

# The Consequences of Mandating Auditor Rotation: Evidence from a Dynamic Structural Model

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*Preliminary and Incomplete.*‡

## Abstract

We construct a dynamic discrete choice model, in which firms make decisions to retain or replace their auditor in multiple time periods. We derive from the discrete-choice probability framework how auditor choice probabilities depend on past auditor tenure and size. For firms with auditor tenures beyond the mandatory rotation rule, a switch to a non-Big 4 relatively to a Big 4 is associated with much lower switching costs. Results from counterfactual analysis show that the long-run annual switching rate should increase by 9 (3) percentage points with a 5-year rotation rule (10-year rotation rule), and these switching rates also increase with tenure by 30 (35) percentage points in the last year of the 5-year (10-year) mandatory term, and lastly, the Big 4 market share drops from 54% to 32%, absent any rule, which falls to 18% (26%) in the long run after a 5-year (10-year) rotation rule. For a firm currently with an auditor tenure of less than the mandatory term, a 5-year (10-year) mandatory rotation rule reduces on average the option value of keeping the auditor by 7% (3%) relative to the case with no mandatory rotation.

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# 1 Introduction

What are the consequences of mandating auditor rotation for the auditing industry? To address this question, this paper offers a simple structural approach to measure auditor switching costs in a dynamic discrete model using auditor tenure and auditor size as determinants of auditor switch, and later, examines the effects of mandatory auditor rotation on switching rates and market share of Big 4 auditors.

The underlying question of mandatory auditor rotation is regularly on the agenda of regulators, although a change of policy seems unlikely to occur in the United States, at least in the short run.<sup>1</sup> The Public Company Accounting Oversight Board voted in August 16th, 2011 to issue a concept release to solicit public comment on ways that auditor independence, objectivity and professional skepticism can be enhanced, including through mandatory rotation of audit firms every few years. The PCAOB encountered fierce resistance to the mandatory auditor rotation idea: after receiving more than 684 letters urging the PCAOB to stop the project of limiting auditor's tenure, three years later, in February 2014, the PCAOB abandoned the project, which never got beyond the concept release stage.<sup>2</sup> Meanwhile, outside the United States, member states of the European Union have approved new regulations requiring audit firms to rotate engagements with public-interest entities every 10 years in April 2014. The new EU rules are applicable since 17 June 2016 throughout the Union.<sup>3</sup>

On one hand, mandatory audit rotation is intended to avoid excessively long relationships between the auditor and the client because it is likely to impair the auditor's judgment and independence. On the other hand, the client firm bears switching costs when it replaces its incumbent auditor by a new one, related to start-up, search and learning costs because it needs to select a new auditor and train him, assess the quality of the audit services, while the auditor needs to invest time to get familiarized

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<sup>1</sup>The American Institute of Certified Public Accountants (AICPA) has initiated audit partner rotation since 1978, where the lead audit partner needs to rotate after seven years for SEC registrants. The Sarbanes-Oxley Act of 2002 (SOX) further shortens the maximum length of the audit engagement to five years for both the lead partner and the reviewing partner. Laurion, Lawrence and Ryans (2016) provide some empirical evidence that mandatory partner rotations can be beneficial because the new partners might use a fresh look in auditing the financial statements.

<sup>2</sup>The Sarbanes-Oxley Act of 2002 (Section 207) required the General Accountability Office (GAO) to investigate the potential effects of mandatory audit firm rotation. However, in July 2013, the U.S. Congress passed the "Audit Integrity and Job Protection Act," effectively ending the evaluation of the merits of audit firm rotation.

<sup>3</sup>The Directive 2014/56/EU, together with the Regulation 537/2014 of the European Parliament, belongs to the broader new E.U. regulatory framework on statutory audit.

with the new client accounting systems.

Examining the effects of mandatory rotation in the US auditing market faces several challenges. Because US firms are not required to rotate audit firms, we do not observe the counterfactual world with mandatory rotation. Moreover, because forward-looking firms account for the implication of their current auditor choice on the future utility, imposing mandatory rotation might cause firms to behave differently from what they would have absent any rule. For example, if a firm anticipates that it will be forced to change to another auditor, it might start shopping for eligible auditors earlier in the process than absent any rule in order to obtain a good match, and hence, we could observe a higher switching rate if the mandatory rotation rule is adopted.

We deal with these challenges by using a dynamic discrete choice model. The model explicitly accounts for the effects of firms' auditor choices on their current utility versus expected future utility. We first use the model to understand the short-run and long-run utility loss firms incur when switching relative to keeping incumbent auditors, which we call switching costs. We then examine the counterfactual short-run and long-run switching costs associated with mandatory auditor rotation, its impact on auditor market shares and the probability of switching to another auditor, and the consequences on the firm's surplus in the short and long run.

In our model, firms make decisions to retain or replace their auditor in multiple time periods. Choosing an auditor first accounts for its effects on firms' payoff today (called period utility). The period utility associated with a chosen auditor represents net benefit or cost that the firm obtains from the auditor today. To maintain a simple structure, the period utility contains two observable factors, i.e., auditor tenure (length of a firm's relationship with its existing auditor) and auditor size, plus auditor-specific random shocks. We argue that auditor tenure captures the reduction of uncertainty in assessing the match quality between the firm and the auditor or the auditor's "learning by doing" as time passes. Auditor size relates to separating Big 4 and non-Big 4 auditing firms. We want to examine whether keeping a Big 4 auditor could generate higher utility than a non-Big 4, and whether switching from a non-Big 4 to a Big 4 might generate additional utility losses relative to the other way around. The auditor-specific random shocks reflect factors not captured by auditor size and tenure, for example, a disagreement between the firm and the auditor on audit fees and services, or on the report, the firm's decision to go opinion-shopping, conflicts of interest, a change of company ownership, or

the firm's need for more specialized auditing firm.

The innovation of this paper is that firms account for not only the period utility but how the decision today impacts the value of making subsequent decisions in the future, i.e., the discounted expected future utility conditional on the current auditor choice and the firm's expectation about the future states, that is, the evolution of auditor tenure and incumbent auditor identity (Big 4 or non-Big 4). Despite a large literature on dynamic discrete choices, the conditional choice probability, hereafter CCP, method has not been applied to auditing research. Isolating the expected continuation payoff is key to our research question.

We estimate our model and recover the effects of auditor tenure and size on firms' auditor choices. The CCP method employed in this paper builds on the seminal work of Hotz and Miller (1993). One of their core insights was to show that we can easily express the individuals' expectations in the future (or future expected utility) as simple functions of the probabilities that particular choices occur, given the observed state variables. The CCP method offers several benefits: the CCP-based estimators are easy to implement and light in computer programming to take a model to data. Only a simple Stata package is needed to use our empirical friendly estimator. Still, this method accommodates for dynamics.

First we adapt the Rust (1987) model to the firm's decision to replace or keep its incumbent auditor using the auditor tenure as the only state variable. This simple research design aims at examining the learning curve between the firm and the auditor or the auditor's "learning by doing," as argued above. We first compute the switching cost associated with replacing an incumbent auditor, which is the total loss of utility (period plus expected future utility) of replacing an incumbent auditor relative to keeping it. If a firm has to switch its auditor after an audit engagement of less than two years, the incurred utility losses are not as large compared to a firm switching after a long auditor tenure, probably because the learning about the match quality or learning by doing is not yet established. To recover from the total losses due to a switch, it takes on average 1.5 years after a switch from an incumbent auditor with a tenure between 3 and 6 years, and on average 2 years after a switch from an incumbent auditor with a tenure between 7 and 11 years. We also find that the importance of expected future utility on the decision to keep an incumbent auditor increases with auditor tenure. Until 5 years of tenure, the period utility losses are more than double the losses of the expected future

utility, whereas beyond 5 years of tenure, the loss of expected future utility becomes heavier, almost at par with period losses after 11 years of tenure.

We next extend the model to incorporate auditor size by differentiating between Big 4 and non-Big 4 auditing firms. First, we find that auditor tenure becomes much less important in the firms' decisions. Second, switching to a Big 4 regardless of the incumbent auditor's type comes at a much larger total utility loss relatively to switching to a non-Big 4: if the incumbent auditor is a Big 4 (non-Big 4), a switch to a Big 4 relatively to a switch to a non-Big 4 is on average 1.775 ( 5.128) times more costly. To make up for the total losses following a switch from an incumbent auditor with a tenure of less than 10 years, it takes more time if a firm switches to a Big 4 than to a non-Big 4: the recovery time is on average 3.5 years after switching within Big 4 auditors and 5.3 years from a non Big 4 to a Big 4, whereas it only takes 2.1 years from a Big 4 to a non Big 4, and 1.1 years within the non-Big 4.

A higher switching cost from non-Big 4 to Big 4 than from Big 4 to non-Big 4 implies a reduction in the Big 4 market share over time because it is more costly to switch back to a Big 4 once a firm ends with a non-Big 4. This force, however, is balanced by a longer average tenure of Big 4 auditors in the data, which increases the likelihood of keeping the incumbent auditor, and by the entry and exits of firms over time. Specifically, about 77% of new firms choose a Big 4 auditor. About 12% of non-Big4 clients disappear every year compared with only 6% of Big4 clients (due to acquisition or bankruptcy).

Holding constant firm preferences for auditors, that is, the effects of auditor tenure and size on the period utility, we forward-simulate the counterfactual auditor choices for firms in the last year of our sample under the cases in which these firms are forced to switch their incumbent auditors if auditor tenure exceeds 5 and 10 years. Fixing the period utility allows us to isolate the changes in Big 4 market share and the probability of switching incumbent auditors that are driven by firms being forward-looking about the likelihood of mandatory rotation.

Our counterfactual analysis identifies an increase in long-run annual switching rate by 9 (3) percentage points with a 5-year rotation rule (10-year rotation rule). The increase in the switching rate is driven by a decrease in the benefit associated with keeping an incumbent auditor with mandatory rotation. Consistent with this, we find that for a firm currently with an auditor tenure of less than

the mandatory term, a 5-year (10-year) mandatory rotation rule reduces on average the option value of keeping the auditor by 7% (3%) relative to no mandatory rotation. Firms are also more likely to switch as they get closer to the end of the 5-year (10-year) mandatory term, ranging from 27% (25%) in the first year of tenure to 52% (51%) in the last year of tenure, representing an increase relatively to no rule in place by 3 (0) percentage points in the first year of tenure and 30 (35) percentage points in the last year of the mandatory term relatively to no rule in place. For firms that initially had auditor tenures beyond the mandatory rotation rule and were forced to switch, a switch to a non-Big 4 is associated with a lower total utility loss, accounting for 64.6% (66.1%) of the total utility loss of switching to a Big 4 given the incumbent auditor is a Big 4 (a non-Big 4). Finally, our simulation predicts a drop in the Big 4 market share, absent any rule from 54% to 32%, which would fall to 18% (26%) in the long run after a 5-year (10-year) rotation rule. The reason for the drop is that mandatory rotation increases the rate of switching. Because the cost of switching from a Big 4 to a non-Big 4 is lower than that of switching from non-Big 4 to Big 4, an increase in the switching rate leads to more firms staying with non-Big4 than with Big 4.

## **Literature Review**

Our paper is related to a vast theory literature on auditing firms. Audit technology is typically characterized by significant start-up costs and thus the incumbent auditor can earn client-specific “quasi-rents” as described by DeAngelo (1981a). A firm is less likely then to switch as time passes because the incumbent auditor possesses cost advantages over potential competitors. At the same time, an incumbent auditor has also incentives to act opportunistically to preserve his client-specific quasi-rent stream, and could threaten the auditor’s independence (Tseng and Magee 1990; Kanodia and Mukherji 1994). The theoretical literature has modeled several reasons for auditor switches. First, the separation between the firm and the auditor occurs once learning about mismatch is established Mortensen (1988a,b). Second, asymmetric information exists at the time of the switch: Kanodia and Mukherji (1994) show that the switch is the firm’s response to the incumbent auditor’s informational advantage and the firm seeks to limit these rents by using the power of competition in the market for auditors. Dye (1991) and Teoh (1992) demonstrate that an auditor switch occurs due to disagreement with the client on the content of the report to outside parties, and the client firm who knows the auditor

to be wrong will switch auditors to find a new auditor who is more likely to be correct. In our paper, we do not explain the specific reasons for an auditor switch, but view auditor tenure as a primitive in determining the firm's decision to retain their incumbent auditor or switch to another auditor, and root our measure of switching costs to a decision-based model.

The literature typically differentiates between Big 4, namely KPMG, PriceWaterhouseCooper, Ernst and Young and Deloitte, and Non Big 4 auditing firms. We account for Big 4 versus Non Big 4 auditing firms to estimate the switching costs in the short and long run. Big 4 firms are usually perceived as providing higher auditing services because they have more expertise and stronger incentives to maintain high quality services audit quality given that they need to preserve their reputation (DeAngelo 1981b), have deeper pockets and hence their expected legal cost of audit failure is more significant, which disciplines auditors (Dye 1993) and benefit from more resources to attract more competent employees, provide high quality training, and develop high quality audit technologies (Dopuch and Simunic 1980).

So far, most empirical papers studying the potential impact of auditor rotation use audit firm tenure as a proxy for rotation to establish connections between rotations and audit quality measures, and to predict the effect of rotation policies (e.g., DeFond and Zhang 2014 for further details). Long auditor tenures could impede the auditor's objectivity and critical judgement by encouraging the auditor to overlook the information provided by the firm and issue a clean opinion without exerting his due diligence to secure his stream of very profitable future cash flows. At the same time, a longer auditor tenure allows the auditor to learn about the firm's business and enhances audit quality (Ghosh and Moon 2005). Empirical evidence is mixed regarding the association between auditor tenure and audit quality.

A direct setting to address the consequences of mandatory audit firm rotation is limited, due to the lack of changes in regulatory requirements to impose rotation policies.<sup>4</sup> Moreover, rare are the firms that have voluntary audit rotations policies (e.g., Zeff 2003) or have a policy of putting its audit business out to competitive bidding every few years like Apple. The collapse of Arthur

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<sup>4</sup>A number of countries have experimented with mandatory rotation within specific industries or for limited periods (see U.S. General Accountability Office [U.S. GAO] 2003; and Cameran, Merlotti, and Di Vincenzo 2005 for further details). In particular, Italy enacted a nine-year rotation rule in 1975; Spain adopted a nine-year rotation rule that only was effective for a short period 1991-1994; Brazil enacted a five-year rotation rule in 1999; South Korea enacted a six-year rotation rule in 2003; Austria enacted a six-year rotation rule in 2004, and both Singapore and Canada enacted rotation rules for domestic banks. Recently, the UK has adopted a mandatory rotation of 10 years starting in January 2015.

Andersen offered some opportunity to study the effect of forced auditor rotation (e.g., Blouin, Grein and Rountree 2007) but the circumstances and the financial environment at the time were quite unique.

Closer to our approach are theory-based papers. Structural estimation has been a method extensively used in economics and marketing. This literature is deep and we only reference a couple of studies to place our paper. In particular, the method that we use in this paper which belongs to the estimation of dynamic discrete choice structural models has been widely studied as surveyed by Aguirregabiria and Mira (2010). In marketing, dynamic consumer choice models are designed to measure how past usage of a product and advertising impact consumers' behaviors in choosing a brand (as a reference, see Erdem and Keane (1996) ) or focus more on switching costs and how the market structure and competition can modify consumers' choices (Klemperer 1987, 1995). In accounting, the only paper in auditing, to our knowledge, using a similar approach to ours is Gerakos and Syverson (2015), where they model firms' auditor choices in a static discrete choice estimating the demand of audit services, and predict the negative effects of mandatory rotations and the exit of a large auditing firm.

## **2 Dynamic discrete choice model**

We estimate a dynamic discrete choice model of the firm to retain its incumbent auditor or replace him by another one. We apply a conditional choice probability approach to estimate the firm's auditor choices and costs of switching incumbent auditors in different specifications. The firm is a forward looking decision maker not only caring about the current period utility but also the stream of expected future utility.

We want to estimate how auditor tenure affects the firm's choice in deciding whether to keep its current auditor or switch to another one. As a first path, we borrow the bus engine example developed in Rust (1987) and apply it to the auditing framework, where the auditor tenure is the state variable. This baseline model introduces several features that are of interest: (i) it models the auditor's switching choice in a simple but yet dynamic model, (ii) the state variable captures in reduced form a learning model. A longer auditor tenure is assumed to map into a reduction of the uncertainty about knowing whether the auditor is a good match. Alternatively, an auditor also learns more about the firm as time passes.

In subsequent sections, we extend the model to account for the auditor size to influence the firm's choice. The auditing market is concentrated and characterized by two types of auditors: it comprises four large auditing firms, commonly referred as the Big-4 auditing firms, that controls 61.8% of the market in 2015 and on average, roughly 60% of the market over our sample period from 2004 to 2015, and 1,153 smaller auditing firms, hereafter, the non-Big 4. We augment the number of choices to include a switch to all specific Big 4 or to a non-Big 4. This extended model can also accommodate to study the differences between switching to another auditor of the same type (Big 4 or non-Big 4) or switching to an auditor of a different type (Big 4 to non-Big 4 and vice versa).

## 2.1 Baseline Model

In each period  $t$ , a firm makes a binary decision  $d_t = (d_{t,1}, d_{t,2})$ : (i) either the firm decides to terminate its relationship with its current auditor by choosing  $d_{t,1} = 1$  or (ii) the firm retains its incumbent auditor for at least one more period by choosing  $d_{t,2} = 1$  such that  $d_{t,1} + d_{t,2} = 1$ .<sup>5</sup> The firm's current period utility depends on its action, i.e., retention or replacement of its incumbent auditor. Specifically, the current utility includes the following terms:

$$u_t(d_t, x_t, \epsilon_t) = d_{t,1}(\epsilon_{t,1}) + d_{t,2}(\theta_0 + \theta_1 x_t + \epsilon_{t,2}). \quad (2.1)$$

The variable  $x_t \in \{1, 2, \dots\}$ , is the auditor tenure, that is, how many years of experience the auditor has acquired since the last switch, observable to the econometrician. The vector  $\epsilon_t = (\epsilon_{t,1}, \epsilon_{t,2})$  represent the choice-specific error vector unobserved to the econometrician. The error terms  $\epsilon_{t,1}$  and  $\epsilon_{t,2}$  are realized and observed by the firm in each period. Auditor tenure increases by 1 year if the firm retains the current auditor and is set to 0 for the current period if the firm switches to another auditor (so the next period tenure is one). Specifically,

$$x_{t+1} = \begin{cases} x_t + 1 & \text{if } d_{t,2} = 1 \\ 1 & \text{if } d_{t,1} = 1 \end{cases}$$

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<sup>5</sup>We do not model the strategic interaction between a manager's incentive to manipulate accounting information and an auditor's incentive to conduct a careful audit to detect manipulation (e.g., Laux and Laux (2009); Lin and Sappington (2015)), which are beyond the scope of this study.

The auditor tenure is bounded above at 19 years.<sup>6</sup> Further, the error terms  $\epsilon_{t,1}$  and  $\epsilon_{t,2}$  are identically, independently drawn from a multivariate extreme value type I distribution. This assumption on the distribution of the choice specific error term makes the expressions particularly simple for the estimation procedure.

In discrete choice models, only differences between choices matter and we normalize the current period payoff of the first choice to  $\epsilon_{t,1}$ . The normalization implies  $\theta_0 + \theta_1 x + \epsilon_{t,2} - \epsilon_{t,1}$  measures the net cost or benefit of keeping the current auditor in period  $t$  for another period in comparison to switching to another auditor.

We assume that the firm discounts the future at rate  $\beta = 0.92$ , which corresponds to an 8.7% equity premium, and solves a dynamic model, where it takes into account the current period payoff as well as how its decision today will affect the future. The firm does so by choosing a sequence of optimal choices  $d_t^*$ , for all possible realizations of the unobserved variable  $\epsilon_t$  and the observed variable  $x_t$  in each time period  $t$ . Formally, the firm maximizes the following objective function in a sequence of discrete choices  $d_t$ :

$$\mathbb{E}_t \left( \sum_{k=t}^{\infty} \beta^{k-t} u_t(d_t, x_t, \epsilon_t) \right), \quad (2.2)$$

where  $d_t = (d_{t,1}, d_{t,2})$  is an auditor choice in period  $t$ ,  $x_t \in \{0, 1, \dots\}$  is the current auditor tenure.

Let the the ex ante value function at the beginning of period  $t$  be denoted

$$V(x) = \mathbb{E}_t \left( \sum_{k=t}^{\infty} \beta^{k-t} u(d_t^*, x_k, \epsilon_k) | x_t = x \right).$$

The value function conditional on a choice  $j$  yields

$$v_j(x) = \begin{cases} \beta V(1) & \text{if } j = 1, \\ \theta_0 + \theta_1 x + \beta V(x + 1) & \text{if } j = 2. \end{cases} \quad (2.3)$$

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<sup>6</sup>In the data, auditor tenures beyond 19 years represent 11.4% in 2015. We restrict the auditor tenure by this upper bound of 19 years, because the switching rate is only 3.4 %, a much lower rate than 21.8% when tenure is one year.

If the firm decides to switch, regardless of its current auditor tenure, the value conditional on switching is  $v_1(1) = v_1(x + 1) = \beta V(1)$ . The conditional choice probabilities are then given by

$$p_j(x) = \frac{e^{v_j(x)}}{\sum e^{v_i(x)}}. \quad (2.4)$$

Arcidiacono and Miller (2011), in equations (3.6) and (3.19), show that the conditional value function can be written as

$$v_j(x) = \begin{cases} \beta v_1(1) - \beta \log [p_1(1)] + \beta \gamma & \text{if } j = 1, \\ \theta_0 + \theta_1 x + \beta v_1(x + 1) - \beta \log [p_1(x + 1)] + \beta \gamma & \text{if } j = 2, \end{cases} \quad (2.5)$$

where  $\gamma$  is the Euler's constant. The expressions above show that the value of each choice depends on the current utility to each choice and the value going forward available following each choice. In the context of the CCP, only the difference between the values is relevant, which yields

$$v_2(x) - v_1(x) = \theta_0 + \theta_1 x + \underbrace{\beta \{ \log [p_0(1)] - \log [p_0(x + 1)] \}}_{\substack{\text{Difference in the expected utility} \\ \text{of keeping and switching incumbent auditor}}}. \quad (2.6)$$

Differences in values imply differences in the likelihood of selecting one action over the other. Since there is a one-to-one correspondence between the value function difference, that is, the expected future utility difference, and the probabilities of choosing actions, as shown in Proposition 1 in Hotz and Miller (1993), it is possible to replace this value difference with a function of the probabilities of taking one or the other action.

## 2.2 Extended Model

We extend the baseline model to allow for switching across different auditors, namely, the individual Big 4, i.e., Ernst and Young, Deloitte, KPMG and PriceWaterHouse Coopers and two non-Big 4 auditing firms. Because the set of the non-Big 4 in the data consists in a large number of auditing firms and few observations for a specific non-Big 4, we do not model each non-Big 4 firm as an individual choice, but instead, create two non-Big 4 firms by randomly assigning observations from the non-Big 4 pool to each non-Big 4 firm created. Specifically, if a firm decides to switch from a Big 4

auditor to a non-Big 4 auditor, we will randomly assign one of the two non-Big 4 auditors modeled. If we start with a firm working with a non-Big 4 auditor, we randomly assign one of the two auditors. If subsequently, this firm decides to switch to another non-big 4, we will assign the other non-Big 4 auditor of the model.

Adapting the baseline model to these 6 choices, the state variable  $k \in \{1, 2, 3, 4, 5, 6\}$  represents the individual auditing firm. For  $i \in \{1, 2, 3, 4\}$ , the auditing firm  $k = i$  represents a Big 4 firm whereas the auditing firms  $k = 5$  and  $k = 6$  are non Big 4.

So far, we have implicitly assumed that all the firms have identical preferences when it comes to deciding between keeping their current auditor or switching to another one. In the Rust model, our state variable  $x_t$  transitions in a deterministic way: the probability of  $x_{t+1}$  given the auditor tenure  $x_t$  in the previous period and the choice  $d_t$  is either zero if the firm replaces the auditor or one if the firm retains the auditor. To account for the heterogeneity in the firms, we introduce another state variable  $\eta_t$ , representing the size or the growth of the firm for example. We assume this additional state variable might be correlated with the other state variable  $k$  but is independent of the choice specific error terms.

We adapt the current utility to allow for those six choices as follows:

$$u_t(d, x, k, \eta, \epsilon_t) = \sum_{1 \leq j \neq k \leq 6} d_j(\alpha_{k,j} + \delta_{k,j}\eta + \epsilon_{t,j}) + d_k(\theta_k x + \alpha_{k,k} + \delta_{k,k}\eta + \epsilon_{t,k}). \quad (2.7)$$

The coefficient  $\alpha_{k,j}$  represents the value of switching to an auditor  $j$  ( $j \neq k$ ) when the prior auditor is  $k$ .  $\theta_k$  represents the value of experience and  $\alpha_{k,k}$  represents the value of auditor  $k$  when the firm keeps him. The choices  $d = (d_1, d_2, d_3, d_4, d_5, d_6)$  are such that  $\sum_{1 \leq j \leq 6} d_j = 1$ .

Now suppose the state variable  $\eta$  takes  $N$  values from  $\{\eta_1, \dots, \eta_N\}$ . Define the Markov transition matrix as

$$\Pi = \begin{pmatrix} \pi_{11} & \dots & \pi_{1N} \\ & \dots & \\ \pi_{N1} & \dots & \pi_{NN} \end{pmatrix},$$

where  $\pi_{mn}$  is the probability of  $\eta = \eta_n$  given  $\eta = \eta_m$ . Define the conditional value function  $v_j(x, k, \eta)$  and the ex-ante value function as *column* vectors of length  $N$

$$v_j(x, k, \eta) \equiv (v_j(x, k, \eta_1), \dots, v_j(x, k, \eta_N))'$$

and

$$V(x, k, \eta) \equiv (V(x, k, \eta_1), \dots, V(x, k, \eta_N))'$$

With a slight abuse of notation, define  $\alpha_{k,j} = \alpha_{k,j}\mathbf{1}$ , where  $\mathbf{1}$  is a column vector of ones with length  $N$ . Define other  $\alpha$ ,  $\theta$ , and  $\gamma$  (the Euler constant) similarly. The discount factor  $\beta$ ,  $\delta$ , the state variables  $x$  and  $k$  remain scalars. The value functions conditional on a choice are given by:

$$v_j(x, k, \eta) = \begin{cases} \theta_k x + \delta_{k,k}\eta + \alpha_{k,k} + \beta\Pi V(x+1, k, \eta) & \text{if } j = k \\ \alpha_{k,j} + \delta_{k,j}\eta_{k,k} + \beta\Pi V(1, j, \eta) & \text{if } j \neq k, \end{cases}$$

which means that if  $j = k$ , the firm keeps the auditor  $k$  with whom he has worked for  $x$  years. If  $j \neq k$ , the firm switches to another auditor  $j$ . The modeling assumption on the non-Big 4 auditing firms implies that the only parameters that differentiate the two non-Big 4 auditors modeled are the iid error terms  $\epsilon_{t,5}$  and  $\epsilon_{t,6}$ . In other words,  $\forall k \in \{5, 6\}$ , the coefficients of the non-Big 4 auditors are identical, that is,  $\forall j$ ,  $\alpha_{5,j} = \alpha_{6,j}$ ,  $\theta_5 = \theta_6$ ,  $\delta_{5,j} = \delta_{6,j}$ ,  $\alpha_{j,5} = \alpha_{j,6}$ ,  $\delta_{j,5} = \delta_{j,6}$ . We can express the conditional value functions as

$$\text{For } j \neq k, v_j(x, k, \eta) = \alpha_{k,j} + \delta_{k,j}\eta + \beta\Pi(v_k(1, j, \eta) - \ln(p_k(1, j, \eta))) + \beta\Pi\gamma \quad (2.8)$$

$$v_k(x, j, \eta) = \alpha_{j,k} + \delta_{j,k}\eta + \beta\Pi(v_j(1, k, \eta) - \ln(p_j(1, k, \eta))) + \beta\Pi\gamma \quad (2.9)$$

$$v_k(x, k, \eta) = \theta_k x + \delta_{k,k}\eta + \alpha_{k,k} + \beta\Pi(v_j(x+1, k, \eta) - \ln(p_j(x+1, k, \eta))) + \beta\Pi\gamma.$$

Expression (2.8) and (2.9) are valid for any  $x$ . Thus,  $v_j(x, k, \eta) = v_j(1, k, \eta)$  and  $v_k(x, j, \eta) =$

$v_k(1, j, \eta)$ . Replacing  $v_k(1, j, \eta)$  by expression (2.9) into equation (2.8) yields:

$$\text{For } j \neq k, v_j(x, k, \eta) = v_j(1, k, \eta) = \alpha_{k,j} + \delta_{k,j}\eta + \beta\Pi \left\{ \alpha_{j,k} + \delta_{j,k}\eta + \beta\Pi \left[ v_j(1, k, \eta) - \ln(p_j(1, k, \eta)) \right] + \beta\Pi\gamma \right\} - \ln(p_k(1, j, \eta) + \beta\Pi\gamma)$$

Rearranging,

$$\text{For } j \neq k, (I - \beta^2\Pi^2)v_j(1, k, \eta) = \alpha_{k,j} + \delta_{k,j}\eta + \beta\Pi(\alpha_{j,k} + \delta_{j,k}\eta) + (\beta^2\Pi^2 + \beta\Pi)\gamma - \beta^2\Pi^2 \ln(p_j(1, k, \eta)) - \beta\Pi \ln(p_k(1, j, \eta)). \quad (2.10)$$

These above expressions are proven to be useful to derive the estimation procedure. Note that when the firm is not forward-looking, that is,  $\beta = 0$ , the choice specific value function becomes

$$v_j(1, k, \eta) = \alpha_{k,j} + \delta_{k,j}\eta,$$

which is simply the period utility of switching from auditor  $k$  to  $j$ . Accounting for dynamic decisions means that future choice probabilities become relevant for current decision making, which are captured by the terms multiplied by the discount factor  $\beta$ .

### 3 Sample Selection and Descriptive Statistics

We collect our sample from Audit Analytics from 2003 to 2015. We choose 2003 as our first year because of the implementation of SOX and the collapse of Arthur Andersen in 2002 that forced many firms to switch auditors and changed the audit industry concentration. When a firm chooses multiple auditors in a fiscal year (for about 4% of the entire sample), we retain the audit firm that receives the highest audit fee.

To construct our sample, we require non-missing auditor tenure observations and the previous year's auditor choice. First, to compute auditor tenure, the dates that firms initially hired an auditor must be available. Whenever Audit Analytics does not provide this information, we search for it from Compustat. Next, the previous fiscal year's auditor choice must be non-missing to ensure that we

properly accumulate auditor tenure. Our final sample contains 133,321 firm-year observations for which we have information for auditor tenure.

**Table 1:** Sample Selection

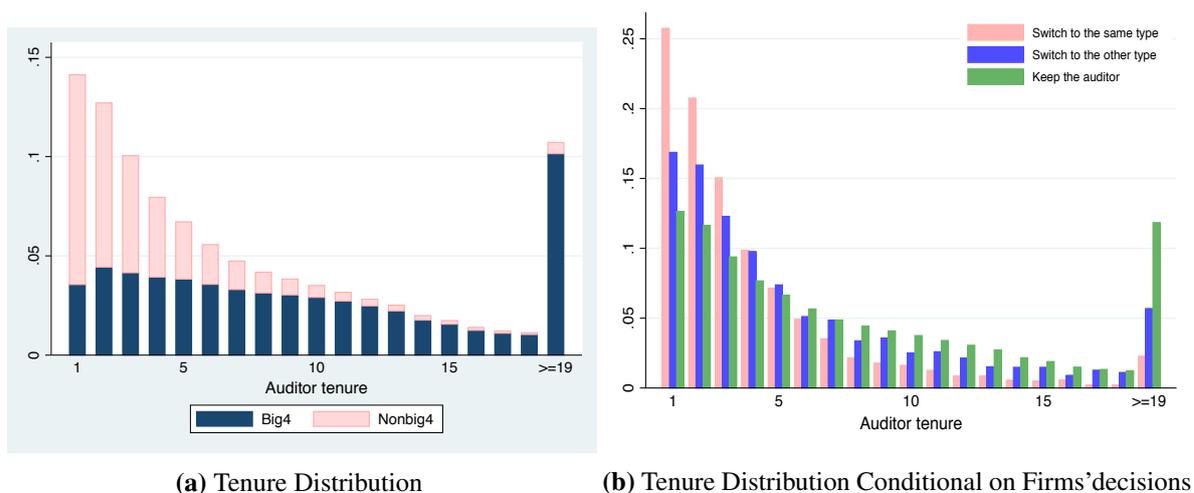
Sample selection	
Audit Analytics 2000-2015	196307
Keep the auditor receiving the highest audit fees in a year	(7949)
Keep year after 2002	(25489)
Drop firm-years that tenure and lagged tenure cannot be calculated	(29548)
Final	133321

For our estimation, we truncate auditor tenure at 19 years. This truncation point is the 90<sup>th</sup> percentile of the auditor tenure distribution. The estimated conditional choice probabilities that we estimate are likely to be inaccurate when auditor tenure is long, because both the number of firms and the auditor switching rate are very low. The truncation balances the loss of information with inaccurate conditional choice probability estimates.

Figure 1a displays the distribution of auditor tenure. The average auditor tenure is 7.3 years against a median of 5 years. Fewer firms have a long tenure. The percentage of firm years that have one year of tenure is 12.9%. The percentage that has 18 years of tenure is significantly lower, i.e., 1.2%. The distribution is right skewed: 42.2% of the firms have short tenures of less than 4 years. Non-Big 4 auditors have shorter tenures compared to Big 4 auditors, which is consistent with clients of non-Big 4 auditors having higher switching rate. Overall the tenure of Big 4 auditors is more evenly distributed than non-Big 4 auditors.

Figure 1b exhibits the tenure distribution conditional on firms' decisions, i.e., whether they keep the auditor, switch to another auditor of the same type or to a different type. Most of the switches to the same type of auditor are concentrated in the early years of tenure, below or equal to 5 years of tenure. Beyond 5 years of tenure, the switches to another type of auditor are higher than the switches to the same type. The majority of the observations when the firm decides to keep the auditor are also concentrated with a tenure less than 5 years.

Figure 2 illustrates the effect of auditor tenure on the probability of switching to another auditor, differentiating between the incumbent auditor being a Big 4 or a non-Big 4. As auditor tenure

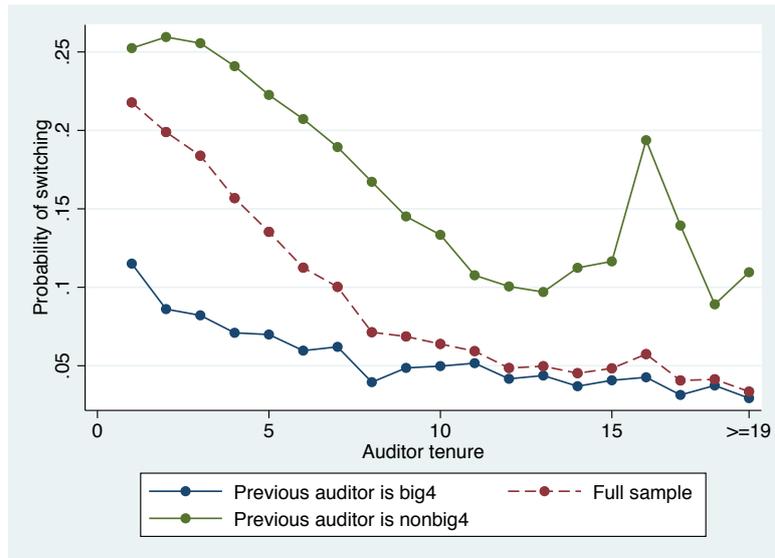


**Figure 1: Tenure and Firm's Decisions**

increases, the probability of switching to another auditor decreases overall, illustrating the learning curve between the client firm and the auditor. However, we observe a jump in the probability of switching when the incumbent auditor is a non-Big 4, but the estimate is likely to be inaccurate because the number of observations in this category is only 160. The probability of switching when the incumbent auditor is a Big 4 does not feature any anomaly and steadily decreases as auditor tenure increases, and consistently remains below the probability of switching when the incumbent auditor is a non-Big 4, ranging from 12% after 1 year of tenure to 1% after 19 and above years of tenure for a Big 4 against 25% after 1 year of tenure to 11% after 19 and above years of tenure for a non-Big 4.

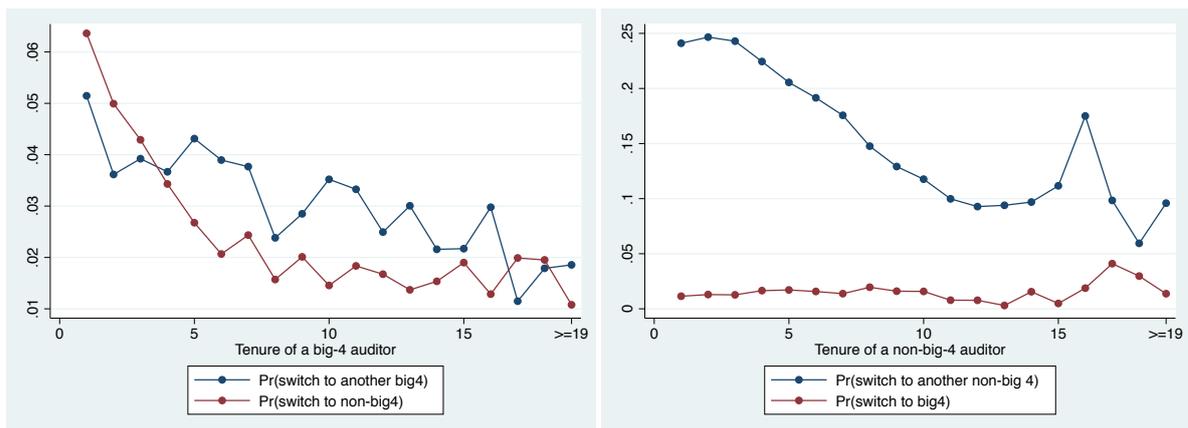
The negative relation between auditor tenure and auditor switch provides support that auditor tenure is a determining factor in explaining the decision to keep or switch auditing firms. Clearly, the distinction between Big 4 and a non-Big 4 auditing firm matters in the firm's decision to switch. A Big 4 auditor seems to make the probability of switching significantly lower especially after a tenure of 8 years, where the probability of switching drops below 5%, plausibly because the quality of the match between the client firm and the auditor is established, or the auditor has an informational advantage about the firm over his competitors that significantly increases the firm's switching costs, and the potential strong negative market response to a switch after a relatively long tenure might constrain the firm to keep its auditor.

We further decompose in Figure 3 the probability of switching to another auditor of a different



**Figure 2:** Tenure and Probability of Switching

type or the same type as a function of the tenure of the incumbent auditor. On the left hand side Figure 3a shows the probability of switching given the incumbent auditor firm is a Big 4. With a Big 4 incumbent auditor, firms rarely decide to switch to another auditing firm. When tenure with a Big 4 is shorter than four years, the firm is slightly more likely to switch to a non-Big 4. Beyond 4 years, the probability of switching to another Big 4 auditor is slightly larger than to a non-Big 4, but remain at low levels, roughly 4%. As tenure increases, the probabilities of switching quickly drop below 4% after 6 years of tenure.



**(a)** Big 4 Incumbent Auditor

**(b)** Non-Big 4 Incumbent Auditor

**Figure 3:** Probability of Switching for Big 4 and non-Big 4 as a Function of Tenure

In Figure 3b, the probability of switching with a non-Big 4 auditor exhibits very different patterns:

the probability of switching to another non-Big 4 is significantly larger ranging from roughly 25% between 1 and 3 years of tenure to 5% after 18 years of tenure. Given a tenure of less than 11 years with an incumbent non-Big 4 auditor, the probability of switching remains at relatively high levels but sharply drops from 25% with a tenure less than 3 years to 10% after 11 years of tenure. The probability stabilizes from 11 to 15 years to 10%, and temporarily increases at 16 years to attain lower levels of less than 10% of probability of switching. The increase is partially driven by bad firm performance.

## 4 Estimation

### 4.1 Baseline Model Estimation

From Hotz and Miller (1993) we know that when  $x$  is an observed variable, we can substitute a first-stage estimate,  $\hat{p}_1(x)$ , for  $p_1(x)$ . We can now derive the likelihood of replacing the auditor given the first-stage conditional choice probabilities. Writing  $\hat{p}_1$  as the vector of conditional choice probabilities and  $d_{nt} \equiv \{d_{nt,1}, d_{nt,2}\}$ , we denote the likelihood value for auditor  $n$  at time  $t$  by  $l(d_{nt}|x_{nt}, s_n, \hat{p}_1)$  given by the expression:

$$\frac{d_{nt,1} + d_{nt,2}e^{v_2(x,s)-v_1(x,s)}}{1 + e^{v_2(x,s)-v_1(x,s)}}. \quad (4.1)$$

We can run a multinomial logit to estimate in second-stage the parameters. Rust (1987) shows that the discount factor  $\beta$  is poorly identified. To run the estimation, we set  $\beta = 0.92$ , which corresponds to an equity premium of 8.7%. The results are not sensitive to  $\beta = 0.9$  (an equity premium of 11%) or  $\beta = 0.95$  (an equity premium of 5.3%).

### 4.2 Extended Model Estimation

#### Estimation without the transition matrix

We first estimate the model by assuming the state space is a singleton, that is  $\Pi = 1$ , and the conditional value functions do not depend on  $\eta$ . We simplify the conditional value functions to the

following expressions.

$$\begin{aligned}
\text{For } j \neq k, v_j(1, k) &= \frac{1}{1 - \beta^2} [\alpha_{k,j} + \beta \alpha_{j,k} - \beta^2 \ln(p_j(1, k))] - \beta \ln(p_k(1, j)) \\
&\quad + \beta^2 \gamma + \beta \gamma. \\
v_k(x, k) &= \theta_k x + \alpha_{k,k} - \beta \ln(p_j(x + 1, k)) + \frac{1}{1 - \beta^2} (\beta^2 \gamma + \beta \gamma) \\
&\quad + \frac{\beta}{1 - \beta^2} [\alpha_{k,j} + \beta \alpha_{j,k} - \beta^2 \ln(p_j(1, k))] - \beta \ln(p_k(1, j)).
\end{aligned}$$

We now normalize by the conditional value function  $v_j(x, k)$  for  $j \neq k$ . We can write the CCP of replacing the auditor  $k$  with  $x$  years of experience by auditor  $j$  as:

$$p_j(x, k) = \frac{1}{1 + \sum_{i \neq j} e^{v_i(x, k) - v_j(x, k)}}. \quad (4.2)$$

The conditional value function differences  $v_i(x, k) - v_j(x, k)$  can be further classified into two cases: (1) keeping the incumbent  $k$  relative to switching to a different auditor  $k, j \neq k$ , (2) switching to one auditor  $i$  relative to switching to another  $j$  when incumbent auditor is  $k, i \neq j \neq k$ :

$$\begin{aligned}
\text{For } j \neq k, \quad v_k(x, k) - v_j(x, k) &= \theta_k x + \alpha_{k,k} - \frac{1}{1 + \beta} \alpha_{k,j} - \frac{\beta}{1 + \beta} \alpha_{j,k} \\
&\quad - \beta \ln(p_j(x + 1, k)) + \frac{\beta^2}{1 + \beta} \ln(p_j(1, k)) + \frac{\beta}{1 + \beta} \ln(p_k(1, j)). \\
\text{For } i \neq j \neq k, \quad v_i(x, k) - v_j(x, k) &= \frac{1}{1 - \beta^2} [\alpha_{k,i} + \beta \alpha_{i,k}] - \frac{1}{1 - \beta^2} [\alpha_{k,j} + \beta \alpha_{j,k}] \\
&\quad + \frac{1}{1 - \beta^2} [-\beta^2 \ln(p_i(1, k)) - \beta \ln(p_k(1, i)) + \beta^2 \ln(p_j(1, k)) + \beta \ln(p_k(1, j))].
\end{aligned}$$

Estimating the model using a logit requires specifying a baseline group, which is chosen as non-big4, say auditor 5. Because we do not differentiate the identity of non-Big 4 auditors, we impose the following constraints:  $\theta_5 = \theta_6$ ,  $\alpha_{5,5} = \alpha_{6,6}$ ,  $\alpha_{5,k} = \alpha_{6,k}$  and  $\alpha_{k,5} = \alpha_{k,6} \forall k \in \{1, 2, 3, 4\}$ .

1. The difference between the conditional value of switching to another auditor different from auditor 5 and the conditional value of switching to auditor 5 yields

$\forall k \neq 5$  and  $k \neq j$ ,

$$\begin{aligned} v_j(x, k) - v_5(x, k) &= A_{j,k} + \frac{\beta^2}{1 - \beta^2} [\ln(p_5(1, k)) - \ln(p_j(1, k))] \\ &\quad + \frac{\beta}{1 - \beta^2} [\ln(p_k(1, 5)) - \ln(p_k(1, j))]. \end{aligned}$$

2. The difference between the conditional value of keeping the same auditor different from auditor 5 and the conditional value of switching to auditor 5 yields

$\forall k \neq 5, k = j$ ,

$$\begin{aligned} v_j(x, j) - v_5(x, j) &= A_{j,j} + \theta_j x - \beta \ln(p_5(x + 1, j)) \\ &\quad + \frac{\beta^2}{1 + \beta} \ln(p_5(1, j)) + \frac{\beta}{1 + \beta} \ln(p_j(1, 5)). \end{aligned}$$

3. The difference between the conditional value of switching from auditor  $k = 5$  to auditor  $j \neq k$ , that is,  $\forall j \in \{1, 2, 3, 4, 6\}$  the conditional value of keeping auditor 5 yield

$$\begin{aligned} v_j(x, 5) - v_5(x, 5) &= A_{j,5} - \theta_5 x + \beta \ln(p_j(x + 1, 5)) \\ &\quad - \frac{\beta^2}{1 + \beta} \ln(p_j(1, 5)) - \frac{\beta}{1 + \beta} \ln(p_5(1, j)). \end{aligned}$$

where

$$\begin{aligned} A_{j,k} &= \frac{1}{1 - \beta^2} (\alpha_{k,j} - \underbrace{\alpha_{k,5}}_{=0} + \beta \alpha_{j,k} - \beta \alpha_{5,k}) \quad \text{for } k \neq 5 \text{ \& } k \neq j \\ A_{jj} &= -\frac{1}{1 + \beta} (\underbrace{\alpha_{j,5}}_{=0} + \beta \alpha_{5,j}) + \alpha_{j,j} \quad \text{for } k \neq 5 \text{ \& } k = j \\ A_{j,5} &= \frac{1}{1 + \beta} (\alpha_{5,j} + \beta \underbrace{\alpha_{j,5}}_{=0}) - \alpha_{5,5} \quad \text{for } k = 5 \text{ \& } k \neq j. \end{aligned}$$

To identify the model, we set  $\alpha_{k,5} = 0, \forall k \in \{1, 2, 3, 4, 6\}$ . All the normalizations boil down to capturing that regardless of the identity of the incumbent auditor, replacing it by a non-Big 4 yields

the same start up costs  $\alpha_{k,5}$ . This assumption is realistic given that we do not differentiate the identity of non-Big 4 auditors.

### Estimation routine

To use the multi logit built-in function *asclogit*, we need to create the choice-specific indicator variables:  $\mathbb{1}_{k \neq 5, k \neq j}$ ,  $\mathbb{1}_{k \neq 5, k = j}$  and  $\mathbb{1}_{k = 5, k \neq j}$ . We can then have:

$$\begin{aligned}
& v_j(x, k) - v_5(x, k) \\
&= \mathbb{1}_{k \neq 5, k \neq j} \left( A_{j,k} + \frac{\beta^2}{1 - \beta^2} [\ln(p_5(1, k)) - \ln(p_j(1, k))] + \frac{\beta}{1 - \beta^2} [\ln(p_k(1, 5)) - \ln(p_k(1, j))] \right) \\
&+ \mathbb{1}_{k \neq 5, k = j} \left( A_{j,j} + \theta_j x - \beta \ln(p_5(x + 1, k)) + \frac{\beta^2}{1 + \beta} \ln(p_5(1, j)) + \frac{\beta}{1 + \beta} \ln(p_j(1, 5)) \right) \\
&+ \mathbb{1}_{k = 5, k \neq j} \left( A_{j,5} - \theta_5 x + \beta \ln(p_j(x + 1, 5)) - \frac{\beta^2}{1 + \beta} \ln(p_j(1, 5)) - \frac{\beta}{1 + \beta} \ln(p_5(1, j)) \right). \quad (4.3)
\end{aligned}$$

To estimate the model, the data should be transformed into an alternative specific format, that is, each firm year will have 6 observations representing 6 potential alternatives that the firm can choose from. The estimation follows three steps.

The first step is to pre-compute all the choice probability terms using the sample average. For example,  $p_5(1, k)$  is simply the probability of choosing auditor 5 given an incumbent auditor  $k$  with one year tenure. Note that these probability terms are alternative specific, that is, they change depending on the potential auditor choice  $j$ . They also vary with the state variables, that is, the incumbent auditor identity  $k$  and tenure  $x$ . We name this alternative specific variable *dCCP*.

The second step is to multiply auditor tenure with the choice specific dummies as in (4.3). There are multiple ways to estimate the auditor-specific coefficients  $\theta_k$ . The simplest way is to create 6 interaction variables of the incumbent auditor dummy  $\mathbb{1}_k$  with adjusted incumbent auditor tenure  $\tilde{x}$ . When  $k \neq 5$ , the adjusted incumbent auditor tenure takes zero if the potential choice is not  $k$ , and  $x$  if the potential choice is  $k$ . When  $k = 5$ , the adjusted incumbent auditor tenure is just  $x$ . Specifically,

this means

$$\mathbb{1}_{k \neq 5} \tilde{x} = \begin{cases} 0 & \text{if } j \neq k \\ x & \text{if } j = k \end{cases}, \quad (4.4)$$

$$\mathbb{1}_{k=5} \tilde{x} = x \quad \forall j, \quad (4.5)$$

where the first line of (4.4) corresponds to the first line of (4.3), the second line of (4.4) corresponds to the second line of (4.3), and (4.5) corresponds to the third line of (4.3).

The reason for doing the adjustment above is to avoid creating too many dummy variables, which can make the estimation messy. The stata package *asclogit* distinguishes between alternative specific variables and alternative invariant variables. From (4.3) and (4.5), when the incumbent auditor is 5,  $\mathbb{1}_{k=5} \tilde{x}$  is not alternative variant because the term appears in all alternatives  $j$  and therefore should be put into the alternative invariant category.<sup>7</sup> In contrast, when the incumbent auditor is not 5,  $\mathbb{1}_{k \neq 5} \tilde{x}$  is alternative variant because it appears only for alternative  $k = j$ .

The third step is to estimate an alternative specific logit model *asclogit*. The choice specific terms include the choice probability terms from the first step *dCCP* and the adjusted tenure variable from the second step  $\mathbb{1}_{k \neq 5} \tilde{x}$ . The choice invariant terms include the incumbent auditor dummy as well as the adjusted tenure variable from the second step  $\mathbb{1}_{k=5} \tilde{x}$ .

### Estimation with the transition matrix

We extend the estimation to accommodate for more richness in the state variables.

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<sup>7</sup>The reason why tenure matters and the effect is not alternative variant is that the choice specific value difference is relative to keeping Auditor 5.

1.  $v_j(x, k, \eta) - v_5(x, k, \eta), \forall k, j \in \{1, 2, 3, 4, 6\}$  and  $k \neq j$ .

$$\begin{aligned}
v_j(x, k, \eta) - v_5(x, k, \eta) &= (I - \beta^2 \Pi^2)^{-1} \left\{ \alpha_{k,j} + \delta_{k,j} \eta \underbrace{-\alpha_{k,5} - \delta_{k,5} \eta}_{\text{disappears as baseline group}} \right. \\
&\quad \left. + \beta \Pi(\alpha_{j,k} + \delta_{j,k} \eta) - \beta \Pi(\alpha_{5,k} + \delta_{5,k} \eta) - \beta \Pi \left( \ln(p_k(1, j, \eta)) - \beta \Pi \ln(p_k(1, 5, \eta)) \right) \right. \\
&\quad \left. - \beta^2 \Pi^2 \left( \ln(p_j(1, k, \eta)) - \beta \Pi \ln(p_5(1, k, \eta)) \right) \right\} \\
&= (I - \beta^2 \Pi^2)^{-1} \left\{ \left[ \alpha_{k,j} + \delta_{k,j} \eta + \beta \Pi \left( (\alpha_{j,k} + \delta_{j,k} \eta) - (\alpha_{5,k} + \delta_{5,k} \eta) \right) \right] \right. \\
&\quad \left. + \beta^2 \Pi^2 \left( \ln(p_5(1, k, \eta)) - \ln(p_j(1, k, \eta)) \right) + \beta \Pi \left( \ln(p_k(1, 5, \eta)) - \ln(p_k(1, j, \eta)) \right) \right\}.
\end{aligned} \tag{4.6}$$

To deal with this case, we can pre-compute  $(I - \beta^2 \Pi^2)^{-1} \eta$  for each observation. Each row of  $(I - \beta^2 \Pi^2)^{-1}$  indexes the current size, so  $(I - \beta^2 \Pi^2)^{-1} \eta$  is a discounted size. The same applies to the probabilities.

2.  $\forall k \in \{1, 2, 3, 4, 6\}$ .

$$\begin{aligned}
v_k(x, k, \eta) - v_5(x, k, \eta) &= \theta_k x + \delta_{kk} \eta + \alpha_{kk} - (I - \beta \Pi)(I - \beta^2 \Pi^2)^{-1} \left( \alpha_{k5} + \delta_{k5} \eta + \beta \Pi(\alpha_{5k} + \delta_{5k} \eta) \right. \\
&\quad \left. - \beta \Pi \left( \ln(p_k(1, 5, \eta)) + \beta \Pi \ln(p_5(1, k, \eta)) \right) \right) - \beta \Pi \ln(p_5(x+1, k, \eta)) \\
&= \theta_k x + \delta_{kk} \eta + \alpha_{kk} - (I - \beta \Pi)(I - \beta^2 \Pi^2)^{-1} \left( \alpha_{k5} + \delta_{k5} \eta + \beta \Pi(\alpha_{5k} + \delta_{5k} \eta) \right) \\
&\quad + (I - \beta \Pi)(I - \beta^2 \Pi^2)^{-1} \beta \Pi \left( \ln(p_k(1, 5, \eta)) + \beta \Pi \ln(p_5(1, k, \eta)) \right) - \beta \Pi \ln(p_5(x+1, k, \eta)).
\end{aligned} \tag{4.7}$$

3.  $v_j(x, 5, \eta) - v_5(x, 5, \eta), \forall j \in \{1, 2, 3, 4, 6\}$ .

$$\begin{aligned}
& v_j(x, 5, \eta) - v_5(x, 5, \eta) \\
&= -\theta_5 x - \delta_{55} \eta - \alpha_{55} + (I - \beta \Pi)(I - \beta^2 \Pi^2)^{-1} \left( \alpha_{5j} + \delta_{5j} \eta + \beta \Pi(\alpha_{j5} + \delta_{j5} \eta) \right) \\
&- (I - \beta \Pi)(I - \beta^2 \Pi^2)^{-1} \beta \Pi \left( \ln(p_5(1, j, \eta)) + \beta \Pi \ln(p_j(1, 5, \eta)) \right) + \beta \Pi \ln(p_j(x + 1, 5, \eta)).
\end{aligned} \tag{4.8}$$

From the derivations above, one can see that we have the discrete choice analogy. All conditional value function differences can be expressed in the form:

$$A(x, k, j, \eta; \Theta) + B(x, k, j, \eta),$$

where  $B$  depends only on the choice probabilities and the transition matrix  $\Pi$ .

## 5 Results

### 5.1 Baseline Model Results

Our baseline model accommodates for dynamics in a very simple way and can easily compare the static and dynamic models. In the dynamic model, the period payoff at period  $t$  from choice  $d_t$  is the same as the utility from the static problem, except that the observed state variable  $x_t$  and idiosyncratic error terms  $\epsilon_t$  are subscripted by time.

In Table 2, we report the coefficients of the multinomial logit for the static and dynamic models. If a firm decides to switch, it incurs a period cost  $\theta_0$  relatively to retaining the auditor in both the dynamic and static model. These costs are of the same magnitude for the dynamic and static model, 1.157 and 1.167 respectively. However, the estimation returns a very different output for the effect of auditor tenure because in the dynamic model, the firm makes decisions in multiple time periods, taking into account how its decision today impacts the value of making subsequent decisions tomorrow. The coefficient of the static model on auditor tenure of 0.132 is four times higher than the coefficient of 0.026 of the dynamic model. This difference is due to the additional structure in the dynamic

model that allows to disentangle the period utility from the expected future utility, and clearly provides evidence that the expected future value significantly changes the magnitude of the coefficient on auditor tenure.

**Table 2:** Auditor tenure and the decision to keep incumbent auditors

We estimate the decision of a firm to keep its incumbent auditor as a function of auditor tenure. Column (1) reports the results of the dynamic model in (2.6):

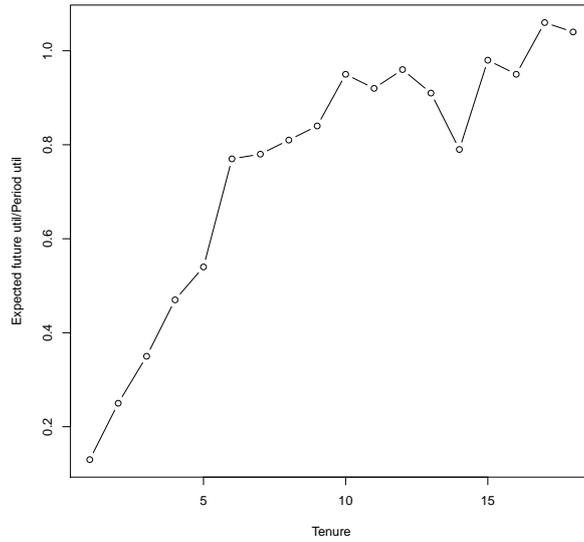
$$v_2(x) - v_1(x) = \theta_0 + \theta_1 x + \beta \{ \log [p_0(1)] - \log [p_0(x + 1)] \}.$$

Column (2) reports the result of a static model assuming  $\beta = 0$ . Bootstrapped standard errors are in the parenthesis.

	Dynamic-Rust model Keeping incumbent=1	Static Keeping incumbent=1
Auditor tenure ( $\theta_1$ )	0.026 (0.001)	0.132 (0.003)
Constant ( $\theta_0$ )	1.157 (0.024)	1.167 (0.015)

In Figure 4, we use equation (2.6) to measure the ratio of the expected future utility or value function to the period utility of retaining the same auditor relatively to replacing him, as a function of tenure. The ratio is steadily increasing in the auditor tenure. After 7 years of auditor tenure, the value function of retaining the auditor relatively to switching already accounts for 76.9% of the period utility. Beyond 11 years, the growth flattens, and the value function stabilizes at a level equal to the period utility. Overall, the importance of the expected future utility in retaining the same auditor increases over time. The fact that increase in value function slows down after 7 years suggests that 7 years is sufficient for the firm to determine whether the auditor is a good match, or alternatively, for the auditor to know the firm.

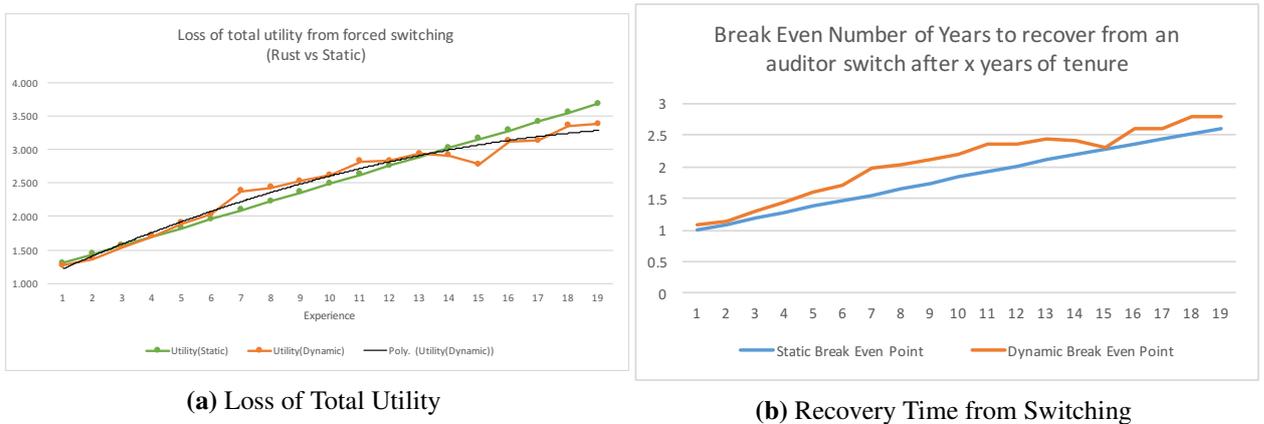
Figure 5 reports the results of a simple and intuitive counterfactual analysis. We want to examine the effect in terms of total utility loss (in the present and in the future) of mandatory auditor rotation. Figure 5a compares the total utility loss of mandatory rotation to the firm as a function of auditor tenure in the dynamic and static model. In the dynamic model, a very short auditor tenure of less than 2 years is associated with a low total utility loss. However any additional year of tenure increases the value of the auditor to the firm, and between 2 and 7 years of auditor tenure, the firm's total utility loss grows fast. After 7 years of auditor tenure, the growth rate of the total utility loss slows down



**Figure 4:** The expected future utility relative to period utility - Rust model

until 13 years of tenure. Between 7 and 13 years of tenure the total utility loss in the dynamic model is larger than in the static model because the expected future value plays more weight in the overall total utility of the firm. Beyond 13 years, the total utility’s growth in the dynamic model slows down, and hence, the utility of the static model that grows proportionally to the auditor tenure overcome the total utility in the dynamic model.

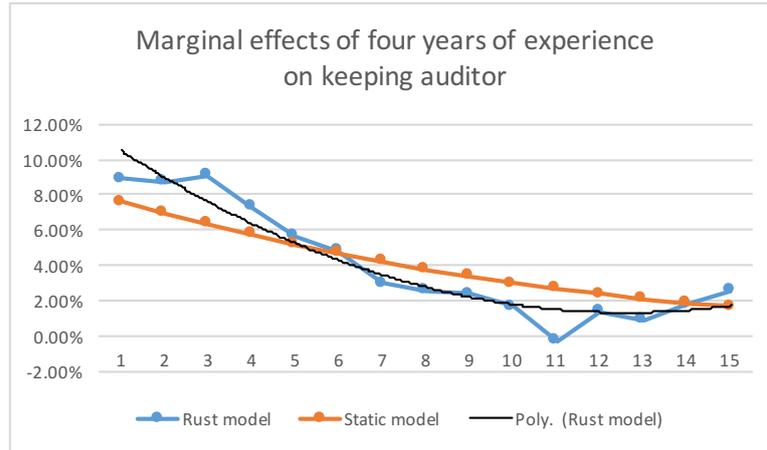
To better understand the consequences of mandatory rotation, we evaluate the average number of years a firm needs to retain its subsequent auditor to break even. The exercise is to provide an intuitive number to facilitate comparisons across various cases. Specifically, a mandatory rotation imposes a



**Figure 5:** Consequences of Forced Switching

total utility loss to the firm. The newly hired auditor brings future utilities that are increasing in his tenure captured by the period utilities. We assume no discounting in the period utilities for simplicity to determine the break even number of years. For example, in the dynamic model, if a firm switches to another auditor after 1 year of auditor tenure, it loses in total 1.267 utility units. If it were to keep the subsequent auditor 1 and 2 years, it would gain 1.184 utility units in the first year and 1.210 utility units in the second year. Hence, the break even point is at  $1 + (1.267 - 1.184)/1.210 = 1.069$  years. In the static model, we apply the same reasoning, noting that in this special case, the total utility loss equals the period utility loss. By construction the number of years to break even after a switch from an auditor with a tenure of a given number of years is linear in the auditor tenure. In Figure 5b, we analyze the trend of the break even number of years for the firm to recover from mandatory rotation. The firm's break-even point mirrors the impact of the expected future utility to recover from the initial total utility loss of switching. As time passes, the firm forgoes larger expected future utility losses, translating into a larger number of years to break even in the dynamic model than in the static model that fails to account for any long term consequences. If the auditor tenure is relatively short, i.e., less than two years, the recovery time is quick, less than 1.149 years. The recovery time quickly increases attaining 2.027 years if the firm replaces an auditor after 7 years of tenure. The number of years to break even continues to increase, but at a much slower pace, if the switch occurs beyond 7 years, mirroring the slowdown in the firm's expected future utility growth. If we interpret the results from the perspective of learning the matching quality between auditor and clients, learning seems to be most valuable between 3 to 11 years of auditor tenure. Beyond 11 years, the break-even number of years gradually levels out, meaning less new knowledge is gained over time whether this knowledge is about the match quality or learning by doing. In contrast, the static model fails to capture any deceleration in the learning curve because auditor tenure linearly affects the firm's utility.

Figure 6 reports the incremental probability of keeping the auditor for 4 additional years as a function of the current auditor tenure. In the static model, the incremental probability of keeping the auditor for 4 additional years almost linearly decreases, and by construction, points to the largest incremental probability of keeping the auditor after 1 year of tenure. Instead, the dynamic model suggests that increasing auditor tenure by 4 years is the most valuable if there is an existing relationship between the auditor and the firm of 3 years. Extending auditor tenure by 4 years has a bigger impact in



**Figure 6: Marginal Effects of Tenure**

the dynamic model in keeping the incumbent auditor if the initial auditor tenure is below 6 years. The incremental effect of 4 years of tenure weakens with initial auditor tenures between 7 and 11 years up to the point where it even has a negative impact of -0.3% on the probability of keeping the auditor from 11 to 15 years. Beyond 11 years of tenure, keeping the auditor for 4 additional years has a positive effect on the incremental probability of retaining the auditor again, implying the firm benefits slightly from very long auditor tenures. Beyond 7 years of auditor tenure 4 years of extended tenure does not increase the probability of keeping the auditor by a large percentage ranging from -0.3% to 2.99%. The marginal effects analysis reinforces the finding that the learning curve is especially steep in the early years of the auditor tenure. Overall between 5 and 10 years of tenure are crucial learning years for the firm. The result also suggests that inference can differ when using a dynamic model relative to a static model.

## 5.2 Extended Model

We estimate the firm’s choice to keep or retain its auditor when it can choose among five other individual auditors. However the focus of the estimation is on differentiating between the Big 4 and non-Big 4 auditing firms. We regroup the Big 4 auditing firms in one category and leave the other non-Big 4 in another one. We set the coefficients of the different auditors belonging to each subgroup to be equal.

Panel A and B of Table 3 report the coefficients of the estimation in the dynamic and static models. The intercept  $\alpha_{ii}$  represents the value of keeping auditor  $i$  against switching to the non-Big 4 auditor

5. The intercepts are positive because if the firm switches to a non-Big 4, it incurs start up and search costs, and it loses the idiosyncratic audit quality that it attributes to its incumbent auditor if it decides to switch. Overall the intercepts  $\alpha_{ii}$  associated with keeping a Big 4 are higher than with keeping a non-Big 4 relatively to switching to a non-Big 4 in the static and dynamic model. The coefficients on tenure are in general not significant for the Big 4 in the dynamic model and are significantly positive in the static model plausibly because the estimation in the dynamic model is noisier.

Because the key feature of interest is the effect of the auditor size on the firm's decisions, we focus on the constrained model where we estimate the different coefficients for the Big 4 versus the non-Big 4 by setting  $\forall k \in \{1, 2, 3, 4\}$ , the coefficients  $\alpha_{kk}$ ,  $\alpha_{5k}$ ,  $\alpha_{k5}$  and  $\theta_k$  to be identical across the Big 4. Panel C and D of Table 3 present the results of the constrained model in both the dynamic and the static model. All the coefficients are capturing the incremental effect relatively to switching to the non-Big 4, auditor 5.

In the dynamic model, the intercept for keeping a Big 4 auditor relatively to switching to the non-Big 4 auditor 5 of 1.213 is slightly higher than the coefficient for keeping a non-Big 4 of 1.100. However, the difference is not statistically different. If the firm has a Big 4 as an incumbent auditor, it incurs an incremental cost of 2.922 in the short run to switch to another Big 4 versus a non-Big 4. Although Big 4 auditors are typically seen as more alike than non-Big 4 auditors, the firm still incurs more cost to switch to another Big 4 in the short run because the market might react more negatively to such a decision and the new Big 4 auditor might charge higher prices to compensate for his risk to take on a new client. Our result also shows an even higher Big 4 premium in the short run when the firm switches from a non-Big 4 to a Big 4, and bears additional start up costs and expertise costs of 6.317, twice as big as for a firm with a Big 4 incumbent auditor and switching within the Big 4 auditors. The learning curve is almost twice faster with a Big 4 versus a non-Big 4, although the coefficient  $\theta_{Big4}$  of 0.010 is marginally significant.<sup>8</sup> It takes less time for a Big 4 auditor to get up to speed with the business — to identify the risk areas and familiarize himself with how the firm works.

The static model, in contrast, does not exhibit the same magnitudes across auditor types. The value of keeping a Big 4 auditor is higher whereas the cost of switching is lower in magnitude compared to the dynamic model because the static model does not take into account the long run effects

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<sup>8</sup>To estimate the conditional choice probabilities, we use a bin estimator that might be noisier than using a logit estimation, and might explain the insignificance of the tenure parameter for the Big4.

**Table 3:** Auditor tenure, size, and rotation – extended model

This table presents results for our extended model. Panel A and B present coefficients estimates for both the dynamic and static models, allowing for different coefficients for each of the Big 4 auditors. Panel C and D present coefficient estimates for the dynamic and static models, constraining all Big 4 auditors to have the same coefficients. We report 90% confidence intervals from 200 times bootstrapping.

Panel A: Unconstrained model (Dynamic)

$\alpha$	1	2	3	4	5	$\theta$	
1	1.139 [0.857,3.416]	-2.628 [-6.618,3.716]	-1.375 [-5.890,4.178]	-1.042 [-4.810,4.604]	0.000	$\theta_1$	0.012 [-0.013,0.030]
2	-2.162 [-8.264,2.304]	1.325 [1.119,2.001]	-1.622 [-6.242,1.939]	-1.277 [-4.809,2.156]	0.000	$\theta_2$	-0.017 [-0.038,0.001]
3	-2.075 [-7.251,2.396]	-3.507 [-6.781,1.123]	1.166 [0.092,2.835]	-2.341 [-5.276,1.880]	0.000	$\theta_3$	-0.013 [-0.034,.0120]
4	-3.588 [-8.679,0.167]	-4.637 [-7.788,-1.012]	-3.274 [-6.831,0.127]	1.058 [0.757,3.314]	0.000	$\theta_4$	0.028 [0.009,0.044]
5	-6.474 [-6.938,-6.038]	-5.989 [-6.375,-5.638]	-6.235 [-6.677,-5.819]	-6.034 [-6.50,-5.636]	1.106 [1.068,1.152]	$\theta_5$	0.006 [0.003,0.010]

Panel B: Unconstrained model (Static)

$\alpha$	1	2	3	4	5	$\theta$	
1	3.423 [3.324,3.527]	-0.076 [-.216,.067]	0.093 [-.043,.229]	0.059 [-.086,.193]	0.000 [0,0]	$\theta_1$	0.110 [.101,.121]
2	-0.271 [-.429,-.153]	3.931 [3.838,4.032]	-0.275 [-.415,-.13]	-0.002 [-.124,.121]	0.000 [0,0]	$\theta_2$	0.046 [.038,.056]
3	0.050 [-.1,.177]	-0.077 [-.251,.067]	3.878 [3.729,3.992]	-0.439 [-.639,-.264]	0.000 [0,0]	$\theta_3$	0.065 [.054,.077]
4	-0.551 [-.729,-.381]	-0.326 [-.489,-.168]	-0.726 [-.91,-.512]	3.565 [3.451,3.692]	0.000 [0,0]	$\theta_4$	0.068 [.057,.08]
5	-4.384 [-4.558,-4.261]	-4.000 [-4.117,-3.842]	-4.240 [-4.392,-4.128]	-4.084 [-4.212,-3.969]	0.997 [.973,1.021]	$\theta_5$	0.072 [.066,.078]

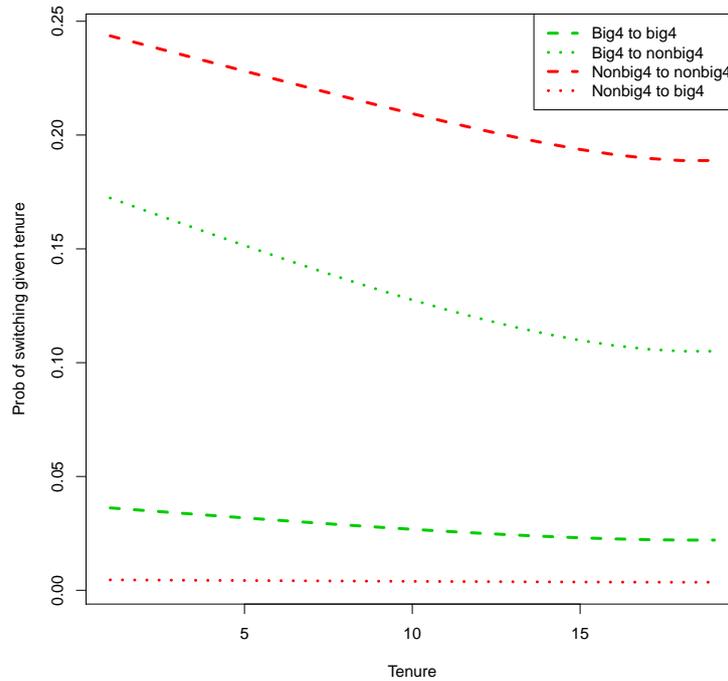
Panel C: Constrained model (Dynamic)

$\alpha_{\text{nonbig4 to big4}}$	$\alpha_{\text{big4 to big4}}$	$\alpha_{\text{keep big4}}$	$\alpha_{\text{keep nonbig4}}$	$\theta_{\text{nonbig4}}$	$\theta_{\text{big4}}$
-6.317 [-6.565,-6.097]	-2.922 [-3.301,-2.662]	1.213 [.938,3.085]	1.100 [1.065,1.147]	0.006 [.003,.01]	0.010 [-.005,.03]

Panel D: Constrained model (Static)

$\alpha_{\text{nonbig4 to big4}}$	$\alpha_{\text{big4 to big4}}$	$\alpha_{\text{keep big4}}$	$\alpha_{\text{keep nonbig4}}$	$\theta_{\text{nonbig4}}$	$\theta_{\text{big4}}$
-4.1677 [-4.234,-4.092]	-0.1864 [-.238,-.126]	3.7118 [3.656,3.77]	0.9972 [.973,1.021]	0.0723 [.066,.078]	0.0719 [.066,.077]

of the firm’s decision and the coefficients absorb the short and long run effects. A major difference with the static model is related to the coefficient on keeping a Big 4 of 3.7118 much higher than the coefficient on keeping a non-Big 4 of 0.9972, and the coefficient on tenure is roughly the same for both types of auditors, 0.07.

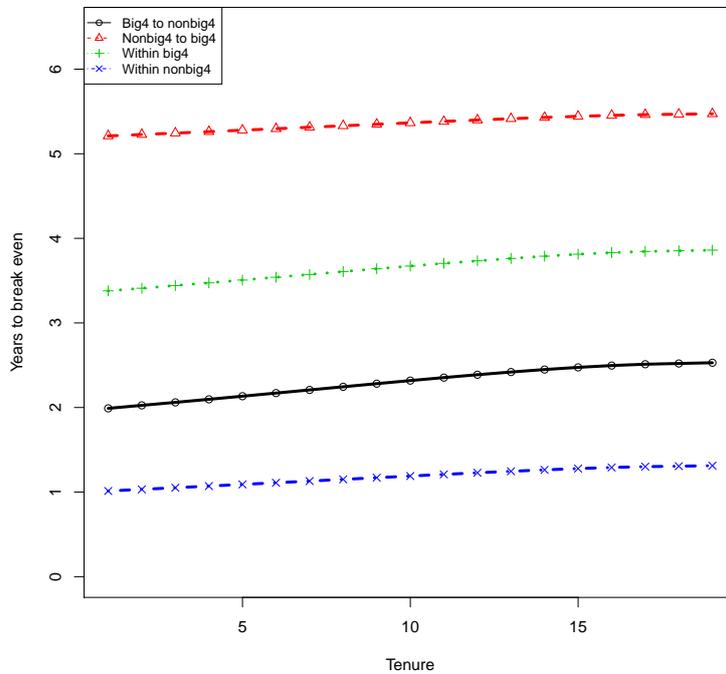


**Figure 7:** Tenure and Probability of Switching

Figure 7 shows the probability of switching conditional on tenure. The probability of switching to a non-Big 4 is bigger than switching to a Big 4, regardless of the type of the incumbent auditor, and declines as tenure increases by roughly 5% after 15 years of tenure. The effect of tenure on the probability of switching to a Big 4 has very little impact. This graph shows that once we introduce the effect of auditor size to explain firms’ decisions to switch, tenure plays a secondary role in determining whether to switch.

To evaluate the effect of mandatory auditor rotation when the firm can switch to an auditor of the same type or to a different type, we repeat the same analysis as in Figure 5. We determine in this context the number of years that a firm needs to keep the same auditor to recover from the total utility loss after switching from an incumbent auditor with a given tenure. The results are displayed

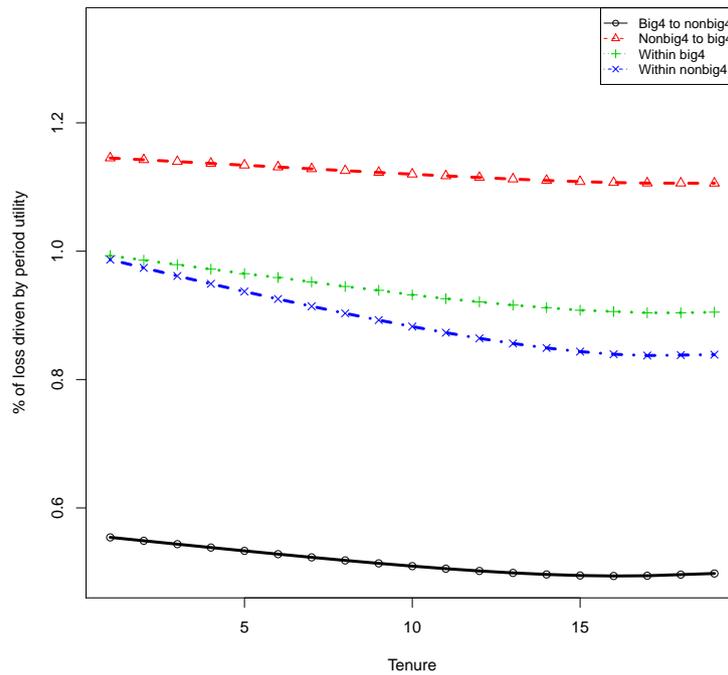
in Figure 8. To understand the importance of forward-looking incentives in driving the results, we present in Figure 9 the proportion of loss driven by the period utility.



**Figure 8:** Consequences of Forced Switching (Extended Model – Dynamic)

When a firm has a Big 4 incumbent auditor, the break even number of years to recover from a switch is higher if the firm switches to another Big 4 than if it chooses to switch within the Big 4 auditing firms. If the switch occurs within the Big 4 (to a non-Big 4), it ranges from 4.174 years (2.575 years) after a switch from an auditor with a one-year tenure to 4.777 years (2.811 years) after a switch from an auditor with a 19-year tenure. The incumbent auditor tenure does not dramatically change the recovery time. The recovery time barely increases by roughly 7 months if the incumbent auditor tenure is 19 years. The total utility loss due to switching relatively to keeping the Big 4 incumbent auditor is mainly due to the period utility loss if the switch occurs within the Big 4, which represents at least 90% of the total utility loss. In contrast, the total utility loss if the switch occurs to a non-Big 4 is evenly split between the period utility loss and the future expected utility loss, regardless of the tenure of the incumbent auditor.

A firm starting with a non-Big 4 auditor experiences very different recovery times depending

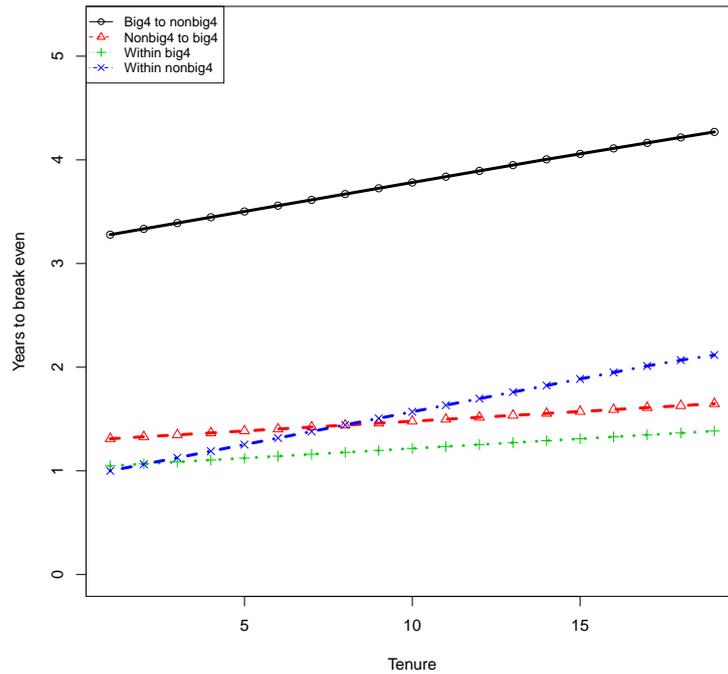


**Figure 9:** The contribution of period utility to the total loss (Extended Model – Dynamic)

on its switching choice: if it switches to another non-Big 4, the recovery time is extremely quick, typically 1 year and a couple of months regardless of the tenure of the incumbent auditor. However a firm experiences a much higher recovery time with a switch to a Big 4, roughly 5 times higher if the incumbent auditor’s tenure is less than 10 years. Switching to a Big 4 versus keeping a non-Big 4 is costly for the firm in terms of period utility losses. In contrast, the firm earns some future expected utility gain by choosing a Big 4. Switching to another non-Big 4 is associated with mainly period utility losses (at least 84%) and some expected utility losses that are slightly increasing in the tenure of the incumbent auditor, from 1% of total utility loss after a one- year tenure of the incumbent auditor through 12% of total utility loss after a 10-year tenure of the incumbent auditor to 16% of total utility loss after a 15-year tenure of the incumbent auditor.

To summarize, one striking feature is the fact that switching to a Big 4 regardless of the incumbent auditor’s type comes at a huge total utility loss: if the incumbent auditor is a Big 4, a switch to another Big 4 relatively to a switch to a non-Big 4 is on average 1.775 times more costly whereas if the incumbent auditor is a non Big 4, a switch to a Big 4 relatively to a switch to another non-Big 4

is even more costly, on average 5.128 times more. The total utility loss is mainly triggered by short run losses if the switch occurs to a Big 4, regardless of the incumbent auditor's tenure. A switch to a non-Big 4 auditor is associated with mainly period utility losses if the incumbent auditor is a non-Big 4, whereas the losses are more evenly distributed between the short and long run for a Big 4 incumbent auditor.



**Figure 10:** Consequences of Forced Switching (Extended Model – Static)

The static model shows different results. Figure 10 shows that the recovery time from a switch is quick if the firm chooses a Big 4, typically 1 year and a couple of months, because the value of a Big 4 is much higher than a non-Big 4 in the static model. A firm experiences a slower recovery time, i.e., 3.279 years after 1 year of tenure with the incumbent auditor to 4.270 years after 19 years of tenure with the incumbent auditor, if it switches from a Big 4 to a non-Big 4. This slower recovery time to switching to a non-Big 4 is mainly due to a lower period utility of keeping a non-Big 4 relatively to a Big 4.

### 5.3 Simulation and Counterfactual Analysis

From a theoretical point of view, a mandatory rotation rule could have both positive and negative implications.

Specifically, one of the main benefits that should accrue from imposing periodical audit firm changes is the increase in audit independence, which is believed to be impaired with long arrangements between the firm and the auditor. Second auditors earn as time passes client-specific quasi-rents (DeAngelo (1981)), and in order to avoid the loss of client-specific quasi-rent, the auditor has the incentive to act opportunistically, e.g., to soften audit controls, if this permits the incumbent auditor to retain the client in the future. Mandatory auditor rotation would mitigate this economic dependence. Third, auditors can also become less diligent as time passes, and mandatory rotation allows the new auditor to assess the financial situation of the firm with a fresh pair of eyes. Fourth, anticipating the venue of a new auditor, the incumbent auditor towards the end of its tenure will have further incentive to provide a diligent work given that his successor will have access to his worksheets. Finally but not least, mandatory rotation could force the firm to expand his choice set beyond the typical Big 4 oligopoly.

Such a rule, however, comes at a cost. Changing the auditor results in costs potentially borne by both parties, the auditor and the firm. On one hand, if the relationship between auditor and client ends, the incumbent auditor loses his client-specific quasi-rent stream (DeAngelo 1981). A potential consequence might lead the auditor to charge higher audit fees. On the other hand, the client firm might suffer from start-up costs, loss of client-specific knowledge, and this can be translated into loss of quality of the service delivered. Specifically, the auditor needs to get familiarized with the accounting systems and the learning curve might be steep at the beginning. More complex and industry-specific businesses of the client can come at the cost of deeper and longer learning curve. Finally mandatory auditor rotation can allow firms to replace their current auditor by a more lenient auditor, e.g., using opinion shopping, without signaling their strategic choice.

In this counterfactual analysis, we quantify the firm's loss of utility, increase in switching rates in anticipation of the end of the mandatory term, and changes in auditor market shares associated with mandatory auditor rotation through several policy experiments. These experiments serve to provide a sense of the economic importance of accounting for forward-looking behavior. However, our analysis

has its own caveats: we cannot measure the effect on audit fees (which are themselves derived from a choice and are highly likely to be correlated with the firm-specific-choice shocks in our model), the market reactions and the welfare implications.

In the policy experiments, we force firms to switch auditors after 5 and 10 consecutive years of engaging with the same auditor. If firms' optimal choice is to keep the existing auditor but they are forced to switch, we assume that they will choose their second best option. To ensure that the policy experiments resemble the data, we take the last year of our data as the starting point.

The simulation uses the point estimates of our baseline model (from Panel C of Table 3). We normalize the period utility of switching (from any auditor) to a non-Big 4 to zero. The simulation procedure relies on the assumption that our policy experiments do not change firms' preference for auditors. For example, forcing mandatory rotation does not change auditors' start-up costs or market perception of voluntary rotation. Because the parameters that enter period utility do not change, the policy experiment affects auditor choices through the expected future payoff.

The simulation follows the procedures below. First, we compute the ex-ante value functions for the original case of no mandatory auditor rotation as well as the two counterfactual cases of mandating rotation if tenure exceeds five years or ten years respectively. An ex-ante value function is the sum of discounted expected future payoffs given a firm's existing auditor and the auditor's tenure. It accounts for the possibility that the firm might switch away from a Big 4 or a non-Big 4 auditor in the future. If a firm is subject to a mandatory rotation rule, it will take into account for the mandatory rotation if it always keeps its existing auditor.

Second, we take all the 8,881 firms in 2015, the final year of our sample. For each firm, we draw random shocks affecting the utility for each of the six auditors (4 Big 4 auditors and 2 non-Big 4 auditors) in the subsequent 100 years. The simulation therefore has a total of  $532,860 = 8,881 * 6 * 10$  random shocks. The random utility for each firm-year is the sum of the period utility, the expected continuation payoff computed in the first step, and the random utility. The firm chooses the alternative that generates the highest utility. The corresponding auditor choice and tenure will be used as the state variables for that firm in the next year. To compute the long run value, we average the outcomes between 51 years and 100 years.

We investigate several outcomes. The first outcome we examine is the average loss of total ex-

pected utility (period utility and value function) that arises from the mandatory switching. To quantify the loss, we differentiate between two cases. In the first case, we examine firms that are immediately subject to the policy experiment. For example, suppose a firm has hired the same auditor for 10 years. This firm will be forced to switch to another auditor and will therefore lose period and future expected utility.

In the second case, we examine firms that are not immediately subject to the policy experiment. For example, suppose a firm hired an auditor for three years. This firm is allowed to keep hiring the same auditor. However, the mandatory rotation might reduce the firm's future expected utility. We express the loss in both cases in percentage terms relative to their utility before the policy experiment.

The second outcome we investigate is the evolution of market share since the policy experiment. We define market share as the probability of firms choosing Big4 versus non-Big4. The outcome aims to examine the effect of mandatory rotation on the market structure. We also compute the percentage of involuntary switches, that is, the likelihood that firms that were forced to switch.

An advantage of this simulation is to take into account the effect of the choice specific shocks, i.e.,  $\epsilon_{t,k}$  where  $k$  is the choice (keeping the current auditor, switching to an auditor of the same type or switching to an auditor of a different type), on the firm's choice. We determine the optimal choices. Mandatory rotations are by construction suboptimal in our model because they do not reflect the optimal policy. By constraining the firms to keep their auditors for a maximum number of consecutive years, we take a suboptimal policy, the second best choice if the firm were to switch.

Table 4 shows the predicted effects of mandatory rotation on a time horizon of 10 years, from 2016 to 2025 on the switching rate per year. Absent any mandatory rotation rule, the switching rate is between 23% and 26% whereas with mandatory rotation of 5 years, the switching rate is much higher, ranging from 29% and 37% translating into an increase between 8% and 12% depending on the calendar year. A 10-year mandatory rotation has more moderate effects on the switching rate, i.e., an increase between 2% and 6%.

Table 5 reports the percentage of loss in future expected utility relatively to the setting absent any rotation rule in the years before the end of the mandatory tenure term. A 5-year rotation rule reduces the future expected value in a similar fashion for both firms with a Big 4 or non-Big 4 incumbent auditor. A firm that has an incumbent auditor with a one-year tenure bears a reduction in future utility

**Table 4: Switching Rate by Year Following Mandatory Rotation**

This table presents simulated switching rates for 10 years following mandatory rotation for firms in the final year (2015) of our sample. Panel A presents results for rotation if tenure exceeds 5 years. Panel B presents results for rotation if tenure exceeds 10 years. Column 1 and 2 do not account for firm entry and exits. Column 3 and 4 account for firm entry and exits. We assume 12% of non-Big 4 clients drop out and 6% of Big 4 clients drop out each year, which are replaced with a new firm that hires Big 4 with 77% probability.

Panel A: Mandatory rotation if tenure exceeds 5 years

Year	No firm attrition		With firm attrition	
	Rotation	No rotation	Rotation	No rotation
2016	35%	23%	35%	23%
2017	29%	24%	29%	24%
2018	31%	23%	30%	23%
2019	33%	25%	32%	24%
2020	37%	25%	34%	24%
2021	32%	24%	31%	23%
2022	34%	26%	33%	23%
2023	34%	25%	32%	23%
2024	33%	25%	32%	24%
2025	34%	26%	32%	24%
Long run	33%	24%	32%	23%

Panel B: Mandatory rotation if tenure exceeds 10 years

Year	No firm attrition		With firm attrition	
	Rotation	No rotation	Rotation	No rotation
2016	27%	21%	27%	21%
2017	26%	22%	26%	22%
2018	26%	22%	26%	23%
2019	27%	23%	26%	22%
2020	26%	23%	25%	22%
2021	26%	23%	24%	22%
2022	26%	24%	26%	23%
2023	27%	24%	26%	23%
2024	27%	24%	26%	23%
2025	27%	23%	25%	22%
Long run	27%	24%	25%	23%

by 5.6% with a Big 4 and 5.2% with a non-Big 4. The expected future losses increase as the firm gets closer to the end of the mandatory tenure term and attain 10.5% with a Big 4 and 10.0% for a non-Big 4, if the incumbent auditor has a tenure of 5 years. A 10-year mandatory rotation rule shows little effects in the earlier years of the tenure, i.e., a reduction by less than 3% for firms with a Big 4 incumbent auditor and 2.2% for firms with a non-Big 4 incumbent auditor with a tenure less than or

**Table 5:** Utility Loss by Tenure Following Mandatory Rotation

This table presents the percentage decrease in the utility of keeping incumbent auditors that arises from mandatory auditor rotation. Panel A presents results for rotation if tenure exceeds 5 years. Panel B presents results for rotation if tenure exceeds 10 years. The rows represent the tenure of the incumbent auditor and the column represents whether the auditor is a Big 4.

Panel A: Mandatory rotation if tenure exceeds 5 years

	Big 4	Non-big 4
Tenure = 1	5.6%	5.3%
Tenure = 2	6.5%	6.1%
Tenure = 3	7.8%	7.4%
Tenure = 4	10.5%	10.0%

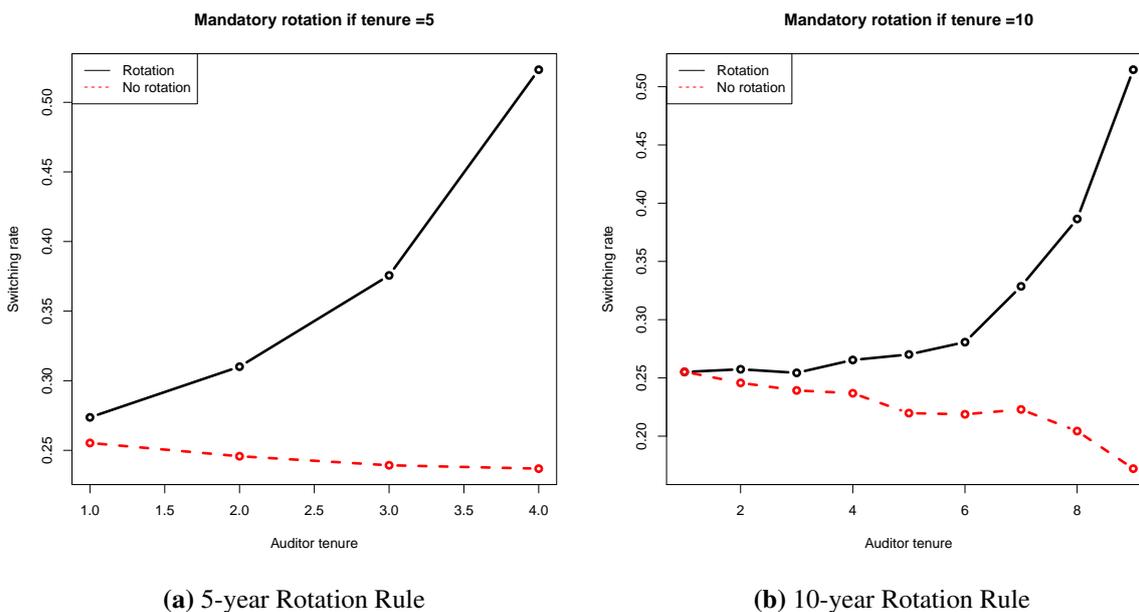
Panel B: Mandatory rotation if tenure exceeds 10 years

	Big 4	Non-big 4
Tenure = 1	1.1%	0.9%
Tenure = 2	1.3%	1.0%
Tenure = 3	1.5%	1.2%
Tenure = 4	1.8%	1.4%
Tenure = 5	2.2%	1.7%
Tenure = 6	2.8%	2.2%
Tenure = 7	3.7%	3.0%
Tenure = 8	5.0%	4.2%
Tenure = 9	7.6%	6.7%

equal to 6 years. However, beyond 6 years of tenure, the expected future losses relatively to a setting absent any rotation rule sharply increase for both firms with Big 4 and non-Big 4 incumbent auditors by 7.6% and 6.7% respectively.

Figure 11 measures the probability of switching as a function of tenure with and without the rule in place. In the early years of tenure, the increase in the probability of switching is marginal, 2% and 6% in the first two years of tenure. As we get close to the mandatory tenure term, the probability of switching jumps by 14% and 29% in the third and fourth year of tenure respectively. A 10-year mandatory rule exhibits the same trend where the sharpest increase in the probability of switching occurs in the last years before the mandatory term ends, attaining 51% in the year preceding the end of the mandatory term, which is the same magnitude as the switching probability in the last year preceding the end of the 5-year rotation term, as depicted in Figure 11b.

Finally, we assess the effect of mandatory rotation on the Big 4 market share in Panel E of Table

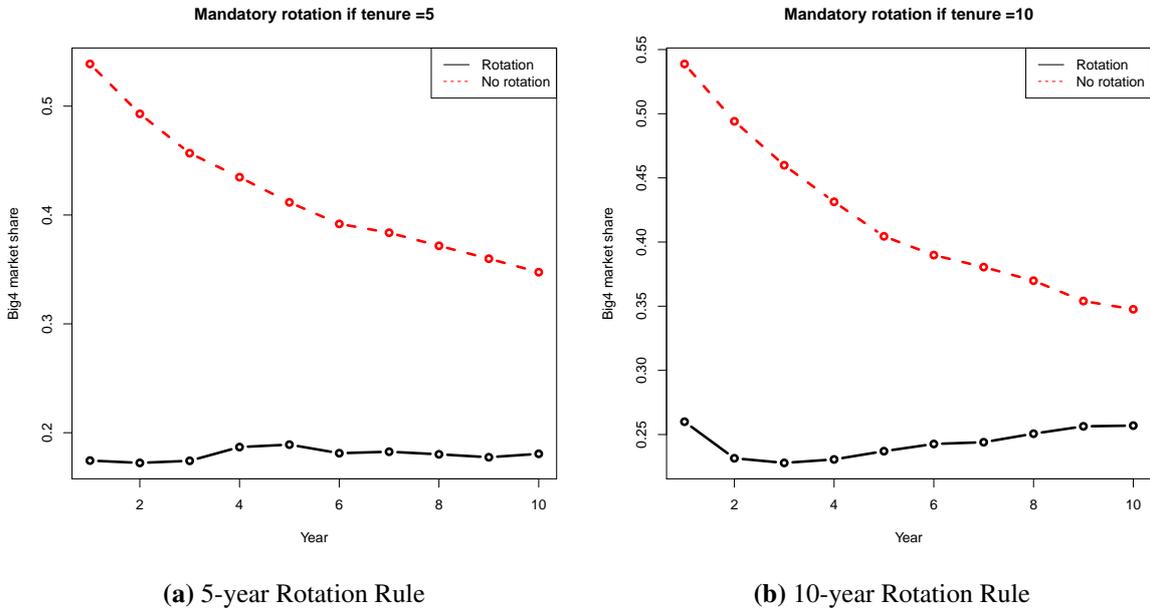


**Figure 11:** Switching Probability and Mandatory Rotation

6. Our simulation shows a huge drop in the market share six years later after the rule is in place to attain an extremely low market share of 3% against 29% absent any rule. This drop is not realistic. Next we try to understand what is causing this issue in the data. First, we assess the long term (or steady state) probability to have a Big 4 auditor in the entire sample conditional on switching, without taking account the effect of tenure.<sup>9</sup> The steady state probability to have a Big 4 is much lower and equals 35%, which gives some assurance that the data implies a decline in the Big 4 market share. Other features in the data that the simulation so far does not take into account are the attrition rate of firms with a non-Big 4 auditor, which is much higher than for a firm with a Big 4 auditor, and a very large proportion of the new firms choosing a Big 4. Therefore, we need to correct the simulation to account for such differences. We use the attribution rates from our sample: 12% of non-Big 4 clients drop out and 6% of Big 4 clients drop out each year, which are replaced with a new firm that hires Big 4 with 77%. Incorporating such firm entry and exit dynamics does not change qualitatively the results for the switching rates. However, the market share for the Big 4 auditing firms absent of any

<sup>9</sup>That is, let us define  $s$ , the steady state probability to have a Big 4 auditor. We now define the transition probabilities as follows:  $q$  and  $p$  are respectively the probability to switch to a non-Big 4 given that the incumbent auditor is a Big 4 and the probability to switch to a non-Big 4 given that the incumbent auditor is a Big 4. We multiply the probability vector  $(s, (1-s))$  by the probability transition step matrix  $\begin{pmatrix} 1-p & p \\ 1-q & q \end{pmatrix}$  and get out the same exact probability vector to determine the steady state probabilities. In other words, nothing changed after the step. Hence, the steady state probability  $s$  is given by:  $(1-p)s + (1-q)(1-s) = s$ , where  $p$  and  $q$  are provided by the data.

rule change declines at a much slower rate, starting at 54% in 2016 to achieve 35% in 2025 absent any mandatory rotation rule. The mandatory rotation rule decreases the market share of the Big 4 auditing firms, stabilized at 18%. Figure 12 shows the evolution of the market share of the Big 4 accounting for the attrition rates of firms and the new firms' auditor choices.



**Figure 12:** Big 4 Market Share and Mandatory Rotation

## 6 Conclusion

Our paper offers a simple dynamic conditional choice probability model where the firm is a forward looking decision maker caring about the current payoff but also the stream of future payoffs of switching relatively to keeping the incumbent auditor. We can separate the firm's relative loss in surplus as a function of past auditor tenure and auditor size and the nature of the current switch, whether it occurs to a Big 4 or a non-Big 4 auditor. Although we are agnostic on the nature of these switching costs, and what they actually represent, they affect the firm's surplus in the short and long run, and are an integral part of the firm's decision to keep or switch its auditor. Further, we rely on the assumption that there is learning process in reduced form, and our dynamic model will separate the positive effect of tenure in the short run from the long term value to the firm of keeping an auditor. However, our model does not distinguish between the learning about the quality match between the firm and the

auditor and the auditor's learning by doing, and future research could focus on separating these two forms of learning.

The dynamics become especially important to measure how the firm anticipates mandatory rotation because it might significantly affect its decision to voluntarily switch its auditor before reaching the maximum years allowed for an audit engagement, and in turn, it might rebalance the market shares between the Big 4 and non-Big 4 auditing firms. This theory-based approach can serve as a basis to predict the impact of auditor rotation through several policy experiments. We show that mandatory rotation increases firms' switching rate prior to the tenure limit and reduces the Big 4 market share.

Our analysis has its own caveats: we cannot measure the effect of auditor rotation on audit fees (which are themselves derived from a choice and are highly likely to be correlated with the firm-specific-choice shocks in our model), the market reactions and more importantly, welfare implications. We still provide some relative economic magnitudes of the loss in surplus at firm level, disentangling the short and the long run consequences. We hope to open doors to more future research tying theory-based measures to evaluate policy implications in the auditing field. A lot of questions remain unanswered, and call for richer ingredients to gauge the impact of auditor rotation on interested parties.

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