Current accounting investigations: effect on Big 5 market shares

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Keywords
Market share, Accounting standards, Accounting, Benchmarking, United States of America

Abstract
Arthur Andersen's conviction and its decision not to audit public firms will transform the Big 5 into the Big 4. Meanwhile, other Big 4 firms face investigations that threaten their future market shares. The article compares the observed post-scandal shifts in market share with those estimated by a Markov model. It then estimates the year-by-year and long-term market shares that the Big 4 firms would have achieved had they remained untouched by these investigations. The study finds that the absence of Arthur Andersen alone would not have led to excessive market share concentration. It demonstrates how the post-scandal shifts reveal the impacts of the investigations on the Big 4 firms and provides market share benchmarks against which the firms can evaluate the long-term effects of the investigations. Finally, the article concludes that a firm's long-term gain in market share depends on its ability to retain audit clients.

Introduction

The imminent demise of Arthur Andersen is evidenced by its loss of many major audit clients, including Merck, Qwest Communications, Worldcom, Halliburton, Freddie Mac, Wyeth, and Peregrine Systems. Arthur Andersen's recent announcement that it would soon cease audit operations for publicly traded firms formalizes the transition from the Big 5 to the Big 4. Meanwhile, other Big 4 firms are also facing investigations into major accounting irregularities. These developments raise questions about the future market shares of the remaining Big 4 accounting firms. From the regulatory point of view, will any firm emerge from this turbulent era to dominate the audit industry? From the industry point of view, what will be the short- and long-term effects of the current accounting scandals on the market shares of the Big 4 firms?

Extensive shifts in audit market shares among the Big 5 firms would affect not only the Big 5 firms, but also clients, regulators, and corporate stakeholders. For accounting firms, market share is a major issue, as it determines their revenue and therefore their profitability. For clients, excessive market concentration could result in higher audit fees. For regulators and corporate stakeholders, increased market concentration, and the concurrent lower competition among accounting firms, would raise concerns about reduced audit quality.

In this paper, we compare the observed post-scandal shifts in US market share resulting from the decline of Arthur Andersen with those estimated by a Markov model. The differences between the observed and the estimated post-scandal market shares allow us to assess the immediate impacts of the investigations involving the Big 4 firms on their market shares. Then we estimate the year-by-year and long-term market shares that the Big 4 firms would have achieved had they all remained untouched by these investigations. These estimates serve as future reference points for the Big 4 firms. For example, if a firm's market share in a future year is higher (lower) than its estimated market share for that year, then we can deduce that the firm fared better (worse) than expected in the current turmoil.

Data and methods

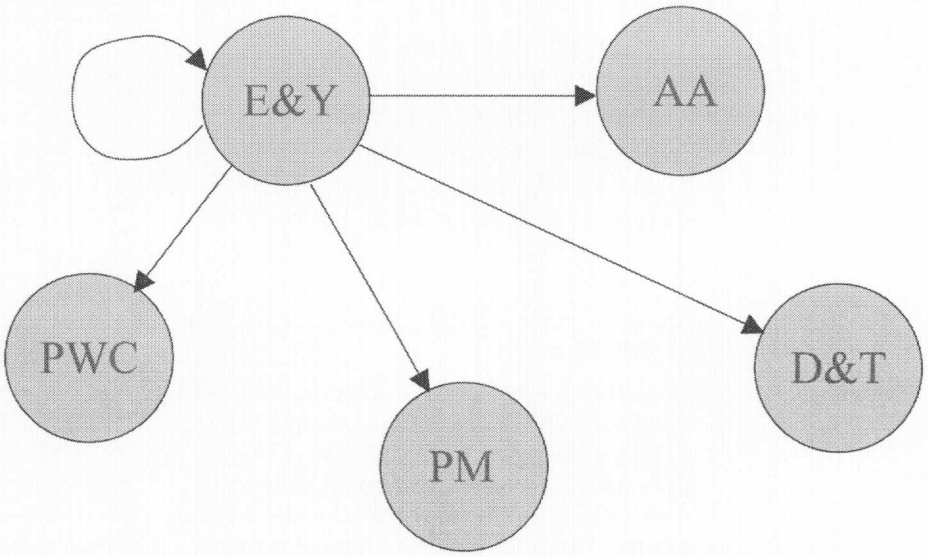
We define the audit market share of a Big 5 accounting firm to be the number of Standard & Poor's (S&P) 500 client firms audited by the given accounting firm divided by the total number of S&P 500 client firms audited by all Big 5 accounting firms. This definition does not reflect the asset value of the client firms, which would provide an alternative definition of audit market share. Because the S&P 500 serves as the US component of the S&P global index family, our results are most applicable to the US audit market. While we restrict our analysis to client firms listed on the S&P 500, we could expand the model to include all auditors that the client might retain.

We collect data from Standard & Poor's Research Insight for the years 1995-1999, providing us with 2,000 observations (500 firms × 4 opportunities to change auditors). We construct a Markov model that depicts the transitions of a client firm among the set of Big 5 accounting firms during this period. Markov models are useful in depicting the probabilistic evolution of a system over time among a set of states, as we show in Figure 1. In this application, the system is one of the S&P 500 client firms and each Big 5 accounting firm is a state. In any year, one of

Managerial Auditing Journal
18/6/7 [2003] 569-576

[ISSN 0268-6902]
[DOI 10.1108/02686900310482704]

Figure 1
Diagram of the Markov model showing the possible transitions of an E&Y client firm among the Big 5 accounting firms



Note: Similar transitions exist for clients audited by each of the other four firms (arrows not shown for clarity). We use the following notation to denote the Big 5 accounting firms: AA = Arthur Andersen; EY = Ernst & Young; DT = Deloitte & Touche; PM = KPMG Peat Marwick; and PWC = PriceWaterhouseCoopers

the Big 5 accounting firms will audit the client firm, meaning that, in any year, the system will reside in exactly one state. Each year, the client firm decides whether to remain with its current auditor or transition to another member of the Big 5, movements that the model captures using transition probabilities.

There are two basic kinds of transitions: those in which the client firm remains with the same auditor, and those in which the client firm switches to a new auditor. The first kind of transition reflects the auditor firms' abilities to retain client firms. We refer to the probability that a client firm remains with a given Big 5 accounting firm from one year to the next as the retention probability of the Big 5 accounting firm. The second kind of transition reflects the auditor firms' abilities to attract client firms from other Big 5 firms. We refer to the ability of a given Big 5 firm to attract client firms as its attractiveness parameter, a number between zero and one with larger values indicating greater ability to attract. We estimate the retention probabilities and attractiveness parameters of each of the Big 5 firms using the methodology described below.

The transition probabilities are important because they allow us to calculate the state probabilities, defined as the probability that any given Big 5 accounting firm will audit the client firm in any given future year. Over many years, the state probability that a given Big 5 accounting firm will audit the client firm approaches a limiting value, which we call the steady-state probability. The model also calculates this long-term, or steady-state, probability. We may interpret these steady-state probabilities as the long-term market shares for the Big 5 accounting firms.

Computing observed transition probabilities

We compute the observed transition probabilities as relative frequencies. The observed transition probability from one Big 5 accounting firm to another (possibly the same) is the ratio of the number of observed transitions from the first firm to the second, divided by the total number of transitions from the first firm to any Big 5 firm, including itself[1].

Computing estimated retention probabilities, attractiveness parameters, and estimated transition probabilities

We next compute those values of the retention probabilities and attractiveness parameters that minimize the sum of the squared differences between the observed and estimated transition probabilities. We use equation (1) in the Appendix for the estimated transition probabilities. This optimization is constrained to ensure that the estimated transition probabilities produce long-term market shares equal to the

observed values. See the Appendix for details.

Modeling the absence of Arthur Andersen

To model the absence of any one of the Big 5 accounting firms, we assume that the retention probabilities of the other four accounting firms will remain the same and we rescale the remaining attractiveness parameters. We then compute the new matrix of transition probabilities for a Markov model that contains only the remaining Big 4 firms (see equation (1) in the Appendix).

We compute the market shares for the remaining Big 4 firms in the first year without Arthur Andersen in two ways. First, we assume that client firms currently audited by Arthur Andersen will move to other Big 4 firms in proportion to their attractiveness parameters. This reflects the situation that would have prevailed had the other Big 4 firms not undergone investigations. We refer to these as the estimated post-scandal market shares. We then use the estimated post-scandal market shares and the new transition matrix to compute the year-by-year and long-term market shares for comparison with market shares that preceded the Enron crisis. We do this for each year using matrix multiplication to multiply the market shares in the previous year by the estimated transition matrix in the absence of Arthur Andersen.

Second, we compute the observed post-scandal market shares based on the actual transitions of S&P 500 client firms from Arthur Andersen to another member of the Big 4 since the onset of the Enron debacle. These market shares incorporate the effects of the investigations into the Big 4 firms. We refer to these as the observed post-scandal market shares.

Results

We use the following notation to denote the Big 5 accounting firms: AA = Arthur Andersen; EY = Ernst & Young; DT = Deloitte & Touche; PM = KPMG Peat Marwick; and PWC = PriceWaterhouseCoopers.

Observed transition probabilities

We show the observed matrix of transition probabilities in Table I. For example, during the five-year period 1995-1999, 98.8 per cent of EY's audit clients chose to remain with EY. We show this percentage in the cell labeled "EY" for both the row and column. During the same five-year period, 0.48 per cent of EY's audit clients switched to DT. We show this percentage in the cell labeled "EY" for the row and "DT" for the column. We derive these percentages as follows. During this period, EY's clients made 418 decisions about whether to remain with EY or switch to another accounting firm. The clients decided to remain with EY in 413 of these instances (98.8 per cent), and to switch to DT in two of these instances (0.48 per cent).

Table I
Observed transition probabilities

	AA (%)	EY (%)	DT (%)	PM (%)	PWC (%)
AA	98.37	0.33	0.65	0.33	0.33
EY	0.48	98.80	0.48	0.24	0.00
DT	0.00	0.00	99.32	0.34	0.34
PM	0.00	0.00	0.44	98.68	0.88
PWC	0.53	0.53	0.35	0.00	98.58

Estimated retention probabilities and attractiveness parameters

From the matrix in Table I, we estimate the retention probabilities and attractiveness parameters using the least squares optimization procedure described in the Appendix. We show the estimated retention probabilities and attractiveness parameters, the observed retention probabilities, and the (observed and estimated) long-term audit market shares in Table II. For example, the estimated retention probability for EY is 98.9 per cent, which is very close to its observed value of 98.8 per cent. The estimated attractiveness parameter for EY is 0.194. The attractiveness parameters reveal that EY has greater ability to attract clients from competitors than does either PM or DT, but less ability than does either AA or PWC. Table II also shows that EY has captured 23.07 per cent of the S&P 500 firms, which equals the market share estimated by the model because of the constraints in the optimization step.

Estimated transition probabilities

We show the estimated transition probabilities in Table III. We compute these values using equation (1) in the Appendix by substituting the estimated retention probabilities and attractiveness parameters. We observe that the estimated transition probabilities in Table III are very close to the observed values in Table I.

Estimates in the absence of Arthur Andersen

Table IV shows the retention probabilities and the rescaled attractiveness parameters in the absence of AA, and Table V shows the resulting matrix of transition probabilities. In this matrix, the estimated retention probabilities are on the main diagonal and

Table II
The observed and estimated retention probabilities, the estimated attractiveness parameters, and the observed (and estimated long-term) market shares of the Big 5 accounting firms

	AA	EY	DT	PM	PWC
Observed retention probability	0.9837	0.9880	0.9932	0.9868	0.9858
Estimated retention probability	0.9841	0.9890	0.9904	0.9863	0.9878
Estimated attractiveness parameter	0.208	0.194	0.107	0.120	0.371
Observed (and estimated long-term) market share	0.1689	0.2307	0.1634	0.1258	0.3113

Table III
Estimated transition probabilities

	AA (%)	EY (%)	DT (%)	PM (%)	PWC (%)
AA	98.41	0.39	0.22	0.24	0.74
EY	0.28	98.90	0.15	0.16	0.51
DT	0.22	0.21	99.04	0.13	0.40
PM	0.32	0.30	0.17	98.63	0.58
PWC	0.40	0.38	0.21	0.23	98.78

Table IV
The estimated retention probabilities and the estimated attractiveness parameters of the remaining Big 4 accounting firms in the absence of AA

	EY	DT	PM	PWC
Estimated retention probability	0.9890	0.9904	0.9863	0.9878
Estimated attractiveness parameter	0.244	0.135	0.152	0.469

Table V
Estimated transition probabilities

	EY (%)	DT (%)	PM (%)	PWC (%)
EY	98.90	0.20	0.22	0.69
DT	0.27	99.04	0.17	0.52
PM	0.40	0.22	98.63	0.76
PWC	0.56	0.31	0.35	98.78

transition probabilities computed using equation (1) in the Appendix are in all other cells.

Table VI shows how the 73 S&P 500 clients that have left AA since the Enron affair have distributed themselves among the remaining Big 4 firms. The table also shows the expected number of AA clients that would have retained each of the Big 4 firms, based on the attractiveness parameters of the firms. A χ^2 test reveals that the observed and expected numbers differ significantly ($\chi^2 = 27.39$, df = 3, p-value < 0.000005). This indicates that DT attracted significantly more of AA's S&P 500 clients than expected during the wave of recent scandals, while PWC attracted significantly fewer than expected. We see that EY and PM have attracted roughly as many such firms as predicted by their attractiveness parameters.

Table VII shows the current market shares and the estimated and observed post-scandal market shares in the first year without AA. By assumption, the attractiveness parameter of a remaining Big 4 accounting firm determines its estimated post-scandal market share increase had it been unaffected by its own accounting difficulties. For example, PWC had the largest attractiveness parameter and thus would have received the largest post-scandal increase in market share.

Table VIII shows current market shares, estimated year-by-year market shares (for

Table VI
The observed and expected distributions among the remaining Big 4 firms of the 73 S&P 500 clients that have left AA since the Enron affair. A χ^2 test reveals that the observed and expected numbers differ significantly

	EY	DT	PM	PWC	Total
Observed number of clients attracted	22	22	14	15	73
Expected bumber of clients attracted	17.8	9.9	11.1	34.2	73
χ^2 contribution	0.97	14.87	0.77	10.78	27.39

Table VII
Current market shares and estimated and observed post-scandal market shares in the first year without AA. Post-scandal increases in market share are shown in absolute and percentage terms

	AA	EY	DT	PM	PWC
Current market shares	0.169	0.231	0.163	0.126	0.311
Estimated					
Market shares in first year without AA		0.272	0.186	0.151	0.390
Post-scandal increase in market share		0.041	0.023	0.025	0.079
Post-scandal % increase in market share		17.7	14.1	19.8	25.4
Observed					
Market shares in first year without AA		0.279	0.220	0.154	0.347
Post-scandal increase in market share		0.048	0.057	0.028	0.036
Post-scandal % increase in market share		20.8	34.8	22.1	11.7

Table VIII
Current market shares and estimated year-by-year (for selected years) and long-term market shares following the demise of AA. Long-term increases in market share are shown in absolute and percentage terms

	AA	EY	DT	PM	PWC
Current market shares	0.169	0.231	0.163	0.126	0.311
Estimated market shares without AA					
Year 1		0.272	0.186	0.151	0.390
Year 2		0.272	0.187	0.152	0.390
Year 3		0.273	0.187	0.152	0.389
Year 4		0.273	0.187	0.152	0.388
Year 5		0.273	0.187	0.152	0.387
Year 10		0.274	0.189	0.153	0.384
Year 15		0.276	0.190	0.154	0.380
Year 20		0.277	0.191	0.155	0.377
Long-term		0.285	0.209	0.160	0.347
Long-term increase in market share		0.054	0.046	0.034	0.036
Long-term % increase in market share		23.4	28.2	27.0	11.6

selected years), and estimated long-term market shares following the demise of AA. The values in Table VIII represent the market shares that the remaining Big 4 firms would have attained had all four been unaffected by their own accounting investigations. Therefore, these estimates serve as future reference points for the Big 4 firms. For example, if a firm's market share in a future year is higher (lower) than its estimated market share for that year, then the firm can deduce that it fared better (worse) than expected in the current turmoil. We observe that the increases in long-term market share among the remaining Big 4 accounting firms would have ranged from 3.4 per cent to 5.4 per cent, a relatively uniform set of increases. Thus, we would not have anticipated excessive long-term market share concentration in any one of the remaining Big 4 accounting firms.

Figure 2 shows what the market share evolution of the Big 4 accounting firms would have been over several decades in the absence of AA. Following the post-scandal increase, the market share of a firm drifts slowly toward its long-term value. We consider these drifts to be of no practical importance for three of the remaining Big 4 accounting firms. Only PWC experiences a drop in market share of 0.044 following its post-scandal increase of 0.079.

We observe in Figure 3 that the increase in the long-term market share of a remaining Big 4 accounting firm is loosely associated with the firm's estimated retention probability. This is consistent with the commonly held view that a business maintains its market share more readily by retaining its existing customers rather than attracting customers from its competitors.

Conclusions

Based on observed post-scandal shifts in market shares immediately following the demise of AA, DT appears to have weathered the current scandals better than expected while PWC has been hurt more than

Figure 2
Evolution of market shares of the Big 5 accounting firms in the absence of AA in 2003 and beyond, using estimated post-scandal market shares and assuming that the other four accounting firms remained unaffected by their own accounting investigations

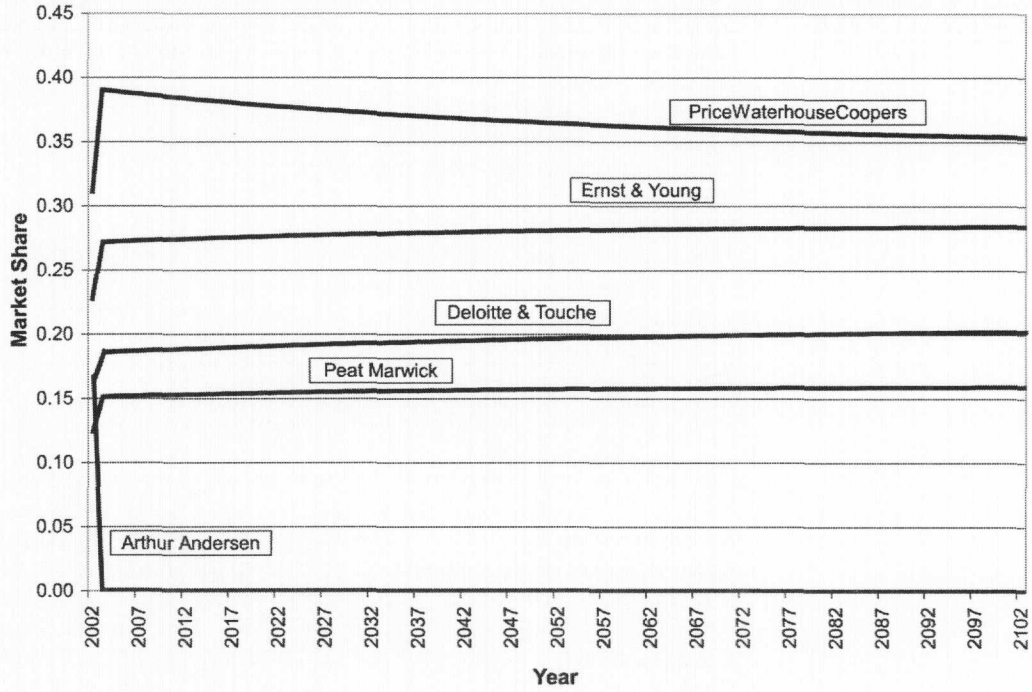
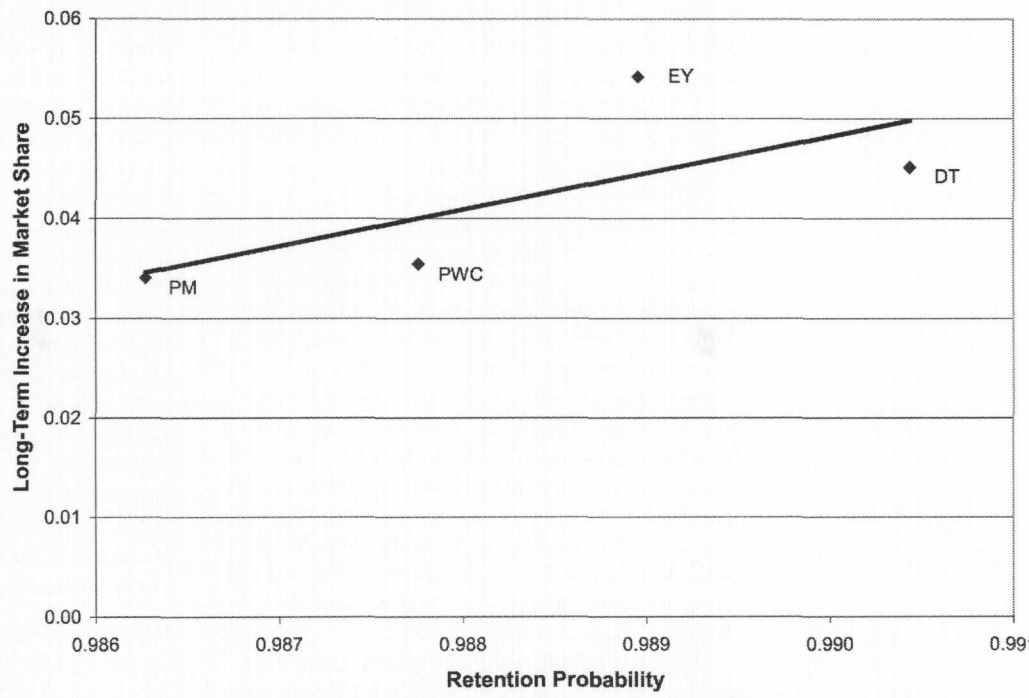


Figure 3
Long-term increases in market share versus estimated retention probability for the remaining Big 4 accounting firms



Note: In the long term, an accounting firm's ability to retain clients notably affects its market share

expected. The observed market share effects on EY and PM are nearly equal to those expected by the model.

Based on our model, in the absence of AA, PWC would have experienced the greatest post-scandal gain in market share because of its high attractiveness parameter. However, EY would have eventually benefited from the greatest long-term gain because of its high retention probability. However, as Figure 2 shows, because market shares drift slowly following their post-scandal increases, it would have taken until the year 2058 before EY's market share gain would have equaled that of PWC.

Our model illustrates that long-term gains in market share depend on the ability of the accounting firm to retain its audit clients. The observed retention probabilities of the Big 5 accounting firms are uniformly high, ranging from 98.37 per cent to 99.32 per cent. On the other hand, the attractiveness parameters of these firms vary considerably, from 0.107 to 0.371 (before the absence of AA). This suggests that S&P 500 firms tend to remain with their accounting firm for long periods but, when they switch, certain of the Big 5 accounting firms are considerably more attractive than others. The variation in attractiveness parameters leads to variation in post-scandal market share increases, but long-term market shares depend more on retention probabilities than on attractiveness. In other words, when a large number of S&P 500 firms are seeking new auditors, the more attractive Big 5 accounting firms will experience the largest post-scandal market share increases. However, over time, the Big 5 accounting firms with greater ability to retain their audit clients are more likely to achieve the larger long-term market share gains. We note that, while retention rates have been very high in the past, the current environment may cause client firms to become less reluctant to switch auditors, resulting in lower retention probabilities in the future.

Certain regulatory policies such as mandatory auditor rotation would greatly increase the frequency with which client firms change auditors. Comunale and Sexton (2002) extend the current Markov model to assess the effects of mandatory auditor rotation and retention on market share. They find that under mandatory auditor rotation, the long-term market share of any given accounting firm would depend most heavily on its ability to attract new clients. As a result, accounting firms would be likely to shift resources to expand their marketing efforts possibly endangering audit quality.

Finally, the absence of AA alone will not lead to excessive market share concentration within the remaining Big 4 accounting firms among the S&P 500 firms. Analysts often use the Gini coefficient to measure market share concentration in an industry. We compute the Gini coefficient using the following formula:

$$\text{Gina coefficient} = 1 - \sum_{j=1}^{n} (\text{market share})_j^2,$$

where n is the number of firms in the industry. Complete market concentration occurs, as a limiting case, when one firm has a 100 per cent market share and all the other firms have 0 per cent market shares. In this situation, the Gini coefficient equals 0. In the absence of market concentration, all n firms have equal market share and the Gini coefficient attains its largest value $1 - (1/n)$.

The Gini coefficient for the Big 5 accounting firms (among the S&P 500 firms) before the accounting scandals equals 0.779, which is 97.4 per cent of its maximum value $1 - (1/5) = 0.8$. This suggests that there was very little market concentration among the Big 5 firms. In the first year without AA, the Gini coefficient for the observed market shares is 0.730, which is 97.3 per cent of its maximum value $1 - (1/4) = 0.75$. Thus, we see that the observed post-scandal shifts in market shares have resulted in essentially the same market share concentration as that which existed before the scandals.

In the first year without AA, if all the other Big 4 firms had remained untouched by the scandals, the Gini coefficient would have been 0.717, which is 95.5 per cent of its maximum value $1 - (1/4) = 0.75$. Thus, the model indicates that a slight increase in market concentration would have occurred in the first year without AA had the other Big 4 firms remained untouched. However, in the long-term, the model indicates that the Gini coefficient would have equaled 0.729, which is 97.2 per cent of its maximum value $1 - (1/4) = 0.75$, and which is almost identical to the current percentage. Thus, market share concentration would have returned eventually to its current level.

Note

1 Before July 1, 1998, when Price Waterhouse (PW) merged with Coopers & Lybrand (CL), we treated the two separate firms as if they were one. Specifically, if a client remained with either PW or with CL, or switched between PW and CL, we counted that as an occurrence of client retention for PWC. If a client firm switched auditors from one of the other four accounting firms to either PW or CL, we counted that as an occurrence of client

attraction for PWC. During the pre-merger period, two client firms left CL for PWC and one firm left PWC for CL, resulting in a net change of only one client firm transition.

Reference

Comunale, C.L. and Sexton, T.R. (2002), "The impact of mandatory auditor rotation and retention on the market shares of the Big 5 accounting firms", paper presented at the 2002 American Accounting Association Annual and Northeast Regional Meetings.

Appendix

We construct a Markov model that depicts the movements of a client firm among the set of Big 5 accounting firms. We have five states in our model, one for each of the Big 5 accounting firms. While we restrict our analysis to client firms listed on the S&P 500, the model is equally applicable to any client firm if we expand the state space to include all auditors that the client might retain. In any given year, the client firm retains one of the accounting firms for audit purposes. Suppose the selected accounting firm is represented by state i. In the next year, the client may remain with accounting firm i, with probability p_{ii}, or may switch to accounting firm j, with probability p_{ij}. Consistent with standard Markov model axioms, we assume that these probabilities are the same for all client firms and that they remain constant over time.

Let $P = (p_{ij})$ denote the 5×5 matrix of transition probabilities. Clearly, our model is ergodic, meaning that the client firm can move from any accounting firm to any other in a finite number of transitions. Thus, we know that there exists a 1×5 vector $\pi = (\pi_j)$ of steady-state probabilities that are independent of the initial state of the client firm. The steady-state probability π_j is the asymptotic probability that the client firm will retain accounting firm j in any year. Therefore, we can interpret the steady-state probability π_j as the long-term market share of accounting firm j. We compute the steady-state vector π as the first row of the matrix M^{-1}, where M is the matrix $P - I$ with the first column replaced by all 1s, and where the matrix I is the 5×5 identity matrix.

We model the transition probabilities as follows:

$$p_{ij} = \begin{cases} r_i, & i = j \\ (1 - r_i)A_j / \sum_{k \neq i} A_k, & i \neq j \end{cases} \quad (1)$$

where we define the parameters r_i and A_i as the retention probability and the attractiveness parameter of accounting firm i, respectively. The retention probability of accounting firm i is the likelihood that a client firm will remain with accounting firm i in the next year given that it retained accounting firm i in the current year. The attractiveness parameter of accounting firm i is a measure of its ability to recruit a client firm from another accounting firm given that the client firm has decided to change accounting firms.

We restrict the attractiveness parameters to sum to 1 so that the denominator of p_{ij} for $i \neq j$ represents the sum of the attractiveness parameters of all accounting firms except i. Thus, the ratio $A_j/(1 - A_i)$ represents the probability that a client firm leaving accounting firm i will move to accounting firm j. Then, for $i \neq j$, p_{ij} equals this conditional probability multiplied by the probability $1 - r_i$ that the client firm leaves accounting firm i.

We estimate the retention and attractiveness parameters by determining the values of r_i and A_i that minimize the sum of the squared differences between the observed transition probabilities and the estimated transition probabilities computed using (1). We perform this minimization subject to the constraints that the estimated transition probabilities produced market shares equal to the observed market shares. In addition, we require that the retention probabilities lie between zero and one, and that the attractiveness parameters sum to one. Thus, we use the Solver add-in in Microsoft Excel to solve

$$\min_{r_i,\, A_i} \left\{ \sum_{i=1}^{5} \sum_{j=1}^{5} (p_{ij} - \hat{p}_{ij})^2 \,|\, \pi_j = \hat{\pi}_j, j = 1, \ldots, 5; \right.$$

$$\left. 0 \leq r_i \leq 1, i = 1, \ldots, 5; \sum_{j=1}^{5} A_j = 1 \right\}$$

The resulting retention probabilities and attractiveness parameters thus produce an estimated transition matrix that is as close as possible to the observed transition matrix while producing identical market shares for all five accounting firms.