maximum tenure, we find that negotiation bias (implying a decrease in audit quality) is constant across all periods. In the mandatory rotation model, negotiation bias is *always* less than in the status-quo model and it decreases each successive period. This implies that audit quality increases each period in the mandatory rotation model. At some point on or before the mandatory rotation period, negotiated bias is zero and audit quality reaches its maximum.

The costs of fraud detection decrease bias in both settings, but the effect is greater in the status-quo setting than in the mandatory rotation setting. The reason for this difference is that fraud detection costs affect reporting bias through the discount factor. The effect on bias decreases with changes in the discount factor and changes in the discount factor are more impactful if the remaining tenure horizon is longer. The tenure horizon in the status-quo model is always infinite. The tenure horizon is finite and decreasing each successive period in the mandatory rotation model.

In today's litigious, post-ENRON society and the adoption of SOX, auditors are being held accountable not only for the detection and deterrence of fraud, but also on the accuracy of the financial statements. As Congress, the SEC and other regulators such as the PCAOB continue to refine the responsibilities of the auditor, we believe our paper provides unique insights into how these seemingly separate responsibilities interrelate and impact the cost of auditing, fraud detection, and the quality of accruals. Our study goes one step further and provides much needed insight into how mandatory auditor rotation impacts all three. We expect future researchers who investigate the impact of auditor size or specialization on financial reporting quality to consider not only the impact of size or specialization on fraudulent reporting or earnings management but also on the underlying uncertainty relating to the reporting of accruals with respect to future unknown values.

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APPENDIX

Proof of Proposition 1:

The expected joint auditor-client-manager payoff is provided in (2):
$E[AudMgr_i] = \left(OC_i - \omega((a_i - y)^2 + 2\mu(a_i - y) + 2\mu^2)\right)(q - \gamma a_i)$. The Nash Bargaining Solution requires that this expression be maximized in the shared payoff ra_i. The first-order conditions for a maximum is:

$$\frac{dE[AudMgr_i]}{dra_i} =$$
$$-\gamma \mathrm{OC}_i + 2\omega(y - \mu - \mathrm{a})(q - \gamma a_i) + \gamma\omega\left(2\mu^2 + (y - a_i)^2 - 2\mu(y - a_i)\right) = 0.$$

The second-order condition for a maximum is:
$\frac{d^2E[AudMgr_i]}{dra_i^2} = -2\omega(q + 2\gamma(y - \mu) - 3\gamma a_i) < 0$. Solving the first-order condition for a_i yields:

$$a_\mathrm{i} = \frac{\mathrm{q}}{3\gamma} + \frac{2(y-\mu)}{3} - \frac{1}{3\gamma\omega}\sqrt{\omega\left(\left(q^2 + 2q\gamma(-y + \mu) + \gamma^2(y^2 - 2y\mu - 2\mu^2)\right)\omega + 3\gamma^2\mathrm{OC}_i\right)}.$$

And substituting this value of a_i into the second-order condition, we obtain.

$$\frac{d^2E[AudMgr_i]}{dra_i^2} = -2\sqrt{\omega\left(\left(q^2 + 2q\gamma(-y + \mu) + \gamma^2(y^2 - 2y\mu - 2\mu^2)\right)\omega + 3\gamma^2\mathrm{OC}_i\right)} < 0.$$

Proof of Corollary 1:

Evaluating the amount that a_i is less than the best estimate of $a_i = y - \mu$, we compute:

$b_i = -\frac{q}{3\gamma} + \frac{y-\mu}{3} + \frac{\sqrt{\omega\left(q^2\omega + 2q\omega\gamma(-y+\mu) + \gamma^2\left(3OC_i + \omega(y^2 - 2y\mu - 2\mu^2)\right)\right)}}{3\gamma\omega}$ in (5).

Proof of Corollary 2:

The expected reputation cost associated with reported accruals a_i are computed as:
$r_i = \int_0^\infty \omega(e - y + a_i)^2 f(e)de = \omega\left(2\mu^2 + (y - a_i)^2 + 2\mu(-y + a_i)\right)$. Evaluating this expression at $b_i = y - \mu - a_i$, we obtain:
$r_i = \omega(\mu^2 + b_i^2)$.

Proof of Proposition 2:

Solving (8) equal to zero implies that $e^{-x}f = (1 - e^{-x})q_f$, which implies $e^{-x} = \frac{q_f}{f+q_f}$. If we substitute that value for e^{-x} into (9) we obtain $k = \frac{f\theta\varphi q_f\omega_f}{f+q_f}$. Solving this equality for φ, we obtain (10). And substituting (10) into (9) and solving for x, we obtain (11). Because the second derivative is positive, (11) is the cost minimizing strategy for the auditor.

Proof of Corollary 3:

Substituting (10) and (11) into the auditor's cost function in (7), we obtain the equilibrium value of A_f^e in (12).

Proof of Corollary 4:

The proof of corollary 4 is shown in the text.

Proof of Corollary 5:

The equilibrium values of $x^* = \text{Ln}\left(1+\frac{f}{q_f}\right)$, $\varphi^* = \frac{k(q_f+f)}{\theta f q_f \omega_f}$, $\delta = \rho\xi\left(1-\frac{k}{q_f\omega_f}\right)$, and $A_f^e = k\left(1+\text{Log}[1+\frac{f}{q_f}]\right)$ are provided in (11), (10), (14), and (12) respectively. The comparative static results in the table are immediate.

Proof of Proposition 3:

We begin with the derivatives of b_i^{SQ} with respect to parameters ω, ℓ, c, δ, μ, and γ. In the SQ model b_i^{SQ} is identical for each period i.

$$\frac{db_i^{SQ}}{d\omega} = -\frac{\delta(\ell+c)\gamma}{2\omega\sqrt{\omega\left(q^2\omega+2q\gamma(-y+\mu)\omega+\gamma^2(3\delta(\ell+c)+(y^2-2y\mu-2\mu^2)\omega)\right)}} < 0.$$

$$\frac{db_i^{SQ}}{d\ell} = \frac{db_i^{SQ}}{dc} = \frac{\gamma\delta}{2\sqrt{\omega(q^2\omega+2q\gamma(-y+\mu)\omega+\gamma^2(3\delta(\ell+c)+(y^2-2y\mu-2\mu^2)\omega))}} > 0.$$

$$\frac{db_i^{SQ}}{d\delta} = \frac{(\ell+c)\gamma}{2\sqrt{\omega(q^2\omega+2q\gamma(-y+\mu)\omega+\gamma^2(3\delta(\ell+c)+(y^2-2y\mu-2\mu^2)\omega))}} > 0.$$

$$\frac{db_i^{SQ}}{d\mu} = \frac{1}{6}\left(-2+\frac{2\left(q-\gamma(y+2\mu)\right)\omega}{\sqrt{\omega\left(q^2\omega+2q\gamma(-y+\mu)\omega+\gamma^2(3\delta(\ell+c)+(y^2-2y\mu-2\mu^2)\omega)\right)}}\right) < 0.$$

$$\frac{db_i^{SQ}}{d\gamma} = \frac{q(-q\omega+y\gamma\omega-\gamma\mu\omega+\sqrt{\omega(q^2\omega+2q\gamma(-y+\mu)\omega+\gamma^2(3\delta(\ell+c)+(y^2-2y\mu-2\mu^2)\omega))})}{3\gamma^2\sqrt{\omega(q^2\omega+2q\gamma(-y+\mu)\omega+\gamma^2(3\delta(\ell+c)+(y^2-2y\mu-2\mu^2)\omega))}} > 0.$$

Next, we consider the derivatives of F_i^{SQ} with respect to parameters ω, ℓ, c, δ, μ, and γ.

$$\frac{dF_i^{SQ}}{d\ell} = \frac{dF_i^{SQ}}{dc} = 1-\delta+\frac{\delta\left(-q\omega+y\gamma\omega-\gamma\mu\omega+\sqrt{\omega\left(q^2\omega+2q\gamma(-y+\mu)\omega+\gamma^2(3\delta(\ell+c)+(y^2-2y\mu-2\mu^2)\omega)\right)}\right)}{3\sqrt{\omega\left(q^2\omega+2q\gamma(-y+\mu)\omega+\gamma^2(3\delta(\ell+c)+(y^2-2y\mu-2\mu^2)\omega)\right)}} > 0.$$

$$\frac{dF_i^{SQ}}{d\delta} = -\frac{(\ell+c)\left(q\omega-y\gamma\omega+\gamma\mu\omega+2\sqrt{\omega\left(q^2\omega+2q\gamma(-y+\mu)\omega+\gamma^2(3\delta(\ell+c)+(y^2-2y\mu-2\mu^2)\omega)\right)}\right)}{3\sqrt{\omega\left(q^2\omega+2q\gamma(-y+\mu)\omega+\gamma^2(3\delta(\ell+c)+(y^2-2y\mu-2\mu^2)\omega)\right)}} < 0.$$

$$\frac{dF_i^{SQ}}{d\gamma} = \frac{2q(-q\omega+y\gamma\omega-\gamma\mu\omega+\sqrt{\omega(q^2\omega+2q\gamma(-y+\mu)\omega+\gamma^2(3\delta(\ell+c)+(y^2-2y\mu-2\mu^2)\omega))})^2}{9\gamma^3\sqrt{\omega(q^2\omega+2q\gamma(-y+\mu)\omega+\gamma^2(3\delta(\ell+c)+(y^2-2y\mu-2\mu^2)\omega))}} > 0.$$

The derivatives $\frac{dF_i^{SQ}}{d\omega}$ and $\frac{dF_i^{SQ}}{d\mu}$ have direct effects on r_i that are opposite the indirect effects of the parameters on r_i^{SQ} through their effects on b_i^{SQ} and, as a result, cannot be signed.

Proof of Corollary 6:

The derivative of b_i^{SQ} (as well as that of b_i^{MR}) with respect to the opportunity cost, OC_i is positive.

$\frac{db_i^{SQ}}{dOC_i^{SQ}} = \frac{\gamma}{2\sqrt{\omega\left(\left(q^2+2q\gamma(-y+\mu)+\gamma^2(y^2-2y\mu-2\mu^2)\right)\omega+3\gamma^2 \mathrm{OC_i^{SQ}}\right)}} > 0$

Because $OC_i^{SQ} = \delta(c+\ell)$, any change that increases δ increases OC_i^{SQ} and therefore increases b_i^{SQ}. So increases in f, q_f, and ω_f and decreases in k will increase b_i^{SQ}.

The derivative $\frac{dF_i^{SQ}}{dk} = \frac{\partial F_i^{SQ}}{\partial \delta}\frac{\partial \delta}{\partial k} + \frac{\partial F_i^{SQ}}{\partial A_f^e}\frac{\partial A_f^e}{\partial k}$.

$\frac{\partial F_i^{SQ}}{\partial \delta} = -(c+l)(q\omega - y\gamma\omega + \gamma\mu\omega + Z)/H$, where

$Z = 2\sqrt{\omega\left(3(c+l)\gamma^2\delta + \left(q^2+2q\gamma(-y+\mu)+\gamma^2(y^2-2y\mu-2\mu^2)\right)\omega\right)} > 0$ and

$H = 3\sqrt{\omega\left(3(c+l)\gamma^2\delta + \left(q^2+2q\gamma(-y+\mu)+\gamma^2(y^2-2y\mu-2\mu^2)\right)\omega\right)} > 0$.

So, $\frac{\partial F_i^{SQ}}{\partial \delta} < 0$. Since $\frac{d\delta}{dk} < 0$, $\frac{\partial F_i^{SQ}}{\partial \delta}\frac{\partial \delta}{\partial k} > 0$. $\frac{\partial F_i^{SQ}}{\partial A_f^e} = A_f^e > 0$. And $\frac{dA_f^e}{dk} > 0$. So, $\frac{dF_i^{SQ}}{dk} > 0$.
Derivatives for f, q_f, and ω_f follow the same logic.

Proof of Proposition 4:
(1) Negotiated bias in the MR setting is less than in the SQ setting for every period.

Period *i* bias in the MR setting is given in (34):

$$b_i^{MR} = \frac{y-\mu}{3} - \frac{q}{3\gamma} + \sqrt{\frac{q^2}{9\gamma^2} - \frac{2q(y-\mu)}{9\gamma} + \frac{(y^2-2y\mu-2\mu^2)}{9} + \frac{(\ell+c)(\delta-\delta^{N+1-i})}{3\omega(1-\delta^N)}}.$$

Substituting $i = 1$ into b_i^{MR}, we obtain:

$$b_1^{MR} = \frac{y-\mu}{3} - \frac{q}{3\gamma} + \sqrt{\frac{q^2}{9\gamma^2} - \frac{2q(y-\mu)}{9\gamma} + \frac{(y^2-2y\mu-2\mu^2)}{9} + \frac{(\ell+c)(\delta-\delta^{N})}{3\omega(1-\delta^N)}}.$$

Period *i* bias in the SQ setting is given in (22):

$$b_1^{SQ} = -\frac{q}{3\gamma} + \frac{y-\mu}{3} + \frac{\sqrt{\omega\left(q^2\omega+2q\omega\gamma(-y+\mu)+\gamma^2\left(\delta(\ell+c)+\omega(y^2-2y\mu-2\mu^2)\right)\right)}}{3\gamma\omega}.$$

$$b_1^{SQ} - b_1^{MR} = \frac{1}{3\gamma\omega}\Big(\sqrt{\omega(q^2\omega - 2q\gamma(y-\mu)\omega + \gamma^2(3(c+\ell)\delta + (y^2-2y\mu-2\mu^2)\omega))} - \sqrt{\omega(q^2\omega - 2q\gamma(y-\mu)\omega + \gamma^2(\frac{3(c+\ell)(\delta-\delta^N)}{1-\delta^N} + (y^2-2y\mu-2\mu^2)\omega))}\Big)$$

Because $\delta > \frac{(\delta-\delta^N)}{1-\delta^N}$ for $0 < \delta < 1$, this expression is positive.

(2) Negotiated bias in the MR setting in period $i+1$ is always less than in period i.
Using (25), we compute the bias in period $i+1$ less the bias in period i as:

$$b_{i+1}^{MR} - b_i^{MR}$$
$$= \frac{1}{3\gamma\omega}\left(-\sqrt{\omega(q^2\omega - 2q\gamma\omega(y-\mu) + \gamma^2(\frac{3(c+\ell)(\delta - \delta^{N+1-i})}{(1-\delta^N)} + (y^2 - 2y\mu - 2\mu^2)\omega))}\right.$$
$$\left.+\sqrt{\omega(q^2\omega - 2q\gamma\omega(y-\mu) + \gamma^2(\frac{3(c+\ell)(\delta - \delta^{N-i})}{(1-\delta^N)} + (y^2 - 2y\mu - 2\mu^2)\omega))}\right)$$

This expression is negative ($b_{i+1}^{MR} < b_i^{MR}$) if $\delta^{N-i} > \delta^{N+1-i}$. Since $\delta < 1$, this condition is satisfied.

(3) The initial audit fees for the period 1 audit are higher in the MR setting than in the SQ setting. The audit fees decrease from period 2 through N in the MR setting but not in the SQ setting.

Proof that the initial fees are greater in the MR setting than in the SQ setting.
The period 1 fee in the MR setting is computed as:
$F_0^{MR} = \ell + v + r_1^{MR} - S^{MR}$, where $S^{MR} = OC_1^{MR} = \frac{(\ell+c)(\delta-\delta^N)}{1-\delta^N}$, $r_1^{MR} = \omega\mu^2 + \omega(b_1^{MR})^2$, and b_1^{MR} can be expressed as $b_1^{MR} = \frac{y-\mu}{3} - \frac{q}{3\gamma} + \sqrt{\frac{q^2}{9\gamma^2} - \frac{2q(y-\mu)}{9\gamma} + \frac{(y^2-2y\mu-2\mu^2)}{9} + \mathrm{OC}_1^{\mathrm{MR}}}$.
Similarly, the period 1 fee in the SQ setting is computed as:
$F_0^{SQ} = \ell + v + r^{SQ} - OC^{SQ}$, where $r^{SQ} = \omega\mu^2 + \omega(b^{SQ})^2\ and$
$b^{SQ} = \frac{y-\mu}{3} - \frac{q}{3\gamma} + \sqrt{\frac{q^2}{9\gamma^2} - \frac{2q(y-\mu)}{9\gamma} + \frac{(y^2-2y\mu-2\mu^2)}{9} + \mathrm{OC}^{\mathrm{SQ}}}$. $F_0^{MR} - F_0^{SQ}$ is computed as:
$OC^{SQ} - OC_1^{MR} - \omega((b_1^{MR})^2 - (b^{SQ})^2)$. This expression must be positive as long as $OC_1^{MR} > \omega\mu^2$ which must hold for $b_1^{MR} > 0$.

Proof that audit fees decrease in the MR setting.
$F_{i+1}^{MR} - F_i^{MR} = r_i^{MR} - r_{i-1}^{MR} = \omega((b_i^{MR})^2 - (b_{i-1}^{MR})^2)$. We have shown that $b_i^{MR} - b_{i-1}^{MR} < 0$. So audit fees are decreasing from each period to the next in the MR setting. After the first period, audit fees are constant in the SQ setting.

(4) If N is sufficiently large, then there exists $\hat{\imath} > 1$, such that the fees are lower in the MR setting than in the SQ setting for all $i \geq \hat{\imath}$.

1. We have shown that audit fees are greater in period 1 $F_0^{MR} > F_0^{SQ}$.
2. We have shown that for all $i \in \{2, N\}$ the fees in the MR setting are monotonically decreasing.

In period N, in the MR setting, the auditor's opportunity cost is zero since she cannot retain the client in period N+1. As a result, $b_N^{MR} = 0$ and $r_N^{MR} = \omega\mu^2$. $F_{N-1}^{SQ} - F_{N-1}^{MR}$ is computed as: $OC_1^{MR} - OC_1^{SR} + (b^{SQ})^2$. Audit fees are greater in the SQ setting than in the MR setting in period N if the following inequality is satisfied.
$\omega(b^{SQ})^2 > \frac{(\ell+c)(\delta^N-\delta^{N+1})}{(1-\delta^N)}$.

The left-hand side does not include N and the right-hand side is decreasing in N. Therefore we solve for equality as a function of N, yielding:

$N^{crit} = -\text{Log}\left[\frac{(\ell+c)(1-\delta)+\omega\left(b^{SQ}\right)^2}{\omega\left(b^{SQ}\right)^2\text{Log}[\delta]}\right]$. If the number of periods in the mandatory rotation exceeds N^{crit}, $F_{N-1}^{SQ} > F_{N-1}^{MR}$. Since, from periods 2 to N, fees in the SQ setting are constant and since they are monotone decreasing in the MR setting, there must be a single point at which the two curves cross.

Proof of Proposition 5:

As N approaches infinity, the initial opportunity costs in the MR setting, $OC_1^{MR} = S^{MR} = \frac{\delta-\delta^N}{1-\delta^N}(\ell + c)$ converge to the initial opportunity costs in the SQ setting, $S^{SQ} = \delta(\ell + c)$. So, the period 1 bias in the MR setting converges to the period 1 bias in the SQ setting. Because the initial opportunity costs converge and the initial bias converges, the first-period fees, F_0^{MR} and F_0^{SQ} converge. But, the bias in the MR setting decreases each period in the MR setting, eventually to zero. Therefore the fees in the MR setting decrease each period as well. So, bias and fees do not converge over time in the MR setting as N approaches infinity.

Proof of Corollary 7:

The derivative $-\frac{dS^{SQ}}{dk} + \frac{dS^{MR}}{dk} = \frac{(c+\ell)\delta^{N-1}\left(N-N\delta-\delta\left(1-\delta^N\right)\right)\xi\rho}{(1-\delta^N)^2 q_f \omega_f}$. This derivative is greater than zero if and only if $N - N\delta - \delta(1 - \delta^N) > 0$ which must be true as long as $\delta \in (0,1)$ and $N > 2$.

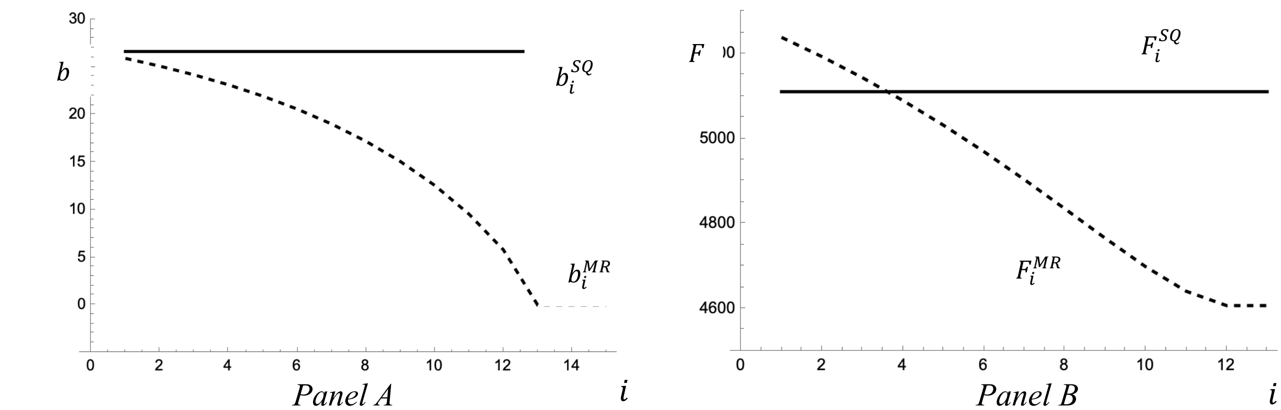
The derivative $-\frac{db_i^{SQ}}{dk} + \frac{db_1^{MR}}{dk}$ will have the same sign as $-\frac{dOC_i^{SQ}}{dk} + \frac{dOC_1^{MR}}{dk}$.

$-\frac{dOC_i^{SQ}}{dk} + \frac{dOC_1^{MR}}{dk} = \frac{(c+\ell)\left(2\delta-N\delta^N-(3-N)\delta^{N+1}+\delta^{2N+1}\right)\xi\rho}{\delta(1-\delta^N)^2 q_f \omega_f}$. This derivative is greater than zero if and only if $2\delta - N\delta^N - (3 - N)\delta^{N+1} + \delta^{2N+1} > 0$ which must be true as long as $\delta \in (0,1)$ and $N > 2$.

Summary of Notation:

x_i	Unknowable true value at $t = i$ to be reported.
y_i	Auditor-client shared signal of x_i at $t = i$.
e_i	Stochastic difference between the shared signal and the true value where $e_i \sim f(e_i) = \frac{1}{\mu} Exp\left[-\frac{e_i}{\mu}\right]$
μ	Mean of the distribution $f(e_i)$
γ	Manager's preference parameter for lower reported accruals
$-q$	Manager's payoff in negotiation fails
ω	Auditor's reputation cost multiplier
r_i	Auditor's reputation cost at $t = i$.
f	The magnitude of material fraud in the fraud component
θ	The risk of material mistatement = Inherent risk X Control risk
k	The unit cost multiplier for fraud detection
φ	The manager's mixed-strategy probability of perpetrating fraud.
ω_f	The auditor's accrued cost multiplier for undetected fraud
q_f	The manager's penalty if perpetrated fraud is detected.
A_f^e	The auditor's total expected cost in each period for the fraud component.
x and $d[x]$	The auditor's choice of fraud detection input and the probability of detection given that input choice
$\Pr[DF]$	The equilibrium probability that fraud is perpetrated and detected in a period
δ	The endogenous comprehensive discount rate for the multi-period interaction
v	Cost of audit work each period for valuation activities
ℓ	Learning costs incurred by non-incumbent auditors
c	Cost to the client firm of switching auditors
a_i^{SQ}	Reported accruals in the SQ setting in period i
b_i^{SQ}	Bias in the SQ setting in period i
F_i^{SQ}	Audit fee in the SQ setting in period $i + 1$ which is determined at $t = i$.
Π_i^{SQ}	Auditor's profit in the SQ setting in period i
OC_i^{SQ}	Auditor's opportunity cost of losing the client after period i for all future periods in the SQ setting.
S^{SQ}	Sum of discounted expected profits from periods 2 to infinity in the SQ setting equal to OC_1^{SQ}
OC_i^{MR}	Auditor's opportunity cost of losing the client after period i for all future periods in the MR setting.
a_i^{MR}	Reported accruals in the MR setting in period i
b_i^{MR}	Bias in the MR setting in period i
F_i^{MR}	Audit fee in the MR setting in period $i + 1$ which is determined at $t = i$.
Π_i^{MR}	Auditor's profit in the MR setting in period i
S^{MR}	Sum of discounted expected profits from periods 2 to N in the MR setting equal to OC_1^{MR}

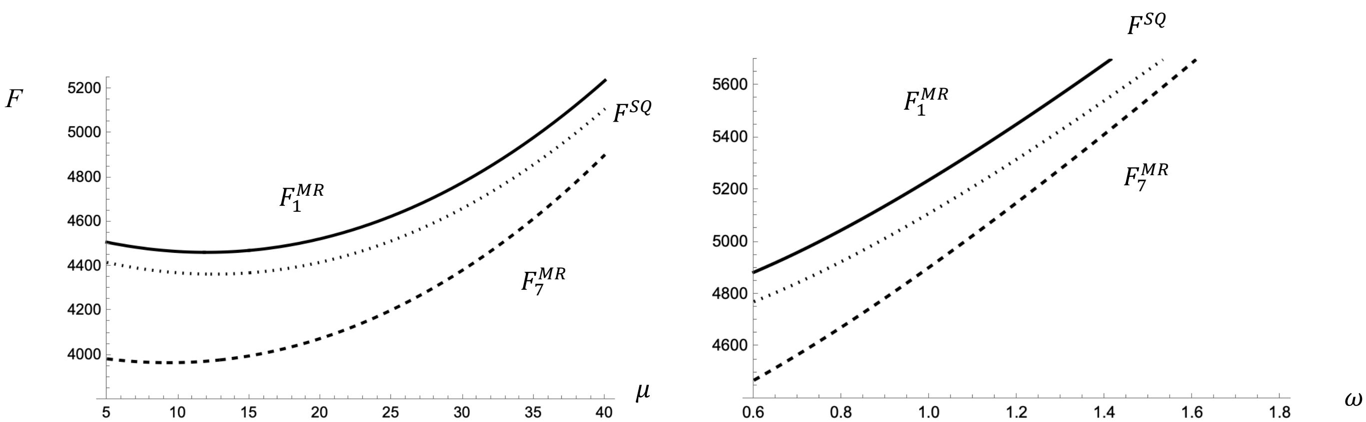
Figures:



Panel A
b_i^{SQ} and b_i^{MR}

Panel B
F_i^{SQ} and F_i^{MR}

Figure 1
Comparison of the bias and fees over time for the SQ and MR settings



Panel A
Fees as a function of μ

Panel B
Fees as a function of ω

Figure 2
Comparison of fees for parameter changes in μ and ω for the SQ and MR settings $(i = 1)$ and $(i = 7)$

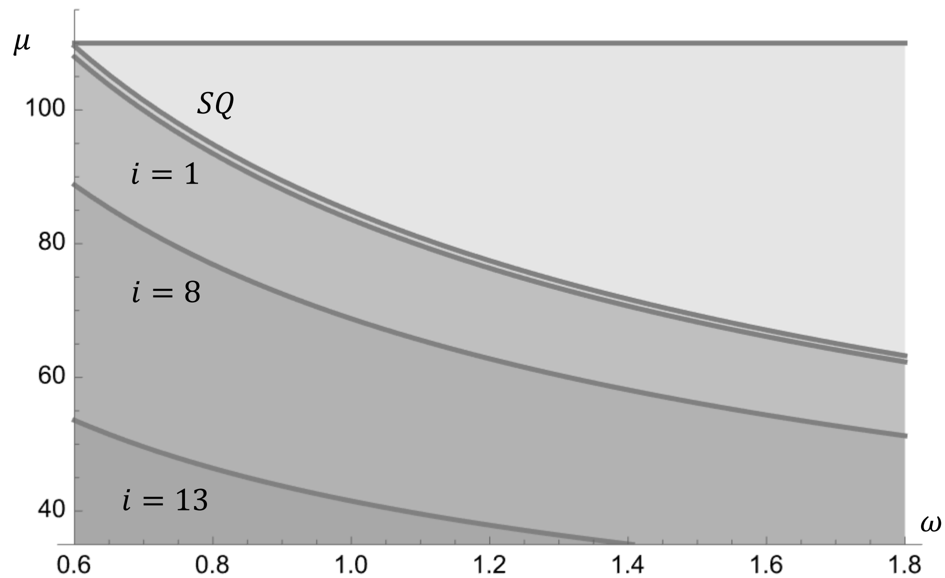


Figure 3
Robustness of equilibrium negotiation across time for μ and ω