Are the most competent auditors in the Big 4 firms?

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ABSTRACT

The CPA exam provides an evaluation of auditors' professional competence in the early stages of their careers. Using information from the results generated in Sweden, this paper shows that i) auditors at Big 4 firms are younger when they take the exam, ii) younger auditors and auditors at Big 4 firms perform better in the exam, iii) there is a positive association between the results of the CPA exam and wage increases after receiving the CPA certification, with the association being stronger in Big 4 firms, iv) the probabilities of switching from a Big 4 firm to a non-Big 4 decreases with wages (the opposite happens with switches from non-Big 4 firms to Big 4 firms). This evidence is consistent with a matching process based on imperfect information about the competences of the auditors in which Big 4 audit firms attract and retain the most competent auditors from each cohort.

JEL classification: J24, J31, J44, M42, M51.

Key words: CPA exam, compensation, competences, Big 4, professional careers.

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1. Introduction

"As the battle in the long-heralded 'war for talent' is joined across industries and countries, it could be worth keeping an eye on how the Big Four are quietly leading the charge" (Accounting for good people, The Economist, July 21st, 2007).

Although the matching of firms and workers in auditing firms has received the attention of the media, we are not aware of any academic research providing evidence on this match. This paper fills this gap. The paper provides evidence about the auditors who take the CPA Exam in Sweden during the period 2006-2012. The evidence is based on personal information (the score in the exam, the age at the time of the exam and gender), information about the firm (the firm and location of the office) and information about compensations for a sample of Public Accountants.

These data let us to provide evidence about three fundamental issues of the literature about internal labor markets (for a summary see Waldman, 2012). First, the heterogeneity in competences among workers from the same cohort. Second, workers' competences are a main driver of their allocation to job positions. Based on "assignment models" (e.g., Sattinger, 1975, 1993) the allocation of auditors to firms will be based on the comparative expected productivity of the matches, and it will be related with their competences and compensation[1]. Third, the matching is dynamic. Following the employer-learning literature (Jovanovic, 1979; Harris and Holmstrom, 1982; Lange, 2007) the match between workers and firms is based on imperfect information about the workers' competences[2]. Workers and firms learn and update their beliefs with time according to the new information generated, in our case the performance in the CPA Exam.

[1] See Garicano and Van Zandt (2012) for a more recent summary of this literature applied to the analysis of hierarchical organizations.
[2] For recent applications see Taylor (2013) or Pan et al. (2015).

This study adds new evidence[3] about these three issues in a whole industry, the Swedish auditing market, in the early phase of the auditors' career and with a particular measurement of the auditors' competences. Evidence about internal labor markets is in general difficult to generate[4], and it is particularly difficult to obtain evidence on the internal labor markets of all the competitors in a specific market.[5] Furthermore, the extant theoretical and empirical analysis is mainly focused on top managers in firms (e.g., Rosen, 1982; Terviö, 2008; Gabaix and Landier, 2008; Taylor, 2013; Bandiera et al., 2015).

The CPA exam provides an evaluation of whether an auditor has the professional competence needed to act as a public accountant. It has some particularities that make it different from other measures of competences used previously in the literature. Unlike measurements of general capabilities, for example intelligence tests (e.g. Farber and Gibbons, 1996 or Altonji and Pierret, 2001), the CPA exam is specifically developed for measuring professional competences and it is key for the auditors' career. Contrary to measurements of performance in the job (e.g., Lazear, 2000; Bandiera et al., 2007), another advantage is that the performance in the CPA exam has no effect on the firm's performance, so it is difficult that incentive contracts based on the exam result exist.

In order to guide and interpret the empirical evidence we develop a theoretical model specially adapted to the context analyzed. Based on the information that auditors and firms have about the auditors' competences they made the following decisions: they decided when the auditors would sit the exam, assigned auditors to firms and

[3] Analyses of one economic sector in one country include that of Chevalier and Ellison (1999) for fund managers in the US, Garicano and Hubbard (2009) for law firms in the US, and Andersson et al. (2009) for engineers in the US.

[4] The seminal paper of Baker et al. (1994) has been followed by some papers referenced in Gibbs and Hendricks (2004) or more recent ones like that of Smeets and Warzynski (2008).

[5] Studies using samples of firms in one country include those of Rajan and Wulf (2006) and Woodcock (2008) for the US, Eriksson and Werwatz (2005) for Denmark and Ortín-Angel and Salas-Fumás (2006) for Spain.

established the wage. The last two decisions are analyzed twice: before sitting the exam and after the exam. Differences between these two periods are expected because performance in the exam provides new information about the auditors' competences. Obviously, a set of simplifying assumptions is needed to make the model tractable and to generate testable hypotheses.

The webpage of Ernst & Young (EY) states[6] that: "While our core business is all about delivering exceptional service to our clients, we know that if we attract and retain the best people – and invest in them – we will deliver the best results for our clients." It seems well established in the auditing literature that Big 4 firms conduct higher-quality audits (e.g., Francis, 2004, 2011; Knechel et al., 2013a). Among the reasons suggested is that auditors at Big 4 firms have greater incentives and higher competency (Watts and Zimmerman, 1981). Our study shows that Big 4 firms hire, on average, more competent people using the performance in the CPA exam as a measure. The study contributes to the knowledge about compensation policies in audit firms. There are few empirical studies in this area and the available evidence is for partners in Big 4 firms (e.g., Knechel et al., 2013b). We present evidence on wage differences between Big 4 and non-Big 4 firms. Furthermore, we find a positive association between an auditor's performance in the CPA exam and posterior wage increases, mainly in Big 4 firms. This result indicates that the match of auditors and job positions is made with imperfect information about capabilities when auditors are hired and that the performance in the CPA exam is used to update the expected capabilities of auditors.

Finally, the study contributes to the literature regarding factors associated with performance in the CPA exam. Studies (Brahmasrene and Whitten, 2001; Grant et al., 2002; Allen and Woodland, 2006; Boone et al., 2006) have analyzed the determinants

[6] The quotation is taken from http://www.ey.com/UK/en/About-us/Corporate-Responsibility (retrieved December 2015).

of passing the CPA exam in the US. However, this literature focuses on the way in which educational requirements affect the performance in the exam. Thus, besides providing evidence from another country, we theoretically and empirically analyze how audit firm affiliation and the age of the candidate is associated with the performance in the exam. We are not aware of any prior study in which the role of capabilities has been studied using theoretical models of entry to auditing or other professions.[7]

The remainder of this paper is organized as follows. Section 2 presents the institutional setting. Section 3 develops the theoretical framework. Section 4 discusses the empirical implications. Section 5 describes the data and Section 6 provides the empirical findings. Section 7 concludes the paper.

2. Institutional setting

2.1 The Swedish audit market

Similar to other EU countries, audits are required for privately and publicly held companies. EU directives give countries the right to exempt smaller entities from the statutory audit requirement. Up to 2010, Sweden had not used this exemption but instead required all limited liability companies to be audited regardless of their size. Since 2010, the smallest limited liability companies have been exempt from the statutory audit. However, the vast majority of all firms audited are privately held companies.

The Big 4 audit firms are dominant in the Swedish audit market. Their accumulated revenues equal 81.2 % of all revenues reported by the 12 largest audit firms, and they employ approximately 50 % of all certified auditors in Sweden. PwC is

[7] Bagues and Perez-Villadoniga (2012) and Bagues and Esteve-Volart (2010) analyze different aspects of access to the Corps of Spanish Judiciary.

by far the largest audit firm in terms of revenues and number of employees, followed by EY, KPMG, and Deloitte. Only 10 out of 268 listed companies were audited by a non–Big 4 audit firm in 2011, including Grant Thornton, BDO and Mazars SET. These three firms have international partners and follow the Big 4 in order of size. Altogether, the Swedish audit market consists of over 900 audit firms. The group of small audit firms includes a large number of sole proprietors.

Only Certified Public Accountants (CPAs) can sign audit reports. The number of CPAs registered with the Supervisory Board of Public Accountants (SBPA) is approximately 4,000. In 2005, there were a total of 4,152 qualified auditors, while this figure was down to 3,994 and 3,857 in 2009 and 2013, respectively. In 2012, the Big 4 firms employed 1,943 CPAs, of whom 591 were audit partners (30.4%).

2.2 CPA certification

Auditors' careers start when audit firms hire them, which typically takes place directly after the completion of university. Once employed, the new auditors start by working with one or several certified auditors as audit associates. They also take a large number of courses that are useful for audit work and as preparation for the CPA exam.[8]

Each of the Big 4 audit firms organizes a large number of courses internally, which audit associates are expected to complete. Audit associates at Big 4 firms rarely take courses that are not arranged in-house, but audit associates employed at smaller audit firms typically take courses that are arranged by FAR Akademi (the Institute of Professional Accountants).

[8] Until 2013, Certified Public Accountants (after two years of experience and certain other requirements) were able to take an additional exam and apply to become an *authorized* public accountant. After the legal change in 2013, there are now only Certified Public Accountants. The analyses in this study are based on the results of the CPA exam. Certified public accountants are qualified to audit all types of companies, including listed companies. Further information can be found at http://www.far.se/.

The CPA exam ensures that the auditors have sufficient theoretical knowledge to conduct statutory audits in companies of different sizes with different types of operations. Furthermore, the exam ensures that the auditors are able to apply the theoretical knowledge in their auditing practice (Auditing Decree § 3). The main requirements for CPA certification are that the auditor (i) has at least three years of practical auditing experience, (ii) has a minimum of a Bachelor's degree with a major in Business Administration, (iii) has passed the examination of professional competence as a Certified Public Accountant (CPA exam), and (iv) meets certain general eligibility criteria (Auditing Act § 4; Auditing Decree § 4). Furthermore, to maintain certification, the auditor must be professionally active as an auditor (at least 1500 hours over a 5-year period), employed by an audit firm and be undertaking continuous education. Failure to adhere to these requirements leads to the loss of certification (Auditing Act §§ 4 and 8; Auditing Decree § 8).

The CPA exam is organized by the Supervisory Board of Public Accountants (SBPA) twice a year (May and December), and the results of the exam are published in July of the same year and January of the following year, respectively. The examination process is organized as follows. An audit firm (typically one of the Big 4) is hired to prepare exam drafts and correct the exams. Different types of experts at the audit firm, such as lawyers and accounting experts, provide input for the process. An examination committee, consisting of three practicing auditors and two university professors, comment on exam drafts and supervise the preparation and correction of the exam. The audit firm that is responsible for correcting the exam receives anonymous files with the applicants' answers. The cost of taking the exam is currently 25,000 Swedish krona (SEK), or around US $3,020 (USD). This expense is typically paid by the employer. Thus, employers are likely to screen possible applicants and only allow those with relatively good chances of passing the exam to participate. The CPA certification gives the auditors the right to sign audit reports. Files with the results of the exam are available upon request from the SBPA. The data include information about the date of the exam, the individual score on the exam, name, gender, birth date, as well as the name of the employer and the location of the audit office when taking the exam.

3. The theoretical framework

3.1 Basic assumptions

The auditing literature suggests that Big 4 firms offer higher-quality services than non-Big 4 firms (e.g., Francis, 2011) and audit larger firms. Big 4 firms audit the vast majority of all publicly-traded clients, which are generally more complex and associated with higher litigation risks than private clients. This suggests that tasks in Big 4 firms are, on average, more demanding than those in non-Big 4 firms, implying that Big 4 firms have a greater demand for more competent workers. At the stage of the auditors' career that we are analyzing, it seems quite reasonable that, generally speaking, the auditors of the same cohort (age) are carrying out similar jobs, so firms are mostly competing to attract the most competent auditors within the different cohorts. In terms of "assignment models", auditors with higher within–cohort abilities will be comparatively more productive in Big 4 firms. In short, our research proposal is to provide evidence regarding the match between Big 4 firms and within-cohort abilities and analyze whether the compensations reflect such matches.

The CPA Exam score provides information about the differences of abilities within the different auditors' cohorts. Hereinafter, and for simplicity's sake, we refer to the differences of abilities within auditors' cohorts as auditors' abilities. It is reasonable to assume that the real ability is not modified by the act of taking the exam, so the exam is basically modifying the set of information that the agents in the market have about the auditors' abilities. Then, our second focus of interest is to test to what extent the matches before the exam have been made with imperfect information about the auditors' abilities. If this is the case, after the exam we will expect changes in the match and compensations of the auditors. Increases (decreases) in wages and movements from non-Big 4 (Big 4) to Big 4 (non-Big 4) firms are expected for those auditors with scores higher (lower) than expected.

In summary, the data observed will be the consequence of a set of decisions about the age of taking the exam, the match and the compensation of the auditors before and after the exam. We need to add more structure (and consequently simplifying assumptions) in order to analyze such decisions and make concrete predictions to guide the empirical evidence. In what follows we assume that auditors and firms are risk neutral have the same information about the auditor abilities, as is usually the case in the "employer-learning literature". Then, we differentiate between the *real* ability of the auditor *i* (m_i) and the *predicted* ability at a certain period of time *t* (m_i^t). Due to the data available, we focus on two periods — before the exam (period $t = 0$) and after the exam (period $t = 1$) — and, consequently, two predicted abilities *prior* (before knowing the score of the exam) and *posterior* (after knowing the score of the exam).

The real ability of the auditors will determine the score in the CPA Exam and their productivity. Predicted abilities will be used for taking decisions. The next sections detail further assumptions for analyzing the consequences of those decisions. Most of them are usual in the literature and are made for developing a tractable model that summarizes the main predictions related with our two research questions.

3.2 Assumptions about the determinants of the CPA Exam score

The members of a cohort are not all evaluated at the same time. Consequently, differences in the scores between auditors are due to differences in capabilities between cohorts, differences in the professional abilities within cohorts and other factors unrelated with the auditors' competences, such as luck, effort in the exam and so on.

For simplicity's sake, let us assume that the score (g_i) of an auditor *i* depends on their age at the time of the exam (a_i), auditors' ability (m_i) and a random variable (ε_i) as follows:

$$g_i = \mu + \gamma(\tau a_i + m_i) + \varepsilon_i.$$

μ is an intercept capturing the expected score of an auditor with competences $(\tau a_i + m_i)$ equal to zero. Based on the human capital literature, we assume that auditors' competences increase with time (Becker, 1964; Mincer, 1974; Blaug, 1976) so τ is a positive parameter equal for all auditors indicating the yearly increase in their competences, and γ is a positive parameter that transforms the measurements of competences into scores. We assume that ε is a random variable not correlated with the auditors' competences. The random variable is assumed to be equally and independently distributed among auditors. For convenience, we assume that ε follows a normal distribution with the mean equal to zero and a standard deviation of σ_ε. It can be observed that when σ_ε=0, the exam is measuring the competences, and consequently abilities of the auditor perfectly. Obviously, factors other than competences or abilities can influence the performance in the exam, suggesting that $\sigma_\varepsilon > 0$.

3.3 Assumptions related with the match, productivity and compensations

We reduce the analysis to four jobs to which the auditors of a cohort can be assigned, with (*CPA*=1) and without CPA certification (*CPA*=0) and to Big (*Big4*=1) and non-Big 4 firms (*Big4*=0). Following usual assumptions in the internal labor markets literature the annual production (Y) of an auditor depends on their abilities and the job position. We propose a simple function consistent with the match and assumptions described in Section 3.1:

$$Y = \vartheta + m + \tau a + (\varphi m - \delta)Big4 + CPA * b$$

Parameter ϑ is the production of a person with zero competences working for a non-Big 4 firm (*Big4*=0) and in a job position where CPA certification is not required (*CPA*=0). The parameter b is the variation in productivity associated with the CPA certification, which is expected to be positive. Parameters φ and δ are positive. This guarantees that auditors with abilities higher than m_B=δ/φ will be more productive in Big 4 firms than in non-Big 4 firms (the reverse occurs for auditors with abilities lower than m_B). This match implies that the marginal productivity of one unit of *m* is higher in Big 4 than non-Big 4 firms (which is φ >0) and also that the productivity of an auditor without a CPA certification or with abilities below m_B is higher in non-Big 4 firms than in Big 4 firms (δ > 0). To avoid nomenclature we do not introduce an error term in the production function. Instead, we assume that the production is not observed. If this were not the case, production would after one year provide perfect information about the auditors' abilities.

At each period *t* the auditors will be assigned to firms in accordance with their predicted ability (m_i^t > m_B=δ/φ to Big 4 firms). We cannot observe the productivity of the auditors and, consequently, we cannot apply the function above. It is usually assumed in the internal labor markets literature that wages are positively correlated with production. Production (Y) is the wealth generated by matching an auditor and a firm. The auditor's wage (*w*) determines the way this wealth is shared (Y-*w* for the firm and *w* for the auditor). It is in the interest of both agents to choose the match that maximizes production. This match is Pareto-Optimal. Compared with less productive matches, it is always possible to establish higher wages without decreasing the profits of the firm. As usual in the internal labor markets literature, we do not model the wage negotiation process, and we assume that the auditors' wages are equal to their expected production[9]:

$$w_i^t = E(Y/m_i^t) = \vartheta + m_i^t + \tau a_i^t + (\varphi m_i^t - \delta)Big4 \;\; + CPA * b$$

3.4 Assumptions related with the decision to take the exam

We assume that the objective of the auditors is to maximize the wealth generated during their career. The expected wealth increase ΔW that occurs when an auditor takes the exam at age *a* can be expressed as

$$\Delta W = b(r-a)P\left(g \geq \underline{g}\right) - f$$

where f, *b* and *r* are positive parameters that are equal for all of the auditors. Parameter f represents the costs of taking the exam, which includes the fees and other costs that cannot be saved for subsequent exams — for example, time displacement or a certain amount of study time. Parameter *b* represents the difference in annual wages due to the CPA certification. Parameter *r* is the final year of the auditors' career; thus, *r-a* are the years in which the auditors have the CPA certification if they pass the exam[10]. The probability of passing the exam, $P\left(g > \underline{g}\right)$, is the probability that the exam score g is higher than the minimum score required to pass exam $\underline{g}$. In short, a delay in the exam can increase the capabilities of the auditor and, consequently, the probabilities of

[9] Most of the negotiation models (except in those cases where the firm appropriates all wealth) predict that the auditors' wages will be positively correlated with their productivity.

[10] We also solved the model when including restrictions, such as minimum legal requirements (and then age) for applying, or that the expected wealth increase must be positive. The main implications are the same. The difference is that the ages are now restricted to a certain interval of values. Proof can be provided upon request.

passing the exam, but it reduces the time that the auditor can enjoy the benefits of being a Public Accountant.

3.5 Assumptions related with the information about auditors' abilities

We focus on the heterogeneity of abilities at the time when an auditor enters the profession. We do not model how or when this heterogeneity has developed, we just assume it exists and analyze how it is distributed among the firms. For simplicity we assume that the distribution of abilities within a cohort of auditors m follows a normal distribution with an expected value of m^E and a standard deviation of σ_m, so $M(m) = \Phi\left(\frac{m-m^E}{\sigma_m}\right)$. We assume that m has the same cumulative distribution function (cdf) $M(m)$ within the population of each cohort of auditors. It is important to note that when $\sigma_m = 0$, there is no heterogeneity, and the differences in abilities among the auditors of the same cohort are null.

The market (firms and auditors) have information about the auditors' abilities. The correlation of this information with the distribution of real abilities is $\rho_0 \geq 0$. Then, the distribution of the predicted abilities of auditors before the exam (period 0), among a cohort of auditors, follows a normal distribution with mean m^E and a standard deviation of $\sigma = \rho_0\, \sigma_m$ (for further details see Appendix A). So m^0 has the following cumulative distribution function (cdf) within the population of each cohort of auditors, $\Phi\left(\frac{m^0 - m^E}{\rho_0\, \sigma_m}\right)$. When $\rho_0 = 1$ there is perfect information and when $\rho_0 = 0$, there is no information about the auditors' abilities.

3.6 Main implications: The model solution

The main implications of the model can be summarized by the following set of propositions:

Proposition 1. Auditors with predicted abilities m_i^t higher than m_B=δ/φ will be allocated to Big 4 firms, otherwise they will be allocated to non-Big 4 firms. The difference between the average abilities of those auditors in Big 4 firms and the average abilities of auditors in non-Big 4 firms before sitting the exam is $\Delta_m = \sigma(\frac{\phi(z)}{1-\Phi(z)} + \frac{\phi(z)}{\Phi(z)})$, which is positive as long as $\sigma > 0$. $\Phi()$ is the cumulative distribution function (cdf) and $\phi()$ is the probability distribution function (pdf) of a normal distribution with a mean of 0 and a standard deviation of 1 and $z = \frac{m_B - m^E}{\sigma}$. (Proof: straight from Section 3.2 and the properties of the truncated normal distribution).

Proposition 2. The optimal age to take the exam is a function of the predicted abilities $a^*(m^0)$ with the following properties: $\frac{da^*(m^0)}{dm^0} < -\frac{1}{\tau} < 0$ (Proof: Appendix B).

Proposition 3. The posterior (after the CPA exam) predicted ability of auditor *i* can be written as follows:

$$m_i^1 = \left(\frac{g_i - \mu}{\gamma}\right)(\frac{1}{I}) + m_i^0\left(1 - \frac{1}{I}\right) - \tau a_i^*(\frac{1}{I})$$

The wage of the auditor will be established in accordance with the following equation:

$$w_i = \vartheta + m_i^0 + \tau a_i^* + (\varphi m_i^0 - \delta)Big4_i +$$

$$CPA_i(b + \tau + \left(\frac{g_i - \mu}{\gamma} - \tau a_i^* - m_i^0\right)\left(\frac{1 + \varphi Big4_i}{I}\right))$$

The parameter *I* is positive and inversely related with the capacity of the exam score to add new information about the auditors' real abilities (see Appendix C for further details and proof).

The next section discusses the propositions and proposes empirical approaches to test them.

4. Empirical implications

4.1 Auditors' age, Big 4 and performance in the exam

A researcher can naturally not access all the information used in the matching process between the firms and auditors, m_i^t. Then, the tests of Proposition 1, that most able auditors are placed at Big 4 firms ($\Delta_m > 0$), need to be based on consistency with the other two propositions or based on available measures correlated with such abilities as the CPA Exam score.

The first test that we propose is related with the consistency of Proposition 1 and Proposition 2. This last proposition is derived from the assumption that the decision to take the exam is based on the auditor's chances of passing it. This means that auditors with lower perceived abilities are more likely to delay the exam. A delay in the exam will increase auditors' experience and they can spend more time preparing for the exam, so it is expected that their competences increase and, correspondingly, their chances of obtaining the CPA certification. However, a delay in the exam reduces the time that the auditor can enjoy the benefits of being a Public Accountant. As a result of the assumptions made, the auditors' decision to take the exam will depend on their perceived abilities, $a^*(m^0)$. Those with higher abilities will take the exam earlier, $\frac{da^*(m^0)}{dm^0} < 0$, and will obtain higher grades than their cohort peers who take the exam later $\frac{da^*(m^0)}{dm^0} < -\frac{1}{\tau}$. Let us define: $a_i = h + h_1 m_i^0$, as the linear approximation of the function $a^*(m^0)$, where h's are parameters and $h_1 \approx \frac{da^*(m^0)}{dm^0} < -\frac{1}{\tau}$. With information about the abilities of the auditors m_i^0 we would estimate the following equation: $a_i = h + h_1 m_i^0 + \varepsilon_{1,i}$. Given our data restrictions, we estimate the following equation:

$$a_i = \beta + \beta_1 Big4_i + v_{1,i} \qquad [1]$$

Proposition 1 predicts that the most able auditors are assigned to Big 4 firms and Proposition 2 predicts that the most able auditors take the exam earlier ($h_1 < 0$), so we expect that $\beta_1 = h_1 \Delta_m < 0$. This relationship is summarized by the following hypothesis:

Hypothesis 1: Auditors assigned to Big 4 firms will take the exam earlier.

The second type of tests that we suggest relates Proposition 1 with the score in the CPA Exam. In accordance with the assumptions made, the expected score of an auditor *i* can be written as:

$$g_i = \mu + \gamma\tau a_i + \gamma m_i + \varepsilon_i = \mu + \gamma\tau a_i + \gamma m_i^0 + \epsilon_i$$

where ϵ_i follows a normal distribution with mean 0 and variance σ^2. Consequently, we estimate the following equation:

$$g_i = \alpha + \alpha_1 Big4_i + \alpha_2 a_i + v_{2,i} \qquad [2]$$

If all the auditors were evaluated at the same age (or if the age of taking the exam were uncorrelated with the auditors' abilities) and given the assumptions made, we expect that $\alpha_1 = \gamma\Delta_m > 0$ and $\alpha_2 = \gamma\tau > 0$. But Proposition 2 suggests that the age of taking the exam is negatively correlated with auditors' abilities.

In accordance with the equation: $a_i = h + h_1 m_i + \varepsilon_{1,i}$, the age of taking the exam is an imperfect signal of the auditors' abilities. In this case (Appendix C provides the proof) the parameter α_1 associated with Big 4 firms is expected to be non-negative[11] ($\alpha_1 \geq 0$) and lower than the parameter that would be estimated when the age of taking the exam is excluded from the regressions ($\alpha_1 \leq \gamma(\Delta_m + \tau\,\beta_1)$). The coefficient associated with the age of taking the exam will be negative: $\alpha_2 = \gamma\left(\tau + \frac{1}{h_1}\right) < 0$, given that, in accordance with Proposition 2, more able auditors will take the exam earlier and

[11] It will be equal to zero when the age of writing the exam is perfectly correlated with the auditors' abilities.

will be more prepared to take the exam, $h_1 < -\frac{1}{\tau}$. The following hypotheses summarize these predictions.

Hypothesis 2: The score on the exam will be negatively related to the age of the auditors when taking the exam.

Hypothesis 3: The average score on the exam will be higher for auditors at Big 4 firms than auditors at non-Big 4 firms. This difference decreases when we control for the age of the auditor.

4.2 Big 4 affiliation, wages and performance in the exam

The third test that we propose is related with the consistency of Proposition 1 and Proposition 3, and in particular, it is a test of the fact that the grades of the exam provide information about the auditors' abilities. For that purpose, we estimate the following empirical version of the wage equation proposed in Proposition 3:

$$w_i = \theta + \theta_1 a_i + \theta_2 Big\ 4_i + \theta_3 g_i + CPA_i(\theta_4 + \theta_5 a_i + \theta_6 g_i) + v_{3,i} \qquad [3]$$

where θ's are the parameters to be estimated. We expect that the wages increase with the auditors' age at the time of taking the exam ($\theta_1 > 0$ due that $\tau > 0$), and with the CPA Certification, ($\theta_4 > 0$ due that $b > 0$). Since auditors with higher predicted abilities are expected to be at Big 4 firms ($m_i^t > m_B = \delta/\varphi$), we expect that $\theta_2 > 0$:

Hypothesis 4: Wages are higher in Big 4 firms than in non-Big 4 firms

If the CPA exam generates information about the auditors' abilities we expect that, after the CPA Certification, the wages of the auditors are going to increase (decrease) when the exam scores are higher (lower) than expected in accordance with their prior predicted abilities, $\left(\frac{g_i-\mu}{\gamma} - \tau a_i^* - m_i^0\right)$, so $\theta_6 > 0$ and $\theta_5 < 0$, but the exam score will not affect the wages before the CPA Certification, $\theta_3 = 0$.

Hypothesis 5: After controlling for the age of the auditor, the wages of the auditors after the CPA certification will be positively correlated with the score in the exam.

Note that the predictions about the coefficients θ_1, θ_2 and θ_5 of equation [3] have been made assuming that the error terms $v_{3,i}$ are independent of the auditor's age at the time of the exam. Appendix F provides a further discussion of when this is not the case and its implications.

We can estimate Equation [3] separately for Big 4 firms and non-Big 4 firms. Given that the marginal productivity of one unit of ability is higher at Big 4 firms ($\varphi > 0$), from Proposition 3 we expect that:

Hypothesis 6: The relationship between the score and wage is stronger in Big 4 firms than in non-Big 4 firms.

Proposition 3 also has implications for switches between firms. The probability that an auditor at a Big 4 firm switches to a non-Big 4 firm decreases with the abilities of the auditor. The opposite relationship is expected for switches from non-Big 4 to Big 4 firms. Based on the assumption that ability is reflected in wages, this suggests that wages (controlling for age) are associated with the probability of switching (see further details in Appendix E).

As we will show in the next section, the number of switches around the CPA exam is quite low. Therefore, we provide evidence relating to the probability of switching with auditors' wages (w) and age using a larger sample covering all the certified auditors. We estimate a probabilistic model for samples of auditors working at Big 4 firms and auditors working at non-Big 4 firms. The dependent variable takes value 1 if an auditor at a Big 4 (non-Big 4) firm switches to a non-Big 4 firm (Big 4 firm) in the next period and 0 otherwise. The next equation relates the latent variable with the independent variables measured the period prior to the switch:

$$\text{Switch}_{i,t+1}^{*} = \vartheta + \vartheta_1 w_{i,t} + \vartheta_2 Age_{i,t} + v_{4,i,t} \qquad [4]$$

For the sample of Big 4 firms, we expect that the probability decreases with the compensations ($\vartheta_1 < 0$) while for the sample of non-Big 4 firms we expect the reverse relationship, ($\vartheta_1 > 0$). Hypothesis 7 summarizes those relationships.

Hypothesis 7: The auditors at the same cohort with lower compensations in Big 4 firms have higher probabilities of moving to non-Big 4 firms, and auditors at the same cohort with higher compensations in non-Big 4 firms have higher probabilities of moving to Big 4 firms.

5. Data and variables

We collect data from three sources. The Supervisory Board of Public Accountants (SBPA) provided us with information about the name, individual score on the CPA exam, the date of the exam, gender, birth date, as well as the name of the employer and the location of the audit office when taking the exam. Files from SBPA were also used to collect information about the age and date of certification. Ratsit provided us with information about the annual income for a ten-year period for those Certified Public Accountants who were active at the end of 2011. Finally, the audit firm affiliation for certified auditors was taken from files provided by UC. Ratsit and UC are business and credit information companies. These sources were used to construct three samples.

Sample A is used to test Hypotheses 1 to 3 and it includes information provided by the SBPA. These data contain observations for 1,377 auditors attempting to take the CPA exam for the first time between 2007 and 2012. The sample includes auditors who passed as well as failed the exam. The sample was composed as follows. We started with 2,386 observations for the 2006 to 2012 period. We excluded observations for the year 2006 and only included an observation the first time it appeared in the data to ensure that only the observation for the first exam attempt is included in the sample. The reason why we include only the first attempt is that the inclusion of subsequent attempts by those who fail would result in an overrepresentation of low capable auditors.[12] We excluded 21 observations for auditors who already had an older certification that allowed them to audit small companies, leaving 1,377 observations for further analysis.

The following variables are used in the empirical estimations of the equations [1] and [2]. The age of the auditor (a_i) at the time of the first CPA exam attempt is measured in years (age of the auditor in days divided by 365.25). The score of the CPA exam (g_i) is measured as the points received. The maximum points for the exam is 100, the minimum is 0, and at least 75 points are needed to pass the exam. Big 4 firms are measured with an indicator variable, taking the value one if the firm is audited by Ernst & Young, PwC, KPMG or Deloitte and zero otherwise. Controls for gender (Female), location of the office (Stockholm, Malmo or Gothenburg) and exam time fixed effects are included.

Sample B is used to test Hypotheses 4 to 6. The sample includes data two years before the CPA certification, the year of certification and the year after the certification of 431 auditors who received the CPA certification from 2006 to 2009. This is a balanced panel with 1,724 observations. The sources of the data are SBPA and Ratsit.

The sample was composed as follows. We started with 723 auditors who passed the exam between 2006 and 2009, but employer turnover is high at audit firms in the

[12] Indeed the cost of this is that we lose information that could be used to study how capabilities evolve between the attempts to take the exam. However, of those 552 auditors in the sample who failed, most either did not attempt to take the exam again (186 / 552) or passed at their next attempt (256 / 552). Therefore, there are several observations for which the improvement in performance could be studied.

early phase of the career, meaning that income data were missing for 150 individuals, leaving 573 auditors.[13] Furthermore, to eliminate auditors who were on parental or sick leave, we exclude observations if the annual income is lower than SEK 240,000. These criteria resulted in an omission of 142 auditors, leaving a balanced panel with 1,724 auditor-years and 431 auditors for the analyses. The main variables used in the empirical estimations of equation [3] are wages (w), defined as the logarithm of the salary income (inflated with CPI to reflect the price level in 2011) and an indicator variable taking a value of one in the year in which the auditor receives the CPA certification and in subsequent years. Consequently, this variable takes a value of zero in the two years before the CPA certification. The remaining variables used in the analyses (exam score, age, gender, affiliation and location) are explained above.

Sample C is used to test Hypothesis 7. It includes 13,108 observations for 2,684 certified auditors. The data cover the period 2006 to 2011 and include certified auditors that are in early as well as later phases of their career. The sources of the data are SBPA, Ratsit and UC. These data are used for estimating Equation [4] on two subsamples, auditors working at Big 4 firms and at non-Big 4 firms. The dependent variable is a dummy taking the value one if the auditor switches from a Big 4 (non-Big 4) to a non-Big 4 (Big 4) firm and the independent variables are wages, age, gender and location.

6. Empirical findings

6.1 Are the most able auditors in the Big 4 firms?

Table 1 presents descriptive statistics on the continuous variables in Sample A that are classified by Big 4 affiliation. Two-thirds of the auditors come from Big 4 audit

[13] Our files include exam results for 2010 to 2012, but we restrict the analyses to the 2006-2009 period to have income data for at least one year after the certification.

firms. The mean (median) age of the auditors (a_i) at non-Big 4 firms is 34.1 (32.01) years, and the mean (median) age of auditors at Big 4 firms is 31.4 (30.3) years. The difference in the means is significant at the 0.01 level.

The 10th and 90th percentiles of the age distribution are 27.81 years and 36.17 years for auditors at Big 4 firms. The corresponding figures for auditors at non-Big 4 firms are 28.02 years and 42.87 years. CPA certification requires a university degree, and the average age at which students in Sweden graduate from university is 29.4 years.[14] Thus, these figures indicate that most auditors began to work at audit firms soon after graduation to gain the practical experience needed for the CPA certification. However, there also seems to be a group that is older and most probably have had another job before starting to consider a CPA certification. In the supplementary analyses, we study whether the key results of our tests of equation [1] change when the oldest auditors are excluded.

The mean (median) points (g_i) in the CPA exam is 70.86 (73) points for auditors at non-Big 4 firms and 75.27 (76) points for auditors at Big 4 firms. Additionally, 49.46 % (227 / 459) of auditors at non-Big 4 firms and 65.14 % (598 / 918) of auditors at Big 4 firms passed the CPA exam. These figures are averages for the entire sample, and the average pass rates among the auditors vary somewhat between exam dates. The data cover 12 exams between 2007 and 2012, and the highest and lowest pass rates in these years are 69.84 % and 52.67 %, respectively (not reported in the tables).

Regarding binary variables in Sample A, 45.97 % of the auditors at non-Big 4 firms are female, while this figure is 51.53 % at Big 4 firms. The difference is statistically significant at the 0.05 level. It was found that 40.38 % of the auditors come

[14] Taken from http://www.ekonomifakta.se/sv/Fakta/Utbildning-och-forskning/Utbildningsniva/Examensalder/

from Stockholm, 12.71 % from Gothenburg and 6.61 % from Malmo (the capital, the second and third largest cities in Sweden). There are no significant differences in the location of the workplaces for auditors at Big 4 and non-Big 4 firms (not reported in the tables).

Table 1. Descriptive statistics

Sample A: CPA exam data

	Age (a_i)	Score (g_i)
Non-Big 4 auditors (N=459)		
Mean	34.10	70.86
Median	32.01	73.00
p10	28.02	56.00
p90	42.87	83.00
Standard deviation	5.06	10.12
Big 4 auditors (N=918)		
Mean	31.40	75.27
Median	30.34	76.00
p10	27.81	63.00
p90	36.17	86.00
Standard deviation	6.44	11.44
P-value	<0.01	<0.01

Sample B: Compensation data covering two years before and after the CPA certification

	LnW	Age (a_i)[a]	Score (g_i)[a]
Non-Big 4 auditors (N=712)			
Mean	5.93	0.74	-0.86
Median	5.92	-0.63	-1.65
p10	5.69	-4.26	-4.65
p90	6.16	8.38	4.35
Standard deviation	0.17	4.94	3.52
Big 4 auditors (N=1012)			
Mean	5.99	-0.52	0.61
Median	5.98	-1.37	-0.65
p10	5.71	-4.09	-4.65
p90	6.27	4.29	7.35
Standard deviation	0.23	3.40	4.43
P-value	<0.01	<0.01	<0.01

Sample C: Compensation data for all certified auditors

	LnW	Age (a_i)
Non-Big 4 auditors (N=7792)		
Mean	6.22	50.30
Median	6.19	51.00
p10	5.88	38.00
p90	6.59	60.00
Standard deviation	0.31	8.29
Big 4 auditors (N=5316)		
Mean	6.44	48.52
Median	6.40	49.00
p10	6.03	37.00
p90	6.84	59.00
Standard deviation	0.35	8.32
P-value	<0.01	<0.01

Notes: P-values are for t-tests for the continuous variables and chi-square tests for the categorical variables. Variable definitions: Age is the age of the auditor in years at the date when the exam was taken; Score is the points in the CPA exam; Female is an indicator variable for females; LnW is the natural log of wages (in thousand SEK); CPA is an indicator variable taking the value one in years when the auditor has a CPA certification.
[a] Variable is centered (value minus average is reported).

Table 2 includes OLS estimations of equations [1] and [2] with Huber/White standard errors. The left-hand regression in the table includes the estimation of equation [1]. The regression is significant at the 0.001 level with R^2 equal to 10.40 %. Hypothesis 1 predicts that auditors at Big 4 firms will take the CPA exam earlier. The coefficient of Big 4 has the predicted negative sign, and it suggests that auditors at Big 4 firms are 2.67 years younger than auditors at non-Big 4 firms when they attempted to take the exam. The coefficient is significantly different from zero at the 0.01 level.

As noted above, some auditors in the sample are fairly older, and most probably had other jobs before working as an auditor. We attempted to re-estimate equation [1] after having excluded the top percentile of auditors who are older than 34.10 years. The coefficient of Big 4 is then -0.22 (p-value 0.09). This is a smaller coefficient than in

Table 2, and the reason is that a higher percentage of the auditors who were older when they attempted to take the exam work for non-Big 4 firms. However, even in this case Hypothesis 1 is supported.

Table 2 OLS regressions of age of the auditor, or scores in the CPA exam, on audit firm affiliation, age and control variables.

Regression	(1)	(2)	(3)
Dependent variable	Age (a_i)	Score (g_i)	
Big4	-2.665	4.521	2.744
	(0.320)***	(0.626)***	(0.591)***
Age (a_i)	-	-	-0.691
	-	-	(0.055)***
Female	-0.004	0.116	0.091
	(0.257)	(0.537)	(0.506)
Location dummies	NR	NR	NR
Exam-date dummies	-	NR	NR
Constant	35.291	72.514	97.529
	(0.382)***	(1.734)***	(2.689)***
Model F-value	26.92***	5.31***	13.82***
R^2	10.40%	6.73%	17.07%
N	1,377	1,377	1,377

Notes: *,**, *** denote two-tailed statistical significance at the 0.10, 0.05 and 0.01 levels, respectively.
Variable definitions: Age is the age of the auditor in years at the date when the exam was taken; Score is the points in the CPA exam; Big 4 is an indicator variable taking the value one if the auditor works at PwC, KPMG, Ernst &Young or Deloitte; Female is an indicator variable for females; Location variables for Stockholm, Gothenburg, Malmo are included in the regression and all other cities are in the reference group; the sample period covers twelve exams (two in each year) so eleven exam-date dummies are included.

The right-hand regressions in Table 2 include OLS estimates of equation [2] with and without age as a control variable. Both models are significant at the 0.001 level, and the R^2 values of the regressions are 6.73 % and 17.07 %, respectively. These regressions provide tests of Hypotheses 2 and 3. Hypothesis 2 predicts that the score for the exam (g_i) decreases with the age of the auditor. The empirical results reported in the right-hand regression in the table show that age (a_i) has a negative coefficient that is significant at the 0.01 level. The coefficient estimate shows that “ceteris paribus,” a candidate on average scores 0.69 points higher than a candidate who is one year older.

We attempted to estimate regression (3) by including an interaction between Big 4 and age to study whether the result that younger auditors perform better is driven by audit firm affiliation. These results show that the association is negative and significant for auditors at Big 4 and non-Big 4 firms (not reported). We also attempted to estimate regression (2) with audit-firm fixed effects (not reported).[15] The age of the auditors (a_i) has negative coefficients that are significant at the 0.01 level, suggesting that the negative association between age and performance on the exam holds even for auditors at the same firm. In summary, the results strongly support Hypothesis 2.

Hypothesis 3 predicts that auditors at Big 4 firms perform better on the CPA exam than auditors at non-Big 4 firms. The coefficient of Big 4 is 4.52 in the regression without controlling for age and is 2.74 in the regression controlling for age. The coefficient of Big 4 is significant at the 0.01 level in both regressions. Furthermore, a Wald-test shows that the difference in the coefficient estimates of the Big 4 in regressions (2) and (3) is significant (p-value < 0.001). Thus, the empirical results support the predictions that auditors at Big 4 firms do better on the CPA exam and that the difference in performance between auditors at Big 4 and non-Big 4 firms decreases when we control for age.

6.2 Does the CPA exam provide new information about the auditors’ abilities?

Table 1 also presents the descriptive statistics on the continuous variables in Sample B when partitioned by Big 4 affiliation. It can be seen that 59 % of the observations are for auditors at Big 4 firms. This proportion is slightly lower than in

[15] To be more precise, the regression included audit firm fixed effects for each firm with three or more auditors attempting to take the exam. Audit firms with only one or two auditors taking the exam were in the same category.

Sample A. Furthermore, 47 % (38 %) of the auditors at Big 4 firms (non-Big 4 firms) are female, which is also a slightly lower proportion than in Sample A. These differences in sample compositions are likely to be driven by the fact that the auditors in Sample B are in a somewhat later phase of their careers.

It can be observed from Table 1 that the mean log of annual wages in thousand SEK (w_i) is 5.93 and 5.99 for auditors at non-Big 4 and Big 4 firms, respectively (p-value < 0.001). This means that the average annual salaries in Swedish krona are 380.5 and 409.7 thousand (in USD, 44.8 and 48.2 thousand). Furthermore, the differences in annual wages between auditors at Big 4 and non-Big 4 firms increase with the phase in the career; it is 20.7 thousand SEK two years before passing the CPA exam, 34.9 thousand SEK for the year in which the exam is passed, and 42.9 thousand SEK the year after passing the CPA exam (not reported in the tables).

Table 3 presents estimates of equation [3]. The left-hand regression (regression 4) includes an OLS estimate on all of Sample B, while the mid-regression and right-hand regression include estimates for the sub samples with only Big 4 (regression 5) and non-Big 4 auditors (regression 6). All regressions are significant at the 0.001 level, and the R^2 values of the regressions vary between 27.23 % and 29.37 %. Robust standard errors clustered on auditors (Rogers 1993) are reported in the regressions. As described above, the sample is made up of a balanced panel with 1,724 observations for 431 auditors. Remember that we use the log of wages (LnW) as the dependent variable, implying that the coefficient estimates approximately express the change in wages as a percent for each unit of change in the dependent variable. The coefficient associated with Big 4 suggests that auditors at those firms have approximately 7.86 % higher wages than auditors at non-Big 4 firms with similar ages before taking the exam. These differences are statistically significant, which is consistent with Hypothesis 4.

Table 3 OLS regression estimates of logarithm of compensation on score in the CPA exam, age at the time of taking the exam and audit firm affiliation.

Regression Dependent variable = LnW	(4) All observations	(5) Big 4	(6) Non-Big 4
Age (a_i)	0.0104	0.0193	0.0057
	(0.0029)***	(0.0067)***	(0.0021)***
Big4	0.0786	-	-
	(0.0142)***	-	-
Score (g_i)	0.0007	0.0041	-0.0022
	(0.0020)	(0.0026)	(0.0026)
CPA	0.1481	0.1549	0.1307
	(0.0059)***	(0.0089)***	(0.0080)***
CPA*Age	-0.0075	-0.0109	-0.0045
	(0.0017)***	(0.0037)***	(0.0013)***
CPA*Score	0.0057	0.0058	0.0024
	(0.0014)***	(0.0019)***	(0.0021)
Female	-0.0689	-0.0533	-0.0834
	(0.0151)***	(0.0224)**	(0.0185)***
Location dummies	NR	NR	NR
Constant	5.8083	5.8614	5.8379
	(0.0122)***	(0.0152)***	(0.0130)***
Model F-value	85.59***	65.62***	37.69***
R^2	28.08 %	29.37%	27.23%
Max VIF	2.10	2.26	2.06
Mean VIF	1.46	1.56	1.50
N	1,724	1,012	712
F-value for Wald-test: CPA*Score$_{reg.5}$ = CPA*Score$_{reg.6}$		1.48	

Notes: *,**, *** denote two-tailed statistical significance at the 0.10, 0.05 and 0.01 levels, respectively.

Variable definitions: LnW is the logarithm of the annual wages; Age is the age of the auditor in years on the date when the exam was taken; Big 4 is an indicator variable taking the value one if the auditor works at PwC, KPMG, Ernst &Young or Deloitte; Score is the points in the CPA exam; *CPA* is an indicator variable taking the value one in the year when the auditor received certification and subsequent years and zero in years before certification; Female is an indicator variable for females; Location variables for Stockholm, Gothenburg, Malmo are included in the regression and all other cities are in the reference group; Female is an indicator variable for females.

Hypothesis 5 predicts a positive correlation between wages after having received the CPA certification and the score on the CPA exam. The coefficient of the interaction CPA*Score expresses this association, and its value in regression 4 is 0.0057, which is statistically significant (p-value < 0.01). For each point higher on the CPA exam, auditors receive approximately 0.57% higher wages on average. Score (g_i) in Table 3 captures the potential association between the performance in the CPA exam and wages before the auditor has taken the CPA exam. A positive association would suggest that the information about the ability conveyed by the performance in the exam is known prior to the exam being taken, and furthermore, this information is taken into account in the wages of auditors. However, the coefficient of Score is insignificant, which is also consistent with the prediction in Hypothesis 5.

Hypothesis 6 predicts that the association between the scores on the CPA exam and LnW is stronger for auditors at Big 4 firms. It can be seen from regressions 5 and 6 that the coefficient estimates of CPA*Score are 0.0058 and 0.0024 for auditors at Big 4 and non-Big 4 firms, respectively. The coefficient estimate is significant at the 0.01 level for auditors at Big 4 firms and insignificant for auditors at non-Big 4 firms. However, although coefficient estimates indicate a stronger association in Big 4 firms, the null hypothesis that the coefficient estimates are equal cannot be rejected (p-value = 0.22). Thus, we do not find clear support for Hypothesis 6.

A further observation that can be made from Table 3 is that the coefficient of the CPA is positive and significant, suggesting that auditors receive a higher salary after they receive the CPA certification compared to before the certification. It should be noted that we have centered Score and Age in the regressions. Thus, the coefficient of CPA suggests that the average inflation adjusted salary is approximately 14.8 % higher in the year of the CPA certification and the following year than in the two years prior to the certification for auditors with average Age and Score. A further noteworthy finding in Table 3 is that Age has a positive and significant coefficient, suggesting that older auditors are paid more. All of these findings are consistent with the predictions made in Section 3.

Referring to the other control variables, being female has a negative and significant coefficient in all models. The magnitude of the coefficient in the full sample indicates that female auditors earn approximately 7 % less than male auditors. Finally, the location variables (Stockholm, Gothenburg and Malmo) are positive and significant (not reported), suggesting that auditors located in the major cities in Sweden earn more than auditors located outside the major cities.

6.3 Audit firm turnover

Panel C in Table 1 presents the descriptive statistics of Sample C. This sample includes observations from auditors at different stages of their careers, and therefore, the average age is much higher than in Samples A and B. The mean (median) age of the auditors at the Big 4 firms is 48.52 (49.00) years. The corresponding ages for auditors at non-Big 4 firms are 50.30 and 51.00 years. The average log of the salary income of auditors at Big 4 firms (non-Big 4 firms) is 6.44 (6.22). The difference is significant at the 0.01 level (t-value = 37.55).

The sample includes 5,316 auditor-year observations for auditors at Big 4 firms and 7,792 observations for auditors at non-Big 4 firms. Audit firm switches are relatively infrequent; auditors at Big 4 firms switched to a non-Big 4 firm in 73 (1.37 %) of the 5,316 auditor-years, and auditors at non-Big 4 switched to a Big 4 firm in 24 (0.31%) of the 7.792 auditor-years.

Table 4 includes estimates of equation [4]. Regression (7) includes observations for auditors at Big 4 firms and the dependent variable in this regression takes the value 1 if the auditor switches to a non-Big 4 firm. The results show that, controlling for age and other variables believed to influence wages, auditors with a lower LnW are more likely to switch to a non-Big 4 firm. Regression (8) includes observations for auditors at non-Big 4 firms and these results show that auditors with a higher LnW at non-Big 4 firms are more likely to switch to a Big 4 firm. The coefficients of LnW are significant at the 0.01 level in both regressions.

Table 4 Logistic regressions of income on the likelihood of an audit firm switch

	(7) Switches from Big 4 to non-Big 4 firms	(8) Switches from non-Big 4 to Big 4 firms
LnW	-1.827	1.072
	(3.78)***	(4.34)***
Age	-0.0314	-0.0013
	(2.43)**	(0.05)
Female	-0.541	-0.634
	(1.80)*	(1.02)
Location dummies	NR	NR
Constant	8.808	-12.30
	(2.86)***	(5.75)***
Model Chi-square	25.69***	35.14***
Pseudo R^2	3.79%	2.32%
N	5316	7792

Notes: *,**, *** denote two-tailed statistical significance at the 0.10, 0.05 and 0.01 levels, respectively. The standard errors are clustered by auditor.
Regression (7) includes observations for auditors at Big 4 firms and the dependent variable takes the value one if an auditor in year t+1 switches from a Big 4 to a non-Big 4 firm. Regression (8) includes observations for auditors at non-Big 4 firms and the dependent variable takes the value one if an auditor in year t+1 switches from a non-Big 4 to a Big 4 firm. LnW is the logarithm of the annual wages; Age is the age of the auditor; Female is an indicator variable taking the value one for females; Location variables for Stockholm, Gothenburg, Malmo are included in the regression and all other cities are in the reference group; Female is an indicator variable for females.

Consequently, the results support Hypothesis 7 and based on the assumption that the information about competences is reflected in wages, these results suggest that auditors at Big 4 firms with lower predicted abilities switch to non-Big 4 firms and vice versa.

7. Discussion and conclusions

A common element of most internal labor market models is that the matches between firms and workers are based on imperfect information about the workers' abilities. In this study, we apply elements of this literature to the audit firm setting to develop testable predictions related to the match. The starting point for our analyses is that large audit firms (Big 4 firms) have the incentive to attract more competent auditors than non-Big 4 firms, and therefore, the most competent auditors are likely to end up in Big 4 firms. Supporting this conclusion is that auditors in Big 4 firms are younger when they take the exam, indicating they need less time to gain the theoretical and practical experience needed to pass the CPA exam, and they perform better in the exam than other auditors.

A set of tests focus on the consistency between compensation policies and the incentive to attract the most competent auditors. Based on assignment models we predict that wages are a function of the expected productivity of auditors and that highly able auditors are more productive in Big 4 firms. This yields the prediction that wages are higher in Big 4 firms, a result that finds strong empirical support.

A set of evidence is provided regarding the fact that the match between auditors and firms is based on imperfect information about ability, and audit firms thereafter update their beliefs. We provide evidence that the performance in the CPA exam is positively associated with wage increases in Big 4 firms. This result indicates that audit firms update their beliefs about the ability of auditors based on the performance in the exam. Additionally, we provide evidence that auditors with lower salaries in Big 4 firms switch to non-Big 4 firms (the opposite happens for switches from non-Big 4 firms to Big 4 firms). These results are consistent with the view that highly capable auditors are more productive in Big 4 firms and that the initial match between auditors and firms is based on incomplete information about their abilities.

The study has a number of limitations. A first limitation is that we do not have information about the sources of heterogeneity in auditors' abilities. We do not have specific measures that could be used to evaluate whether this heterogeneity is innate, whether it had developed before the auditors entered the profession or over the years when the auditors worked as an audit associate before they took the exam. One could argue that the courses and training is of higher quality in Big 4 firms and that this could influence some of our results, but it is difficult to suggest that they also explain the positive relationship between CPA Exam score and wages. In short, we interpret our results as evidence that some of the heterogeneity was generated before the auditors entered the profession. A second limitation is that we do not know who is learning about auditors' abilities. So, the evidence can be consistent with models where there is asymmetric information about the auditors' abilities. We simply claim that the CPA certification is providing new information to some market agents about auditors' abilities. A third limitation is that we do not have measures of the effort made in the exam. In the model there is freedom of movement among firms, then the incentives for the auditors to exert effort in the exam are independent of the firm where they work.

On the whole, our study highlights that big firms have the capacity to attract the most competent auditors based on the imperfect information available about their competences.

Appendix A: The predicted abilities of the auditors before the exam

In this appendix we discuss the information available for predicting the ability of the auditors before taking the exam, the prior predicted ability m_i^0. From now, the assumptions seek to benefit from previous results of Murphy (1986), standard in the "employer-learning models".

Prior to the exam (period t = 0), the auditors and firms know the distribution but do not exactly know the concrete ability of each auditor. They have accumulated information about the performance of each auditor. We assume that the distribution of the values of this information (I_0) among a cohort of auditors follows a normal with expected value $E(I_0) = m^E$, variance $\sigma_0^2 = var(I_0)$, and the correlation with the distribution of real abilities is ρ_0 (Appendix C provides further discussion about these assumptions). This information is not correlated with luck on the exam (ε). At period t=0, particular information about an auditor is available ($I_{i,0}$). All agents are rational and update their expectations with the information available, so they use the Bayesian inference. Following the usual results in econometrics (De Groot, 1970), the predicted ability of auditor i will be a normally distributed random variable with the expected value $m_i^0 = E(m/I_{i,0}) = m^E + \sigma_m \frac{\rho_0}{\sigma_I} (I_{i,0} - m^E)$ and variance $var(m/I_{i,0}) = (1-\rho_0^2)\sigma_m^2$.

Consequently, before taking the exam, the score of the exam for auditor i is a normally distributed random variable with an expected value of $E(g/I_{i,0}) = \mu + \gamma(m_i^0 + \tau a)$ and variance of $\sigma^2 = var(g/I_{i,0}) = \sigma_\varepsilon^2 + \gamma^2(1-\rho_0^2)\sigma_m^2$. The score of an auditor i could be rewritten as: $g_i = \mu + \gamma\tau a_i + \gamma m_i + \varepsilon_i = \mu + \gamma\tau a_i + \gamma m_i^0 + \epsilon_i$, where ϵ_i follows a normal distribution with mean 0 and variance σ^2.

Appendix B. The decision to take the exam.

From the Appendix A, the score of the exam for auditor i is a normally distributed random variable with an expected value of $E(g/I_{i,0}) = \mu + \gamma(m_i^0 + \tau a)$ and variance of $\sigma^2 = var(g/I_{i,0}) = \sigma_\varepsilon^2 + \gamma^2(1-\rho_0^2)\sigma_m^2$. As we analyze the decision to take the exam based only on the auditors' prior predicted abilities, there is no room for confusion with the real abilities (or posterior predicted abilities). To simplify the notation, we will use m in this Appendix to refer to the predicted abilities of the auditor before taking the exam. This does not mean that we assume that $\rho_0^2 = 1$, a situation of perfect information, simply that the conclusions are practically the same[16] as a situation of imperfect information ($\rho_0^2 < 1$). Although real abilities and prior predicted abilities are the same in the first case, this does not occur in the second case.

[16] Aside from the differences in the variance of scores, σ^2, a technical difference also exists. In the case of perfect information, the optimal age $a_i^*(m)$ is interpreted as the age at which an auditor with unobserved ability m takes the exam. In the case of imperfect information, it is interpreted that at the age of a_i^*, all auditors with prior predicted abilities $m \leq a_i^{*-1}(m)$ will take the exam if they have not already taken it. This is due to the fact that predicted abilities can change over time.

Therefore, the probability of obtaining a CPA certification $P\left(\mathrm{g} > \underline{g}\right) = 1 - P\left(\mathrm{g} \leq \underline{g}\right)$ can be written as follows: $P\left(\mathrm{g} > \underline{g}\right) = 1 - \Phi((\underline{g} - \mu - \gamma(m + \tau a))/\sigma)$.

The auditors' problem is to maximize the wealth increase ΔW defined in Section 3.4: $\mathrm{Max}_a \Delta \mathrm{W} = \mathrm{Max}_a b(r-a)(1-\Phi\left(\frac{\underline{g}-\mu-\gamma m-\gamma\tau a}{\sigma}\right)) - \mathrm{f}$.

The following proposition summarizes the solution.

Proposition: An auditor with prior predicted ability *m* maximizes the expected wealth increase Δ if the CPA exam is taken at the following age:

$$a^* = (\underline{g} - \mu - \gamma m)/\gamma\tau - \frac{\sigma}{\gamma\tau} H^{-1}(\frac{\gamma\tau}{\sigma} r - \frac{\underline{g}-\mu-\gamma m}{\sigma}) \equiv a^*(m)$$

where $x = H^{-1}(z)$ is the inverse function of $z = H(x) = \frac{1-\Phi(x)}{\phi(x)} - x = \Psi(x) - x$, with $\Psi(x)$ being the Mills ratio.

Proof: It is well established that $\Psi(x) < \frac{1}{x}$ for all $x > 0$, given that the $\lim_{x\to\infty} \Psi(x) = \frac{1}{x}$ (see Gordon 1941). From these results, $\lim_{x\to\infty} H(x) = -\infty$, and changing variable $d = -x$ yields $\lim_{x\to-\infty} H(x) = \lim_{d\to\infty} \frac{1}{\phi(d)} - \frac{1-\Phi(d)}{\phi(d)} + d = \infty$. It can also be established that $\lim_{x\to\infty} z = -\infty$ and $\frac{dH()}{dx} = x\,\Psi(x) - 2 < -1$, with $\lim_{x\to\infty} \frac{dH()}{dx} = -1$. Let us define $x = (\underline{g} - \mu - \gamma m - \gamma\tau a^*)/\sigma$ and note that, from the assumptions made,

$$d\,P\,(a)\,/\,d\,a = \frac{\gamma\tau}{\sigma} d\;\Phi / \,da = \frac{\gamma\tau}{\sigma}\phi((\underline{g} - \mu - \gamma m - \gamma\tau a)/\sigma) > 0$$

The first order condition (FOC) for a maximum (or minimum) of the expected wealth increase Δ is: FOC: $b((r - a^*)\frac{\gamma\tau}{\sigma}\phi(x) - \left(1 - \Phi(x)\right)) = 0$

The optimal age a^* will always be lower than r. The first order condition and the second order will be fulfilled if and only if

$$\text{FOC: } \frac{\gamma\tau}{\sigma}r - \frac{\underline{g}-\mu-\gamma m}{\sigma} - H(x) = 0$$

$$\text{SOC: } \frac{\gamma\tau}{\sigma}\frac{dH(x)}{d(x)} < 0$$

Thus, for any m, there is a unique age that maximizes the expected wealth increase Δ:

$$a^* = (\underline{g} - \mu - \gamma m)/\gamma\tau - \frac{\sigma}{\gamma\tau}H^{1}\left(\frac{\gamma\tau}{\sigma}r - \frac{\underline{g}-\mu-\gamma m}{\sigma}\right) \text{ QED.}$$

<u>*Corollary:*</u> $\frac{da^*}{dm} = -\frac{1}{\tau}\left(1 + \frac{dH^{-1}(z)}{dz}\right) < -\frac{1}{\tau}$ given that $-1<\frac{dH^{-1}(z)}{dz}<0$.

Appendix C. Wage decisions

This Appendix summarizes the predictions of the model regarding the wages before and after the exam. To avoid misunderstandings, in this Appendix, m_i refers to the *real* abilities of auditor *i*, m_i^0 indicates the *prior* (before knowing the score of the exam) abilities, and m_i^1 is the *posterior* (after exam) predicted (by firms and auditors) abilities. The wages of auditors at period *t* are equal to the auditors' expected productivity, which depends on their predicted abilities at that period:

$$w_i^t = E(Y/m_i^t) = \vartheta + m_i^t + \tau a_i^t + (\varphi m_i^t - \delta)Big4 \ \ + CPA * b$$

At period 0, the exam score provides more information about the real abilities of the auditors. Since we have assumed $g_i = \mu + \gamma\ (m_i + \tau a_i) + \varepsilon_i$, the agents have the following signal $s_{i,0} = (g_i - \mu)/\gamma - \tau a_i^* = m_i + u_{i,0}$, about the auditor's real abilities.

Consequently, the distribution of these signals s among a cohort of the population is a random variable normally distributed with mean $E(s) = m^E$; variance $var(s) = \sigma_s^2 = (\sigma_m^2 + (\sigma_\varepsilon/\gamma)^2)$ and is correlated with real abilities $\rho_s = \frac{\sigma_m}{\sigma_s}$. Before receiving the scores, firms and auditors have accumulated information I_0. Let us interpret this information as a collection of J signals[17] $(s_{i,j} = m_i + u_{i,j})$, each one of them ($j$= $1, \dots, J$) equally informative with regard to the scores, so $u_{i,j}$ is the realization for auditor i at period j of the independent random variables equally distributed as normal with the mean equal to zero and a standard deviation $\sigma_u = \sigma_\varepsilon/\gamma$.

Corollary 2 establishes the main implications of all of these assumptions, and it is also the basis for defining the wage equation presented below.

Corollary (Intermediate result): The posterior (after the CPA exam) predicted ability of auditor i can be written as follows:

$$m_i^1 = \left(\frac{g_i-\mu}{\gamma}\right)\left(\frac{1}{I}\right) + m_i^0\left(1-\frac{1}{I}\right) - \tau a_i^*\left(\frac{1}{I}\right), \text{where } I = J + 1 + \frac{\sigma_u^2}{\sigma_m^2}.$$

Proof: The real ability of auditors at period t that have the same average of signals, or information $I_{i,t} = (\sum_{j=1-t}^{J} \frac{s_{i,j}}{J+t})$, follows a normal distribution (De Groot, 1970) with an expected value of $E(m/I_{i,t}) = m_i^t = m^E + \sigma_m \frac{\rho_t}{\sigma_t} \ (I_{i,t} - m^E)$ and variance $var(m/I_{i,t})$ = $(1-\rho_t^2)\, \sigma_m^2$. Following Murphy (1986), $\sigma_t^2 = var(I_t) = \sigma_m^2 + \frac{\sigma_u^2}{J+t}$ is the variance of values $I_{i,t}$ among the population of auditors of a certain cohort, while $\rho_t = \frac{\sigma_m}{\sigma_t}$ is the correlation of those values with the distribution of real abilities among the population ($var(I_t/m)$= $\frac{\sigma_u^2}{J+t}$= $(1-\rho_0^2)\sigma_t^2$). Let us call m^E the predicted ability of an

[17] One could argue that the number of signals collected is related to the age of the auditors, $J = a_i^*$. This complicates the algebra without important changes in the main conclusions.

auditor when there is no information, while $I_{i,t}$ is the information available about the abilities of auditor *i*. The predicted ability m_i^t of auditor *i* at period *t* will be a weighted average of both: $m_i^t = m^E(1- X_i^t) + I_{i,t}X_i^t$. The weight of the information is $X_i^t = \sigma_m \frac{\rho_t}{\sigma_t} = \frac{1}{1+\frac{\sigma_u^2}{\sigma_m^2(J+t)}} < 1$. From the equation above, $m_i^0 = (1 - \frac{1}{1+\frac{\sigma_u^2}{J\sigma_m^2}})m_E + \frac{1}{1+\frac{\sigma_u^2}{J\sigma_m^2}}\left(\sum_{j=0}^{-1} s_{i,j}/J\right)$. With some algebra, this can be computed as m_i^1, taking into account that $s_{i,0} = (g_i - \mu)/\gamma - \tau a_i^*$ and $I_{i,1} = \frac{s_{i,0}+I_{i,0}J}{J+1}$. QED.

<u>*Corollary (Final result):*</u> The theoretical wage equation depends on the firm for which the auditor works and whether the auditor has the CPA certification. The <u>*theoretical wage equation*</u> is

$$w_i = \vartheta + m_i^0 + \tau a_i^* + (\varphi m_i^0 - \delta)Big4_i +$$

$$CPA_i(b + \tau + \left(\frac{g_i - \mu}{\gamma} - \tau a_i^* - m_i^0\right)\left(\frac{1 + \varphi Big4_i}{I}\right))$$

Proof: Consider that the auditors' age when they take the exam is a_i^* and $a_i^* + 1$ the period after. Replace the posterior (to the CPA certification) predicted ability m_i^1 of auditor *i* in the wage expression of w_i^t and, with some algebra, the theoretical wage equation is obtained. QED.

<u>Appendix D: The age of taking the exam as an imperfect measure of unobserved abilities</u>

From the text: $a_i = h + h_1 m_i^0 + \varepsilon_{1,i}$, with $\varepsilon_{1,i}$ being a random variable which is equally and independently distributed among auditors that follow a normal distribution with the mean equal to zero and a standard deviation of σ_1.The coefficients estimated by the following equation: $a_i = \beta + \beta_1 Big4_i + v_{1,i}$ are going to be: $\beta = h + h_1\underline{m}$, $\beta_1 = h_1\Delta_m$ and $\underline{m} = m^E - \Delta_m(1 - \Phi(z))$. Then: $v_{1,i} = h_1(m_i^0 - \underline{m}) - \beta_1 Big4_i + \varepsilon_{1,i}$.

The expected value of the coefficients estimated with the score on the CPA exam:

$g_i = \alpha + \alpha_1 Big4_i + \alpha_2 a_i + v_{,2}$

can be found replacing $m_i^0 = (a_i - h - \varepsilon_{1,i})/h_1$ in the following equation:

$g_i = \mu + \gamma\tau a_i + \gamma m_i^0 + \epsilon_i$

It is easy to show that we expect that $\alpha_2 = \gamma(\tau + \frac{1}{h_1})$. Furthermore: $v_i = -(\gamma/h_1)(\varepsilon_{1,i} - \underline{\varepsilon}) - \alpha_1 Big4_i + \epsilon_i$ is an unobserved variable and $\alpha = \mu - \frac{\gamma}{h_1}(\underline{\varepsilon} + h), \alpha_1 = -(\gamma/h_1)\Delta_{m1}$, are parameters given that $\underline{\varepsilon} = -\Delta_{m1}(1 - \int \Phi(z)f(a)da)$ and $\Delta_{m1} = (\sigma_1)\int(\frac{\phi(z)}{1-\Phi(z)} + \frac{\phi(z)}{\Phi(z)})f(a)da$ is the average difference in unobserved abilities between Big 4 firms and non-Big 4 firms, which is positive as long as $\sigma_1 > 0. \Phi()$ is the cumulative distribution function (cdf) and $\phi()$ is the probability distribution function (pdf) of a normal distribution with a mean of 0 and a standard deviation of 1 and $z = \frac{-h_1 m_B + a_i - h}{\sigma_1}$. The distribution of ages among the population of auditors follows a function *f*(*a*) which in accordance with the assumptions made is a normal distribution with mean $h + h_1 m^E$ and variance $\sigma^2 + \sigma_1^2$.

It should be noted that we can also estimate the following Equation:

$g_i = \alpha_{0,1} + \alpha_{1,1} Big4_i + v_1$

Replacing $a_i = h + h_1 m_i^0 + \varepsilon_{1,i}$ in $g_i = \mu + \gamma\tau a_i + \gamma m_i^0 + \epsilon_i$, it is easy to check that the random variable is $v_{i,1} = (\gamma + \gamma\tau h_1)(m_i^0 - \underline{m}) - \alpha_{1,1} Big4_i + \gamma\tau\varepsilon_{1,i} + \epsilon_i$ and $\alpha_{0,1} = \mu + \gamma\tau h + (\gamma + \gamma\tau h_1)\,\underline{m}$ and $\alpha_{1,1} = \gamma(\Delta_m + \tau\,\beta_1)$ the expected value of the parameters to be estimated. This coefficient $\alpha_{1,1}$ is lower than α_1 because the age is negatively correlated with Big 4 firms. In those cases in which those variables are uncorrelated the coefficients will be the same.

Appendix E. Matching changes

Regarding the auditors' movements we can consider two cases, which are the expected changes when there is information about the auditors' performance, and when this is not the case. For the first case we have very few observations, so we are going to focus on the second case.

We can ask at moment 0 for the probabilities that an auditor with "a priori" expected capability of m_i^0 will change firm after the CPA exam. If they are at Big 4 firms: Prob (($m_i^1 \leq m_B$)/m_i^0); otherwise: Prob (($m_i^1 > m_B$)/m_i^0) = 1- Prob (($m_i^1 \leq m_B$)/m_i^0).

From the assumptions made:

$$m_i^1 = \left(\frac{g_i - \mu}{\gamma}\right)\left(\frac{1}{J+1+\frac{\sigma_u^2}{\sigma_m^2}}\right) + m_i^0\left(1 - \frac{1}{J+1+\frac{\sigma_u^2}{\sigma_m^2}}\right) - \tau a_i^*\left(\frac{1}{J+1+\frac{\sigma_u^2}{\sigma_m^2}}\right)$$

before taking the exam, the score of the exam for auditor i is a normally distributed random variable with an expected value of E($g/I_{i,0}$) = μ + $\gamma(m_i^0 + \tau\ a$) and variance of $\sigma^2 = var(g/I_{i,0}) = \sigma_\varepsilon^2 + \gamma^2(1-\rho_0^2)\sigma_m^2$. Consequently:

$$m_i^1 = \left(\frac{\epsilon}{\gamma}\right)\left(\frac{1}{J+1+\frac{\sigma_u^2}{\sigma_m^2}}\right) + m_i^0$$

Where ϵ is a random variable normally distributed with an expected value of 0 and variance of $\sigma^2 = var(g/I_{i,0}) = \sigma_\varepsilon^2 + \gamma^2(1-\rho_0^2)\sigma_m^2$. The auditors at Big 4 firms will move to non-Big 4 firms when:

$$m_i^1 - m_B = \left(\frac{\epsilon}{\gamma}\right)\left(\frac{1}{J+1+\frac{\sigma_u^2}{\sigma_m^2}}\right) + m_i^0 - m_B \leq 0 \text{ or } \epsilon \leq (m_B - m_i^0)\gamma(J+1+\frac{\sigma_u^2}{\sigma_m^2})$$

So the Prob $((m_i^1 \leq m_B)/m_i^0)$ = Prob $(\epsilon \leq (m_B - m_i^0)\gamma(J+1+\frac{\sigma_u^2}{\sigma_m^2}))$ =

$$\Phi(((m_B - m_i^0)\gamma(J+1+\frac{\sigma_u^2}{\sigma_m^2}))/\sigma)$$

where $\Phi()$ is the cumulative distribution function (cdf) of a normal distribution with a mean of 0 and a standard deviation of 1. As intuition predicts, the probability decreases (so Prob $((m_i^1 > m_B)/m_i^0)$ increases) with m_i^0.

Appendix F: Error terms in empirical wage equations

One can interpret the predictions about the parameters of equation [3] presented in the text as the case where $a_i = h + h_1 m_i + \varepsilon_{1,i}$ and the variance of the error term $\varepsilon_{1,i}$ is high. In this appendix, we will discuss the implications of the case that this error term is low, or more concretely the variance is null: $a_i = h + h_1 m_i$.

The theoretical wage equation can be rewritten as

$$w_i = \vartheta + c(a_i^*) + (\varphi m(a_i^*) - \delta)Big4_i +$$

$$CPA_i(b + \tau + \left(\frac{g_i - \mu}{\gamma} - c(a_i^*)\right)\frac{1+\varphi Big4_i}{a_i^*+1+\frac{\sigma_u^2}{\sigma_m^2}})$$

where $c(a_i^*) = \frac{-h}{h_1} + \left(\tau + \frac{1}{h_1}\right) a_i^*$ is the capability of the worker at the age of taking the exam, which we have shown as decreasing with age. The differences with the predictions made in the text are now:

θ_1<0, which is reinforced in the case of Big 4 firms, θ_2< 0 and $\theta_5 > 0$. If we are closer to these coefficients (high variance of $\varepsilon_{1,i}$) or those proposed in the text (low variance of $\varepsilon_{1,i}$), this is an empirical concern.

Regardless, there are no changes in the predictions of Hypothesis 4, 5 and 6, θ_3, θ_6 and parameter θ_4.

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