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ABSTRACT

The CPA exam provides an evaluation of the auditors' professional competences at the early stages of their careers. Using information from the results generated in Sweden, the 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 in the CPA exam and wage increases after having received the CPA certification and the association is stronger at Big 4 firms. This evidence is consistent with a theoretical model where Big 4 audit firms attract and retain the more capable auditors of each cohort, based on the imperfect information about the capabilities of the auditors that they have.

Key words: CPA exam, auditors' compensation, unobserved capabilities, Big 4, professional careers.

1. Introduction

"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". This statement is from the web page of EY but presumably most audit firms would agree with it.[1] There is evidence suggesting that Big 4 firms conduct audits of higher quality (e.g., Francis, 2004; 2011; Knechel et al., 2013). One would expect the differences in strategic focus of Big 4 and non-Big 4 firms would have consequences for their hiring and compensation policies. This paper focuses on some of these differences.

The appointment of apt workers is complicated by the fact that information about the ability of workers is to a large extent unknown at the time of employment (for a review of related literature in personnel economics, see Lazear and Oyer, 2012). Based on literature about employer learning models (Harris and Holmström, 1982; Lange 2007) and assignment models (e.g., Sattinger, 1975; 1993), we study some issues related to the capabilities of auditors. We focus on the early phase of auditors' careers, namely the years before and after passing the CPA exam. Audit firms employ workers as audit associates at least during a 3-year period before the CPA exam is taken but the length of this period varies, among other things, with how well-prepared auditors feel they are to take the exam. We develop a theoretical model predicting that more able auditors will do the exam earlier and perform better than their cohort mates. Then, if Big 4 audit firms have a competitive advantage for attracting and retaining the most proper auditors of each entering cohort, we expect that auditors at Big 4 firms do the exam earlier and perform better. Furthermore, if firms have imperfect information about the auditor's capabilities, the performance in the exam will provide information about the capabilities of the

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

auditor. Thus, the performance in the CPA exam is expected to be used for updating believes about auditors' capabilities and consequently their wages.

We provide empirical tests of the predictions. Using data for 1,377 auditors that attempted to take the Swedish CPA exam for the first time in the 2007 to 2012 period, we find empirical support for the predictions that the performance in the exam is a function of age and Big 4 affiliation. Furthermore, using wage data two years before and two years after the CPA certification for 431 auditors, we find support for the prediction that the performance in the exam is positively associated with wage increases. Furthermore, this result appears to be mainly driven by auditors at Big 4 firms.

The study contributes to the literature in several ways. Firstly, although it has been suggested that the Big 4 accountancy firms have lots to teach other companies about managing talented people[2], there are few studies attempting to use economic theory to analyze personnel economics issues in the auditing industry. The available evidence we are aware of focus on auditors much later in their careers. To mention a few contributions, Trompeter (1994) provide experimental evidence indicating that partners with compensation more closely linked to client retention are less likely to require downward adjustments of the client's earnings, suggesting that the design of compensation schemes can have an impact on auditors' objectivity. Liu and Simunic (2005) provide a theoretical analysis of how features of compensation plans in audit firms are expected to vary with client complexity. The sole empirical study we are aware of is Knechel, Niemi and Zerni (2013), who empirically study the determinants of compensation of audit partners in Swedish Big 4 audit firms. All the studies above focus on issues relevant for auditors in charge of assignments. We are not aware of any prior analytical or empirical studies focusing on the early phases of the career of auditors.

[2] See "Accounting for good people, The Economist, July 21st of 2007, available at: http://www.economist.com/node/9507322. (Retrieved December 2015).

More generally, this study adds new evidence for the understanding of internal labor markets in a whole industry, the Swedish auditing market. The CPA exam generates data with a set of unique properties. It provides a measure of professional competences homogenous for workers of all the firms competing in a concrete market. The performance in the CPA Exam has not a direct impact on the profits of the firms and it took at the early stages of the auditors' careers. We are not aware of any prior studies in which the role of unobserved capabilities has been studied in theoretical models of entry to the auditing or other professions.[3] While most of the evidence available about the assignment of workers to firms is focused at the top of the hierarchical organizations (e.g. Bandiera et al., 2015; Terviö, 2008; Gabaix and Landier, 2008) this paper provides evidence on the assignment to firms in the early phase of auditors' careers.

Initial empirical evidence related with employer learning about workers' capabilities has focused on the variance of wage equations (e.g., Murphy, 1986; Baker et al., 1994; Poppo and Weigelt, 2000; Ortín-Ángel and Salas-Fumás, 2006). Another approach has been to assume that researchers have a better proxy of the capabilities of the employee than employers have and test how the correlation between wages and the proxy of the capabilities increases with time (e.g., Farber and Gibbons, 1996; Altonji and Pierret, 2001; Bauer and Haisken-DeNew, 2001; Lange, 2007). Recently, Taylor (2013) analyzes how the CEO wages are updated when new information related with the innate abilities of the workers is generated. This paper extends this evidence. More concretely, we show how the firms update the wages of the auditors based on a capabilities' measure, the scores in the CPA exam, unrelated with the performance of the firm. This makes us more confident that the relationship between wages and information is not due to incentive contracts.

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

Finally, the study contributes to the literature about factors associated with the performance in the CPA exam. There is literature (Brahmasrene and Witten, 2001; Grant et al., 2002; Allen and Woodland, 2006; Boone et al., 2006) analyzing the determinants of passing the CPA exam in the US. However, this literature focuses on how educational requirements affect the performance in the exam. Thus, besides providing evidence from another country, we also focus on other factors affecting the performance in the exam. The paper provides first evidence that the audit firm where the auditor is employed plays a significant role in the decision of taking the CPA exam and the performance in the exam. Furthermore, following Reilly and Stettler (1972) the predominant theoretical benchmark in this literature has been the human capital theory highlighting the impact of the investments made before the exam. Against a straightforward application of the human capital theory, Morgan (2015) stresses the fact that a delay in the exam is negatively correlated with the success in the CPA exam, what is supported also in our data. Our model reconciles this evidence with a more elaborated application of the human capital theory.

The remainder of this paper is organized as follows. Section 2 presents the institutional setting. Section 3 develops the theoretical framework. The empirical approach is presented in Section 4 and Section 5 provides the empirical findings. Section 6 discusses the results and concludes the paper.

2. Institutional setting

2.1 The Swedish audit market

Similarly as in other EU countries, audits are statutory for privately as well as 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 possibility but instead required all limited liability companies to be audited regardless of their size. Starting from 2010 the very smallest limited liability companies are exempted from the statutory audit. However, the vast majority of all firms audited are yet privately held companies.

The Big 4 audit firms are dominant at the Swedish audit market. Their accumulated revenues equal 81.2 % of all revenues reported by the twelve largest audit firms, and they employ around 50 % of all certified auditors in Sweden. PwC is by far the largest audit firm in terms of revenues and number of employees, followed by EY, KPMG, and Deloitte. Only ten out of 268 listed companies were audited by a non–Big 4 audit firm in 2011, the auditing firms were Grant Thornton, BDO and Mazars SET. These three firms have international partners and followed in size order after the Big 4. In all, the Swedish audit market consists of over 900 audit firms. The group of small audit firms include 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 around 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 which 591 where audit partners (30.4%).

2.2 CPA certification

The career of auditors starts when audit firms hire them, which typically takes place directly after having completed the university education. Once employed, they start by working together with one or several certified auditors as audit associates and in parallel they take a large amount of courses that are useful for audit work and as a preparation for the CPA exam.[4]

[4] Until 2013, those approved public accountants (after two years of experience and some other requirements) can do another exam and apply for being an *authorized* public accountant. After the legal change in 2013, there are now only approved public accountants. The analyses in this study are based on the results in the exam for being approved public accountant. Approved public accountants were qualified to audit all types of companies, including listed companies. Further information can be found at http://www.far.se/.

Each of the Big 4 audit firms arrange a large portfolio of courses internally, which audit associates are expected to complete. Audit associates at Big 4 firms only rarely take courses that are not arranged in-house. Audit associates employed at smaller audit firms instead typically take courses that are arranged by “FAR Akademi”, the Institute of Professional Accountants.

The CPA exam shall assure that the auditors have a sufficient theoretical knowledge to conduct statutory audits in companies of different sizes having different types of operations. Furthermore, the exam should assure the auditors have the ability to apply the theoretical knowledge in their auditing practice (Auditing Decree § 3). The main requirements for CPA certification are that the auditor (i) have at least three years of practical auditing experience, (ii) have at least a Bachelor’s degree with a major in Business Administration, (iii) have passed the examination of professional competence as approved public accountant (CPA exam), and (iv) meet some general eligibility criteria (Auditing Act § 4; Auditing Decree § 4). Furthermore, for upholding certification it is also required that the auditor is professionally active as an auditor (at least 1500 hours over a 5-year period), is employed by an audit firm and undertakes continuous education; otherwise certification will be lost (Auditing Act §§ 4 and 8; Auditing Decree § 8).

The CPA exam is organized by the Supervisory Board of Public Accountants (SBPA) twice a year, in May and December, and the results from the exam are published in July and January of the same or next year respectively. The work with the examination is organized as follows. An audit firm (typically one of the Big 4) is hired to prepare exam drafts as well as to correct the exams. Different types of experts at the audit firm, such as lawyers and accounting experts, provide input to the process. An examination committee, consisting of three practicing auditors and two university professors, comment exam drafts, and supervise the preparation and the correction of the exam. The audit firm which is responsible for correcting the exam receives only anonymous files with the applicants' answers. The cost of writing the exam is currently 25,000 Swedish krona (SEK); around 3,020 US Dollars (USD). This expense is typically paid by the employer. Thus, employers are likely to screen possible applicants and only allow those with fairly good possibilities to pass the exam to participate. The CPA certification gives the right to sign audit reports. Files with the results in the exam are available upon request from the SBPA.

3. The theoretical framework

3.1 Capabilities in personnel economics: main building blocks of the model.

Issues related to the professional competence and capabilities plays an important role in the internal labor markets and personnel economics literatures (e.g., Waldman, 2012; Lazear and Oyer, 2012). Below we briefly review the related literature and present the building blocks of our model. One stream of literature focuses on human capital development in firms. Starting from Mincer (1974) a typical approach has been to model the accumulation of human capital as an additive and increasing function of investments in education and experience. A summary of the early "human capital" literature can be found in Blaug (1976). A second stream of literature focuses on the assignment of workers to different types of firms (e.g., Sattinger 1975, 1993). Applied on our setting, this literature focuses on the matching of right auditors with the right audit firms and job positions.[5]

A final stream related to our study is the literature about "employer learning models". Starting from Harris and Holmström (1982), this literature has used Bayesian inference for

[5] An example of an application of an "assignment models" in another setting is Bandiera et al. (2015), who studied managers in the sale and service sectors in Italy. Terviö (2008), as well as Gabaix and Lander (2008), used assignment models as the starting point for their studies of CEO compensation.

modeling how current performance is used for learning about workers' innate abilities.[6] Applied on our setting, "employer-learning models" suggest that firms and auditors base the hiring and compensation decisions on the imperfect information that they have about auditors' capabilities, and this information is updated (they learn) accordingly with the signals that the performance of the auditors generates.

In the prior literature learning has frequently been modeled as a function of the experience of the employer with the worker. We study a specific signal, namely the performance in the CPA exam. The CPA exam is an evaluation of the auditors' professional competences and, as described above, taken when the audit firm has a few years of experience with the audit associate but yet at a point in time when the audit firm is likely to have far from complete information about the capability of the auditor. Thus, the CPA exam arguably provides new information to the audit firm about the auditor's capabilities.

Another feature of the Swedish setting is that the timing of the CPA exam will convey information about the capabilities of auditors. A minimum of three years of practical experience is needed before an auditor can attempt to take the CPA exam but auditors will postpone the exam if they feel they are not well prepared enough. In practice, this decision is likely to be taken after discussions with the employer, since the employer typically pays the examination fee and may also allow the auditor to use working time for studies. The preparation is naturally also time-consuming and costly for the auditor, and therefore, the decision to attempt to take the CPA exam will be a thoughtful one. On the one-hand the postponement of the exam will increase the chances of passing at the first attempt but on the other hand it will also delay the wage increases and other benefits associated with the CPA certification. Besides that the trade-off will be influenced by the learning environment at the audit firm, it will also be influenced

[6] There is also a number of empirical studies, mainly of CEO compensation, based on learning models (e.g., Taylor 2013; Pan et al. 2015).

by the capability of the auditor, a fact used in our theoretical model. In effect, based on "human capital models" one would expect that the performance in the CPA exam is improving with tenure (measured as age in the model below). However, "employer-learning models" recognize that some differences among auditors of the same cohort exist. Market agents, auditors and firms, have imperfect information about such differences in capabilities.

Following "assignment models" we assume that audit firms use this information for allocating auditors to job positions and there are complementarities between the size of the firm and the auditors' capabilities. Big 4 firms audit the vast majority of all publicly traded clients, which are in general more complex and associated with higher litigation risk than private clients. Furthermore, some studies also suggest that Big 4 firms supply services of higher quality than non-Big 4 firms (e.g., Francis 2011). This suggests that tasks in Big 4 firms on average are more demanding than in non-Big 4 firms, implying that have a demand for more skilled workers. We capture this feature of the audit market in the model by assuming that the marginal productivity of capabilities is higher in Big 4 firms.

In fact, the assumptions related with auditors' capabilities used in the model have been previously combined (Gibbons and Waldman 1999 and 2006, Ortín-Ángel and Salas-Fumàs 2006, Waldman 2012) for analyzing different contexts than the one analyzed in this paper. Next we formally state the model assumptions.

3.2 General Assumptions

The expected wealth increase Δ when an auditor takes the exam at age a can be expressed as:

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

where f, b and r are positive parameters equal for all the auditors. The parameter f represent the costs of taking the exam, which includes the fees and other costs that are not useful for next exams, for example time displacement or some hours of study. The parameter *b* represents the difference in annual wages due to the CPA certification. The parameter *r* is the final year of the auditors' career, so *r-a* are the years that the auditors will enjoy the CPA certification if they pass the exam. 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 the exam $\underline{g}$.

The exam score ($g = \mu + \gamma\ c + \varepsilon$) is an imperfect measure of the auditors' capabilities *c* given that we assume that ε is a random variable uncorrelated with the auditors capabilities which is equally and independently distributed among auditors and follows a normal distribution with mean equal to zero and standard deviation σ_ε. The parameter μ is the expected score in the exam of an auditor with a capability equal to zero and γ is a positive parameter that transforms the measurements of capabilities into scores.

The capabilities of the auditors are given by $c = m + \tau\ a$, where τ is a positive parameter and equal for all the auditors indicating the yearly increase of their capabilities. The variable *m* is the capability of the auditor at age 0, so the "employer-learning models" usually refer to this variable as the innate ability. Section 3.3 discusses the information available in the market about the innate ability of the auditors and about the most appropriate interpretation of this variable in our context.

Each year a cohort of auditors enter in the labor market and another one is retired. As a consequence, each year all the cohorts are promoted, i.e. are allocated to a new hierarchical position and there is no substitutability among the auditors of different cohorts. This is assumed because unfortunately in the empirical application we do not have information about the hierarchical levels of the auditors.

This is a never ending process. The auditors of the entry cohort have to be allocated to different firms and positions. Then they will be promoted. So we reduce the analysis to four jobs where the auditors of a cohort can be allocated, with (*CPA*=1) and without CPA certification (*CPA*=0), and to Big (*Big4*=1) and non-Big 4 firms (*Big4*=0). Although the main empirical application is focused on these firms, we also provide empirical evidence related with Top 7 audit firms. By law, an auditor without a CPA certification cannot occupy a position requiring the certification.

The auditors' annual production depends on the match between auditors and job positions in the following way:

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

The parameter ϑ is the production of a person with zero capabilities working for a non-Big 4 firm (*Big4*=0) and in a job position where CPA Certification is not required (*CPA*=0). The parameters φ and δ are positive. The marginal productivity of one unit of innate ability is higher in Big 4 than in non-Big 4 firms (which is $\varphi > 0$). The productivity of an auditor having neither CPA certification nor capabilities ($\delta > 0$) is higher in non-Big 4 firms than in Big 4 firms. Those auditors with innate abilities higher than $m_B = \delta/\varphi$ will be more productive in Big 4 firms than in non-Big 4 firms (the reverse occurs for auditors with innate abilities lower than m_B). Based on the information available about the auditors' innate abilities (see Section 3.3) they will be allocated to the job position where they are expected to be more productive. The production (Y) is the wealth generated by matching an auditor and a firm. The auditor wage determines (*w*) the way that this wealth is shared (Y-*w* for the firm and *w* for the auditor). Then, it is in the interest of both agents to choose the match that maximizes the 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. For simplicity we do not model the wage negotiation process assuming from now that auditors' wages are equal to their expected production[7].

3.3 Assumptions about the information related with the auditors' capabilities

The variable *m* (called innate ability until now) plays different roles in our model. First, this is a way to recognize that the capabilities of the auditors are determined by other factors different than their age. So *m* is capturing the heterogeneity of capabilities among the auditors of the same cohort. For simplicity, we assume that the distribution of *m* among a cohort of auditors follows a normal distribution with an expected value m^E and standard deviation σ_m, so $M(m) = \Phi\left(\frac{m-m^E}{\sigma_m}\right)$. Then, we assume that *m* has the same cumulative distribution function (cdf) $M(m)$ among the population of each cohort of auditors. Take not that when $\sigma_m = 0$ there is no heterogeneity, the differences of capabilities among the auditors of the same cohort is null.

The second role is to consider the existence of imperfect information about the auditor's capabilities. As usual in the "employer-learning models", we model a situation where firms and auditors have symmetric but imperfect information about auditors' capabilities. Our model follows pretty close Murphy (1986). So when $\sigma_m > 0$, the real capability of auditor *i* ($c_i = m_i + \tau a_i$) is unknown, due that this is the case with the concrete value of m_i.

Therefore, we are going to differentiate between the *real* capability of auditor *i* ($c_i = m_i + \tau a_i$) and their *predicted* capability at a certain period of time *t* ($c_i^t = m_i^t + \tau a_i$). While the auditors' performances are due to their *real* capabilities, all the decisions are based on their predicted capabilities. *Real* and *predicted* capabilities will be the same in the case of perfect information. Due the data available, we are going to focus on two periods, before the exam (period $t = 0$) and after the exam (period $t = 1$), so we are going to talk about two predicted

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

capabilities: the *prior* (before knowing the score of the exam) and the *posterior* (after knowing the score of the exam). It seems reasonable to assume that the real capability is not modified by the fact of doing the exam, so it is assumed that m_i is the same before and after the exam. Then, it is clear that we are talking about the capabilities at the time of taking the exam and not about innate capabilities. From now we are going to refer to m_i as *real* ability and m_i^t as *predicted* ability at period *t*. Now we are going to discuss the information available for predicting the ability of the auditors before taking the exam, prior predicted ability m_i^0.

Prior to the exam (period $t = 0$), the auditors and firms know the distribution but not exactly the concrete ability of each auditor. Previously, 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 (Section 3.5 provides further discussion about these assumptions). This information is uncorrelated with the luck in the exam (ε). At period t=0 it is available particular information about an auditor ($I_{i,0}$). All the agents are rational and update their expectations accordingly with the information available, so they use Bayesian inference. Following usual results in econometrics (De Groot, 1970) the predicted ability of auditor *i* will be a normally distributed random variable, with 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 an 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 $\sigma^2 = var(g/I_{i,0}) = \sigma_\varepsilon^2 + \gamma^2(1-\rho_0^2)\sigma_m^2$. In the next section we analyze the decisions of taking the exam based only on the auditors' prior predicted abilities, so there is no room for confusion with the real abilities (or posterior predicted abilities). For simplifying notation, we are going to use *m* in the next section for referring to the predicted abilities of the auditor before taking the exam. This does not mean that we are assuming that ρ_0^2 =1, a situation of perfect information, just that the conclusions are practically the same[8] as in a situation of imperfect information (ρ_0^2 <1), although in the first case real abilities and prior predicted abilities are the same while this does not occur in the second case.

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:

$$P\left(\mathrm{g} > \underline{g}\right) = 1 - \Phi((\underline{g} - \mu - \gamma(m + \tau a))/\sigma)$$

where $\Phi()$ is the cumulative distribution function (cdf) and $\phi()$ is the probability distribution function (pdf) of a normal distribution with mean 0 and standard deviation 1.

3.4 The decision of taking the exam: The model solution

The auditors will take the exam at the age a^* that maximizes their expected wealth increase[9]:

$$\Delta = b(r - a)(1 - \Phi\left(\frac{\underline{g} - \mu - \gamma m - \gamma \tau a}{\sigma}\right)) - \mathrm{f}$$

The following proposition summarizes the results:

Proposition 1: An auditor with prior predicted ability *m* maximizes the expected wealth increase Δ if the CPA exam is taken at the age:

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

[9] We also solved the model including restrictions like there are minimum legal requirements (and then age) for applying or that the expected wealth increase has to be positive. The main implications are the same. The difference is that now the ages are restricted to a certain interval of values. Proofs can be provided upon request.

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

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

Proofs: It is well establish that $\Psi(x) < \frac{1}{x}$ for all $x > 0$, being the $\lim_{x\to\infty} \Psi(x) = \frac{1}{x}$ (See Gordon 1941). From these results, $\lim_{x\to\infty} H(x) = -\infty$, and making the change of 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 $\frac{dH()}{dx} = x\,\Psi(x) - 2 < -1$ being $\lim_{x\to\infty} \frac{dH()}{dx} = -1$. Let us to define $x = (\underline{g} - \mu - \gamma m - \gamma\tau a^*)/\sigma$ and take 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:

$$\text{FOC: } b((r - a^*)\frac{\gamma\tau}{\sigma}\phi(x) - (1 - \Phi(x))) = 0$$

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:

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

The next corollary summarizes the implication of the equation above and relates the decision to take the exam to the firm at which the auditor is working.

<u>*Corollary 1:*</u> The auditors' age at the time of taking the CPA exam decreases with their prior predicted abilities. Among those that have decided to take the exam, it is expected that younger auditors on average will get higher scores. Given that those auditors with prior predicted abilities $m > m_B$ will be allocated to Big 4 firms, the results above imply that:

a) They take the exam earlier than those allocated to non-Big 4 firms.

b) When they take the exam, they have higher expected scores than those allocated to non-Big 4 firms.

Proofs: Auditors with higher prior predicted abilities will do the exam earlier due to $\frac{da^*}{dm} = -\frac{1}{\tau}(1 + \frac{dH^{-1}(z)}{dz})$ is negative given that $-1 < \frac{dH^{-1}(z)}{dz} < 0$. When they take the exam they have higher expected capabilities, and consequently, expected scores due that $\frac{dE(g)}{dm} = \gamma \frac{dc}{dm}$ and $\frac{dc}{dm} = 1 + \tau \frac{da^*}{dm} = - \frac{dH^{-1}(z)}{dz} > 0$. The results related with differences between Big 4 and non-Big 4 firms are immediate. QED.

The empirical implications of Corollary 1 are summarized in the following hypotheses:

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

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

Furthermore, Corollary 1 suggests that the scores of the exam will be higher for those auditors working at Big 4 firms. A literal interpretation of Corollary 1 suggests that the effect disappears when it is controlled for the age of the auditors. However, a more relaxed interpretation, for example assuming that there are other random factors that affect the decision of taking the exam, will suggest that after controlling for age the effect is reduced but not eliminated altogether. Appendix I provides a further discussion. A final empirical implication of Corollary 1 is that:

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

3.5 Information about capabilities: wages and scores

The existence of imperfect information about auditors' capabilities implies that the exam score adds information about the real capabilities of the auditors. Consequently, the exam score will be used for updating the initially predicted capabilities of the auditors and a positive correlation between wages and exam scores is expected. In fact, the model also suggests that some auditors move to other firms. Because of lack of data we omit this analysis.

This section summarizes the predictions of the model regarding the wages before and after the exam. For avoiding misunderstandings, in this section m_i refers to the *real* ability of auditor i ; m_i^0 indicates the *prior* (before knowing the score of the exam) and m_i^1 is the *posterior* (after exam) predicted (by firms and auditors) abilities. The wage 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. Given that we have assumed $g_i = \mu + \gamma\ (m_i + \tau a_i) + \varepsilon_i$, we can define the following signal $s_{i,0} = (g_i - \mu)/\gamma - \tau a_i^* = m_i + u_{i,0}$. 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 correlated with real abilities $\rho_s = \frac{\sigma_m}{\sigma_s}$.

Previously to the scores, firms and auditors have accumulated information I_0. Let us to interpret this information as a collection of J signals[10] ($s_{i,j} = m_i + u_{i,j}$) each one of them (j= $1, \dots, J$) equally informative as the scores, so $u_{i,j}$ is the realization for auditor i at period j of independent random variables equally distributed as a normal with mean equal to zero and standard deviation $\sigma_u = \sigma_\varepsilon/\gamma$.

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

<u>*Corollary 2 (Intermediate result):*</u> The posterior (after the CPA exam) predicted ability of auditor i can be written as:

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

Proofs: 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 auditor when there is no information, while $I_{i,t}$ is the information available about the auditor i abilities. 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

[10] One could argue that the number of signals collected is related with the age of the auditors, $J = a_i^*$. This complicates the algebra without important changes in main conclusions. Appendix II discusses the implications of this assumption.

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 can be computed 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.

Corollary 2 (Final result): The theoretical wage equation depends on the firm for which the auditor works and whether the auditor has the CPA certification or not. The ***theoretical wage equation*** is:

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

$$CPA_i(b + \tau + \left(\frac{g_i - \mu}{\gamma} - \tau a_i^* - m_i^0\right)\left(\frac{1 + \varphi Big4_i}{J + 1 + \frac{\sigma_u^2}{\sigma_m^2}}\right))$$

Proof: Take into account that the auditor's age when she takes the exam is a_i^* and $a_i^* + 1$ the period after. Replacing the posterior (to the CPA certification) predicted ability m_i^1 of an auditor *i* into the wage expression of w_i^t and, with some algebra, the theoretical wage equation is obtained. QED.

The main empirical implication from Corollary 2 is that the exam score provides new information to the market agents about the real capabilities of the auditors. This information is used for updating the predictions about the real capabilities of the auditors and consequently the wages after the CPA certification will be positively correlated with the exam scores. This is summarized in the following hypothesis:

Hypothesis 4: 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.

The parameter $\frac{(\frac{1}{\gamma})(1+\varphi Big4_i)}{J+1+\frac{\sigma_u^2}{\sigma_m^2}}$ suggests that the relationship between the score and wage is stronger in Big 4 firms, and furthermore $((\varphi m_i^0 - \delta)Big4_i)$ suggests that the wages at Big 4 firms are higher before certification (due that auditors with innate abilities higher than m_B=δ/φ will be allocated in Big 4 firms). These empirical implications are summarized in the following hypotheses:

Hypothesis 5: Wages are higher in Big 4 firms than in non-Big 4 firms.

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

4. Empirical approach

4.1 Data

We use samples with CPA exam results and compensation data for testing the empirical predictions. The CPA exam data (denoted Sample A below) contains observations for 1,377 auditors attempting to take the CPA exam for the first time between 2007 and 2012. The data was received from SBPA and contains auditors that passed and failed in the exam. The data includes information about the date of the exam, the individual score in the exam, name, gender, birth date, as well as the name of the employer and the location of the audit office at the moment of taking 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 in order to assure that only the observation when the auditor attempted to take the exam for the first time is included in the sample. We also excluded 21 observations for auditors already having an old type of certification allowing them to audit small companies when they did the CPA exam leaving 1,377 observations for further analyses.

The compensation data (Sample B) includes wages two years before the CPA certification, the year of certification and the year after certification of 431 auditors that received the CPA certification in years 2006 to 2009. This is a balanced panel with 1,724 observations.

The sample was composed as follows. We received the salary income and total income for each individual being active as a CPA at the end of 2011 from Ratsit, a business and credit information company. We started with 723 auditors that passed the exam in years 2006 to 2009 but the employer turnover is high at audit firms in the early phase of the career implying that income data was missing for 150 leaving 573 auditors.[11] Finally, in order to eliminate auditors if they have been on parental or sick leave, we exclude observations if the annual income is lower than SEK 240 thousand. These criteria resulted in an omission of 142 auditors leaving a balanced panel with 1,724 auditor-years and 431 auditors for the analyses.

4.3 Econometric models

We estimate the following equations on Sample A:

$$a_i = \beta + \beta_1 Big4_i + \sum_{k=2}^{K+2} \beta_k X_{k-1,i} + v_{1,i} \qquad [1]$$

$$g_i = \alpha + \alpha_1 Big4_i + \alpha_2 a_i + \sum_{k=3}^{K+3} \alpha_k X_{k-2,i} + v_{2,i} \qquad [2]$$

where X's are K control variables, $\alpha's$ and $\beta's$ are parameters to be estimated and v's are error terms. Hypothesis 1 implies that $\beta_1 < 0$, Hypothesis 2 that $\alpha_2 < 0$ and Hypothesis 3 that $\alpha_1 > 0$. The following variables are used in the empirical estimations of the equations. The age of the auditor (a_i) at the time of attempting to take the CPA exam for the first time is

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

measured in years (age of the auditor in days divided by 365.25). The score in the CPA exam (g_i) is measured as the points received when the auditor attempted to take the exam for the first time. The maximum points in the exam are 100, the minimum is 0 and at least 75 points is needed in order to pass the exam. Note that this sample includes auditors that passed as well as failed in the exam. Big 4 is measured with an indicator variable taking the value one if the firm is audited by Ernst & Young, PwC, KPMG or Deloitte and zero otherwise[12]. Controls for gender (Female), location of the office (Stockholm, Malmo or Gothenburg) and exam time fixed effects are included.

Sample B provides data for estimating the empirical approximation to the theoretical wage equation derived in Corollary 2:

$$w_i = \theta + \theta_1 a_i + \theta_2 Big\ 4_i + \theta_3 g_i + CPA_i(\theta_4 + \theta_5 a_i + \theta_6 g_i) + \sum_{k=6}^{K+6} \theta_k X_{k-5,i} + v_{3,i} \quad [3]$$

where $\theta's$ are parameters to be estimated. Hypothesis 4 implies that $\theta_6 > 0$ and $\theta_3 = 0$, Hypothesis 5 that $\theta_2 > 0$ and Hypothesis 6 refers to differences in parameter $\theta_6$between Big 4 firms and non-Big 4 firms. Furthermore, from the theoretical wage equation and given the assumptions made along section 3 one would expect that wages increases with age (θ_1>0), that CPA Certification is associated with higher wages ($\theta_4 > 0$) and a negative interaction between age and the CPA Certification, ($\theta_5 < 0$). Note that our predictions about the coefficients θ_1, θ_2 and θ_5 of equation [3] has been made assuming that the error terms $v_{3,i}$ are independent of the exam age of the auditor. Appendix III provides further discussion of why this could not be the case and its implications. We measure CPA with an indicator variable taking the value one in the year when the auditor receives the CPA certification and in subsequent years. Consequently, the variable takes the value zero in the two years in the data before the CPA

[12] We conducted several tests for checking if there are differences among the Big 4 firms in the regressions estimated. Overall, the main results are qualitatively similar for all Big 4 firms.

certification. We include controls for gender (Female) and location (Stockholm, Malmo or Gothenburg) in the empirical estimates of the equations.

5. Empirical findings

5.1 Capability of auditors measured with age and performance in the CPA exam

Table 1 presents descriptive statistics on the continuous variables in Sample A classified by Big 4 affiliation. Two thirds of the auditors taking the exam for the first time come from Big 4 audit firms. The mean (median) age of the auditors (a_i) at non Big 4 firms when they attempted to take the CPA exam for the first time is 34.1 (32.01) years. The mean (median) age of auditors at Big 4 firms is 31.4 (30.3) years. The difference in 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 when students in Sweden graduate from university is 29.4 years.[13] Thus, these figures indicate that most auditors have started to work at audit firms soon after the graduation in order to get the practical experience needed for the CPA certification. However, there seems also to be a group that is older and most probably have had another work before starting to target a CPA certification. In supplementary analyses, we study whether the key results in 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. 49.46 % (227 / 459) of the auditors at the non-Big 4 firms and 65.14 % (598 / 918) of the auditors at Big 4 firms passed the CPA exam. These figures are averages for the entire sample and the average pass rates among the

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

auditors taking the exam for the first time vary somewhat between exam-dates. The data covers 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 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. 40.38 % of the auditors come from Stockholm, the capital of Sweden, 12.71 % from Gothenburg and 6.61 % (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 tables).

Table 2 includes OLS estimations of equation [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 pointed out above, some auditors in the sample are fairly old and most probably had other jobs before starting to work as an auditor. We attempted to re-estimate equation [1] after having excluded the top quartile of auditors that 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 fraction of the auditors that were old when they attempted to take the exam work for non-Big 4 firms. Even in this case Hypothesis 1 is supported.

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 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 in 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 significant at the 0.01 level. The coefficient estimate shows that "ceteris paribus" a candidate on average obtains 0.69 points more than a candidate who is one year older.

We attempted to estimate regression (3) by including an interaction between Big 4 and age in order 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 as well as non-Big 4 firms (not reported). We also attempted to estimate regression (2) with audit-firm fixed effects (not reported).[14] The age of the auditors (a_i) has negative coefficients significant at the 0.01 level suggesting that the negative association between age and performance in the exam holds when human capital investments are controlled for. In summary, the results strongly support Hypothesis 2.

Hypothesis 3 predicts that auditors at Big 4 firms perform better in the CPA exam than auditors at non-Big 4 firms. The coefficient of Big 4 is 4.52 in the regression without control for age and it is 2.74 in the regression with a control 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 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 in 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.

Finally, we attempted to run logistic regressions with an indicator variable taking the value one if the auditor passed the exam (results not reported). The odds-ratio of Big 4 in the

[14] More exactly, 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.

regression with the same explanatory variables as in regression (2) in Table 2 is 1.89 (p-value < 0.001) and the odds-ratio is 1.37 (p-value = 0.02) in a regression with the same explanatory variables as in regression (3). This suggests that auditors at Big 4 firms are 89 % more likely to pass without control for age and 37 % more likely when age is controlled for.

5.2 Wages, scores and further related evidence

Table 1 also presents the descriptive statistics on the continuous variables in Sample B 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 Sample A. Furthermore, 47 % (38 %) of the auditors at Big 4 firms (non-Big 4 firms) are female, which is also slightly lower proportions 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 seen from Table 1 that 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 are increasing with the phase in the career; it is 20.7 thousand SEK two years before passing the CPA exam, 34.9 thousand SEK in the year of passing, and 42.9 thousand SEK in the year after passing the CPA exam (not reported in tables).

Table 3 presents estimates of equation [3]. The left-hand regression (regression 4) includes an OLS estimate on the full Sample B, while the mid-regression and right-hand regression include estimates on the sub samples with only Big 4 (regression 5) and non-Big 4 auditors respectively (regression 6). All regressions are significant at the 0.001 level and the R^2 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. Recall also that we use the log of wages (LnW) as the dependent variable implying that coefficient estimates approximately express the change in wages as a percent for each unit of change in the dependent variable.

Hypothesis 4 predicts a positive correlation between wages after having received the CPA certification and the score in 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 more in the CPA exam, auditors receive on average around 0.57% higher wages. 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 is taken, and furthermore, this information is taken into account in wages of auditors. However, the coefficient of Score is insignificant, which also is consistent with the prediction in Hypothesis 4.

The coefficient associated with Big 4 suggests that auditors at those firms have around 7.86 % higher wages than auditors at non-Big 4 firms with similar ages before doing the exam. These differences are statistically significant which is consistent with Hypothesis 5.

Hypothesis 6 predicts that the association between the scores in 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 to Hypothesis 6.

A further observation that can be made from Table 3 is that the coefficient of CPA is positive and significant, suggesting that auditors receive a higher salary after they have received the CPA certification than before the certification. Notice we have centered Score and Age in the regressions. Thus, the coefficient of CPA suggests that the average inflation adjusted salary is around 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 these findings are pretty consistent with the predictions made in section 4.3.

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

5.3 Top 7 audit firms

The audit firms Grant Thornton, BDO and SET Mazars are all fairly large in Sweden. In fact there is empirical evidence (Sundgren and Svanström 2013) suggesting that the quality of their auditing services are not significantly different than those provided by Big 4 firms and better than the remaining audit firms.

Thus, we extend the classification of audit firms into three categories: Big 4, Next 3 and non-Top 7 firms. The following observations were made when we re-estimated the regressions in Table 2. Big 4 and Next 3 have negative coefficients significant at the 0.01 level in the regression with Age as the dependent variable (that is, a regression comparable with regression 1). The coefficient estimates for Big 4 and Next 3 are -3.75 and -2.83 respectively. Thus, the results show that auditors at Big 4 firms are younger than auditors at Next 3 firms when they take the exam but also that auditors at Next 3 firms are younger than auditors at non-Top 7 firms. The difference between the coefficient estimates of Big 4 and Next 3 is significant (p-value = 0.033).

We also re-estimated the regressions with Score as the dependent variable. The coefficient estimate of Big 4 and Next 3 are 6.17 and 4.35 respectively in a regression without Age. Both coefficients are significant at the 0.01 level showing that auditors at Big 4 firms, as well as Next 3 firms, perform better in the CPA exam than auditors at non-Top 7 firms. Furthermore, a Wald test shows that the differences in the coefficient estimates of Big 4 and Next 3 is significant at the 0.05 level.

We also attempted to run the regression with Age as an additional control variable (comparable with regression 3). The coefficient estimates of Big 4 and Next 3 were then 3.75 and 2.49, with a p-value lower than 0.001 and 0.016 respectively. The difference between the coefficient estimates of Big 4 and Next 3 was then insignificant (p-value = 0.124). In sum, the results suggest that auditors at Big 4 are younger and perform somewhat better in the CPA exam than auditors at the Next 3 firms. However, auditors at the Next 3 firms are younger and perform better in the exam than auditors at non-Top 7 audit firms.

Next we estimated variants of equation [3] with the three audit firm categories. Firstly, we ran a regression on the full sample with the three audit firm categories. Surprisingly, Next 3 had a negative coefficient (-0.033) significant at the 0.10 level indicating that auditors at Next 3 firms obtain somewhat lower wages than auditors at non-Top 7 firms. The regression also showed that salaries are significantly higher in Big 4 firms than in Next 3 firms (p-value <0.01).

Secondly, we tested Hypothesis 4 separately on the sub-samples with Big 4, Next 3 and non-Top 7 audit firms. The coefficients (p-values) of the interactions CPA*Score are 0.058 (p-value = 0.002), 0.0045 (0.272) and 0.0020 (0.452) for Big 4 firms, Next 3 firms and non-Top 7 firms respectively, indicating that the association is decreasing with audit firm size. However, perhaps as a consequence of the small sample sizes, Wald tests show that the differences between the coefficients are insignificant. The number of observations in the Big4, Next 3 and non-Top 7 categories are only 1012, 236 and 476 respectively. In summary, the results are fairly consistent with a market of talent allocation where the competitiveness of the firms (in the sense of attracting and retaining more talented people) is positively related with its size.

6. Discussion and conclusions

We study the Swedish audit market in order to get an understanding of how imperfect information about the differences in the capabilities of a cohort of auditors is reflected in the hiring and compensation policies in the early phase of auditors' careers. Auditors need a minimum of three years of practical experience before they can take the CPA exam. However, the timing of the exam can be delayed if the auditor or the employer feels the auditor is not yet ready, suggesting that the timing of the exam may convey information about what they know relative to the capabilities of the auditor. We present a model suggesting that the predicted difference in capability is positively associated with the performance in the CPA exam and negatively associated with the age of the auditors when they take the exam for their first time. If the most capable auditors of a cohort are allocated in Big 4 firms, the model suggests that auditors at these firms will be younger when they take the exam and that they perform better. Our empirical results are consistent with these predictions. Indeed, an alternative explanation is that Big 4 firms invest more on the education, coaching and other human capital development activities than non-Big 4 audit firms. Big 4 firms have large amounts of audit associates implying that they may take advantage of scale economies in the supervision and preparation of audit associates for audit work in general as well as the CPA exam. Although we cannot conclusively rule out this explanation, a result suggesting that innate ability plays a role is that the age of the auditors when they attempt to take the exam for the first time is negatively associated with performance in the exam when we include audit firm fixed effects in the regressions as controls for human capital investments. A further result consistent with the view that Big 4 firms attempt to attract the more capable auditors is that wages at Big 4 firms are higher.

Furthermore, based on the assumption that the results in the CPA exam is used to update the beliefs about the capabilities of auditors, we predict a positive association between the performance in the CPA exam and wage increases, and this association is expected to be stronger for auditors at Big 4 firms. Generally, our results are also consistent with these predictions, indicating that audit firms have imperfect information about auditors' capabilities and that exam results provides new information.

The main thesis of this study is that firms and auditors have information about the differences of capabilities among a cohort of auditors and this information is used for hiring and retaining auditors and deciding when to take and the performance in the CPA exam. However, we cannot rule out that parts of our results are driven by differences in incentives to put in effort. For example, the result that auditors at Big 4 firms are paid higher wages in the first years of their careers is consistent with the view that they are paid a wage premium in order to work hard (cf. Shapiro and Stiglitz 1984). Consequently, auditors at Big 4 firms are also expected to exert a higher effort in the preparation and execution of the CPA exam. Although input of effort could constitute a partial explanation to some of the results, it does not explain why a positive correlation between wages and the performance in the CPA exam is found at least if the input of effort is considered as a one-time event. On the other hand, if the ability to exert effort is a trait of an auditor, that is, he or she has the ability to continuously exert a high effort, then it can be considered as a component of the auditor's capabilities in the model developed in this study.

As pointed out in an article in the Economist, Big 4 accountancy firms has a lot to teach other companies about how to manage talent: “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 of 2007). This study is one of surprisingly few studies attempting to use economic theory in order to analyze the personnel economics issues in the auditing industry. This study is a first attempt to fill this gap but further studies are needed in order to fully understand the hiring and retention policies in Big 4 firms.

Appendix I. The expected score and the age of taking the exam

In this Appendix we discuss two possible origins of error terms in the relationship between expected scores and ages. The first one is related with linear approximations of the function. The second one is related with variations in other parameters of the model r, γ, τ and σ. Finally we present the static comparative of the optimal age with respect these parameters.

Linear approximations of the scores function. From Proposition 1, the expected score will be: $E(g) = \mu + \gamma m + \gamma \tau a^* = \underline{g} - \sigma H^{-1}(\frac{\gamma\tau}{\sigma} r - \frac{\underline{g} - \mu - \gamma m(a^*)}{\sigma})$.

We can not observe the innate abilities of the auditors, but we can observe their decisions about the age of writing the CPA:

$$\frac{\partial E(g)}{\partial a} = -\sigma \frac{\partial H^{-1}(z)}{\partial z} \frac{\partial z}{\partial m} \frac{\partial m}{\partial a^*} = \frac{\tau\gamma}{\psi'(x)} < 0$$

$$\frac{\partial^2 E(g)}{\partial a^2} = -\frac{\tau\gamma\psi''(x)}{(\psi'(x))^2}) < 0$$

The first derivative implies Hypothesis 2. The second derivative implies a convexity in the relationship between expected scores and age. So for those with lower ages (Big 4) it is possible that the score is underestimated while for those with higher ages (non-big 4) the score will be overestimated (Hypothesis 3).

Other parameters variations. Additionally to the innate abilities, could be other parameters that change among firms.

The first order condition implies that:

$$(r - a^*) = \frac{\sigma}{\gamma\tau} \psi(\frac{\underline{g} - E(g)}{\sigma})$$

If r, γ, τ and σ are equal among auditors, all the auditors that have made the exam at the same age will have the same expected score.

But, given a certain age a^* of writing the exam:

$$\frac{\partial E(g)}{\partial r} = -\frac{\gamma\tau}{\psi'(x)} > 0; \quad \frac{\partial E(g)}{\partial \gamma} = -\frac{\sigma\psi(x)}{\gamma\psi'(x)} > 0; \quad \frac{\partial E(g)}{\partial \tau} = -\frac{\sigma\psi(x)}{\tau\psi'(x)} > 0 \text{ and}$$

$$\frac{\partial E(g)}{\partial \sigma} = \frac{\psi(x)}{\psi'(x)} - x = \frac{\psi(x) - x^2\psi(x) - x}{x\psi(x) - 1}$$ this derivative is zero for $x \approx$ - 0,84 (or 80% of probability of success) and positive for higher values (negative for lower ones).

For example, one could argue that the innate ability is not only a stock of capabilities, it can also affect the capacity to learning τ . If we expect that those auditors with higher learning capacities are allocated in Big 4 firms, then, even if we have controlled by the age of the auditors, we expect higher scores in Big 4 firms (Hypothesis 3). Mathematically, similar arguments can be replied for r, γ and σ .

Given the expression of $\frac{\partial E(g)}{\partial a}$, if τ is higher in Big 4 firms, we will expect that the negative relationship between age and wages will be higher in Big4 firms than in the rest of firms.

Other static comparative of $a^*(m)$.

$$\frac{\partial a^*}{\partial r} = -\frac{\partial H^{-1}(z)}{\partial z} > 0; \quad \frac{\partial a^*}{\partial \gamma} = -\frac{1}{\gamma}\left(a^* + r\frac{\partial H^{-1}(z)}{\partial z}\right) - \frac{1}{\gamma\tau}\left(m\left(1 + \frac{\partial H^{-1}(z)}{\partial z}\right)\right.$$

$$\frac{\partial a^*}{\partial \tau} = -\frac{1}{\tau}\left(a^* + r\frac{\partial H^{-1}(z)}{\partial z}\right); \quad \frac{\partial a^*}{\partial \sigma} = -\frac{1}{\gamma\tau}\left(H^{-1}(z) - \frac{\partial H^{-1}(z)}{\partial z} z\right) = \frac{1}{\gamma\tau}\,\frac{\psi(x) - \psi'(x)x}{\psi'(x) - 1}$$

$\frac{\partial a^*}{\partial \sigma}$ is Zero for $x \approx$ - 0,84 (or 80% of probability of success) and positive for higher values (negative for lower ones).

Appendix II: Model solution when the information quality depends on the age

In this Appendix we are going to revise the solution to the model (Section 3.3) assuming that *J*= a_i^*. The main implication of this assumption is that the precision of the predicted innate ability changes with the age of the auditors. Accordingly with the assumptions made in Section 3.2, this will be a random variable distributed like a normal 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, $var(m/I_{i,t}) = \left(1+\frac{\sigma_m^2}{\sigma_u^2}a_i\right)^{-1}\sigma_m^2$. The score in the exam g will be a random variable, normally distributed with expected value equal to $\mu - \gamma m_i^t - \gamma\tau a_i$ and variance $\sigma_g^2 = \gamma^2\sigma_m^2\left(1+\frac{\sigma_m^2}{\sigma_u^2}a_i\right)^{-1} + \sigma_\varepsilon^2$. Consequently, the average of the predicted innate ability can change each year m_i^t and the standard deviation of the predicted innate ability σ_g = $\left(\gamma^2\sigma_m^2\left(1+\frac{\sigma_m^2}{\sigma_u^2}a_i\right)^{-1} + \sigma_\varepsilon^2\right)^{1/2}$ is reduced with time $\frac{\partial\sigma_g}{\partial a} = -\frac{1}{2}\left(\gamma^2\sigma_m^2\left(1+\frac{\sigma_m^2}{\sigma_u^2}a_i\right)^{-1} + \sigma_\varepsilon^2\right)^{-1/2}$ $\gamma^2\sigma_m^2\left(1+\frac{\sigma_m^2}{\sigma_u^2}a_i\right)^{-2}\frac{\sigma_m^2}{\sigma_u^2}$ <0.

The auditors expected wealth increase is the same defined in the Section 3 of the paper, $\Delta = b(r-a)(1-\Phi(x(a))) - \mathrm{f}$, where now $x(a)=(\underline{g} - \mu - \gamma m_i^t - \gamma\tau a_i)/\sigma_g$. The first order condition will be fulfilled if and only if: $G(x,a)= -(r-a)\frac{\partial x}{\partial a} - \psi(x(a)) = 0$.

The main differences with respect Section 3.3 is that now a delay in the exam has a new effect, it increases the precision of the predicted innate abilities, so $\frac{\partial x}{\partial a} = -\frac{\gamma\tau + \frac{\partial\sigma_g}{\partial a}x(a)}{\sigma_g}$ is not a constant like in Section 3.3, $\frac{\partial x}{\partial a} = -\frac{\gamma\tau}{\sigma}$.

Implications:

The first order condition implies:

$$\frac{r-a}{\sigma_g}\ (\gamma\tau+\frac{\partial\sigma_g}{\partial a}x(a)) \quad - \quad \psi(x(a)) \ = 0$$

The ratio of mills is convex $\frac{\partial^2\psi(x(a))}{\partial x(a)^2}>0$. Let us to define x_0 as $\psi(x_0)x_0-1$ = $\frac{r-a}{\sigma_g}$

$\frac{\partial\sigma_g}{\partial a}$

Situation 1: $\psi(x_0)>\frac{r-a}{\sigma_g}\ (\gamma\tau+\frac{\partial\sigma_g}{\partial a}x_0)$ Given a certain *a* there isn't any *m* that solves the first order condition.

Situation 2. $\psi(x_0)\leq\frac{r-a}{\sigma_g}\ (\gamma\tau+\frac{\partial\sigma_g}{\partial a}x_0)$ there are two *m*'s or *x*'s that solves the first order condition, $-\gamma\tau/\frac{\partial\sigma_g}{\partial a}\geq x_H\geq x_0\geq x_L$ The mills ratio is decreasing, $\psi(x_H)\leq\psi(x_0)\leq$ $\psi(x_L)$, and convex: $x_H\psi(x_H)-1\geq x_0\psi(x_0)-1=\frac{r-a}{\sigma_g}\frac{\partial\sigma_g}{\partial a}\geq x_L\psi(x_L)-1$.

$$x_H - x_L=(\frac{\psi(x_H)}{\psi(x_L)}-1)\ (\gamma\tau/\frac{\partial\sigma_g}{\partial a}+x_L)$$

Take note that:

$$\frac{\partial G(x,a)}{\partial x}\ \frac{\partial x}{\partial m}=\frac{\gamma}{\sigma_g}((x\psi(x)-1)-\frac{r-a}{\sigma_g}\frac{\partial\sigma_g}{\partial a})$$

Let us to define m_L as the innate abilities that for a given *a* fulfils

$x_L = \underline{g} - \mu - \gamma m_L - \gamma \tau a / \sigma_g$ and this is a maximum $\frac{\partial G(x,a)}{\partial a} < 0$. Then $\frac{\partial G(x_L,a)}{\partial x} \frac{\partial x}{\partial m_L}$ <0 and we can reproduce the main result of Proposition 1,

$$\frac{\partial a^*}{\partial m} = -\frac{\partial G(x,a)}{\partial a} / \frac{\partial G(x,a)}{\partial x} \frac{\partial x}{\partial m}\text{; so } \frac{\partial a^*}{\partial m_L} < 0 .$$

Obviously we can define in a similar way m_H. Take note that m_H is lower than m_L so for sufficiently high values of f/*b* the wealth career increase associated with m_H will not be positive. We assume that this is the case, and they will not do the exam.

Appendix III: Error terms in empirical wage equations

As commented in the text there are more and less strong tests of the model. The stronger test implies that we adopt literally Proposition 1. More relaxed tests assume that there are some random terms not considered in the model which affects the decision about the age of taking the exam.

One can interpret the predictions about the parameters of equation [3] presented in the text as a relaxed test of the model. In this appendix we are going to discuss the implications of the stronger test of the model.

From Proposition 1, the expected innate abilities of an auditor at the time of writing the exam are related with the age of writing it accordingly with the following relationship: $m_i^0 = m(a^*) = a^{*-1}(m)$. So the wage equation in Corollary 2 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 $c(a_i^*)$ is the capability of the worker at the age of taking the exam, which we have shown that it is decreasing with this 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 $\theta_5 > 0$. So if we are closer to these coefficients (random errors in the exam age are not relevant) or the proposed in the text (random errors in the exam are relevant) is an empirical concern.

Anyway, there are no changes in the predictions of hypothesis 4, θ_3, θ_6 and parameter θ_4. Furthermore, in a literal interpretation of Proposition 1, the wages would be fully explained by the observed variables.

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Table 1. Descriptive statistics

Sample A: CPA exam data

	Age (a_i)	Score
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.

	LnW	Age (a_i)[a]	Score[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

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

	(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 years) so eleven Exam-date dummies are included.

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

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:			
$CPA*Score_{reg.2} = CPA*Score_{reg.3}$		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 at 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.

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