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Concentration without differentiation: A new look at the determinants of audit market concentration

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Abstract

We show that a model of undifferentiated price competition closely predicts US audit market concentration. Contracting practices, client size distributions and differences in auditor productivity jointly determine audit firms' market shares. In contrast to prior literature, neither quality differences nor economies of scale for larger firms are necessary in our model to explain audit market concentration.

JEL classification: C6; D2; L1; L8; M4

Keywords: Audit industry structure; Audit market concentration; Capacity commitment; Leverage

1. Introduction

This study explains audit market concentration with a model of undifferentiated price competition. Our results depend on three features of our model. First, clients buy the entire audit from one firm. This all-or-nothing nature of audit demand makes audits *indivisible*. Second, because of this indivisibility, the distribution of client sizes affects the pattern of audit firm market shares. Third, differences in labor productivity across firms affect audit costs. Jointly, these three features enable us to predict US audit market concentration.

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Audit market concentration has been a topic of research and regulatory interest for several decades. In 1976 a Congressional Staff study questioned the anti-competitive nature of the then Big Eight firms' market dominance (US Congress, 1976). Subsequently, merger activity has reduced the Big Eight to the Big Six and the proposed merger of Price Waterhouse with Coopers and Lybrand would further reduce this number to five. The most recent round of merger activity appears to have revived regulatory concerns about market shares of dominant firms (Wall Street Journal, 1998). We find that as of 1995, the Big Six firms audited all publicly traded non-financial clients with total assets greater than $5 billion and over 60% of the clients with assets less than $25 million. This highly concentrated pattern of market shares has prevailed since the time of the 1976 Congressional Staff Study.

We examine whether this pattern of market shares can be explained with a model of pure price competition. We assume firms produce audits using a two-factor Cobb–Douglas technology with one fixed (partners) and one variable (staff) input. Demand for staff and the optimal staff-to-partner ratio – denoted *leverage* – are endogenously determined by the firm's cost minimization program. Short-run factor demands yield the short-run cost functions needed to construct equilibria through market simulation. Our equilibria are renegotiation-proof in that the only way a non-incumbent firm can acquire an incumbent firm's client is by making a bid that cannot recover the non-incumbent's incremental cost of auditing that client. The equilibrium industry structure in our simulated market, using 1995 data on client size and audit firm size and leverage, resembles quite closely the actual industry structure.

Prior literature offers two explanations for industry concentration. First, Dopuch and Simunic (1980) and DeAngelo (1981) argue that some firms produce quality-differentiated products and reputation for superior quality explains their market dominance. Because our analysis assumes that clients choose auditors based solely on price, quality differentiation plays no role in our markets. Second, Dopuch and Simunic (1980) and Danos and Eichenseher (1986) argue that economies of scale in audit production favor market dominance by a few firms. We replicate observed market structure under the assumption that firms use a constant-returns-to-scale technology that exhibits diseconomies of scale in the short run when the supply of one factor of production is constrained. Thus our approach requires neither differentiation nor economies of scale to explain industry concentration.

The outline of the rest of the paper is as follows: Section 2 derives audit cost functions, Section 3 explains the market clearing process and Section 4 the data sources. Results are reported in Section 5 and in Section 6 we summarize and conclude.

2. Audit cost functions

If audits (hereafter, interchangeably, jobs) truly are undifferentiated products, audit markets ought to be characterized by price competition. The classical economic model of price competition assumes that producers set price equal to marginal cost. We assume this to be true of audit firms' fee bids as well; each firm will bid its incremental cost as its fee on each job. In equilibrium, the lowest bidder will be awarded the job at a fee equal to the bid or incremental cost of the second lowest bidder.

The model of audit production we use to derive audit firms' cost functions assumes that (a) producers are of different sizes which cannot vary in the short run, and (b) demand is heterogeneous but lumpy because jobs are indivisible. The set of audit firms and audit clients is given exogenously, as are, in the short run, client sizes and audit firm sizes and leverage. Under these assumptions, we first derive short-run audit cost functions and then discuss their salient properties.

2.1. Derivation

Each multi-client audit firm uses a Cobb–Douglas audit production technology with one fixed (partners) and one variable (staff) factor of production. The firm's total endowment of partners, f, is called its *size*, and cannot, by assumption, be varied in the short run. All firms can buy unlimited amounts of staff labor, l, from a perfectly competitive market for a unit wage w. The amount of work to be done on a job is denoted by q and is our measure of job size. The level of factor inputs used on a given audit is determined endogenously by the firm's cost minimization program that in turn determines the firm's out-of-pocket or short-run costs of hiring staff. Short-run costs do not include the opportunity costs of the short-run fixed factor, i.e. partners.

To produce q_j on the jth job, each firm uses f_j partners and l_j staff to satisfy

$$q_j = f_j^a l_j^b \tag{1}$$

where both a and b are strictly positive. The firm's allocation of the fixed factor to its jobs is subject to the constraint that the total allocation cannot exceed its initial endowment, f, i.e.,

$$\sum_j f_j \leq f. \tag{2}$$

For a multi-client firm of size f, the total short-run cost of serving a set of clients J, with sizes q_j is the total variable cost of hiring staff, i.e.,

$$C(J,f) = w\sum_{j\in J} l_j \tag{3}$$

and the optimal l_j's are chosen to minimize Eq. (3) subject to Eqs. (1) and (2). The incremental cost to a firm of size f of auditing an additional client k of size q_k, given an existing set of clients J, is then

$$IC(J, k, f) = C(J \cup k, f) - C(J, f). \tag{4}$$

Let $s_j = q_j^{1/(a+b)}$ and $\ell = a/b$. The solution to the firm's optimization (here cost minimization) problem is presented in Appendix A where we show that Eq. (4) can be written as

$$IC(J, k, f) = w\frac{(\sum_{j \in J} s_j + s_k)^{\ell+1} - (\sum_{j \in J} s_j)^{\ell+1}}{f^{\ell}}. \tag{5}$$

Eq. (5) yields the incremental cost of a job which becomes each firm's bid on the job. These bids are used to assign clients to the lowest bidders and later to compute the client dissatisfaction measures that determine the order in which clients are reassigned during the market clearing process. The winning audit firm's fee on a given job is the second lowest bid received on that job, equivalently the nearest rival's incremental cost of performing that audit.

2.2. Discussion

For a professional firm, skilled or experienced human capital is a key resource which is costly to vary quickly. We assume that a firm cannot change its number of partners in the short-run and use that number as our measure of firm size. A firm's total staff needs in our model depend on the total size of the firm's clientele. The optimal *leverage*, or staff-to-partner ratio, is endogenously determined by ℓ, the ratio of the firm's factor productivities and in our model, a firm with a lower ℓ will use higher leverage (see also Beckmann, 1987, p. 153). Intuitively, as ℓ decreases, a firm uses more leverage because for a given amount of staff labor, fewer partners have to be assigned to a given job. Even when all firms enjoy identical returns to scale $(a + b)$, the optimal mix of staff and partners varies across firms, reflecting variations in the relative productivity (a/b) of their partners and staff.

Our empirical analysis assumes that all firms enjoy identical returns to scale, so that $a + b$ is constant for all firms. Because s_j is the same for all firms, using s_j rather than q_j to denote the *size* of the client leads to no ambiguity and Eq. (5) has several immediate implications for a cost-minimizing firm. First, what matters for price competition is the relative incremental cost of the same job across firms. When all firms enjoy the same returns to scale, incremental cost differences increase with the ratio of factor productivities $(\ell = a/b)$. Second, size and leverage act as substitutes in our model since short-run incremental costs of audit production in Eq. (5) are decreasing in firm size, f, and in leverage (increasing in ℓ). Third, when firms enjoy constant returns to scale $(a + b = 1)$

and the supply of partners is fixed in the short run, our cost function displays *dis*economies of scale.

Our approach differs in several respects from O'Keefe et al. (1994) who assume that the audit firm uses an input vector $\boldsymbol{h}$ of four different types of labor to produce a given level of quality $\boldsymbol{q}$ on a job. They assume a firm's demand for the jth component of $\boldsymbol{h}$ is an exogenously defined function of the individual client's characteristics and trade-offs between the components of $\boldsymbol{h}$ are exogenously given. In our model, these trade-offs are endogenous, depend on the characteristics of a firm's production technology as well as on the size of its total clientele, and are non-linear in the size of the firm's clientele (from Eq. (5) the labor input to be hired is increasing convex in the total size of the firm's clients).

3. Market clearing

Our market mimics a process of pure price competition in which firms' bids are based on short-run or out-of-pocket incremental costs. A short-run equilibrium is determined by firms competing on price till every client finds an auditor and no client wants to move to another auditor (we discuss the long-run stability of these equilibria later). Clients are free to switch auditors whenever they can find a lower price, implying that in equilibrium every job is assigned to a firm whose bid on that job cannot be undercut by any other firm: that is, the market has cleared. After all jobs are assigned, each incumbent firm charges its client a fee equal to the lowest of the incremental costs of all other firms in the market *given the final assignment*. Profit is the difference between a firm's total fee income and total cost.

The market clearing process, illustrated in Fig. 1, governs the order in which clients select auditors, determines the 'bids' firms make on that client, and determines whether any clients need to search for a lower cost. At the end of the assignment process, no client has a price incentive to switch firms.

When the market opens all firms have empty client rosters. In each round an unassigned client is randomly selected for assignment. Each audit firm bids its incremental cost and the client is assigned to the lowest bidder. After all jobs are assigned, we check to see whether there are any dissatisfied clients. A client is *dissatisfied* when the incumbent auditor's incremental cost is higher than the incremental cost of at least one rival for the same job. The excess of the incumbent's incremental costs over the lowest-cost rival's incremental cost is the client's measure of dissatisfaction and is non-positive only when the client is satisfied. When a client is dissatisfied, the measure is positive, and the client desires to switch auditors.

As long as there is a dissatisfied client in the market, we calculate the dissatisfaction score and move the client to the auditor with the lowest incremental cost of auditing that client. Our dissatisfaction score is a measure of

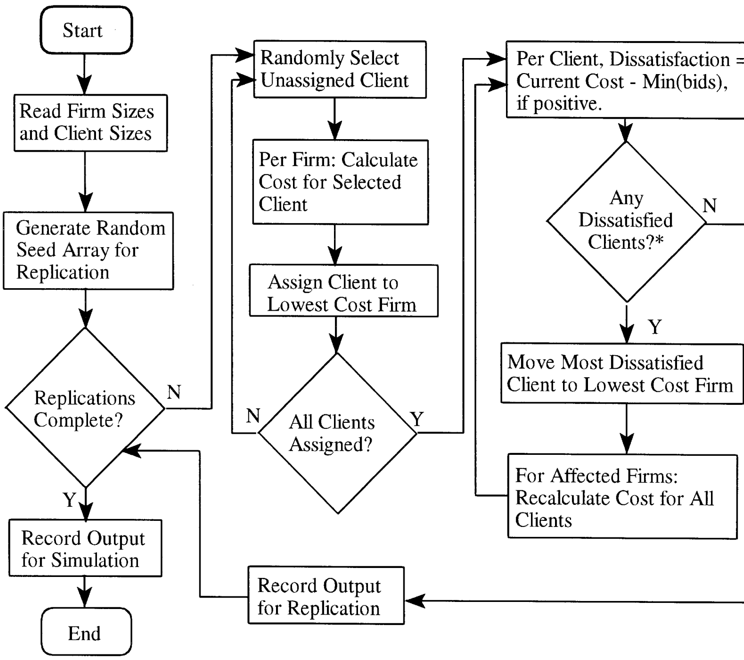

Fig. 1. Flow chart illustrating simulated market.
The left side of this flow chart illustrates the main loop controlling replications, the center shows the client assignment loops, and the right side shows dissatisfaction-based movement. A client is dissatisfied when the incumbent auditor's incremental cost is higher than the incremental cost of at least one rival for the same job. The excess of the incumbent's incremental costs over the lowest-cost rival's incremental cost is the client's measure of dissatisfaction and is non-positive only when the client is satisfied. When a client is dissatisfied, the measure is positive, and the client desires to switch auditors.
In our simulation only a few of the smallest clients are dissatisfied after the initial allocation.

client savings from switching auditors and our algorithm allows clients who stand to gain most to switch first, though our results are not sensitive to moving dissatisfied clients in random order. When a dissatisfied client moves from one auditor to another, the firms that gain or lose a client experience a change in their sum of job sizes (Σs_j). We then recalculate all incremental costs for all clients and identify a new most dissatisfied client, until no client remains dissatisfied. Since clients are assigned to firms in random order, the consistency of market shares resulting from multiple runs of the process illustrates the robustness of the industry structure resulting from this model of price competition.

Our analysis of short-run price competition takes firm sizes as fixed and ignores the opportunity cost of the fixed factor of production. In the long run, however, firms will choose sizes optimally. If firms' observed sizes are to be optimal in the long run, a minimal requirement is that short-run profits must cover partners' opportunity costs of remaining in the audit profession. Although we do not have a general proof that the short-run equilibria we identify will always generate sufficient profits to cover all firms' opportunity costs, additional analysis (available from the authors on request) suggests that at least the high leverage firms will, at a minimum, recover their long-run opportunity costs.

4. Data

Our sample consists of 5320 US non-financial companies[1] and the 306 firms[2] that audit them, identified from *Compustat PC-Plus*, *Who Audits America*, *Dun and Bradstreet's Million Dollar Directory* and the *Dow-Jones Disclosure* service. We measure job size as the natural logarithm of a firm's total assets.[3] Audit firm sizes are measured by the number of partners. We use data from *Public Accounting Report* (*PAR*) to compute staff-to-partner ratios for 43 audit firms and collect size information for another 24 firms.[4] For these 67 audit firms in our sample, we have definite information on audit firm size.[5]

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[1] The sample of 5320 firms was selected as follows: From an initial sample of 5900 companies with SIC Codes less than 6000 listed in the 1995 *Compustat PC-Plus* database we eliminated 427 companies described as ADRs, ADSs, American shares, companies whose names end in NV, GMBH, LTD and SA as well as other companies we were able to identify as foreign firms, 17 companies for which total assets are unavailable or non-existent, 56 companies which *Compustat* reports as 'unaudited' and 80 companies for which we were unable to identify auditors.

[2] The auditors of 4832 of the 5320 companies in the sample are identified using the *Compustat* auditor identity variable. The rest of the auditors are identified from *Dun and Bradstreet's Million Dollar Directory* (193 companies), *Who Audits America* (169 companies) and the *Dow-Jones Disclosure* database (126 companies). To test for errors, we compared the *Compustat* auditor for a random sample of 250 firms to *Dow-Jones Disclosure and Who Audits America* and found no discrepancies.

[3] Since some clients have assets fewer than one million dollars, and our model cannot accommodate negative job sizes, job sizes are measured in logs of dollars, not millions of dollars as in prior literature. Davis et al. (1993, Table 3) present evidence that the natural log of total assets is the only publicly available variable which consistently significantly explains the natural log of hours worked. Our model also ignores all client characteristics which may influence audit fees but not out-of-pocket costs of audit production. Liability or litigation costs are zero in our model.

[4] Each year *PAR* publishes a list of the 100 largest accounting firms in the US. In 1995, 57 of the 100 largest accounting firms listed in *PAR* do not appear in our auditor sample. 32 of the 57 have no SEC clients and the other 25 missing firms may specialize in audits of financial clients (banks are a notable category) or of OTC and pink-sheet market companies too small to appear on *Compustat*. The other 24 firms are selected as follows. A total of 39 firms not in the *PAR* 100 list audit either one or more of the largest 60% of clients in our sample (16 firms) or have 3 or more clients in our entire sample (31 firms) and 8 firms fall in both categories. Of these 39 firms, 7 could not be traced, for example because they no longer exist (2). We contacted the remaining 32 firms to find out how many partners they had in 1994: 24 responded (4 firms refused to divulge the information and 4 did not return any of our three calls).

[5] The data on partners and staff published by *PAR* is for the entire firm, not just for the audit division. This aggregation introduces noise in our measure of leverage.

Audit firms vary considerably in size and leverage with most firms being quite small relative to the Big Six. The Big Six have between 928 and 1764 partners. The next five largest have between 100 and 384 partners and another five firms have between 50 and 100 partners. We call these ten firms the national firms in what follows. Of the remaining 51 (= 67-6-10) firms whose sizes we do know, 16 have between 20 and 49 partners, 19 have between 10 and 19 partners, and 16 have fewer than 10 partners. Big Six leverage ratios vary between 14 : 1 and 6.7 : 1 (mean $\ell = 0.12$, mean leverage = 8) while the non-Big Six firms' values range from 11.5 : 1 to 2.5 : 1 (mean $\ell = 0.217$, mean leverage = 4.6).

The number of partners for 239 of our sample of 306 audit firms is not available publicly.[6] We set the sizes of these 239 firms at 5 partners each and $\ell = 0.217$, the mean of the non-Big Six firms whose leverage we do know. However, our results are not sensitive to reasonable alternative estimates of their size. We refer to the 51 firms with fewer than 50 partners and these 239 firms as the small firms.

Table 1 shows the market shares of the Big Six and other firms in the final sample of 5320 non-financial US companies by client-size class using a size-based classification scheme similar to that employed by *Who Audits America*. Note the dramatic drop in Big Six market share in the small client segment. The Big Six audit 4530 (85%) of the 5320 clients in the sample, 100% of clients with total assets larger than \$5 billion, and over 90% of clients with more than \$50 million in total assets. Even in the smallest client segments, where clients have total assets ranging from a few thousand dollars to \$50 million, Big Six firms' market share is over 60% of the clients. This decreasing pattern is consistent with prior research (Dopuch and Simunic, 1980; Danos and Eichenseher, 1982).

5. Results

This section presents the results from our primary market simulations and various sensitivity analyses. We rely on two measures of goodness of fit in evaluating our results. The first is a simple χ^2 test, based on the frequencies of Big Six clients in each client class that compares the empirically observed distribution with that obtained from the market. The second is the combined market shares of the Big Six firms. Our model predicts industry concentration well. Additional tests show that our principal findings are not sensitive to noise in our measures of client size, firm sizes and leverage.

[6] Of these 239 firms, 62 firms audit only two clients in the smallest 30% of clients and 177 firms audit only one client in the smallest 20%. Because these 239 firms have a very slight market presence, we did not attempt to identify their exact sizes.

Table 1
1995 audit firm market shares for audit clients in a sample of 5320 *Compustat* non-financial firms

		Audit clients classified by total assets in dollars[a]							
	Total	> 5b	1–5b	0.5–1b	250–500 m	100–250 m	50–100 m	25–50 m	< 25 m
Big Six	4530	241	548	363	472	713	592	550	1051
National	349	0	2	7	11	30	39	59	201
Other	441	0	1	2	4	9	17	31	377
Total	5320	241	551	372	487	752	648	640	1629
Percent	100	4.5	10.4	7.0	9.2	14.1	12.2	12.0	30.6

Audit clients are classified into one of eight size classes based on Total Assets. The size-class cutoffs are those used by *Who Audits America*. The Big Six firms are, in alphabetical order, Arthur Andersen, Coopers and Lybrand, Deloitte and Touche, Ernst and Young, KPMG Peat Marwick and Price Waterhouse. National firms comprise the ten next-largest firms in our sample and have between 50 and 400 partners. Small firms comprise 51 firms with fewer than 50 partners and the remaining 239 firms in our sample about which we do not have size information.

[a] b = billion, m = million.

5.1. The main results

Results of 30 runs of the market simulations using two alternative measures of client size are reported in Table 2. In each run, audit firms start with no clients and the order in which clients are assigned is randomly chosen. For each measure of client size, Table 2 reports the average predicted market shares of three classes of firms in the eight client-size classes corresponding to Table 1.[7] We compare the predicted market shares of Big Six firms reported in Table 2 to their actual market shares in Table 1, using a χ^2 test. The null hypothesis is that the pattern of predicted market shares is not significantly different from the actual pattern of market shares.

Consistent with prior work, measuring client size by linear transformations of the natural logarithm of total assets, ($q = \alpha + \beta \ln TA$) best explains observed industry structure. Panel *A* of Table 2 reports average market shares when $\alpha = 0, \beta = 1$ and firms enjoy constant returns to scale ($a + b = 1$), i.e., when client size is measured by the natural log of the client's total assets ($s_j = \ln TA_j$).[8] The average market shares from multiple runs reported in Panel *A* of Table 2 do not differ significantly from the empirically observed market shares in Table 1 ($\chi^2 = 11.3$, $p \leq 0.13$). The overall market share of the Big Six is higher in the simulation than in the actual data; they win 4720 of the 5320 clients in the simulated market, compared to 4530 in the actual data. Big Six firms lose on average less than one client in the largest category and have higher market shares in every other category.[9] Overall, the Big Six add about 200 clients to their collective portfolio, an increase in market share of just under 4%. The Big Six win most of their additional clients at the expense of the national and regional firms, who lose about a third of their clientele. Even so, each middle tier firm still has over twenty clients. Note that the small audit firms have, on

[7] The results reported in Table 2 assume that the small firms use the average non-Big-Six leverage of 0.217. The mean ℓ for the entire sample is 0.203. Assigning this somewhat lower value of leverage to all smaller firms does not change our results significantly from those reported in Table 2.

[8] Using different values of α and β and varying assumptions about returns to scale by setting $a + b = 2$ (increasing returns) and $a + b = 0.8$ (decreasing returns) leaves our results qualitatively invariant. When we run our simulations with $TA^{0.5}$ as the measure of job size, the bigger jobs are too large, swamping the effect of differing firm sizes. The Big Six have high market shares in every segment but the market shares are constant across clients instead of decreasing sharply in smaller clients. Thus the square-root transformation does not appear to work as well as the logarithmic transformation for our purposes.

[9] After adjusting for the difference in the total Big Six market shares shown in Panels *A* and *B*, a χ^2 test for the differences in market shares by client category, the distributions of market shares across categories are statistically insignificantly different ($\chi^2 = 3.3$, *alpha* $= 0.86$). Repeated trials consistently produce the same industry configuration: the variances around the market shares across 30 trials are small.

Table 2
Simulated audit firm market shares under price-competition: predicted averages over 30 simulated markets

	Total	Audit clients classified by total assets in dollars[a]								χ^2	$\hat{\alpha}$[b]
		> 5b	1–5b	0.5–1b	250–500 m	100–250 m	50–100 m	25–50 m	< 25 m		
Panel A											
Simulated Outcomes using natural log of total assets as measure of job size and actual leverage											
Big Six	4719.1	240.7	550.4	371.1	484.8	745.2	633.6	601.4	1091.9	11.3	0.13
National	237	0.3	0.6	0.9	2.2	6.8	13.9	26.5	185.8		
Other	363.9	0	0	0	0	0	0.5	12.1	351.3		
Panel B											
Simulated outcomes using alternative measure of job size and actual leverage.[c]											
Big Six	4922.5	241	551	372	487	751.8	643.9	619.6	1256.3	56.3	0
National	267.8	0	0	0	0	0.2	4.1	20.4	243.1		
Other	129.7	0	0	0	0	0	0	0	129.7		

Audit clients are classified into one of eight size classes based on Total Assets. The size-class cutoffs are those used by *Who Audits America*. The Big Six firms are, in alphabetical order, Arthur Andersen, Coopers and Lybrand, Deloitte and Touche, Ernst and Young, KPMG Peat Marwick and Price Waterhouse. National firms comprise the ten next-largest firms in our sample and have between 50 and 400 partners. Small firms comprise 51 firms with fewer than 50 partners and the remaining 239 firms in our sample about which we do not have size information.

[a]b = billion, m = million.

[b]$\hat{\alpha}$ is used following Conover (1980): 'The critical level $\hat{\alpha}$ is the smallest significance level at which the null hypothesis would be rejected for the given observation.' The null hypothesis is H_0: The obtained distribution of Big Six frequencies is from the same distribution as the empirically observed distribution.

[c]Job size is measured as $s_j = e^{-1.5+0.5 \ln TA}$ based on estimated coefficients computed by Simunic (1997).

average, no clients larger than \$100 million. The combination of capacity and leverage available to the Big Six firms enables them to underbid smaller firms on all jobs bigger than a certain size in our market.

Following a suggestion by Simunic (1997), we re-run our analysis using the scaling $s_j = e^{-1.5+0.5 \ln TA}$ to measure client sizes.[10] The average market shares from 30 runs of this market are reported in Panel *B* of Table 2. The alternative measure of job size over-estimates market shares for Big Six firms, both overall and in the small client categories. The χ^2 test indicates that the actual market shares in Table 1 and the predicted shares in Panel *B* of Table 2 are significantly different. However, our basic finding that significant supplier concentration can result purely from the interaction of empirical client size distributions, a reasonable audit production technology, and the all-or-nothing nature of audit assignments, is robust to alternative measures of client size.

Why might our model over-predict Big Six market share? One reason might be noise in our measures, a possibility further discussed in Section 5.3. Some studies of audit pricing suggest that Big Six firms charge premium prices and price-ration their services to all but the very largest clients (Francis, 1984; Francis and Simon, 1987). In this case, our results indicate the extent to which the Big Six would attract even more small clients if they drop their premium pricing. For example, Panel *A* of Table 2 suggests that the Big Six could increase market shares in all market segments except the very largest. Their largest gains would be in the \$50 million to \$100 million category (7%) and in the \$25 million to \$50 million category (9%). In any event, both Panels *A* and *B* of Table 2 suggest that quality differentiation by the Big Six, if it exists in fact, does not result in higher market share for these firms relative to the market share predictions from a benchmark model of pure price competition.

5.2. *Capacity vs. Leverage*

Audit firm size in our model is an exogenously determined capacity commitment whereas leverage is endogenously determined by the relative productivity of the firm's partners and staff. Eq. (5) indicates that leverage crucially affects relative incremental costs and, therefore the firm's clientele. To isolate the role capacity plays in determining our results, we also run a series of market simulations in which Big Six and non-Big-Six firms have identical leverage. Panels *A* and *B* of Table 3 show that capacity alone explains industry structure poorly. With equal leverage and job sizes measured by the natural log of Total Assets, Panel *A* of Table 3 shows that the Big Six get far fewer clients that they actually have. The loss of market share among smaller clients is particularly pronounced. When job sizes are measured by the alternative measure, the results

[10] We thank Dan Simunic for sharing the relevant parameter values.

Table 3
Audit firm market shares simulated assuming equal leverage for all audit firms

		Audit clients classified by total assets in dollars[a]									
	Total	> 5b	1–5b	0.5–1b	250–500 m	100–250 m	50–100 m	25–50 m	< 25 m	χ^2	$\hat{\alpha}$[b]
Panel A											
Simulated outcomes using natural log of total assets as a measure of job size											
Big Six	3560.7	238.9	534.7	350.7	440.3	633.7	494.1	408.8	459.5	397	0
National	701.5	2.1	16.2	20.1	37.3	85.7	105.9	134.3	299.9		
Other	1057.7	0	0.1	1.2	9.4	32.6	48	96.9	869.5		
Panel B											
Simulated outcomes using alternative measure of job size[c]											
Big Six	1562.5	241	535.8	310.2	293.3	159.9	15.3	3.9	3.1	2652	0
National	792.9	0	15.2	61.8	191	401.6	90	19.3	14		
Other	2964.6	0	0	0	2.7	190.4	542.7	616.9	1611.9		

Audit clients are classified into one of eight size classes based on Total Assets. The size-class cutoffs are those used by *Who Audits America*. The Big Six firms are, in alphabetical order, Arthur Andersen, Coopers and Lybrand, Deloitte and Touche, Ernst and Young, KPMG Peat Marwick and Price Waterhouse. National firms comprise the ten next-largest firms in our sample and have between 50 and 400 partners. Small firms comprise 51 firms with fewer than 50 partners and the remaining 239 firms in our sample about which we do not have size information.

[a]b = billion, m = million.

[b]$\hat{\alpha}$ is used following Conover (1980): 'The critical level $\hat{\alpha}$ is the smallest significance level at which the null hypothesis would be rejected for the given observation.' The null hypothesis is H_0: The obtained distribution of Big Six frequencies is from the same distribution as the empirically observed distribution.

[c]Job size is measured as $s_j = e^{-1.5+0.5 \ln TA}$ based on estimated coefficients computed by Simunic (1997).

reported in Panel *B* of Table 3 are less similar to the empirically observed distribution. Comparing Panels *A* and *B* of Table 2 to Panels *A* and *B* of Table 3 indicates that leverage is an essential variable in our model. Capacity alone does a poor job of explaining market shares, either in the aggregate or by client segment.

5.3. Other sensitivity analyses

In our model, both size and leverage are sources of competitive advantage. We conduct additional tests to examine how potential noise in our measures of size and leverage might affect our findings. In our main analysis reported above, we conservatively assume that the firms for which we have no size data are small and each have 5 partners and those for which we have no leverage data have $\ell = 0.217$, the average for non-Big-Six firms. This translates to a staff-to-partner ratio of roughly 5 : 1 for smaller firms. Smaller firms are more likely to have small numbers in both the numerator and the denominator, so that their leverage is more likely to be mis-measured than that of large firms, suggesting that we may have underestimated the leverage for smaller firms. Alternatively, the Big Six firms may use lower leverage for their audit practices and higher leverage for their consulting practices (Stevens, 1991 pp. 110–112). If so, using aggregate firm-wide leverage measures overstates Big Six audit practice leverage.

Table 4 reports results under a variety of alternative assumptions about small firms' size and leverage. The overall conclusion from these additional tests is that if we relax the conservative assumptions made in Section 5.1, we obtain even better fit. In Panel *A* of Table 4 we assume that small firms each have 5 partners and $\ell = 0.17$, the average for the Big Six and national firms combined. In effect, we allow smaller firms to have a staff-to-partner ratio approximating 6 : 1 instead of the near 5 : 1 value used in the main analysis. Allowing small firms higher leverage improves the ability of the model to replicate the empirical distribution in Table 1.

In Panels *B* and *C* we assume all small firms have 15 partners each, much closer to the average of 16 partners for the 51 small firms whose sizes we know. For Panel *B* we assume that the small firms have $\ell = 0.217$, as in our main tests, while panel C assumes $\ell = 0.17$, the value used in Panel *A* above. The results of Panel *B* are a significant improvement in fit over Table 2, Panel *A*. Finally in Panel *C* of Table 4 we assume smaller firms have 15 partners each and a leverage of about 6 : 1, yielding predictions quite close to the observed distribution, with an alpha level above 0.8. These results suggest that our conclusions are robust, and within a range of reasonable values for smaller firms' sizes and leverage, our observations about industry structure remain stable.

Table 4
Audit firm market shares simulated under varying assumptions about audit firm sizes and leverage.[a]

		Audit clients classified by total assets in dollars[b]									
	Total	> 5b	1–5b	0.5–1b	250–500 m	100–250 m	50–100 m	25–50 m	< 25 m	χ^2	$\hat{\alpha}$[c]
Panel A											
Simulated outcomes after increasing leverage for small firms of unknown leverage to 0.17											
Big Six	4704.8	240.7	550.4	370.8	484.6	741.6	612.1	576.7	1127.9	9.3	0.23
National	236.7	0.3	0.6	1.2	2.4	9.2	16	21.6	185.4		
Other	378.7	0	0	0	0	1.2	19.9	41.8	315.8		
Panel B											
Simulated outcomes after increasing size for small firms of unknown size to 15 partners.											
Big Six	4660.4	240.7	550.4	370.8	484.1	742.2	626.4	599.6	1046.2	8.2	0.32
National	232.4	0.3	0.6	1.2	2.9	8.1	14.4	27.1	177.8		
Other	427.2	0	0	0	0	1.7	7.2	13.3	405		
Panel C											
Simulated outcomes after increasing both leverage and size for small firms of unknown leverage or size.											
Big Six	4609.6	240.7	550.3	370.4	483.6	738.2	614.5	576.2	1035.7	3.7	0.81
National	229.9	0.3	0.7	1.6	3.3	9.5	17.6	25.3	171.6		
Other	480.4	0	0	0	0.1	4.3	15.9	38.5	421.6		

Audit clients are classified into one of eight size classes based on Total Assets. The size-class cutoffs are those used by *Who Audits America*. The Big Six firms are, in alphabetical order, Arthur Andersen, Coopers and Lybrand, Deloitte and Touche, Ernst and Young, KPMG Peat Marwick and Price Waterhouse. National firms comprise the ten next-largest firms in our sample and have between 50 and 400 partners. Small firms comprise 51 firms with fewer than 50 partners and the remaining 239 firms in our sample about which we do not have size information.

[a] Job size is measured by the natural log of total assets in all three markets reported here.

[b] b = billion, m = million.

[c] $\hat{\alpha}$ is used following Conover (1980): 'The critical level $\hat{\alpha}$ is the smallest significance level at which the null hypothesis would be rejected for the given observation.' The null hypothesis is H_0: The obtained distribution of Big Six frequencies is from the same distribution as the empirically observed distribution.

6. Summary and conclusions

We examine the industry structure of audit markets under pure price competition, with both quality differentiation and economies of scale absent. Audit firms are modeled as collections of human capital of two kinds – one that can be freely varied in the short-run (staff) and one that cannot (partners) – that follow a Cobb–Douglas production function. A firm's competitive power in our model is based partly on the size of its pool of fixed human capital and partly on the productivity of that human capital, as reflected in the *leverage* or staff-to-partner ratio. Our model predicts concentration measures higher than or statistically indistinguishable from concentration measures observed in the market for publicly traded US non-financial firms.

Two decades of research explains audit market concentration as a result of quality differentiation by large audit firms or of economies of scale in audit production. Consistent with the differentiation hypothesis, studies find the Big Six earn a fee premium, at least among smaller clients (Simunic, 1980; Francis, 1984; Palmrose, 1986; Francis and Simon, 1987; Ettredge and Greenberg, 1990; Craswell et al., 1995). Dopuch and Simunic (1980), Eichenseher and Danos (1981), Danos and Eichenseher (1982, 1986) and Penno and Walther (1996) present the case for economies of scale affecting audit market concentration. In our simulations, audit contracting practices, the distribution of client sizes and differences in auditor productivity across firms yield market shares for Big Six firms statistically indistinguishable from their actual market shares, without including either economies of scale or quality differences among firms in our model.

Our finding that capacity and leverage act as substitutes and that both are necessary to accurately predict audit market concentration extends prior work which has focused on capacity alone as an explanation of concentration. While capacity alone is sufficient to ensure the concentration of the very largest audits in the hands of a few large firms, we show that it explains the overall pattern of market shares quite poorly. When we incorporate the actual leverage used by firms, however, our model predicts market shares quite well. Our finding that audit firms' actual staff-to-partner ratios do indeed help accurately predict industry structure suggests that our formulation of the audit production function may be a reasonable first approximation to the true but unobservable audit production function.

The role of capacity in our model also suggests a strategic reason for audit firm mergers. Observers note that additional economies of scale from large firm mergers may be limited (Economist, 1997) and that quality differentiation cannot explain mergers among the dominant firms since the merging firms enjoy similar reputations for quality (Novak, 1998). In our model, size enables firms both to better defend their existing clientele from price competition by other firms and to compete more aggressively for other firms' clients. This suggests mergers may represent ways for firms to compete for industry leadership or to cope with competitive pressure from rivals, independent of any opportunities to exploit additional economies of scale or to enhance reputation for audit quality.

In conclusion we note that our analysis is inherently short run, since we take audit firms sizes as exogenously fixed and do not investigate what determines the observed distribution of audit firm sizes. We leave to future research an examination of the implications of our model for audit firm mergers and for the size and number of audit firms in the long run.

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Appendix A. Derivation of the Incremental Cost Function (Eq. (6))

Theorem. For a firm of size f doing a set of jobs J with sizes s_j, $j \in J$, *the total short-run cost of auditing,* $C^*(J,f)$ *is*

$$C^*(J,f) = w\left(\sum_{j\in J} s_j\right)^{\ell+1} \Big/ f^{\ell} \tag{A.1}$$

Proof. A cost minimizing firm will choose job-wise allocations of fixed and variable resources, f_j and l_j to minimize Eq. (3) subject to Eqs. (1) and (2). Substitute $l_j = s_j^{\ell+1}/f_j^{\ell}$, from Eq. (1) into Eq. (3), to remove l_j from the problem. The firm then minimizes Eq. (3) subject to Eq. (2) by choice of the f_j's. Using standard techniques, it follows that the optimal f_j^*'s satisfy

$$f_j^* = \frac{s_j}{\sum_{j\in J} s_j} f$$

and from Eq. (1),

$$l_j^* = s_j \left(\frac{\sum_{j \in J} s_j}{f} \right)^{\ell}$$

(A.1) follows by noting $C^*(J,f) = w\Sigma l_j^*$.

Substituting (A.1) into Eq. (4) yields Eq. (5).

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