



# Effects of the PricewaterhouseCoopers merger on the UK audit services market

Pricewaterhouse-  
Coopers merger

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## Abstract

**Purpose** – This paper seeks to investigate the effect of the PricewaterhouseCoopers (PwC) merger on the market for audit services in the UK. To this end a “what if” analysis is conducted comparing estimated outcomes prior to the merger with those expected under post-merger conditions. Particular attention is given to the effect of the merger on the relative performance of the top tier and non-top tier audit firms.

**Design/methodology/approach** – The paper employs a Markov chain model to estimate the long-term market shares of audit firms’ pre-merger and post-merger. Concurrently, an optimisation model is employed to generate parameters reflecting the relative attractiveness of audit firms and the probability that a client company continues with the current audit firm.

**Findings** – Prior to the PwC merger, this model would predict a large reduction in the share of the non-Big Six from 17 per cent to a long run 7 per cent. However, the effect of the PwC merger appears to be that the position of the non-Big Five has been improved and the model predicts a slight increase in long-term market share to 18 per cent.

**Research limitations/implications** – The Markov model employed makes a number of assumptions that may restrict the generality of the implications that can be drawn from the analysis.

**Practical implications** – The results show that, contrary to the worries of the competition authorities, the long-term impact of the PwC merger, *ceteris paribus*, would be to improve the position of the non-top tier of auditing firms.

**Originality/value** – Auditor concentrations studies have been mostly descriptive. This paper reports an analytical study of the potential effect of audit mergers on market concentration.

**Keywords** Markov processes, Auditing standards, Competitors, United Kingdom

**Paper type** Research paper

## Introduction

The audit services market is of great interest both to researchers and to regulators. In particular, regulators are concerned with promoting competition among audit firms and maintaining or improving the quality of audit work. To some extent, these two regulatory requirements may work against each other, as a more competitive audit services market could result in lower quality audits being performed because of the lower fees that the competitive market brings. This paper is concerned only with competition in the audit services market, as influenced by the number of audit firms, and the subsequent effect on market share.



The objective of our paper is to investigate the effects of the PricewaterhouseCoopers (PwC) merger on the listed company audit services market by estimating the relative attractiveness of audit firms, their likely continuation as auditors of existing client companies and their long-term steady state market shares. To do this we look at changes in the market shares of the leading audit firms in the UK for that part of the audit services market that comprises the audits of companies listed on the London Stock Exchange. There are two reasons for limiting the inquiry to the audits of listed companies. The first relates to the greater importance of the audited financial statements of listed companies, arising from the greater separation of ownership from control in such companies when compared to private companies. This greater need to monitor the actions of management means that the audited financial statements of listed companies are regularly read by investment analysts and the financial community. In contrast, the audited financial statements of private companies have a much more limited readership. The second reason is pragmatic as it is possible to use the *Stock Exchange Year Book* to cover the population of listed companies, but there is no equivalent source for private companies, of which there are a considerably greater number than listed companies. We use historic data of the changes within the listed company audit services market to construct a Markov model of auditor change and to estimate long-term market shares. Concurrently, an optimisation model is employed to produce estimates of parameters reflecting the relative attractiveness of audit firms and the probability that a client company continues with its current audit firm. We examine the effect of the PwC merger on these parameters and estimated long-term market shares, by partitioning the data into two periods, one before and one after the PwC merger, thus conducting a “what if” analysis.

The first half of the paper describes the nature of the UK audit services market in the 1990s, considers the effect of audit firm mergers on competition from both regulatory and empirical view points, and describes the back ground to the PwC merger and the anticipated consequences for the audit services market. We then move on in the second half of the paper to discuss the merits of employing Markov chain and optimisation models in the current context, describing in detail the development of these models. In the second half of the paper, we also discuss the data used in the construction of the models and present the results of the analysis, before summarising and drawing conclusions.

### **The UK audit services market in the 1990s**

For many years, the UK audit services market had enjoyed price stability with the profession restricting competition in any form. However, in 1983, the Office of Fair Trading decided to attack a number of professions for practices that “lead to inefficiency and high charges to the general public, undue conservatism and a sluggish attitude to change” (Parker-Jarvis, 1987). The resulting competition between auditors surfaced publicly in November 1987, with the launch by Coopers & Lybrand (CL) of a £1 million advertising campaign in newspapers and selected magazines to promote a new audit approach (Walters, 1987, p. 20). From this point, the general impression has been one in which competition within the audit services market has increased and that audit fees are being squeezed as a result. A 1991 survey by the City Research Group reported that an increasing number of financial executives had questioned their company’s audit fee. About 81 per cent said that they had already challenged the size or make-up of the fee, with an 80 per cent success rate (figures quoted in Anonymous, 1991). In the same paper, the following comment is made:

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The size of the fee has also led an increasing number of clients to consider changing auditors. One in five said that they were likely to review their auditors' appointment over the next 12 months, by inviting competitive proposals from other firms (inevitably the Big Six, which audited 80 per cent of the top companies). This compares to the one in eight which had carried out a review since the beginning of 1990.

The anecdotal evidence that exists also shows that towards the end of the 1980s there had been increasing competitiveness in the audit services market. Swinson (1991) mentions the fact that "the position of auditors has been affected by increasingly severe price competition". Other evidence comes from a June 1991 survey of 79 qualified accountants based in the City of London. The survey found that 61 per cent of the sample agreed that "the practice of discounting audit fees by accountancy firms was widespread these days" (Lea, 1991). A spectacular example of this was the Price Waterhouse (PW) tender document leaked to *Accountancy Age*, which allegedly contained a £900,000 discount offer in order to obtain the audit. As Plender (1991) commented in the *Financial Times*:

Perhaps, the worst revelation for the accountants came in the leak of Price Waterhouse's submission to the Prudential, when the giant insurance company put its audit out to tender. This stated that Price Waterhouse did not want to lose the Pru's audit on grounds of fee alone, leaving outsiders with the impression that one of Britain's biggest audit and consultancy conglomerates was in the business of offering the audit as a loss leader.

This price competition has continued in the 1990s as can be seen from the work of Pong (2004), which looks at the audit fees of listed UK public limited companies during the period 1991-1995. He found that after controlling for size, complexity and risk of the auditees that the audit market experienced a 17.5 per cent reduction in inflation adjusted fees over the five year period. His conclusions were that as these changes occurred during a period when the concentration in the audit services market had increased markedly, there was no evidence of oligopoly pricing and hence that the market remained competitive.

An individual figure for the audit income earned by the accounting firms is no longer disclosed by them. However, it is possible to compare the total fee income of the accounting firms and the income of the top 15 accounting firms in both 1991/1992 and 1999/2000 is shown in Table I.

Table I indicates that there was a significant difference between the Big Six in 1991/1992 and the next largest medium sized accounting firm, with the smallest accounting Big Six firm (Arthur Andersen (AA)) having almost three times the fee income of the largest medium sized firm (Grant Thornton). In 1999/2000, a similar difference between the Big Five and the medium sized firms is observed, with the smallest Big Five (AA) having more than three times the annual income of the largest medium (Grant Thornton). The comparison of the two columns shows the effect of the merger in July 1998 of PW and CL to form PwC, which in 1999/2000 had significantly higher total fees than the next nearest firm of KPMG. This reflects the fact that in the UK, PwC is effectively a combination of three of the old Big Eight firms of CL, Deloitte Haskins & Sells and PW.

### **Competition considerations of audit firm mergers**

There have been several academic studies of the effects of accounting firm mergers on competition, mainly relating to the Big Eight mergers of 1989 which saw mergers

	91/92 firm	1991/1992	1999/2000 firm	1999/2000
1	Coopers & Lybrand Deloitte (CL)	577	PwC	1,843
2	Peat Marwick (KPMG)	495	KPMG	1,038
3	Price Waterhouse (PW)	400	EY	713
4	EY	399	DT	684
5	TR	350	AA	563
6	AA	331	Grant Thornton	164
7	Grant Thornton	118	BDO Stoy Hayward	160
8	Binder Hamlyn	114	Pannell Kerr Forster	98
9	Pannell Kerr Forster	86	Howarth Clark Whitehall	75
10	Stoy Hayward	68	Baker Tilly	70
11	Clark Whitehill	54	HLB Kidsons	68
12	Robson Rhodes	37	The Smith & Williamson Group	61
13	Moore Stephens	36	Moore Stephens	61
14	Neville Russell	33	Mazars Neville Russell	53
15	Moores Rowland	31	RSM Robson Rhodes	47
	Total	3,129	Total	5,698

**Table I.**  
Total fee income (£m) for  
the top 15 accounting  
firms in 1991/1992 and  
1999/2000

**Notes:** The figures are taken from surveys appearing in *Accountancy Age* in June 1992 and July 2000; the abbreviations are those used in later tables

between Arthur Young and Ernst & Whinney and between Deloitte Haskins & Sells and primarily Touche Ross (TR) (CL in the UK). The predictions made and subsequent empirical findings are contradictory, however.

One of the first studies, Hermanson *et al.* (1990), outlines the antitrust considerations relevant to the 1989 mergers. The paper notes that the relevant competition test of the Justice Department and Federal Trade Commission at the time was the Hirschman-Herfindahl Index (HHI), with horizontal mergers being challenged if the HHI moved by a particular number of points dependent on the starting value. The two mergers produced HHI changes that could have triggered action. The paper made the following predictions of the effects of the merger concluding:

If the recent mergers are not opposed by the Justice Department or FTC, there will be significant effects on competition, clients and other CPA firms. Price competition is likely to decrease. Some domestic clients may decide to switch from the largest firms to national, regional or local firms. Thus, there may be a resurgence of these smaller firms (Hermanson *et al.*, 1990, p. 15).

Minyard and Tabor (1991) computed what would be the effect of the Big Eight mergers using the Herfindahl index for 40 US industrial classifications for 1988. Their paper was attempting to show how competition authorities could undertake a similar analysis when judging whether a merger of accounting firms was likely to operate against the public interest.

Other studies have examined empirically what took place in the audit services market subsequent to the 1989 mergers. The findings regarding the impact on competition have been contradictory, as discussed below.

A number of studies report a positive effect of the 1989 mergers on the competition in the audit services market. For example, Tonge and Wootton (1991) found that the mergers would not necessarily result in less competition and higher prices.

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By merging, the smaller Big Eight firms became more competitive with larger firms and hence the firms remaining after the merger would be more comparable in size, market shares and resources available. Wootton *et al.* (1994) found that the Big Eight mergers had a substantial effect on concentration for clients listed on the US stock markets. Ivancevich and Zardkoohi (2000) reports a descriptive explanatory investigation into the effects of the 1989 mergers. Data for the four firms involved in the mergers were compared to data for competitor firms not involved in mergers (direct rivals) to help to control for the effect of market forces. The post-merger period in the USA was characterised by a slight decline in market share for the merged firms compared to their direct rivals, a decline in audit fees for both groups and a decrease in factor costs for the merged firms relative to their rivals. The results of their data analysis are consistent with the premise that the 1989 mega-mergers predominantly resulted in increased efficiencies with the audit market that were then passed through to end-users in the form of lower prices. Sullivan (2002) has a similar finding, although because of her methodology she could not make any inferences about the effects of the mergers on the prices paid by established clients as she was using solely client switching data. The conclusion of her paper is that merging allowed the constituent merging firms to combine their staff of specialists and their complementary locations, thus enabling the merged firms to compete more effectively for large audit buyers. The reallocation of customers over competing suppliers may have resulted in a more efficient utilization of resources.

Some studies found little evidence to support the view that the 1989 mergers had any effect on competition. Menon and Williams (2001) looked at the audit fees of clients of the Big Six firms over the period 1980-1997. The 1989 mergers appeared to have a significant effect on audit fees only for three years after the mergers (1991-1993) after a one year lag. This is consistent with a short lived premium that is obtained in the three years following the merger but dissipates thereafter. Similar results were found in the UK by Iyer and Iyer (1996), who compared the audit fees of the Big Eight in 1987 with those of the Big Six in 1991 for the same companies (banks and financial companies being excluded). They found that, despite the Herfindahl index increasing from 0.08 in 1987 to 0.11 in 1991, there was no evidence to suggest that the mergers led to any significant increase in external audit fees. More recently a study by Oxera for the Department of Trade and Industry and the Financial Reporting Council (Oxera, 2006) provides a detailed analysis of the audit market in the UK, analysing factors that determine companies' choice of auditor and the dynamics of the evolution of the market structure. One of the conclusions of the report is that the current market structure in the UK is likely to persist, due to high entry barriers. In the event of a Big Four becoming a Big Three scenario, substantial market entry by mid-tier firms might become feasible only if the existing barriers, in terms of perception (reputation) and low switching rates, are reduced.

In contrast, to the USA and the UK results, Tai and Kwong (1997) found that in Hong Kong real audit fees significantly increased rather than decreased in the period 1988-1991. Choi and Zéghal (1999) investigated accounting firm concentration both before and after the 1989 accounting firm mergers in ten countries (Canada, Denmark, France, Germany, Italy, The Netherlands, Sweden, Switzerland, the UK and the USA). Their study used concentration ratios and Herfindahl indices to measure the extent of concentration. The study found that the large firms dominated the audit services

market before the mergers and increased their dominance after the mergers. Using a regression model, the paper shows that in five countries (Canada, France, Germany, The Netherlands and the UK) the leading Big Eight/Six audit firms significantly outperformed other firms even before the mergers and that this phenomenon persisted after the mergers.

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### **The PwC merger: historical perspective, predicted consequences and preliminary findings**

Given the interest shown by the competition authorities in the 1989 mergers, it was not surprising that in 1997 when there was the possibility of two further Big firm mergers (PW with CL and Ernst & Young (EY) with KPMG), both the European Commission and the US Department of Justice were reported to be considering these two proposals (Anonymous, 1998a). The European competition authorities were expected to be more challenging as the EC did not have a single, unified stock market regulator like the SEC in the USA. Additionally, in the same *Accountancy* article, Deloitte & Touche (DT) was reported as being aggressive in its opposition to the proposed mergers, hiring an immediate past head of the Department of Justice's antitrust division to demonstrate that the mergers would cause irreparable competitive damage. The position was partially resolved on Friday 13, February 1998, when EY and KPMG announced that their merger would not go ahead (Anonymous, 1998b). A statement released by KPMG blamed the collapse of the merger proposal on the cost and time of regulatory investigations and the disruption this was causing to clients. Regulators were reported to have become increasingly concerned about the potential size of an EY/KPMG combination that would dominate the multinational market. Both the EU's Merger Task Force and the US Department of Justice had extended their investigations and requested further audit pricing information.

Following the demise of the EY/KPMG merger proposal, the way forward for the creation of PwC was made easier and eventually the European Commission approved the merger and the new firm was launched on 1 July 1998. The EC conducted an in-depth investigation into the merger and is reported to have characterised the audit services market as having a low rate of innovation with "many elements that would be conducive to the creation of collective dominance" and that it was a market "relatively insensitive to price" with clients locked into the incumbent auditors for long periods because of "significant switching costs". However, despite these characteristics, the EC was reported to have found "no conclusive proof that the merger would create or strengthen a position of collective dominance" (Anonymous, 1998c). The EC go-ahead meant that none of the individual competition authorities had raised an objection to the merger with the US Department of Justice having giving it earlier clearance to proceed (Payne and Stocks, 1998). The Australian Competition and Consumer Commission (ACCC) also examined the PwC merger and a discussion of its competition assessment is given in Goddard (1998). The ACCC concluded that the merger was unlikely substantially to reduce competition and that there was no necessity for it to intervene. Thavapalan *et al.* (2002, p. 154) note that the ACCC "carefully examined the proposed merger and concluded that it would be unlikely to substantially lessen competition, because among other reasons, 'five vigorous competitors' would remain in the marketplace".

To date there has been little empirical work investigating the effect of the PwC merger on concentration and price competition in the market for audit services.

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Thavapalan *et al.* (2002) have looked at the effects of the PwC merger in Australia. They examined the market share of publicly listed companies for audit firms for each industry category pre- and post-merger to ascertain levels of auditor concentration. Their paper shows that the conclusions of the ACCC, highlighted above, could be supported. Concentration, as measured by the percentage of clients and audit fees for the top four auditing firms, has increased. However, they found that when the distribution of market share between the top four audit firms is considered, the effect of the merger on competition became less clear. Using the Herfindahl index, the authors observed that in a number of industries, auditor concentration had actually decreased. In many situations, the PwC merger created a viable competitor (of similar size) to previous dominant firms in an industry. In particular, the merger created a firm of comparable size to the dominant firm pre-merger (KPMG). A similar result for the USA was noted by Wolk *et al.* (2001) which reports amongst other results that a five firm Herfindahl index subsequent to the creation of PwC ranged from 0.2039 for the AMEX to 0.2098 for the NYSE, indicating a relatively well-balanced marketplace (a balanced market would have a value of 0.2).

### Markov analysis and optimisation

A Markov analysis can be used to investigate a sequence of events, and analyses the tendency for one event to be followed by another. Thus, it is a means of identifying the future direction in which a process or system will move and can be used to determine how the system will move from state to state. A process that is stochastic in nature and that evolves over time in a probabilistic manner can be modelled by a Markov chain model. A special feature of a Markov chain model is that the dynamics of how the process will evolve depends only on the present state of the process and so is independent of the history of the process. The Markov chain model is generally represented as a matrix of conditional probabilities, which determine the manner in which the process will move between states, and as such is known as the transition matrix. The process will move between states with known transition probabilities and it is assumed that these transition probabilities are stationary and do not change over time. It is also necessary to assume that there exist a finite number of possible states and that the process represents a “closed” system. For a full discussion of the properties of Markov chain models see Feller (1971) and Resnick (1992). Comunale and Sexton (2003) employed the Markov chain and optimisation approach to analyse the market shares of auditors of the S&P 500 companies in the USA. Their paper views the market for audit services as a stochastic process that evolves over time in a probabilistic manner. Each year there is a positive probability that a new (i.e. different) audit firm will conduct the audit of a particular client company. For our part, we believe that the market for audit services can be captured by a Markov chain model, in which the audit firms represent the states of the model and each year a client company can be in any one of these states. There are a finite number of audit firms and, therefore, only a finite number of states as required in the Markov chain model. To ensure that the process represents a “closed” system, the number of client companies must remain constant over the period under analysis (see below for a discussion of the data employed).

Before discussing the construction of the Markov chain and optimisation models, it is prudent to comment on the strengths and limitations of this approach to investigate

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the effect of the PwC merger on the market for audit services. The main advantage of employing a Markov chain model is the theoretically rigorous approach that it brings to modelling the audit firms' market shares. The model provides steady-state probabilities that a client company will appoint a given audit firm. These probabilities can be interpreted as estimated long-term market shares. This approach is more rigorous than merely reporting statistics from a descriptive analysis of previous and current market shares, because it provides a forecast of the likely long-term effect, not just an indication of the immediate impact. Another strength is the simplicity of the two-parameter optimisation model employed. The continuation and attractiveness parameters capture the numerous factors at play when client companies change audit firm, thus allowing the use of a relatively simple non-linear optimisation model. Attempting to develop an optimisation model that featured all the potential factors responsible for client companies changing audit firm would be unfeasible.

There are three special features of the Markov chain model that are worthy of note. The first is that the evolution of the process is dependent only on the present state of the process and so is independent of its history. The system has no memory, therefore, the probability of a client company changing to another specified audit firm is affected only by its choice of current audit firm and no consideration is given to who the prior auditors were. How limiting this assumption is depends on how frequently client companies change audit firms. If clients change auditors very frequently, say every year, the assumption would be very limiting. However, as discussed below, over the periods considered, the rate of change of auditor is very slow, thus this assumption does not greatly limit the analysis conducted. A second assumption of the Markov model concerns the time-invariant nature of the transition probabilities. This assumption is required if the long-term steady-state transition probabilities, and therefore long run steady-state market shares, predicted by the model are to materialise. For our purposes, however, this is not essential. We do not suggest that these long run steady-state market shares will actually materialise, as other factors (e.g. other mergers) will subsequently affect the transition probabilities. Instead we conduct a "what if" analysis and investigate what would happen if, *ceteris paribus*, the audit services market continued to function as it had. Thus, we can compare what would have happened to the market had it continued unabated prior to the merger with what would happen if it were to continue unabated after the merger. Any differences are due to the effect of the PwC merger on the functioning of the audit services market. Finally, the Markov model requires the assumption of a "closed" system, thus the number of client companies must be held constant. This is a simplifying assumption that does not reflect reality, with new firms listing and old firms de-listing from the London Stock Exchange. Procedures were employed to ensure this assumption was not violated (see discussion of data below). One consequence of this limitation is that our models are applicable only to companies that are continually listed on the London Stock Exchange. This is not so concerning, however, as the number of continually listed companies far out-weighs the number of incoming and outgoing companies, thus our models are appropriate for the majority.

### **Development of the Markov chain and optimisation models for the audit services market**

The discussion to follow sets out how the market for audit services can be translated into a Markov chain model and then modelled using non-linear optimisation. Assume  $K$  firms



of auditors. A client company is said to be in state  $i$  if it is currently a client of audit firm  $i$ . At the next step through the Markov chain the client company may “continue” with audit firm  $i$ , with probability  $p_{ii}$  or may switch to audit firm  $j$ , with probability  $p_{ij}$ . Thus,  $\mathbf{P} = (p_{ij})$  represents a  $K \times K$  matrix of transition probabilities, which are assumed to be stationary. For any state  $i$ ,  $p_{ij}^{(n)} > 0$  for some  $n > 0$  and all states are classified as accessible (i.e. a client company can switch from audit firm  $i$  to any audit firm  $j$  at some step  $n$  in the future). All states in the process are said to communicate (i.e. at a later stage, the client company can choose to move back to audit firm  $i$ ) and the system is said to be irreducible because there is only one class of states. As the model is a finite-state Markov chain, all states can be classed as positive recurrent states (i.e. starting at state  $i$ , there is a finite time before the process re-enters state  $i$ ) and the model is said to be ergodic. For any irreducible ergodic Markov chain, a vector  $\pi_j$  exists and gives the steady-state probabilities for the model. These steady-state probabilities are independent of the initial distribution of probabilities (i.e. the initial state of the client company). Thus, a  $1 \times K$  vector  $\pi_j$  exists, with  $\sum_{j=0}^K \pi_j = 1$ . If the market share of audit firm  $j$  is calculated as a proportion of the total number of clients in the market, then  $\pi_j$  can be interpreted as providing the long-run market share of audit firm  $j$ , which will be independent of the initial state  $i$  of the client company.

The Markov model described above is based on the observed transition probabilities and provides observed  $\pi_j$ . We concurrently run a non-linear optimisation model the purpose of which is to provide values for parameters reflecting the audit firm’s attractiveness and the probability that an audit client continues with the current audit firm. To this end the observed transition probabilities  $p_{ij}$  are modelled to provide estimated transition probabilities  $\hat{p}_{ij}$  as follows:

$$\hat{p}_{ij} = \begin{cases} c_i, & i = j \\ \frac{(1-c_i)A_j}{\sum_{k \neq i} A_k}, & i \neq j \end{cases} \quad (1)$$

The probability  $c_i$  can be termed a continuation probability and represents the probability that a client company with audit firm  $i$  at step  $n$  will continue to be associated with audit firm  $i$  at step  $n + 1$ . Thus,  $(1 - c_i)$  represents the probability that the client company will have an auditor other than audit firm  $i$ . The attractiveness parameter  $A_j$  represents the relative attractiveness of audit firm  $j$  and reflects its ability to be awarded the audit of a company that previously used audit firm  $i$ . Thus, the attractiveness parameter  $A_j$  is restricted to be non-negative, with a value of zero indicating that audit firm  $j$  is unable to attract any client companies from any other audit firm. The sum of all attractiveness parameters is further restricted with  $\sum_{k=i}^{k=j} A_k = 1$  and so  $A_j/(1 - A_i)$  gives the probability that a company will choose audit firm  $j$  having ceased to use audit firm  $i$ . Therefore, for  $i \neq j$ , the probability  $\hat{p}_{ij}$  that audit firm  $j$  will attract a new client from audit firm  $i$  at the next step of the process is equal to the probability  $(1 - c_i)$  that the client company leaves audit firm  $i$  multiplied by the probability the client moves to audit firm  $j$  ( $A_j/(1 - A_i)$ ).

The purpose of modelling the transition probabilities is to obtain values for the parameters  $c_i$  and  $A_i$ . This is achieved by generating an estimated transition probability matrix  $\hat{\mathbf{P}} = (\hat{p}_{ij})$ , where  $\hat{p}_{ij}$  are computed based on equation (1) (i.e. by allowing  $c_i$  and  $A_i$  to vary). The estimated transition probabilities  $\hat{p}_{ij}$  will

produce estimated steady-state probabilities denoted  $\hat{\pi}_j$ . To generate an unbiased estimate of  $\hat{p}_{ij}$ , and values of  $c_i$  and  $A_i$  that are as reliable as possible, the sum of the squared differences between observed and estimated transition probabilities must be minimised subject to a number of constraints. First, the estimated steady-state probabilities  $\hat{\pi}_j$  must equal the observed steady-state probabilities  $\pi_j$ . Next, the continuation probabilities  $c_i$  are restricted to lie between zero and one. Finally, the attractiveness parameters  $A_k$  must sum to one and are restricted to be non-negative. Thus, the model becomes a non-linear optimisation problem of the form:

$$\min_{c_i, A_i} \left\{ \sum_{i=1}^K \sum_{j=1}^K (p_{ij} - \hat{p}_{ij})^2 \mid \pi_j = \hat{\pi}_j, j = 1, \dots, 11; 0 \leq c_i \leq 1, i = 1, \dots, 11; \sum_{j=1}^K A_j = 1; A_j \geq 0 \right\} \quad (2)$$

and the optimal solution can be found using a computer-based optimisation tool such as the Solver add-in in Microsoft Excel. The purpose of the optimisation model is to generate values of  $c_i$  and  $A_i$  that minimise the condition above, subject to the given constraints.

### Analysis of the data

The *Stock Exchange Year Book* was used to provide data on changes of auditors by all companies listed on the London Stock Exchange in the period from 1 October 1995 to 31 December 2001. To investigate the effect of the PwC merger the data was separated into two periods, one before the merger (1 October 1995-30 June 1998) and one after the merger (1 July 1998-31 December 2001). The end date of 31 December 2001 was chosen as the period just before the impact of the Enron scandal on AA would have any effect on client companies, since companies with a 31 December 2001 year-end, would not have been in a position to change auditors. As the main purpose of the paper was to test the effect of the PwC merger on competition, we restricted our analysis to the individual Big Six/Five audit firms plus the remainder. This allows us to consider client movement both within the Big Six/Five and across the Big versus non-Big distinction. The rationale for this approach can be seen from Table I, where the smallest Big Six/Five firm (AA) was always about three times larger than the largest of the medium sized audit firms (Grant Thornton). It can also be seen that the market share of the non-Big Six/Five was of a similar order to the individual Big Six/Five firms. Hence, the Markov model incorporates seven and six states, for the pre- and post-PwC periods, respectively. The auditor changes each year were aggregated for each of the three periods to help reduce any random noise in the data. To ensure that the "closed" system requirement of the Markov chain process was satisfied for each time period, those client companies that became listed on the London Stock Exchange after the beginning of the period or that ceased to be listed before the end of the period were excluded from the data. The number of client companies included in the pre- and post-merger periods are 1,680 and 2,135, respectively. The explanation for the increase in the population size across the periods reflects the large increase in the number of public listed companies during the period. The company had to be listed throughout the time period to qualify for inclusion in the model and so there appears to be a step

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change at 1 July 1998 reflecting the number of companies that floated after 1 October 1995. The data for the two time periods is presented in Table II

To interpret Table II, one needs to start at the right hand column and then to read from right to left and then down to the bottom of the Table. Hence, for Panel A, KPMG at 1 October 1995 had 322 listed audit clients, which represented 19.17 per cent of the market. In the period to 30 June 1998, it lost 18 clients (three to AA, three to CL, two to DT, one to EY, five to PW and four to the non-Big sector). KPMG thus retained 304 listed clients and gained 28 (one from AA, four from CL, three from DT, six from EY, one from PW and 13 from the non-Big sector giving it 332 clients at 30 June 1998, representing 19.76 per cent of the market).

Table II Panel A shows that of the population of 1,680 listed companies, 1,357 of them had Big Six auditors at the beginning of the period, representing a CR6 of 80.8 per cent, which is very similar to the closing CR6 for Panel A of 79.4 per cent. By the end 30 June 1998, there were 1,393 companies with Big Six auditors, a CR6 of 82.9 per cent, showing that the Big Six were continuing to gain from the other audit firms. The number of companies having a change in auditors within the seven categories in the 2.75 year period, 1 October 1995-30 June 1998, was 165 representing 9.8 per cent of the whole. At this rate, it would take approx 28 years for all companies to change their auditors.

Table II Panel B shows the position following the creation of PwC. The population has increased considerably to 2,135 as a result of the influx of new companies to the Exchange. At 1 July 1998, the number of companies with Big Five auditors was 1,713, representing a CR5 concentration ratio of 80.2 per cent, a slight reduction from the CR6 of 82.9 per cent, caused by the higher than average proportion of non-Big Five audit firms for new entrants to the Stock Exchange. At 31 December 2001, the number of companies with Big Five auditors had fallen to 1,705, representing a CR5 concentration ratio of 79.9 per cent. In the 3.5 year period (1 July 1998-31 December 2001), there were 220 changes of auditors, representing 10.3 per cent of the total population of 2,135 companies. At this rate, using the same basis as above, it would take 33.4 years for all companies to change their auditors. Hence, there is some indication that the reduction in the choice of audit firms by the creation of PwC has slowed the rate of auditor change.

A comparison of the opening and closing positions reported in Table II indicates which audit firms were net gainers and losers. It is interesting to note that PW was the highest net gainer before its merger with CL (+26), whereas, CL was losing clients pre-merger (a net effect of -15). Following the merger PwC became the highest net loser of clients, which can be attributed to the negative influence of CL outweighing the positive influence of PW. There might also have been some negative reaction on the part of client company management to the merger, for example, if some company managers wished to avoid having the same audit firm as a competitor. The two highest gainers post-merger are DT and EY. AA represents an interesting case. Before the PwC merger, it had a net gain of 13 clients, whereas after the PwC merger, it had a net loss of 15 clients. It is unlikely that this is directly caused by the Enron effect, because the negative publicity associated with Enron had not impacted on its clients in 2001.

### Markov chain and optimisation models results and analysis

A discussion of the results follows, beginning with an analysis of the raw data on the number of audit switches within the pre- and post-merger time periods and moving on to the results from the Markov chain and optimisation models. These models generate

**Table II.**  
Movement of audit clients  
between audit firms

Gained from	AA	CL	DT	Lost to EY	KPMG	PW	non-Big	Starting position	Per cent
<i>Panel A: 1 October 1995-30 June 1998 – pre-merger</i>									
AA	131	2	0	1	1	4	3	142	8.45
CL	5	250	8	3	4	5	7	282	16.79
DT	1	1	139	1	3	0	7	152	9.05
EY	4	4	3	227	6	3	4	251	14.94
KPMG	3	3	2	1	304	5	4	322	19.17
PW	0	0	2	1	1	203	1	208	12.38
Others	11	7	7	10	13	14	261	323	19.22
Closing position	155	267	161	244	332	234	287	1,680	100.00
Per cent	9.23	15.89	9.58	14.52	19.76	13.93	17.09		
<i>Panel B: 1 July 1998-31 December 2001 – post-merger</i>									
AA	123		7	2	3	3	16	154	7.21
DT	2		202	1	4	2	3	214	10.02
EY	3		1	283	3	5	7	302	14.15
KPMG	6		7	9	386	5	10	423	19.81
PWC	2		12	18	11	552	25	620	29.04
Others	3		10	9	18	13	369	422	19.77
Closing position	139		239	322	425	580	430	2,135	100.00
Per cent	6.51		11.19	15.08	19.91	27.17	20.14		

parameter estimates for  $\hat{\mathbf{P}} = (\hat{p}_{ij})$ ,  $c_i$  and  $A_i$ , along with predictions of estimated steady-state probabilities  $\hat{\pi}_j[1]$ .

In order to undertake the Markov chain analysis, the data on the number of clients reported in Table II needs to be translated into observed transition probabilities. This produces two  $K$  by  $K$  the matrices  $\mathbf{P} = (p_{ij})$ , one for each of the two time periods under consideration. The model in equation (2) was then solved via non-linear optimisation using Excel's Solver add-in. The resulting estimated transition probability matrices  $\hat{\mathbf{P}} = (\hat{p}_{ij})$  for the pre- and post-merger periods are presented in Table III. These estimates are generated by allowing the parameters for  $c_i$  and  $A_i$  to vary, whilst minimising the sum of the squared differences  $\sum_{i=1}^K \sum_{j=1}^K (p_{ij} - \hat{p}_{ij})^2$  subject to the constraints imposed in equation (2). To ensure  $\hat{\mathbf{P}} = (\hat{p}_{ij})$  were as reliable as possible the level of "precision" and "convergence" specified in the Solver optimisation model were  $1 \times 10^{-8}$  and  $1 \times 10^{-13}$ , respectively. The resulting  $\sum_{i=1}^K \sum_{j=1}^K (p_{ij} - \hat{p}_{ij})^2$  of 0.005091 pre-merger and 0.002987 post-merger are small and provide evidence in support of the unbiased nature of the  $\hat{\mathbf{P}} = (\hat{p}_{ij})$  matrices. It is also important to note that Solver converged to the optimal solution for all time periods, thus the final values for  $c_i$  and  $A_i$ , reported in Table IV, are stable and do not simply represent local optima.

Comparing Panel A and Panel B in Table IV shows that the effect of the PwC merger on the relative abilities of the firms to attract and retain clients was dramatic. Pre-merger PW has the highest continuation probability parameter  $c_i$  of 0.957, but this declined substantially to 0.896. A similar, though even more pronounced decline is evident for AA with  $c_i$  falling from 0.921 pre-PwC merger to 0.795 post-PwC merger. The non-Big Six grouping showed the largest improvement in  $c_i$  from 0.817 to 0.862, indicating that the effect of the merger was to improve the chances of the non-Big Six grouping retaining their audit clients.

As noted above, during the 1995-1998 pre-merger period PW gained the highest number of new clients (31) and this is shown by its relatively high attractiveness

	AA	CL	DT	Lost to		PW	non-Big	Total
				EY	KPMG			
<i>Panel A: 1 October 1995-30 June 1998 – pre-merger</i>								
AA	0.9211	0.0067	0.0097	0.0071	0.0117	0.0273	0.0164	1.000
CL	0.0108	0.8912	0.0131	0.0097	0.0159	0.0370	0.0223	1.000
DT	0.0080	0.0068	0.9219	0.0072	0.0118	0.0276	0.0166	1.000
EY	0.0090	0.0076	0.0110	0.9093	0.0133	0.0310	0.0187	1.000
KPMG	0.0058	0.0049	0.0070	0.0052	0.9454	0.0198	0.0119	1.000
PW	0.0057	0.0048	0.0070	0.0051	0.0084	0.9571	0.0118	1.000
Others	0.0206	0.0175	0.0251	0.0185	0.0304	0.0709	0.8170	1.000
Total	0.9811	0.9395	0.9947	0.9621	1.0370	1.1707	0.9147	7.000
<i>Panel B: 1 July 1998 to 31 December 2001 – post-merger</i>								
						<i>PwC</i>		
AA	0.7949		0.0305	0.0277	0.0370	0.0324	0.0774	1.000
DT	0.0058		0.9430	0.0081	0.0108	0.0095	0.0227	1.000
EY	0.0056		0.0086	0.9443	0.0104	0.0092	0.0219	1.000
KPMG	0.0082		0.0125	0.0114	0.9229	0.0133	0.0317	1.000
PWC	0.0107		0.0165	0.0149	0.0200	0.8961	0.0418	1.000
Others	0.0187		0.0287	0.0260	0.0347	0.0304	0.8615	1.000
Total	0.8440		1.0398	1.0324	1.0359	0.9909	1.0570	6.000

**Table III.**  
Estimated transition probability matrices  $\hat{\mathbf{P}} = (\hat{p}_{ij})$

parameter  $A_j$  of 0.314, which is considerably greater than the next highest attractiveness parameter of 0.189 for the non-Big Six firms as a group. The lowest attractiveness parameter was that of CL at 0.077. It is therefore not surprising that the attractiveness parameter of the merged firm of PwC fell to 0.144, reflecting the apparent unattractiveness of CL as well as the effect of creating such a large accounting firm. The non-Big firms showed a spectacular increase in their attractiveness parameter relative to the Big Five, rising from 0.189 pre-merger to 0.344 post-merger. Looking at the long run steady-state market shares shows that PwC loses its dominant status in the market for audit services dropping to an estimated long-term market share of 0.132. This would be predicted from the long-term performance of CL had the merger not taken place, when its long-term steady-state position is predicted to be only 5.0 per cent from an opening position of 16.8 per cent. Hence, instead of having the desired effect of increasing market share, the PwC merger appears to have had potentially the opposite effect if the trends shown prior to 31 December 2001 had continued. As is evident from Table III, despite being able to attract a reasonable number of new client companies, PwC was losing existing clients at a relatively high rate. The two biggest winners in the post-merger period are DT and EY with  $\hat{\pi}_j$  of 0.229 and 0.215, respectively. Once more Arthur Andersen experiences a decline in the post-merger period to a very small long run share of 0.044.

The predictions of the Markov chain analysis make for a fairly depressing reading for the non-Big Six firms prior to the PwC merger, with a predicted long run market share for the 1995-1998 period being only 7.1 per cent. However, the effect of the PwC merger appears to have been to revive the fortunes of the non-Big Five sector, which sees its predicted market share increasing to 18.1 per cent post-merger[2].

### Summary and conclusions

In this paper, we set out to investigate the effect of the PwC merger on the audit services market for all listed UK companies that were in existence over two particular periods (1995-1998 and 1998-2001). We did not look at events after 2001, because of the possible confounding effects created by the demise of Andersen following the Enron debacle. We used the Markov chain approach and non-linear optimisation to estimate attractiveness and continuation parameters and to show what would be the long-term steady-state result if existing trends continued. Comparing the period immediately preceding the merger (1995-1998) with the period after the merger (1998-2001), we observed that the long run steady state market share of PwC (13.2 per cent) was

	AA	CL	DT	EY	KPMG	PW	non-Big
<i>Panel A: 1 October 1995-30 June 1998 – pre-merger</i>							
Continuation probability $c_i$	0.921	0.891	0.922	0.909	0.945	0.957	0.817
Attractiveness $A_j$	0.091	0.077	0.111	0.082	0.135	0.314	0.189
Steady-state Market Share $\hat{\pi}_j$	0.089	0.056	0.107	0.070	0.181	0.425	0.071
<i>Panel C: 1 July 1998-31 December 2001 – post-merger</i>							
						<i>PwC</i>	
Continuation probability $c_i$	0.795		0.943	0.9443	0.923	0.896	0.862
Attractiveness $A_j$	0.089		0.136	0.123	0.164	0.144	0.344
Steady-state Market Share $\hat{\pi}_j$	0.044		0.229	0.215	0.198	0.132	0.181

**Table IV.**

Estimated parameters from Markov chain and optimisation models

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considerably less than that for PW (42.5 per cent) in the period leading up to the merger. We attributed this dramatic shift to changes in both the attractiveness of PwC to new clients and its ability to retain existing clients. In the period 1995-1998, the attractiveness rating for PW of 0.314 was significantly better than that of any other Big Six audit firm or the non-Big Six as a group. Similarly, the ability of PW to retain clients was also the highest at a retention rate of 95.7 per cent. In contrast, CL had the lowest retention rate (continuation probability) of the Big Six and the lowest attractiveness. We are thus able to represent the effects of the merger on listed clients in the UK by using these two measures. From this perspective, the PwC merger was between the most attractive and the least attractive of the Big Six and between the Big Six firm most able to retain its clients and the one least able. We believe that this approach offers a unique insight into the events leading up to the merger and what happened subsequently. The merged PwC attractiveness rating was lower at 0.144 than that of PW (0.314), but considerably better than that of CL (0.077). The ability of the merged firm to retain clients at 89.6 per cent was nearer to CL (89.1 per cent) than PW (95.7 per cent). The effects of these two parameters can be seen by considering the long run steady state market shares that they would produce. In the pre-merger period 1995-1998, the Markov chain models converged to steady-state market shares of 42.5 per cent for PW and 5.6 per cent for CL, but for the merged PwC the steady state market share was 13.2 per cent. These results suggest that PW was on a course to become the dominant player in the market for audit services before the merger, but that post merger the firm's position will be more like the other members of the Big Five.

We see the methodology that we have employed as being potentially of value to competition authorities. One of the worries that have been expressed is that having only five audit firms is likely to reduce competition and hence potentially reduce the competitiveness of the audit services provided to listed UK companies. However, our results show that the effect of the merger between PW and CL has been to increase the relative attractiveness of non-Big Five audit firms. The steady-state market share predictions from the Markov chain model show a Big Six long-term market share of 92.9 per cent pre-merger, but a Big Five long-term market share of only 81.9 per cent post-merger. Hence, our results would suggest that the non-Big Five are likely to prosper more with only five top tier international auditing firms than when there were six. Thus, our findings suggest that whilst the immediate effects of a consolidation with the accounting firms will reduce the amount of competition, it may not necessarily be deleterious to competition in the longer term.

As with all research, the methodology we employ has potential limitations. The Markov chain model requires some strong assumptions, discussed above, that may limit the generality of the results. For example, the assumption of time-invariant transition probabilities effectively means that audit firms are unable to affect the likelihood of attracting new clients by such actions as fee cutting or advertisement. However, we do not find these problematic for our stated purpose of conducting a "what if" analysis of the impact of the PwC merger, whereby we compare what would have happened to the market had it continued unabated prior to the merger with what would happen if it were to continue unabated after the merger. Any differences are due to the effect of the PwC merger on the functioning of the audit services market. We do not claim that the steady-state market shares will be realised, but use these to demonstrate that the merger had a substantive impact on the market for audit services.

The fascinating question is of course, what will happen following the demise of AA, which in the UK merged with DT in the middle of 2002 due to the loss of reputation as a result of the Enron scandal, resulting in only four large international accounting firms. Such a situation gave concern to the competition authorities throughout the world. For example, in the USA, the General Accounting Office (GAO) concluded that the creation of a Big Four could present a range of problems in the future, including reduced competition and fewer choices for audit clients. According to the GAO study, the four largest USA accounting firms audited more than 78 per cent of public companies and 99 per cent of the market in terms of public company annual sales (GAO, 2003). In the UK, the possible effects of the Andersen demise are discussed by Beattie *et al.* (2003), who produced similar findings to the USA for the year 2002, with the Big Four auditing 82.6 per cent of public listed company audits (96.3 per cent by audit fee). Such a concentration has led to calls by the National Association of Pension Funds in the UK for an inquiry by the UK's Competition Commission into the activities of the Big Four (Grant, 2004). The Oxera (2006) report concluded that high barriers to entry would lead to the continuing dominance of the Big Four.

In contrast, our results would suggest that whilst the headline dominance by the Big Four is huge, the effects of the loss of Andersen should result in the non-Big Four being more likely to find that their market share has improved as a result of this further consolidation of the top tier of auditing firms. Thus, our results would suggest that the creation of an elite top four is more likely to strengthen rather than weaken the position of the remaining smaller firms and hence that the application of simple concentration measures may miss part of the dynamics of the process, in which the non-top tier firms are likely to be advantaged rather than disadvantaged by the creation of a smaller top tier. Unfortunately, time needs to elapse before such a prediction can be observed empirically and so we leave this to other researchers to pursue in due course.

## Notes

1. The Markov chain and optimisation models described here were developed using some of the assumptions of the model presented in Comunale and Sexton (2003). However, there are important differences between the two studies. First, Comunale and Sexton's (2003) model is based on only S&P 500 companies which limits the analysis to the Big Five (giving only five states) and produces only 23 changes. Second, Comunale and Sexton (2003) use an aggregate variable for PwC throughout, whereas the partitioning of the data pre- and post-merger here allows the effect of the merger to be investigated. Third, in the specification of their Markov chain model Comunale and Sexton (2003) restrict the estimated long-term market shares (generated by the Markov model) to be equal to the observed market shares. This produces anomalous results whereby DT gain the highest number of new clients (seven), but end up with an estimated attractiveness parameter much lower than PwC who gain fewer new clients (four).
2. To ensure that we were capturing the effect of the PwC merger and not simply reflecting trends that were present prior to the merger we performed two robustness checks. First, we collected additional data from 1 October 1992 to 30 September 1995. Running the Markov Chain and optimization models on this time period produced parameter estimates for  $c_i$ ,  $A_i$  and  $\hat{\pi}_i$  that were, on the whole, similar to those reported for the pre-merger period. Comparison of the long run predicted market shares  $\hat{\pi}_i$  across the two periods suggests that in the period leading up to the PwC merger, there had been a relative decline in the prospective fortunes of CL and the non-Big Six firms (i.e. lower  $\hat{\pi}_i$  in the pre-merger period), but a relative improvement in the long run expectations of PW (i.e. higher  $\hat{\pi}_i$  in the pre-merger period). The fact that the long run predicted market share for the non-Big Six, falls from 13.1 per cent for the



period 1 October 1992-30 September 1995 to 7.1 per cent for the pre-merger period, but then increases to 18.1 per cent for the post-merger period clearly indicates that the effect of the merger is to reverse the fortunes of the non-Big Six and that this is not merely the effect of a trend. Second, we took the data from the pre-merger period and “merged” CL and PW to create a “pre-merged PwC”. We re-ran the Markov Chain and optimization models producing parameter estimates for  $c_i$ ,  $A_i$  and  $\hat{\pi}_i$  of 0.9381, 0.2697 and 0.3220, respectively, for the “pre-merged PwC” which are all markedly higher than the values reported for PwC post-merger. Again, this evidence supports the view that the merger itself had a major impact on the retention of clients, relative attractiveness and long run predicted market share of PwC.

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