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Independence, low balling and learning effects

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Abstract:
Independent auditors serve as gatekeepers of public securities markets, but ongoing competition among audit firms could harm auditors' independence. For instance, a Green Paper of the European Union finds that especially audits of large and prestigious clients are hard-fought in terms of price competition. Major concerns are related to a pricing behavior called low balling. Here, the auditor sets the first period's fee below the audit costs -incurring a loss for the initial audit- in order to win the client. However, as a quasi-monopoly emerges for the incumbent auditor, he expects to offset this loss in the future. Mainly, this offset occurs due to reduced audit costs in subsequent periods. Recent management publications highlight that learning effects influence the cost behavior over time in two ways. On the one hand, cost reductions emerge from experience due to performing jobs repeatedly. Thus, learning is supposed to be an important strategic factor in low-automation industries, like auditing. On the other hand, learning effects can be fostered by investments in learning, i.e., learning is manageable. Bundling non-audit services, like risk advisory- or performance measurement-related assurance services, with audits could be interpreted as audit-quality improving investments in learning about a client's business. Accordingly, the goal of our paper is to analyze how learning effects according to the theory of learning curves affect competition on the audit market and thus the low-balling problem.

Our analysis proceeds in several steps: In the first step, we model-endogenously identify conditions for the existence of price competition in audit markets. This step of analysis is important, because in most low-balling models competition is assumed to exist, although empirical evidence is mixed. In the second step, we analyze how different types of learning

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influence fee setting over time. Here, we assume auditors to have identical learning rates. This means competition in a given segment is considered, e.g., between Big-4 auditors or between National Majors. In the third step, we regard auditors with different learning abilities. Thus, auditors of different size -measured in number of clients- occur. In this step we capture the fact that empirically size is an important competition factor.

Our results give hints to regulators under which conditions low balling might be a threat to auditor independence. Further, some recently introduced regulations, which aim at improving auditor independence, can be evaluated using the framework of our analysis.

Key Words: Auditing, Big-Four, Fee-Cutting, Independence, Low Balling, Sarbanes-Oxley Act, Scheduling, Theory of Learning Curves

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1 Introduction

The concept of auditor independence covers several notions and has undergone a profound change over time. For instance, in the 19th century in England auditors were forced to hold a fraction of their clients' shares. In contrast, for sake of independence most present legislations prohibit "auditors from owing shares of their clients' stock and from possessing any direct financial interest or material indirect financial interest in their clients."[1] Basically, 'independence in fact' means that an auditor abstains from any collusive behavior with management. However, as auditing crucially relies on confidence and reputation 'independence in appearance' is much more important.[2] This means that no "facts and circumstances are so significant that a reasonable and informed third party ... would ... conclude a[n audit] firm's ... integrity, objectivity or professional skepticism [to be] compromised."[3] Accordingly, "[a]t least since the Securities Acts, independence has been the focus of almost constant controversy, debate and analysis."[4]

This debate was intensified once again when enacting Sarbanes-Oxley Act (SOA).[5] Some commentators generally doubt that auditor independence is worth being saved.[6] Other authors suppose auditors to be "the gatekeepers of the public securities markets."[7] Empirical evidence supports the latter point of view. Investor protection in the sense of well-functioning corporate governance heavily relies on high-quality audits.[8] Auditing serves as an important instrument mitigating agency-conflicts between shareholders and management. Especially in countries with equity-financed companies, like the U.S., Australia, or the U.K., auditing serves as a monitoring device and provides insurance to investors.[9] Similarly, in emerging capital markets the monitoring function is important with respect to agency-conflicts between controlling owners and minority shareholders because of weak governance regulations.[10] Further, in countries where debt is the dominant financing source,

[1]Cf. Antle (1981, p. 14).
[2]Cf. Gosh/Moon (2005, p. 587).
[3]Hayes et al. (2005, p. 85). For an illustration of potential threats to auditors' independence, see, e.g., Messier et al. (2006, pp. 742), Hayes et al. (2005, p. 87), or Whittington/Pany (2004, pp. 66).
[4]Cf. Antle (1984, p. 1).
[5]Cf. SEC (2003).
[6]See, e.g., Ketz (2005).
[7]Cf. Gosh/Moon (2005, p. 588).
[8]Cf. Francis et al. (2003, pp. 14) for an international survey.
[9]Cf. Mansi et al. (2004, pp. 756), Ashbaugh/Warfield (2003, p. 4), Gul/Tsui (2001, p. 76), or Francis/Wilson (1988, p. 680). For an international comparison see Nikkinen/Sahlström (2004, pp. 255).
[10]Cf. Fan/Wong (2005, pp. 37).

like, e.g., in France or Germany, reputation transfers from auditors to clients increase financial reporting credibility, facilitating contracting procedures, i.e., agency-conflicts between shareholders and bondholders are alleviated.[11] Consequently, a lot of political effort is dedicated to independence topics. Nevertheless, despite of the intended improvements ongoing competition among audit firms could harm auditors' independence. For instance, a Green Paper of the European Union finds that especially audits of large and prestigious clients are hard-fought in terms of price competition.[12] Obviously, auditor compensation agreements will be suitable to derogate auditors' independence, if the remuneration is conditioned on the audit's outcome. Thus, due to the self interest and advocacy threat contingent audit fees are forbidden in many countries.[13] But other fee setting strategies exist which might impair independence less obviously. Major concerns are related to a pricing behavior called low balling. Here the auditor sets the first period's fee below the audit costs -incurring a loss for the initial audit- in order to win the client. However, as a quasi-monopoly emerges for the incumbent auditor, he expects to offset this loss in the future. Mainly, this offset occurs due to reduced audit costs in subsequent periods.

The goal of our paper is to analyze how learning effects in the sense of the theory of learning curves affect competition on the audit market and thus the low-balling problem. Recent management publications highlight that learning effects influence the cost behavior over time in two manners. Firstly, cost reductions emerge from experience due to performing jobs repeatedly. Thus, learning is supposed to be an important strategic factor in low-automation industries, like auditing. Secondly, learning effects can be fostered by investments in learning, i.e., learning is manageable. Bundling non-audit services, like risk advisory- or performance measurement-related assurance services, with audits could be interpreted as audit-quality improving investments in learning about clients' business. Although the strategic implications of learning are known from the operations management literature since the seminal paper by *Wright* (1936), the concept of learning curves has not been integrated into low-balling models, yet.

The major contributions of our paper are the following: We introduce into the auditing literature dynamic learning effects which occur with a decreasing marginal rate over the whole lifetime of the auditor-client relationship. This contrasts other low-balling models,

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[11] Cf. Mansi et al. (2004, pp. 773), Ashbaugh/Warfield (2003, pp. 3), or Piot (2001, p. 486) analyzing American, German, or French data, respectively.
[12] Cf. EU Green Paper (1996, p. 21, no. 4.11).
[13] Cf. Messier et al. (2006, p. 760) or Hayes et al. (2005, p. 88).

where learning effects are in general assumed to vanish after the initial audit. Our new approach of integrating learning effects highlights the common grounds of the *DeAngelo* (1981) and the *Dye* (1991) interpretation of low balling. Further, it explains the mixed empirical results on low balling, as we show that fee discounts are not necessary but sufficient for low balling. This holds true, because service conditions can also be used as strategic competition factors. Moreover, in contrast to the present paper in other articles the audit costs are given exogenously and they are independent of the auditor's characteristics and the duration of the auditor-client relationship. Due to a more comprehensive modeling, we derive conditions under which low balling lasts for more than one period, which is in line with the observations in business practice. Finally, our model approach is rich enough to include benefits of tenure, learning and size as well. All these factors have been proven to be important competition factors, empirically.

The remainder of the paper is organized as follows: In section two the related literature is reviewed briefly. In the third section the considered economic setting is described, the model assumptions are introduced and the model formulation is developed. In the fourth section the model results are interpreted. Here the analysis proceeds in five steps: In the first step we derive model-endogenously conditions under which low balling is likely to occur. In the second step we analyze the duration of low balling and discuss benefits of auditor tenure in the third step. Next, we identify the benefits of learning and lastly, we concentrate on analyzing advantages of auditor size. The fifth section concludes. All proofs are given in the appendix.

2 Literature review and empirical evidence

Already in the 1970ies several literature contributions suspected low balling to impair auditor independence.[14] A theoretical rationale for this price setting behavior was given in *DeAngelo* (1981). She defines a set of assumptions, henceforth referred to as DeAngelo-world, which are rather common to low balling papers: (1) auditors compete for initial audits via their pricing strategies, (2) all competing auditors posses the same audit technology, (3) initial audits cause start-up costs additional to the regular audit costs, and (4) clients will face transaction costs in case of an auditor change. In equilibrium, audit fee setting for follow-up audits ensures that clients stay with their respective auditor, although

[14]Cf. Schatzberg (1994, pp. 33) and the references given there.

fees exceed costs. However, as competition is modeled by a zero-profit condition, in the first period low balling occurs in order to win the client. The initial audit fee is defined as the one leading to an NPV of zero for the auditor's profits over the expected lifetime of the mandate.[15] Hence, a premature termination of the auditor-client relationship causes a loss from the auditor's perspective. Consequently, he might be willing to accept debatable accounting practices, in order not to annoy the client, i.e., the profits expected in future periods harm the auditor's independence. This argumentation is contrasted by another prominent explanation of low balling. *Dye* (1991) identifies information asymmetries with respect to pricing to cause initial audit fee discounts.[16]

In the literature several extensions of low balling models can be found. *Magee/Tseng* (1990) derive results similar to *DeAngelo* (1981). However, they relax the assumption of homogeneous auditors. Only one of two types of auditors might suffer from independence problems. The most important differing assumption in *Kanodia/Mukherji* (1994) is that the bargaining power with respect to fee setting is assigned to the client instead of the auditor. Further, *Schatzberg* (1994) combines opinion-shopping and low balling showing –consistent to *Dye's* (1991) argumentation– that information asymmetry instead of transaction costs might induce low balling. In his model the level of auditor's accuracy varies, permitting rents to occur, which finally enable low balling. *Gigler/Penno* (1995) relax the assumption of identical auditing technologies and allow for auditors with different audit costs inducing true rents to occur. Contrary to other models, *Lee/Gu* (1998) find that low balling is conductive to auditor independence. The reversion of their findings compared to *DeAngelo* (1981) is caused by the assumption that shareholders instead of management contract the auditor. As a consequence, the auditor reports all debatable accounting practices conducted by the management in order to prevent shareholders from terminating the mandate. *Chan* (1999) combines auditor specialization and low balling. Refining a hotelling problem he shows that client segments exist where due to specialization no competition arises. However, with decreasing levels of specialization fee cutting and then low balling occur. An application of low balling theory in the context of software engineering can be found in *Whang* (1995).

Any empirical evidence of low balling is hard to find, because even if audit fees are observable, cost data are frequently lacking. Further a lot of determinants influences fee setting, see, e.g., *Taylor/Simon* (1999), *Chung/Lindsay* (1988) or *Simunic* (1980). More-

[15]Cf. DeAngelo (1981, p. 122).
[16]Cf. Dye (1991, pp. 362).

over, *Bockus/Gigler* (1998) –explaining why auditor resignations occur instead of price adjustments– or *Simunic/Stein* (1990) –applying a portfolio evaluation to auditor's client acceptance decision in order to price risk accurately– show analytically that audit fees should include more cost components than only direct ones. This means that low balling could take place even if fees cover direct costs. Due to these restrictions most studies concentrate on fee cutting instead of low balling. Given the former one the initial fee is lower than subsequent ones, whereas for the latter one to be present at least the initial audit costs have to exceed fees. Several empirical studies report initial audit fee discounts of approximately 25 %, see, e.g, *Deis/Giroux* (1996, pp. 68), *Ettredge/Greenberg* (1990, p. 209) or *Simon/Francis* (1988, p. 263).[17] Further the latter report the low balling effect to last over the first three years of an auditor-client relationship with decreasing fee-cost gaps in the second and third year.[18] *Pong/Whittington* (1994) relying on U.K. data find that new auditors charge only slightly less than incumbent auditors. Taking into consideration start-up costs, they interpret their findings as consistent with the low-balling hypothesis. *Craswell/Francis* (1999) report for the Australian audit market that fee cutting can be observed only for auditor switches from a non-Big-8 to a Big-8 auditor.[19] They conclude that this finding is inconsistent with DeAngelo's theory of transaction costs induced low balling. Instead they prefer *Dye's* (1991) argumentation of information asymmetry. In contrast to other studies, *Gregory/Collier* (1996) analyze whether fee discounts occur as well for non-voluntary auditor changes caused by mergers of audit companies.[20] Since this does not hold true, they conclude that reduced fees following a voluntary auditor change are a marketing instrument. From the new auditor's point of view fee discounts help winning the client. Thus, fee discounts do not account for improved auditing technologies, which could be an alternative explanation. Another way of analyzing low balling similar to the cited empirical literature is conducting experimental studies, like *Schatzberg* (1994) or *Calegari et al.* (1998). The latter identify a variety of relations between low balling and impairment of independence.[21]

Some authors argue that low balling in the initial phase of an auditor-client relationship and subsequent premium earnings are just two sides of the same medal.[22] In fact, several

[17] An earlier study of Francis (1984, p. 147) fails to detect fee cutting.
[18] Cf. Simon/Francis (1988, pp. 260).
[19] Cf. Craswell/Francis (1999, p. 203).
[20] Cf. Gregory/Collier (1996, p. 25).
[21] Cf. Calegari et al. (1998, p. 274).
[22] Cf. Pong/Whittington (1994, p. 1072).

empirical studies report a Big-X premium between 20 % and 30 % according to reputation effects.[23] For Hong Kong an even higher premium is reported.[24] More interestingly, beside Big-6 reputation and industry specialization premiums the authors find that a large local firm does not earn a price premium but exploits its economies of scope to set lower fees and to gain market share.[25]

Extending the literature review with respect to crucial assumptions of our model in the first step, empirical literature referring to the assumption of a *competitive market for initial audits* is reviewed. There exist two different approaches in analyzing market competitiveness. On the one hand, fee setting decisions can be analyzed directly. Here a model for calculating competitive prices has to be developed, as done, e.g., in *Simunic* (1980). He concludes "the hypothesis that price competition prevails throughout the market for audits of publicly held companies cannot be rejected."[26] Similar results are provided by *Maher et al.* (1992, p. 206), *Palmrose* (1986, p. 108) or *Francis* (1984, pp. 147). But, the observed price differences cannot be used for analyzing the level of competition. On the other hand, concentration studies are conducted, relying on the idea that big audit market shares suggest an oligopoly to exist where competition vanishes. E.g., *Hogan/Jeter* (1999) report for the American audit market that in 1976 - 1993 those audit companies increased their market shares, which already had an advantage in size before. An additional indicator for growing competition might be observed mergers of audit companies.[27] However, static measures of market supplier concentration might be misleading.[28] Consequently, *Buijink et al.* (1998) use a dynamic approach, when comparing the Dutch and the German audit market with respect to the level of competitiveness. They show that the Dutch market is characterized by higher concentration as well as significantly higher dynamics in market structure compared to the German market.[29] This explains the inconsistency, why reg-

[23]Taylor/Simon (1999, p. 384) find a large firm fee premium on a global level. Craswell et al. (1995, p. 310) report a premium of 34 % for the Australian audit market. Moreover, they find a premium for industry specialization of 16 %. Rose (1999, pp. 150) and Simon et al. (1992, p. 239) considering the examples of Malaysia and Singapore show that Big-6 premiums are prevailing in markets for multinational clients. Palmrose (1986, pp. 107) observes higher audit fees for Big-8 auditors and favours the explanation of Big-8 being a quality indicator over the explanation of monopoly pricing. Francis/Stokes (1986, p. 392) find Big-8 premiums on the Australian market for small auditees, only. Francis (1984, p. 142) reports a premium for the Australian Big-8.

[24]Cf. DeFond et al. (2000, p. 50).

[25]Cf. DeFond et al. (2000, p. 61).

[26]Simunic (1980, p. 187).

[27]Cf. Hogan/Jeter (1999, p. 2).

[28]Cf. Buijink et al. (1998, p. 388).

[29]Cf. Buijink et al. (1998, p. 397).

ulators conclude from concentration statistics a lack of competition while simultaneously practitioners feel a 'cutthroat competition'.[30]

Another important assumption in our model is that the client has the *bargaining power* to insist on his preferred accounting opinions, because otherwise auditor independence could not be impaired. The threat of dismissal can serve as an empirical proxy for this assumption. *Hartwell et al.* (2001) state for their sample of SEC listed companies with at least two auditor changes from 1989 to 1994 that in 73 % of all considered cases the client terminated the relationship. Moreover, *Hudaib/Cook* (2005) find for their sample, which is considered to be representative for non-financial U.K.-companies listed at the LSE from 1987 to 2001, that the more severe the qualification of the audit opinion is the higher is the probability of an auditor switch.[31]

A major contribution of our paper is to model the effects of learning more comprehensively. Some auditing papers deal with improvements of audit quality due to learning and knowledge spill-over effects, like *Simunic* (1984), who considers management advisory services as a learning device. A similar idea is presented by *Beck/Wu* (2006), where the auditor learns more intensively about the client's distribution of earnings by providing non-audit services (NAS). Moreover, *Morgan/Stocken* (1998) consider the audit service itself to be a device of learning. In contrast to these analytical papers, *King/Schwartz* (1999), *Solomon et al.* (1999) and *Low* (2004) conduct experiments. The former study analyzes the impact of different liability regimes on auditors' learning strategies, whereas the latter two studies concentrate on the impact of industry specialization on auditors' learning behavior. Our approach –belonging to the group of analytical papers– is to integrate into a low balling model results from the theory of learning curves, as described by *Wright* (1936).[32] Recently, the effects of learning with respect to labor have been highlighted in the management literature; see *Ittner et al.* (2001), *Lapre/van Wassenhove* (2001) or *Lapre et al.* (2000). As labor is –due to the low level of automation– the most important factor in auditing, it is apparent to integrate learning into low balling models.[33] In accordance with the above cited papers we distinguish between client-specific learning and client-independent autonomous learning.

The assumption of *client-specific learning* is strongly supported by empirical stud-

[30]Cf. Chung/Lindsay (1988, p. 20).
[31]Cf. Hudaib/Cook (2005, p. 1735).
[32]For overviews about the theory of learning curves refer to Zangwill/Kantor (1998), Venezia (1985), Cochran (1960) or Conway/Schultz (1959).
[33]For the importance of the factor labor in auditing, cf. Buijink et al. (1998, p. 392).

ies identifying a positive effect of auditor tenure on audit quality or reporting credibility.[34] E.g., *Carcello/Nagy* (2004) find that fraudulent financial reporting occurs in the early years of an auditor-client relationship quite often; the same result is found in *Geiger/Raghunandan* (2002), who identify reporting failures to occur significantly more often in the first five years of an auditor-client relationship.[35] Similarly, the *AICPA* documents allegations of audit failures to be increased almost by factor three for first- or second-year audits.[36] Focusing on the user perspective *Gosh/Moon* (2005) find evidence that investors and rating agencies rely on audited financial reports more strongly as auditor tenure increases.[37] Moreover, *Myers et al.* (2003) find extreme accounting choices to be constrained more strongly given auditor tenure is high.[38] Finally, *Mansi et al.* (2004) report that costs of debt decrease with auditor tenure.[39] In contrast, *Vanstraelen* (2000) discovers a negative relationship between auditor tenure and the probability of qualified opinions.[40] Overall, the empirical evidence supports the assumption of client-specific learning. The same holds true for industry-specific learning.[41]

Additionally, client-independent *autonomous learning* is regarded, i.e., cost reductions emerge from experience gains due to repeatedly performing audit tasks, when serving different clients. *Hogan/Jeter* (1999) state that "superior operating efficiency or economies of scale ... are not limited to regulated industries but extend to non-regulated industries as well."[42] *Simunic* (1980) considers economies of scale as well as learning effects to be determinants of audit fees; however, for the given data sample scale economies cannot be shown.[43] In contrast, *Francis/Stokes* (1986) conclude diseconomies of scale to exist for Australian non-Big-8 auditors when the clients are large.[44]

Lastly, we assume *waiting* to be an important factor for client satisfaction, too. Existing low balling models neglect the importance of audits taking place immediately after the

[34] Cf. DeFond et al. (2000, p. 50).
[35] Cf. Carcello/Nagy (2004, p. 57) or Geiger/Raghunandan (2002, p. 74).
[36] Cf. Myers et al. (2003, p. 782).
[37] Cf. Gosh/Moon (2005, p. 599 and 602).
[38] Cf. Myers et al. (2003, p. 789).
[39] Mansi et al. (2004, p. 773).
[40] Vanstraelen (2000, p. 435).
[41] A hybrid form of learning is industry specialization, i.e., elements of client-specific as well as client-independent learning occur simultaneously. For empirical evidence, cf., e.g., DeFond et al. (2000, p. 50), for Hong Kong data or Hogan/Jeter (2000, p. 15) for American data. Cf. Myers et al. (2003, p. 780), too.
[42] Cf. Hogan/Jeter (1999, p. 3). Cf. earlier studies by Kwon (1996) or Danos/Eichenseher (1982), too.
[43] Cf. Simunic (1980, pp. 174).
[44] Cf. Francis/Stokes (1986, p. 385).

accounting date, which means that the clients compete for restricted audit capacities.[45] Studies dating from the 1990's confirm that time pressure –i.e., the existence of scare time budgets– can be responsible for minor audit quality.[46] Waiting imposes costs on the clients, meaning that the scheduling of audits has an impact on the clients' satisfaction and thus their willingness to pay.[47]

3 Assumptions and Model

In our analysis the fee setting strategy of a single auditor is considered, who competes on the market for initial audits. An important factor influencing fees are the regarded cost categories. Although we make use of the zero-profit condition defined in *DeAngelo* (1981), we concentrate on different cost categories. Introducing a dynamic concept of learning, we focus on direct audit costs decreasing with a decreasing marginal rate over the whole time-interval the auditor-client relationship exists. These costs contrast the commonly used static start-up costs, defined as the difference between the direct audit costs of an initial audit compared to the identical costs of all follow-up audits. Moreover, it is assumed that all clients wish to be served as soon as possible, i.e., clients are impatient. Accordingly, the cost category of waiting costs is introduced in our analysis. Lastly, in line with *Dye's* (1991) argumentation, we omit transaction costs, defined as all costs a client will have to bear, if he changes the auditor, as they are not crucial in our setting.

Without loss of generality, auditor size can be defined in our model as the number of clients. All clients $j, j = 1, 2, ..., n$ to be audited in the considered period $t, t = 0, 1, ..., T$ are known when scheduling takes place.[48] For ease of presentation we will assume further that no new client will be accepted in periods $t > 0$, meaning that the considered auditor wins the optimal number of clients in the initial period.[49] Without taking into consideration learning the required audit time is assumed to be given by a standard audit time, τ^S,

[45] This means we abstract from continuous audits.

[46] Cf. Pierce/Sweeney (2004, p. 433).

[47] Cf. Jahnke et al. (2005). Hui/Tse (1996) report that a negative impact on customers' satisfaction occurs after a waiting time of five minutes in the context of computerized services. Taylor (1994) states thirty minutes to be the critical threshold for airline services.

[48] From a modeling perspective, this is not an assumption, as in equilibrium no client will switch auditors. For a confirmation from business practice, see Barton (2005, p. 554). He reports that most Andersen clients (95 %) stayed with their auditor until Anderson was indicted of criminal misconduct.

[49] This kind of client acquisition may be justified by the fact that auditor resignations are rare events, cf. Bockus/Gigler (1998, p. 192).

being equal for all clients. Note that this standard audit time τ^S is assumed only for reasons of simplicity. It implies that each permutation, i.e., each possible sequence of audit jobs, is equally good from the scheduling perspective.[50] Considering mandates of different workloads would require a more sophisiticated scheduling procedure, which is beyond the scope of our paper.

Deriving the actual audit time needed for serving a certain client with given auditor tenure requires accounting for both types of learning, i.e., client-independent autonomous learning and client-specific learning have to be integrated. Starting with the former, we introduce learning effects sequentially. As the auditor repeatedly performs several activities for different clients, e.g., planning the audit procedures, assembling audit teams or preparing risk assessments, learning effects arise. Further, in course of time the auditor's team becomes more experienced and performs certain audit tasks more quickly. It learns about standard routines for performing certain audit tasks and becomes more familiar with understanding an unknown company's book-keeping. The more audits an audit team completes the stronger the client-independent autonomous learning effects should be.[51] Thus, the required audit time is reduced for all clients except the one scheduled in the first position. The required audit time including client-independent autonomous learning effects, $\tau^P_{[pos]}$, is defined by:

$$\tau^P_{[pos]} = \tau^S (1 - l_P)^{pos} \tag{1}$$

Here $[pos], pos = 0, 1, ..., n-1$ symbolizes the respective audit job's position in the schedule. The term $(1 - l_P)$ depicts the client-independent autonomous learning rate, where l_P is the learning index. For ease of presentation, the standard approach for modeling learning effects –a logarithmic formulation– is replaced by a simpler multiplicative function, which slightly overemphasizes the learning effects. Moreover, observe that client-independent autonomous learning only affects the audit time in the considered period, as can be inferred from (1). Hence, autonomous learning is forgotten when a new audit cycle starts. This can be motivated by auditor's assistants resigning, by enactment of new accounting rules destroying past experience or by performing other non-audit activities superposing the acquired auditing experience.

For periods $t, t > 0$, i.e., for all follow-up audits, client-specific learning has to be considered.[52] In general, it is argued that "auditors have to develop an in-depth knowledge of

[50] Cf. Biskup/Simons (2003) for an overview of scheduling and learning.

[51] For empirical evidence on autonomous learning in auditing see page 12.

[52] See the empirical evidence presented on page 11.

the client's business operations, processes and systems."[53] For example, the auditor learns step-by-step about a client's critical accounting issues which require particular attention. Moreover, he has to develop over time contacts to employees being company's experts for certain accounting issues. Further, he acquires knowledge referring to organizational or product-related characteristics of the company by-and-by improving his ability to judge the adequacy of chosen accounting alternatives. Typically, referring to this learning phase start-up costs are modeled to occur in the initial audit period. In the present approach this kind of learning is modeled in a more comprehensive way. The auditor learns about the client over time with decreasing marginal rates; the corresponding learning rate is $(1 - l_S)$. Hence, the actual required audit time τ^L for an audit job at position $[pos]$ in period t is given by:

$$\tau^L_{t,[pos]} = \tau^S (1 - l_P)^{pos} (1 - l_S)^t = \tau^P_{[pos]} (1 - l_S)^t \tag{2}$$

Comparable to our notion of client-specific learning is the modeling of Bayesian learning in *Beck/Wu* (2006). They assume that auditors accumulate client-specific knowledge so that their audit quality increases, measured in terms of precision of posterior beliefs.[54] In our model instead of an increasing a constant audit quality is assumed, which can be achieved with decreasing effort over time. In the light of liability considerations attaining a constant quality seems to be more plausible. Moreover, the effect of client-specific learning diminishes over time. Additionally, modeling decreasing marginal learning rates takes into account that audit services require a minimum of time, in order to ensure sufficient audit quality and to provide the client with a satisfactory audit atmosphere.[55] In contrast to the client-independent autonomous learning, it is assumed that client-specific learning can be institutionalized, i.e., the reduction of required audit time is accumulated. This assumption is in accordance with the empirical evidence showing that auditor tenure matters, see page 12.

The total required audit time, τ^G_t, in period t is calculated by summing up over all clients the audit times according to (2):

$$\tau^G_t = (1 - l_S)^t \tau^S \sum_{pos=0}^{n-1} (1 - l_P)^{pos} = (1 - l_S)^t \tau^S \frac{1 - \rho^n}{1 - \rho}, \tag{3}$$

[53]Cf. Geiger/Raghunandan (2002, p. 70).
[54]Cf. Beck/Wu (2006, p. 4).
[55]Formally, a lower bound of audit time and thus of audit costs can be derived, see (9).

with $\rho = 1 - l_P$. A client's j waiting time in period $t, t = 0, 1, ..., T$, is the sum of all previously served clients' audit times including the own audit time. Thus, the corresponding sum of waiting times, τ_t^W, which occur in period t over all clients, is given by (4):[56]

$$\tau_t^W = (1 - l_S)^t \tau^S \sum_{pos=0}^{n-1} \frac{1 - \rho^{pos+1}}{1 - \rho} \tag{4}$$

When thinking about the fee for a certain client, the auditor has to be aware of the direct audit costs, because he wants to be compensated for his expenses. Further, he has to take into consideration the client's waiting costs, because otherwise the client might lobby for another service date. Finally, learning spillovers have to be considered. Let factor α be the costs per unit of audit time, e.g., the hourly salary of the audit team. The total audit costs of a period t, C_t^A, are then given by $C_t^A = \alpha \tau_t^G$, implying that audit costs behave proportionally in audit times. Analogously, β depicts the monetary equivalent of one hour of waiting. For ease of presentation assume $\beta = 1$. Then the total waiting costs, C_t^W, are defined as $C_t^W = \tau_t^W$. Accordingly, α can be interpreted as the weight of audit costs relative to waiting costs. Total costs, C_t^G, are calculated by $C_t^G = C_t^W + C_t^A$ as given in (5):[57]

$$C_t^G = \frac{\tau^S (1 - l_S)^t}{1 - \rho} \left[n + 1 + \alpha - \frac{1 - \rho^n}{1 - \rho} - (1 + \alpha)\rho^n \right] \tag{5}$$

Consider the following example for a demonstration of how (5) is used for deriving fee setting in equilibrium. Assume that the regarded auditor conducts the second follow-up audit for his three clients. Without learning each audit would last for 10 time units [TU], however client-independent autonomous learning takes place with a learning index of 10 %, client-specific learning shows a learning index of 20 %. The direct costs per time unit of audit time is supposed to be 10 monetary units [MU].

Example: Given these pieces of information, the parameters are

$$n = 3; t = 2; \tau_S = 10 \text{ [TU]}; l_P = 0.1; l_S = 0.2 \text{ and } \alpha = 10 \text{ [MU/TU]}.$$

Then, the schedule without any learning effects looks as depicted in Figure 1: Thereby, each audit job is indicated by a box. The number in the upper left corner of each box indicates the job's position in the schedule and the number in the upper right corner represents the

[56] For the derivation refer to appendix 1.
[57] For the derivation refer to appendix 2.

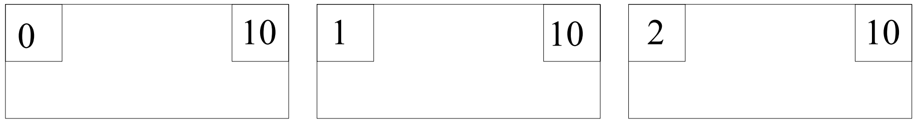

Figure 1: schedule without learning

respective processing time.

Considering autonomous learning only, the schedule would change to the presented in Figure 2:

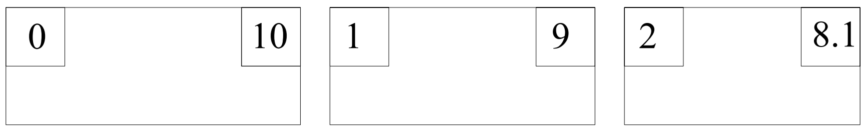

Figure 2: schedule with autonomous learning

Taking into consideration both learning types, the actual schedule is given by:

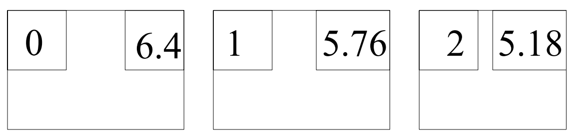

Figure 3: schedule with autonomous and client-specific learning

The actual schedule given in Figure 3 transfers into the following cost situation, presented in Table 1. Given the cost data, the charge G_t can be calculated.
The reading example for client 1 is presented in the following: The audit lasts for 6.4 [TU] according to Figure 3. Multiplying with the direct audit costs per unit of 10 [MU/TU] results in direct costs of 64.00 [MU]. Additionally, 6.4 [TU] of waiting have to be considered, i.e., waiting costs of 6.4 [MU] have to be added. Thus, total costs of 70.40 [MU] are caused by auditing client 1.

Note that in the example given acquiring additional clients is beneficial to the auditor, since the total costs are decreasing from 70.40 [MU] over 69.76 [MU] to 69.14 [MU] over the clients. However, the given cost allocation is not a stable one. By assumption, all clients have the same attributes, especially, they all require the same standard audit time. Just by chance -or to be more precise just as a result of scheduling- client 3 shows lower total costs, as he benefits from the learning effects gathered by the auditor when auditing clients 1 and 2. Obviously, a cost re-allocation has to take place, because otherwise client 1 would

	client 1	client 2	client 3	$\sum$	remark
direct audit costs	64.00	57.60	51.80	173.4	
waiting costs	6.40	12.16	17.34	35.9	
total costs	70.40	69.76	69.14	209.3	$\frac{209.3}{3} = 69.77 = G_t$
maximal fee	63.37	57.60	52.43		69.77 - waiting costs
cross-subsidizing	-0.63	0.00	0.63		

Table 1: cost calculation

prefer being scheduled in the last position. Thus, in equilibrium the average total costs of 69.77 [MU] should be imposed on each client. Since client 1 has faced waiting costs of 6.40 [MU] already, the fee should equal 63.37 [MU], only. Proceeding this way, every client has to bear costs of 69.77 [MU] in total. Thus, a cross-subsidizing occurs, when charging the clients, i.e., the total direct costs caused by a respective audit differ from the fee to be actually paid.

4 Interpretation and implications of the model results

4.1 Conditions for a competitive market of first audits to exist

From a regulator's perspective, it is important to know, under which circumstances low balling is likely to occur, i.e., when does a competitive market for initial audits emerge?[58] This question is important, because a competitive market implies that acquiring new clients is advantageous to auditors. At a first glance, the zero-profit condition in *DeAngelo* (1981) contradicts the idea of growing auditors. However, this contradiction might be resolved when acquiring new clients could yield competitive advantages due to learning effects. This is the case, when the auditor benefits from increasing the number of his clients, as it was shown in the example above. From inspecting (5) in more detail a formal condition can be derived. A competitive market for initial audits will emerge model-endogenously, if the average total costs are monotonously decreasing in the number of clients.[59] This can be

[58]Cf. the empirical evidence presented on page 10, too.
[59]Cf. Pong/Whittington (1994, p. 1075), who explicitly test for economies of scale.

checked by calculating the first difference as given in (6).[60]

$$\Delta_1 C_t^D(n+1) = \frac{\tau^S(1-l_S)^t}{1-\rho} \frac{[(n+1)\rho^n - n\rho^{n+1} - 1]\,[(1+\alpha)(1-\rho) - 1]}{(n^2+n)(1-\rho)} \tag{6}$$

Equating (6) to zero and rearranging terms yields:

$$\left[(n+1)\rho^n - n\rho^{n+1}\right][(1+\alpha)(1-\rho)-1] = [(1+\alpha)(1-\rho)-1] \tag{7}$$

The first term on the left hand side of (7) is always positive but never greater than one, thus, (8) follows:[61]

$$\Delta_1 C_t^D(n+1) \begin{cases} > 0 & \text{if and only if} \quad (1+\alpha)(1-\rho) < 1 \\ = 0 & \text{if and only if} \quad (1+\alpha)(1-\rho) = 1 \\ < 0 & \text{if and only if} \quad (1+\alpha)(1-\rho) > 1 \end{cases} \tag{8}$$

Summing up, a competitive audit market will be explained model-endogenously, if and only if the condition in the last row of (8) is fulfilled, i.e., if one of the following two constellations is given. Firstly, competition is induced, if waiting costs are relatively unimportant, i.e., $\alpha > \frac{\rho}{1-\rho}$. Secondly, if client-independent autonomous learning effects are strong, i.e., $l_P > \frac{1}{1+\alpha}$, competition will arise.[62] Given a competitive market exists, the average total costs per client in period t are restricted by a lower bound $\underline{C}_t$ which is achieved by calculating C_t^D for $n \to \infty$:

$$\underline{C}_t = \frac{\tau^S(1-l_S)^t}{1-\rho} \tag{9}$$

Our finding is consistent to *Simunic/Stein* (1990), who state that "in the limit, th[e] diversification effect drives industry structure to a single auditing firm."[63] Since (8) is independent of n, for $\Delta_1 C_t^D(n+1) < 0$, the auditor intends to grow unboundedly. Further, our finding is consistent to *Francis et al.* (1999), who argue that market leadership is an important strategic factor to signal superior quality and to built up a brand reputation.[64] In our context, superior quality respectively a brand reputation could be interpreted as a high learning index, which induces the auditor to grow. This means our reasoning

[60] For the derivation refer to appendix 3.
[61] For the derivation refer to appendix 4.
[62] This finding is consistent to Elitzur/Falk (1996, p. 48).
[63] Cf. Simunic/Stein (1990, p. 338).
[64] Cf. Francis, Stokes, Anderson (1999, p. 188).

is reversed compared to *Francis et al.* (1999). However, the close relationship between market leadership and brand reputation can be established.

4.2 Duration of low balling

For several reasons a second interesting question is how long low balling takes place in a certain auditor-client relationship. On the one hand, the results might indicate whether regulators should focus on mandates with rather short or with rather long auditor tenure when aiming at protecting auditor independence or improving audit quality.[65] On the other hand, in *DeAngelo* (1981) low balling lasts for only one period per definition. However, empirical findings by *Simon/Francis* (1988) report the low balling effect to last for more than one period.[66] Thus, a contradiction occurs, which is to be resolved in our model.

Analyzing the duration of low balling in our model context proceeds in three steps: Firstly, we derive the auditor's dominant pricing profile by comparing the considered auditor to another one, who is equally large in terms of number of clients and shows identical learning indices, l_S and l_P.[67] In the second step we apply the zero-profit condition, in order to calculate the charges' actual amounts. In the third step, we compare these charges to the costs incurred by an audit according to (9). Identifying the first period, in which the former exceeds the latter, gives the achieved result.

Given a competitive market, according to (8) the auditor intends to win as many clients as possible. His only device for winning a client is the applied charging profile $\Omega, \Omega := (G_0, G_1, ..., G_\infty)$, where the charge, G_t, imposed on a client in period t consists of the audit fee and the waiting costs, as can be inferred from Table 1. The applied charging profile has to be selected from the set of all feasible profiles, i.e., $\Omega \in \mathcal{G}$. Taking into consideration the zero-profit condition, charge discounts in one period have to be offset in other ones. Further, as the client selects the auditor offering the lowest charge in each period and the auditors are identical in terms of size and learning capabilities, it suffices to analyze pairs (G_0, G_F), with $G_1, G_2, ... = G_F$. Thus, the following charging profiles are feasible; $\mathcal{G} = \{(G; G), (G - \varepsilon; G + \kappa), (G + \varepsilon; G - \kappa)\}$, where κ symbolizes the rent being NPV-equivalent to ε, with $\varepsilon > \kappa$.

[65] For the importance of independence see page 5 and for empirical results on auditor tenure see page 12.
[66] Cf. Simon/Francis (1988, p. 260).
[67] Assuming equally large auditors implies audit service to be a homogeneous good, i.e., we concentrate on competition within the group of Big-4, national or local auditors, respectively, cf., e.g., Barton (2005, p. 555).

Table 2 shows the pairwise comparison of the strategies; reading examples are given immediately below the table. If an auditor following the row-strategy competes against an auditor following the column-strategy, two results have to be considered. The first entry in brackets shows the outcome in the initial period t_0 and the second entry depicts the outcome in the subsequent period t_F, given the row-player was selected as auditor in t_0. For the subsequent period t_F it has to be recognized, that the row-auditor (if incumbent) sets the charge G_F, whereas the column-auditor once again plays G_0.

	$(G;G)$	$(G-\varepsilon;G+\kappa)$	$(G+\varepsilon;G-\kappa)$
$(G;G)$	**(tie, tie)**	**(loss, –)**	(win, keep)
$(G-\varepsilon;G+\kappa)$	**(win, loss)**	**(tie, loss)**	(win, keep)
$(G+\varepsilon;G-\kappa)$	(loss, –)	(loss, –)	(tie, keep)

Table 2: pairwise comparison of strategies

As a reading example consider the first row, i.e., the regarded auditor chooses the charging strategy $(G;G)$. Depending on the opponent's strategy, different outcomes arise:

1. Facing another auditor following $(G;G)$, in the initial period t_0 a tie occurs, because both auditors offer $G_0 = G$ as a charge. Assume for a moment, that the regarded auditor is selected. Then, in the subsequent period t_F, he charges $G_F = G$. The opponent still offers $G_0 = G$. However, as both offers are G a tie occurs, again.[68]

2. Facing an auditor following strategy $(G-\varepsilon;G+\kappa)$, in t_0 the regarded auditor offers $G_0 = G$, whereas the opponent offers $G_0 = G-\varepsilon$. Accordingly, the regarded auditor is not selected. Hence, the question whether the regarded auditor is able to keep the client in the subsequent period has not to be answered.

3. Facing an other auditor following the strategy $(G+\varepsilon;G-\kappa)$ the regarded auditor wins the client in the initial period by offering $G_0 = G < G+\varepsilon$. In the subsequent period the regarded auditor offers $G_F = G$, whereas the opponent once again uses his initial offer $G_0 = G+\varepsilon$. Accordingly, the regarded auditor retains his client.

By comparing strategy $(G;G)$ to strategy $(G+\varepsilon;G-\kappa)$ it becomes obvious, that the former strategy strictly dominates the latter, because its outcomes are strictly better in two cases and equal in case of competing against strategy $(G-\varepsilon;G+\kappa)$. Thus, after

[68]For simplicity, assume that in case of a tie the regarded player is selected as auditor.

eliminating the dominated strategy $(G+\varepsilon; G-\kappa)$, only the bold entries in Table 2 have to be considered. At a first glance, strategy $(G-\varepsilon; G+\kappa)$ seems to perform better, because the client is won in the initial period t_0. However, the clients leave the auditor for sure in the subsequent period t_F. Consequently, after having granted a discount ε in the initial period, the auditor definitely loses money when selecting this strategy. Thus, in equilibrium, only strategy $(G; G)$ is played. This means, charges are equally high for all periods, implying $G_t = G \; \forall t$. Let Ω^* denote the optimal charging profile and G^*_∞ the optimal charge in equilibrium.

Taking into consideration the zero-profit condition the charge G^*_∞ can be derived by transforming the NPV of the average total costs into a constant annuity.[69] The NPV of the audit costs over an infinite time horizon for an interest rate i is given by (10).[70]

$$NPV_G(i,\infty) = \frac{\tau^S}{1-\rho}\frac{1+i}{i+l_S} \tag{10}$$

Because in period $t=0$ the initial audit takes place, the optimal charge G^*_∞ can be derived by multiplying the NPV calculated according to (10) with the factor $\frac{i}{1+i}$, accounting for an infinite annuity due:

$$G^*_\infty = \frac{\tau^S}{1-\rho}\frac{i}{i+l_S} \tag{11}$$

A lower bound t^* for the time interval where low balling occurs can be derived by searching for the period in which the audit charge according to (11) is for the first time greater than the total average costs according to (9):

$$\frac{\tau^S}{1-\rho}\left[\frac{i}{i+l_S} - (1-l_S)^{t^*}\right] > 0 \Leftrightarrow t^* > \frac{\ln\frac{i}{i+l_S}}{\ln(1-l_S)} \tag{12}$$

Using the data from the example on page 18, according to (11) the charge in equilibrium would equal $G^*_\infty = \frac{10}{0.1}\frac{0.1}{0.3} = 33.33$. Calculating t^* according to (12) yields 4.92, stating that low balling should not be observed from the fifth follow-up audit onwards. However, calculating the average total costs in $t=5$ for the data of the example gives:
Obviously, the charge of 33.33 is smaller than the total average costs of 35.73. The reason for this is that only three clients are considered. Calculating with 100 clients yields average

[69] The idea of a multi-period pricing incorporating the cost reduction due to learning can already be found in Simunic (1980, p. 187).
[70] For the derivation refer to appendix 5.

	client 1	client 2	client 3	$\sum$	remark
direct audit costs	32.77	29.49	26.54	88.8	
waiting costs	3.28	6.23	8.88	18.39	
total costs	36.05	35.72	35.42	107.19	$\frac{107.19}{3} = 35.73$

Table 3: costs in $t = 5$

total costs of 33.09, establishing the claimed result.

Condition (12) yields a low balling interval of length $t^* > 1$ for realistic parameter settings with $l_S < (1 - i)$, i.e., low balling occurs for more than one period. Thus, the above identified contradiction between the finding in *DeAngelo* (1981) and the empirical evidence presented in *Simon/Francis* (1988, p. 260) is resolved. Modeling dynamic learning effects instead of using the concept of start-up costs explains the occurrence of low balling for more than one period. After this low balling phase, where a loss is accumulated, charges exceed costs and loss-offsetting takes place. However, according to the assumption of an infinite time-horizon, the auditor never regains complete independence.[71]

4.3 Benefit of auditor tenure

A very similar question compared to the section above is, whether auditor tenure is beneficial or not. This question turned out to be especially important from the clients perspective, when mandatory auditor rotation was discussed in the U.S.[72] "Proponents of tenure regulation argue that requiring auditor rotation would improve audit quality by periodically providing a new perspective and that rotation would reduce the client's ability to influence the auditor by limiting the value of incumbency."[73] The aspect of 'controlling the controllers' is not represented in our model. Nevertheless, cost consequences of mandatory auditor rotation can be analyzed. In order to highlight the effects most prominently, consider an auditor rotation would be required after two periods, i.e., only one follow-up audit is permitted. Because the considerations about the charges in equilibrium remain unchanged, it can be derived in the same way as in the section above.[74] Let G_2^* denote the

[71] Cf. the reviewed empirical findings on auditor tenure on page 12.
[72] Cf. Gosh/Moon (2005, p. 588) for a literature review on the discussion of mandatory auditor rotation.
[73] Cf. Geiger/Raghunanandan (2002, p. 69).
[74] For the derivation refer to appendix 6.

charge in equilibrium, if only two audits are allowed:

$$G_2^* = \frac{\tau^S}{1-\rho}\frac{2+i-l_S}{2+i} \tag{13}$$

Comparing (13) with (11) shows the increase in charges:

$$\Delta G(i, l_S, \rho) = G_2^* - G_\infty^* = \frac{\tau^S}{1-\rho}\frac{l_S(2-l_S)}{(2+i)(i+l_S)} \tag{14}$$

From (14) it becomes obvious that l_S heavily influences the increase of charges. Assuming $i = l_S = l_P = 0.1$ the charge increases by 90.8 % compared to an infinite time horizon.

4.4 Benefit of learning

In this section benefits of learning are considered, which especially addresses the question of auditor specialization.[75] Specialization offers an opportunity to earn true rents by realizing not anticipated improvements in learning, i.e., the learning index is increased respectively the learning rate is reduced. The ex ante calculated loss from low balling is overcompensated in advance. In the present modeling approach two alternatives of generating true rents exist. On the one hand, the auditor could improve client-specific learning. This could be done for example by assigning the same audit team to the client every year. Another way of improving client-specific learning would be to provide non-audit services additionally, which gives the opportunity to acquire further insights in the client company's structure. Given an infinite time horizon increasing the client-specific learning index leads to the following reduction of costs:

$$\frac{\partial NPV_G(i,\infty)}{\partial l_S} = -\frac{\tau^S}{1-\rho}\frac{1+i}{(i+l_S)^2} \tag{15}$$

On the other hand true rents could be realized by a not anticipated improvement of client independent autonomous learning l_P. This could be done for example by specializing on a certain industry. Further international accounting harmonization or national accounting harmonization with respect to companies' legal structure could allow for improvements of client-independent autonomous learning, as the diversity of accounting practices is reduced.

[75] This is an important trend in auditing, see, e.g., Ferguson/Stokes (2002, p. 87) or Craswell et al. (1995, pp. 300).

Lastly, abolishing legal accounting options could have a similar impact. The auditor's benefit of this kind of learning can be inferred from (16):

$$\frac{\partial NPV_G(i,\infty)}{\partial l_P} = -\frac{\tau^S}{(1-\rho)^2}\,\frac{1+i}{i+l_S} \tag{16}$$

Comparing (15) and (16) helps identifying the more promising learning improvements. Given $l_S < l_P - i$, investing in client-specific learning earns higher true rents than investing in autonomous learning and vice versa.

Further the motivation to achieve client-specific learning improvements depends on the rotation regime. Under a mandatory auditor rotation after two audits, the cost reduction is:

$$\frac{\partial NPV_G(i,2)}{\partial l_S} = -\frac{\tau^S}{(1-\rho)(1+i)} \tag{17}$$

Comparing (15) and (17) shows that the auditor's benefit given an infinite time horizon is $\left(\frac{1+i}{i+l_S}\right)^2$ times greater than given a two period horizon. Note that the benefits are realized over heavily varying time intervals. Nevertheless, from the economy's perspective it is evident that the auditors' incentives to improve the audit technology by learning are reduced significantly under a mandatory rotation.

4.5 Benefit of size

In practice significant differences in size exist between large multi-national audit firms and national majors or national minors.[76] Accordingly, the last question to be addressed in this paper is whether auditor size matters with respect to low balling and independence.[77] Empirical studies indicate that a positive association between auditor size and audit pricing exists. This means the larger an audit firm is the higher are the fees it can demand.[78] This holds true even if national minors differing very little in size are compared to each other.[79]

When deciding upon the charging strategy the larger auditor has not to regard the own costs but he has to take into consideration the charges of the next largest competing

[76]Cf. Francis/Wilson (1988, p. 664): "Taken literally, DeAngelo's argument suggests that a cardinal ordering of auditor size can be used to proxy for audit quality." It is assumed often that auditor size is an indicator for reputation and audit quality, cf., e.g., Barton (2005, p. 554) or Palmrose (1986, p. 98).

[77]For a discussion on how to measure auditor size, refer to Pong/Whittington (1994, p. 1075).

[78]Cf. De Fond et al. (2000), Rose (1999), or Simon et al. (1992).

[79]Cf. Niemi (2004, p. 556); Vander Bauwhede and Willekens (2004) obtain contradicting results for the Belgian audit market.

auditor. Thus, advantages in size allow the realization of true rents. In the following the advantage with respect to audit costs is quantified by comparing the average total costs depending on the number of clients. For this reason it is assumed that the smaller auditor serves n clients whereas the large one attends $m = n + \Gamma$ clients. Hence:

$$\begin{aligned} C_t^D(n) - C_t^D(m) &= \frac{\tau^S(1-l_S)^t}{1-\rho}\left[\epsilon(n) - \epsilon(m)\right] \\ &= \frac{\tau^S(1-l_S)^t}{(1-\rho)} \underbrace{\left[\frac{(1+\alpha)(1-\rho)-1}{n(n+\Gamma)(1-\rho)}\left[\Gamma - n\rho^n(1-\rho^\Gamma) - \Gamma\rho^n\right]\right]}_{\gamma(\Gamma)} \end{aligned} \tag{18}$$

The term $\gamma(\Gamma)$ is always positive, see appendix 7. This indicates that the larger auditor realizes a cost advantage. Summing up over the infinite time horizon yields the NPV of the true rent $\Pi(\Gamma)$:

$$\Pi(\gamma) = \frac{\tau^S}{1-\rho}\gamma(\Gamma)\sum_{t=0}^{\infty}(1-l_S)^t = \frac{\tau^S}{1-\rho}\frac{\gamma(\Gamma)}{l_S} \tag{19}$$

This finding is consistent to *Niemi* (2004) that larger firms can achieve true rents, whereas smaller ones cannot, because $\gamma(\Gamma)$ depends on the difference between $\varepsilon(n)$ and $\varepsilon(m)$.

Presupposed that low balling harms auditor independence (19) offers an interesting alternative for alleviating the problem. Given the audit market would be segmented according to auditor size -which can be observed in reality- smaller audit firms in each segment would guarantee the independence of the larger firms in this segment.[80]

5 Conclusion

The present paper models more comprehensively learning effects in the context of auditing, because these learning effects are the key points for low balling. With the presented modeling approach it has been possible to show

1. under which circumstances the common assumption of competitive audit markets in low balling models can be justified model-endogenously,

2. that low balling lasts for longer than only the initial audit period,

[80] This result is consistent with the finding in Piot (2001, p. 491) that Big-6 and national major audit firms compete in the same market segment.

3. that low balling is prevalent even if the audit charges remain constant over time,
4. that mandatory external auditor rotation imposes non-negligible costs on the clients, and
5. that a segmentation of the audit market, where size of audit firms' and clients' are correlated, can alleviate the problem of low balling.

Although the assumptions of a DeAngelo world, which are applied here, are relatively restrictive our analysis gives some interesting insights which could serve as thought-provoking impulses:

1. As low balling is difficult to detect in empirical studies due to data restrictions, fee-cutting is often interpreted as an indicator for low balling. Our results suggest that low balling might exist, even if no fee-cutting can be observed.
2. The empirical findings referring to the relationship between size and reputation are mixed. Our results could serve as an explanation why this is the case. Probably some of the analyzed audit markets are competitive whereas others are not.
3. Mandatory auditor rotation and the restriction of non-audit services should not be discussed detached from learning effects as costs could be doubled by ad-hoc changes.
4. For ensuring auditor independence the revenues resulting from a single client are legally capped in many countries. If this induces a matching of big audit and big client firms this mitigates the problem of auditor-independence in the light of our results shown in (19). However if it restricts the market access for small audit firms it even exaggerates the problem in our model context, because the existence of small audit firms is beneficial to the big audit firms' independence.

Appendix

Appendix 1: A client's j waiting time in period $t, t = 0, 1, ..., T$, is the sum of all previously served clients' audit times including the own audit time:

$$\begin{aligned}\tau_t^W = (1-l_S)^t \tau^S \sum_{h=0}^{n-1} \sum_{pos=0}^{h} (1-l_P)^{pos} &= (1-l_S)^t \tau^S \sum_{h=0}^{n-1} \frac{1-\rho^{h+1}}{1-\rho} \\ &= (1-l_S)^t \tau^S \sum_{pos=0}^{n-1} \frac{1-\rho^{pos+1}}{1-\rho} \qquad (20)\end{aligned}$$

Replacing h by pos is feasible, because both indicate the position of a client in the schedule.
Appendix 2: The total costs C_t^G are the sum of audit and waiting costs. Splitting up the sum and adding ρ^0 yields the presented result.

$$\begin{aligned}C_t^G &= \tau^S(1-l_S)^t \left\{ \alpha \frac{1-\rho^n}{1-\rho} + \sum_{pos=0}^{n-1} \frac{1-\rho^{pos+1}}{1-\rho} \right\} \\ &= \tau^S(1-l_S)^t \left(\frac{1-\rho^1}{1-\rho} + \frac{1-\rho^2}{1-\rho} + ... + \frac{1-\rho^{n-1}}{1-\rho} + (1+\alpha)\frac{1-\rho^n}{1-\rho} \right) \\ &= -\frac{\tau^S(1-l_S)^t}{1-\rho} \left[-n + \rho^0 - \rho^0 + \rho^1 + \rho^2 + ... + \rho^{n-1} - \alpha + (1+\alpha)\rho^n \right] \\ &= \frac{\tau^S(1-l_S)^t}{1-\rho} \left[n + 1 + \alpha - \frac{1-\rho^n}{1-\rho} - (1+\alpha)\rho^n \right] \qquad (21)\end{aligned}$$

Appendix 3: The first difference of the average total costs is given by:

$$\begin{aligned}\Delta_1 C_t^D(n+1) &= C_t^D(n+1) - C_t^D(n) \\ &= \frac{\tau^S(1-l_S)^t}{(1-\rho)} \left[1 + \frac{1+\alpha}{n+1} - \frac{1-\rho^{n+1}}{(n+1)(1-\rho)} - \frac{1+\alpha}{n+1}\rho^{n+1} - \right. \\ &\quad \left. 1 - \frac{1+\alpha}{n} + \frac{1-\rho^n}{n(1-\rho)} + \frac{1+\alpha}{n}\rho^n \right] \\ &= \frac{\tau^S(1-l_S)^t}{(1-\rho)} \frac{[(n+1)\rho^n - n\rho^{n+1} - 1]\,[(1+\alpha)(1-\rho) - 1]}{(n^2+n)(1-\rho)} \qquad (22)\end{aligned}$$

Appendix 4: The first term in brackets of (7) is always positive but never greater than one:

$$(n+1)\rho^n - n\rho^{n+1} > 0 \Leftrightarrow \frac{n+1}{n} > \rho \qquad (23)$$

The last ratio in (23) is greater than one, whereas ρ is smaller than one per definition, hence the last inequality is true.

$$\begin{aligned}(n+1)\rho^n - n\rho^{n+1} &< 1\\ \Leftrightarrow n\rho^n(1-\rho) &< 1-\rho^n\\ \Leftrightarrow n\rho^n &< \frac{1-\rho^n}{1-\rho}\end{aligned} \tag{24}$$

The last inequality is true, because on the right hand side of (24) a geometric row with n elements is shown. Due to $\rho < 1$ each of the elements is greater than ρ^n.

Appendix 5: The average audit costs of a client in period t are given by:

$$\frac{C_t^G}{n} = \frac{\tau^S(1-l_S)^t}{1-\rho} \underbrace{\frac{n+1+\alpha-\frac{1-\rho^n}{1-\rho}-(1+\alpha)\rho^n}{n}}_{\varepsilon(n)} \tag{25}$$

Summing up the discounted average audit costs over all periods results in an infinite row, which can be calculated explicitly for positive interest rates i. $\varepsilon(n)$ can be eliminated from the sum, because it is independent of t:

$$NPV_G(i,\infty) = \frac{\tau^S}{1-\rho}\varepsilon(n)\sum_{t=0}^{\infty}\left(\frac{1-l_S}{1+i}\right)^t = \frac{\tau^S}{1-\rho}\frac{1+i}{i+l_S}\varepsilon(n) \tag{26}$$

For equally large audit firms $\varepsilon(n)$ is identical, hence it can be neglected. For large audit firms, i.e., $n \to \infty$, it approaches one.

Appendix 6: The NPV of the total audit costs for a two period horizon is given by:

$$NPV_G(i,2) = \frac{\tau^S}{1-\rho}\left[1+\frac{1-l_s}{1+i}\right] = \frac{\tau^S}{1-\rho}\frac{2+i-l_S}{1+i} \tag{27}$$

$$G_2^* = \frac{(1+i)^2 i}{(1+i)^2-1}\frac{1}{1+i}\frac{\tau^S}{1-\rho}\frac{2+i-l_S}{1+i} = \frac{\tau^S}{1-\rho}\frac{2+i-l_S}{2+i} \tag{28}$$

Appendix 7:

$$
\begin{aligned}
\gamma(\Gamma) &> 0 \\
\Leftrightarrow m - (n+m)\rho^n + n\rho^{n+m} &> 0 \\
\Leftrightarrow m(1-\rho)^n &> n\rho^n(1-\rho^m) \\
\Leftrightarrow m\frac{1-\rho^n}{1-\rho^m} &> n\rho^n
\end{aligned} \tag{29}
$$

For $m = 1$ (29) equals (24). For increasing m the condition (29) is relaxed, because the left hand side increases in m.

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