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CEO-Firm Match Quality and Firm Performance

By

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Abstract

Much of the empirical research on CEO pay is based on agency theory and has studied the incentives executives have to make decisions that benefit shareholders. This study takes a different look at CEO success by focusing on the quality of the match between the CEO and the firm's needs. Compared to lower quality matches, highly productive matches are characterized by executives that have long tenures as CEOs and better per period firm performance over their time as CEO. A simple modification of a widely used Bayesian model of learning (DeGroot 1970) is proposed where the board of directors dismiss a CEO when they conclude the probability true firm-CEO match quality falls below a critical match quality threshold is greater than a threshold probability. This separation decision rule means CEOs are positively selected on match quality. The empirical results confirm this prediction; a statistically and economically significant relationship between the total time an executive serves as CEO (completed tenure) and monthly stock returns is found. We also find that stock returns in period t are correlated with completed tenure for CEOs that survive to period t. These results suggests investors are making valid judgments about firm-CEO match quality and boards of directors are making CEO retention decisions as they learn about CEO productivity in the firm. The results are inconsistent with models that predict long tenured CEOs become entrenched in their positions at the expense of shareholders.

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> "…new CEOs are likely to have been selected with at least some consideration for their skills and how those skills match the perceived needs of the firm and its context."
>
> Finkelstein, Hambrick & Cannella (2009, p. 201)

Much of the research on executive performance has focused on the central issue raised by agency theory (Jensen & Meckling 1976); how successfully do CEO compensation contracts and corporate governance mechanisms manage the conflicting objectives of executives and shareholders? An important strand of research on this topic has focused on estimating the financial returns CEOs receive when they make decisions that increase shareholder wealth (Jensen & Murphy 1992, Hall & Lieberman 1998, Murphy 1999, Hall & Murphy 2002, Frydman & Jenter 2010, Murphy 2012). These studies suggest the financial returns earned by CEOs when they make decisions that benefit shareholders have increased substantially over the last 20 years because of the growing use of stock options in executive compensation packages Other studies suggest that CEO power over boards of directors (BoD) has decreased as boards have gained greater independence because of more outside directors, the introduction of incentive pay for board members, greater monitoring by boards and stronger voices in the boardroom from large institutional investors (Hermalin 2005).

While this evidence suggests that on average firms may now be better managed for the benefit of shareholders than was the case 30 years ago, this conclusion is not undisputed. The evidence of a causal link between the design of CEO compensation

plans and firm performance is more limited (Daily, Dalton & Cannella 2003, Lazear & Gibbs 2009) and others (Bertrand & Mullainathan 2001, Bebchuk & Fried 2004) have argued CEO pay reflects successful rent seeking by executives made possible by CEO dominance over the pay-setting process.

A related issue that has received less attention in the empirical literature on CEO pay and behavior is the quality of the match between a CEO's skills and abilities and the leadership needs of the firm and how this match quality influences firm performance. Even though candidates for the CEO position typically have many decades of managerial experience, often with the hiring firm, the business press is replete with examples that suggest the match between the skills and abilities of CEO candidates and the firm is not precisely known by the BoD when a new CEO is hired. For example, Fritz Henderson, a long-tenured GM executive, led General Motors through bankruptcy in 2008 but was dismissed in late 2009 when the new BoD that came out of the bankruptcy proceedings concluded he was not the right person for the job because "Fritz was just not enough of a change agent."[1] The recent experience at Hewlett-Packard shows several recent failures to find a CEO that was a good match for the firm. Hewlett-Packard had 5 different CEOs from July 1999 when Carly Fiorina became CEO through September 2011 when Leo Apotheker was fired after serving as CEO for less than 11 months. Included among the five were two interim CEOs that served 2-3 months following the unexpected departure of two non-interim CEOs.[2] These examples suggest firms learn about the quality of the

[1] International Herald Tribune, December 3, 2009.

[2] ExecuComp reports Carly Fiorina served from July 17, 1999-February 8, 2005; Robert Paul Wayman served from February 9, 2005-March 1, 2005; Mark Hurd served from April 1, 2005-August 1, 2010;

match over time as they observe the decisions of the new CEO and at some point the BoD may conclude they made a hiring mistake based on the BoD's estimate of match quality.

Hermalin & Weisbach (1998) develop a theoretical model where CEO tenure and the monitoring of the CEO by the BoD are endogenous outcomes of the BoD's estimate of firm-CEO match quality.[3] A favorable estimate of CEO-firm match quality by the BoD gives the CEO greater bargaining power that is used to both increase her compensation and negotiate for greater CEO discretion or reduced monitoring by the BoD. In firms where the CEO is long-tenured firm performance may remain at a high level because of superior match quality or firm performance may decline because the agency costs of less monitoring more than offset the benefits of a high quality match. [4] A number of recent studies support the predicted link between CEO tenure and Board monitoring that is predicted by Hermalin & Weisbach. Ryan & Wiggins (2004) find that as CEO tenure increases and the proportion of insider directors increases CEO pay is less sensitive to firm performance; Boone et al (2007) find that measures of CEO bargaining power and tenure are negatively correlated with board independence and Ryan, Wang &

Catherine Lesjak served from August 6, 2010-November 1, 2010 and Leo Aapotheker served from November 1, 2010-September 22, 2011.

[3] See also Hermalin (2005).

[4] An interesting and unusual example of the impact of estimated CEO-firm match quality on corporate governance occurred in the negotiations between Apple and Steven Jobs over the terms for his return to Apple as CEO in 1997. After the Apple BoDs fired the incumbent CEO and were negotiating over the terms of Jobs' return to Apple, Jobs insisted that all but one member of the BoD resign so that Jobs could appoint an entirely new Board loyal to him. The Board and Apple agreed to retain two Board members, all of the other members agreed to resign and Jobs and one of the holdovers appointed a new BoD. At one point Arthur Levitt, a former SEC chairman was asked to serve on the Board by Jobs. Jobs later withdrew the invitation after reading a speech Levitt gave that argued for strong and independent board members (Isaacson 2011, pp 318-32)

Wiggins (2009) find BoDs meet less frequently and the proportion of inside directors increases with CEO tenure. These studies do not test whether CEO tenure is a function of firm learning about CEO-firm match quality or whether firm performance remains at a high level even as Board monitoring decreases.

The empirical literature on CEO-firm match quality includes research (Allgood & Farrell 2003, Brookman & Thistle 2009) that tests whether the CEO turnover hazard follows an inverted-U shape as predicted by Jovanovic's (1979) matching model. Using data on CEO tenure over the 1981-93 period, they plot the unconditional turnover hazard which shows the hazard increases to about five years of tenure and then declines. They do not condition the turnover hazard on any observable covariates. Brookman & Thistle estimate an accelerated failure time survival model of CEO tenure using data from ExecuComp from 1992-2001 where the turnover hazard is modeled as a function of a set of observed covariates and an error term that is modeled as a generalized gamma distribution. This distribution nests an exponential hazard (constant hazard rate), a Weibull hazard (strictly increasing or decreasing hazard rate) and a log-normal hazard (inverted-U hazard rate). The data reject the exponential and Weibull distributions and fail to reject the log-normal hazard (p-value < .427). Evaluated at the sample means for the observed covariates, they estimate that the turnover hazard peaks at 13 years where the annual risk of turnover is 3.8 percent.

This study differs from the previous empirical studies of CEO-firm match by focusing on the relationship between the total time an executive serves as CEO ("completed tenure") and average firm performance over the CEO's tenure and the relationship between firm performance and current CEO tenure conditional on an

executive's completed tenure. Predictions about these relationships are based on a model that assumes the match between the skills and abilities of CEO candidates and the firm is not precisely known by the BoD when they hire a new CEO and the BoD and investors learn about CEO-firm match quality over the tenure of the CEO. The analysis is based on a simple modification of a widely used (Farber & Gibbons 1996, Altonji & Pierret, 2001, Lange 2007) Bayesian model of learning (DeGroot 1970) where the firm learns about the quality of the CEO each period from a new, noisy signal of match quality. CEO turnover is added to this model by assuming a CEO is replaced when the BoD's estimate of match quality leads it to conclude that the probability true firm-CEO match quality falls below a critical match quality threshold is greater than a threshold probability. This separation decision rule means surviving CEOs are positively selected on match quality so that the estimated expected and actual match quality is higher for CEOs that serve for a longer time period. Thus, the model predicts higher quality matches produces CEOs with longer completed tenures and these matches generate superior outcomes for shareholders if CEO-firm match quality is an important determinant of firm performance.[5]

The empirical tests of this simple matching model focus on the relationship between completed tenure and the total time an executive serves as CEO of a firm and

[5] I define firm-CEO match quality slightly differently from the definition used in labor economics where unobserved match quality represents the part of worker productivity distinct from that due solely to either unobserved firm or worker characteristics. To identify this form of firm-employee match quality requires data on CEOs that serve as CEO for different firms within the study time frame. The number of CEOs in ExecuComp that satisfy this requirement is very small. I prefer to use the term match quality because CEOs that are not firm founders typically come into this position late in the careers with proven ability as a manager but this previous management experience may not match with what the firm needs from a new CEO.

average monthly stock returns over an executive's tenure as CEO. A statistically and economically significant positive relationship is found between completed tenure (CT, hereafter) and mean monthly stock returns calculated over a CEO's tenure for a subsample of CEOs included in the ExecuComp survey. The preferred estimate shows the mean predicted monthly return calculated over the tenure of an executive that serves for four years is .12 percent versus .92 percent for a CEO with completed tenure equal to eight years. For a $4 billion company, this difference in monthly returns produces an expected $409 million difference in market value over a 12 month period.[6]

An additional prediction from the matching model describes how *estimated* match quality changes with current CEO tenure and completed CEO tenure. BoDs update their estimates of match quality each period as they observe a new, imperfect signal of true match quality. Each period the BoD obtains a more precise estimate of match quality based on the cumulative effect of the signals observed over the previous periods. At the end of period t for a sample of CEOs that have survived through period t, the estimated mean match quality for CEOs that will leave office sooner are lower than the estimated mean match quality for CEOs that will stay longer in the position. This relationship exists because the separation rule assures that mean match quality over a career is greater for longer serving CEOs relative to CEOs that have short tenures in the job; at any value of current CEO tenure the estimated match quality of surviving CEOs is positively correlated with the total remaining time these CEOs serve in the position.

[6] $409 million=$[(1+.00924)^{12} – (1+.0012)^{12}]$*($4 billion). Over the sample of firm-year observations in ExecuComp over the 1992- 2008 period, the median firm market in 2010 prices was $1.8 billion and the mean was $8.36 billion. A firm-year with a market value of $4 billion was at the 68th percentile among the firm-year observations included in 1992-2008 ExecuComp.

If investors observe a noisy signal of match quality each period so that firm value at the end of period t partially reflects the market's estimate of match quality, for CEOs that have survived to the end of period t, firm returns in period t and through period t will be positively correlated with the total length of time these executives will eventually serve as CEO. In other words, the market can predict, with error, the length of time a CEO will serve in the position. This prediction is confirmed by data for executives that serve as a CEO up to about 10 years of CT. The estimates consistently support this prediction. For CEOs that serve a total of eight years, the preferred estimate shows the estimated mean monthly return in month 24 is .0119 (SE=.0005) while for executives where CT equals four years the estimate month return in month 24 is .0012 (SE=..0006). The difference between these estimated mean returns is .0107 (SE=.0006).[7]

The data required to test the empirical implications of the matching model requires information on a subsample of CEOs where stock returns are observed over the entire time an executive serves as CEO. By definition this excludes all CEOs in ExecuComp who were still in office at the end of 2008 - the end of the study period. This sub-sample differs from the entire sample of CEOs in ExecuComp because it under-samples CEOs that will serve for "long" time periods.

Several supplemental analyses were conducted to assess how this sampling frame affects the results. Models were estimated using only the sub-sample of firm-CEO pairs where the CEO served for 10 or fewer years in the position. This removes the impact of long-tenured CEOs on the estimates in case the long-tenured CEOs in the ExecuComp

[7] These estimates are based on the results reported model 6 in Table 5.

sampling frame are not representative of the population of long serving CEOs. A weaker prediction of the matching model was tested for CEOs that were still in office at the end of 2008. Results from each of these tests were consistent with the predictions of the matching model.

A Simple Model of Firm-CEO Match Quality

The model used to describe how firm's learn about CEO match quality applies a standard Bayesian learning model (DeGroot 1970) using the normal distribution where employers and the CEO do not know the quality of the match when the CEO is hired and both parties update their estimates of match quality as they observe the firm under the CEO's leadership. Over time the parties updated beliefs about match quality become more precise as CEO tenure increases and eventually beliefs about the match converge on the true match quality between the firm and the CEO.[8] While this model has motivated empirical literature on employer learning and wages (Farber & Gibbons 1996, Altonji & Pierret 2001, Gibbons et al. 2002, Lange 2007), it has received little attention in studies of CEOs.[9]

Five variables are relevant for understanding the normal learning model's application to firm-CEO match quality: (1) $\alpha_{i,f}$ is the true productivity of the match

[8] In Jovanovic (1979) "ability" is not an innate characteristic of the employee (like cognitive ability), but a characteristic of the quality of the match between a firm and worker. Since Jovanovic's theoretical work and starting with Farber and Gibbons (1996), labor economists have sought to test if firm learning about worker ability is an important factor in the evolution of wages where worker ability is either an employee trait valuable to many employees or a trait that is more productive to a particular firm, industry or occupation (Gibbons et al., 2002).

[9] See Murphy (1986) for an early application of this model to the CEO labor market.

between CEO "i" and firm "f" and this value is constant over the executive's tenure as CEO, (2) $\hat{\alpha}_{t,i,f}$ or $(\alpha_{i,f}|tenure = t)$ is the BoD's best estimate of CEO-firm match quality given the information available to the BoD at the end of the t[th] period in the CEOs tenure on the job, (3) $(\hat{\alpha}_{t,i,f}|CT = T)$ is the the BoD's beliefs about match quality at the end of period t for CEOs that have survived to the end of period t and who ultimately serve in the position for T periods (completed tenure = CT), and (5) $(\tilde{\alpha}_{t,i,f}|CT = T)$ is the market's estimate of $(\hat{\alpha}_{t,i,f}|CT = T)$ at the end of period "t" for executives that serve for a total of T periods. The firm and the market's estimates of match quality for a particular firm-CEO pair at time t depends on the pattern of signals observed by the firm and the market.

The normal learning model assumes that true match quality, $\alpha_{i,f}$, is unknown to the parties when the CEO begins his/her duties at t=0 but is equal to a constant value determined by a random draw from a normal distribution with a known mean of mm and variance of σ^2_v. $\alpha_{i,f} \sim N(mm, 1/p_v)$ where p_v is the precision of the estimate and equal to $1/\sigma^2_v$. mm is the best estimate the parties' have about match quality at t=0 because the parties are assumed to have no specific information about match quality when a CEO begins in the position.[10] At the end of the first period the BoD observe $S_{t,i,f}$, an imperfect signal of match quality that is drawn from a normal distribution with a mean equal to the CEO's true match quality, $\alpha_{i,f}$, with precision p_ε:

[10] Investors and a BoD may have prior information about match quality and this information may vary based on, for example, if the new CEO is an inside hire or brought into the firm from the external labor market. The impact of prior information on learning is beyond the scope of this paper and is left for future research.

(1) $S_{t,i,f} = \alpha_{i,f} + \varepsilon_t$ where $\varepsilon_t \sim N(0, \sigma^2_\epsilon)$.

The quality of the signal depends on σ^2_ϵ or the validity of the information about $\alpha_{i,f}$ contained in the signal. The mean of the posterior distribution of the BoD's beliefs about firm-CEO match quality following the signal ($\hat{\alpha}_{1,i,f}$) is normally distributed with a mean equal to (DeGroot 1970):

(2) $E(\hat{\alpha}_{1,i,f}) = \frac{(mm)(p_v)+(S_{1,i,f})(p_\epsilon)}{p_v + p_\varepsilon}$ where $p_v = 1/\sigma^2_v$ and $p_\varepsilon = 1/\sigma^2_\varepsilon$.

and precision equal to $p_v + p_\epsilon$ or $(1/\sigma^2_v + 1/\sigma^2_\epsilon)$or $((\sigma^2_v+\sigma^2_\epsilon)/ (\sigma^2_v\sigma^2_\epsilon))$. Eq. (2) can be rewritten as the weighted sum of the uninformed estimate of match quality before the signal (mm) and the signal:

(3) $E(\hat{\alpha}_{1,i,f}) = (1-K) * mm + K * S_{1,i,f}$

where $K = \sigma^2_v/(\sigma^2_v + \sigma^2_\varepsilon)$.

As $K \rightarrow 1$ or $\sigma^2_\varepsilon \rightarrow 0$ more weight is placed on the signal when the firm updates its estimate of match quality and less weight is given to average match quality in the population of firm-CEO pairs. Note also that $K^{1/2}$ is equal to the simple correlation (r) between the signal and true match quality.[11]

The BoD observes an additional signal of match quality each period and updates its estimate of match quality with the information contained in the signal. The revised estimate becomes more precise as tenure increases and eventually converges to $\alpha_{i,f}$ if

[11] Since K measures the validity of the signal this links to the industrial psychology literature which has long studied the validity of selection tests (signals of future job performance) and performance appraisal instruments (measures of job performance). See Campbell et al (1970) for an early modern discussion of these concepts as applied to managerial employees.

there is no turnover. Prior to converging to $\alpha_{i,f}$, two firm-CEO pairs could have identical values for true match quality but different estimates of match quality at time t because $\hat{\alpha}_{t,i,f}$ depends on the unique history of signals observed by each firm. If "t" is the number of signals observed by the BoD then the estimate (DeGroot 1970, p 167) of match quality after the t^{th} signal is (DeGroot 1970, Lange 2007):

$$(4)\ \hat{\alpha}_{t,i,f} = (1 - K_t)mm + K_t\bar{S}_{t,i,f}\ \text{, where } K_t = \frac{t\sigma_v}{\sigma_\epsilon + t\sigma_v}$$

K_t converges to one as t increases and measures how quickly $\hat{\alpha}_{t,i,f}$ converges to $\alpha_{i,f}$ with additional observations of CEO performance. The precision of $\hat{\alpha}_{t,i,f}$ is $p_v + tp_\varepsilon = 1/\sigma^2_v + t/\sigma^2_\varepsilon$) which means the variance in $\hat{\alpha}_{t,i,f}$ equals $(\sigma^2_v\sigma^2_\varepsilon)/(t\sigma^2_v + \sigma^2_\varepsilon)$; the variance in $\hat{\alpha}_{t,i,f}$ declines with t.

Since employers and CEOs are assumed to know mean match quality in the population of firm-CEO matches (mm), as tenure increases the parties have greater confidence in concluding if they are in a low or high quality match by comparing $\hat{\alpha}_{t,i,f}$ with mm or the match quality they could expect from a new CEO randomly selected from the CEO applicant pool. In the Jovanovic's (1979) matching model there is no involuntary turnover (from the worker's perspective) because wages adjust upward or downward as the parties revise their estimates of match quality and the match dissolves when wages decline sufficiently in a poor quality match such that both parties recognize they could both do better in a different employment relationship. In a poor match involving non-executives, the firm could also respond by moving a manager to a lower position in the firm where he/she has less impact on the performance of the firm. This is

not an option for an incumbent CEO so I assume the BoD will ask the CEO to leave the firm when it believes the CEO's true match quality ($\alpha_{i,f}$) falls below a threshold value Z with a probability greater than Q^* or the $Pr(\alpha_{i,f} < Z \mid \hat{\alpha}_{t,i,f}) > Q^*$.

The firm faces a trade-off when setting Q^* or how confident the BoD beliefs must be about the quality of the match before firing a CEO. A low value for Q^* increases the probability the BoD will make a false-negative decision and dismiss a CEO that would have eventually been a very good CEO. The largest opportunity costs associated with false-negative decisions are likely to be reputational costs in the executive labor market that may make it difficult for a firm to attract high quality applicants if it is thought the BoD does not give a new CEO sufficient time to show he/she is a high quality match. These reputational concerns might cause the firm to set a high value for Q^*. On the other hand, a high Q* increases the probability the firm will be in a low quality match for several years which is also costly to the firm.[12]

From Eq 4 the distribution of true match quality conditional on estimated match quality is:

$$f(\alpha_{i,f} \mid \hat{\alpha}_{t,i,f}) \sim N[(1 - K_t)mm + K_t \bar{S}_{t,i,f},\ (\sigma^2_v \sigma^2_\varepsilon)/(t\sigma^2_v + \sigma^2_\varepsilon)].$$

The probability true match quality conditional on estimated match quality is less than Z equals:

[12] Q* might very well differ across industries because of differences in the costs of false-positive and flase-negative hiring decisions. Exploring this possibility is beyond the scope of this paper and left for future research.

$$\Pr(\alpha_{i,f} < Z \mid \hat{\alpha}_{t,i,f}) = \Phi\left(\frac{Z-((1-K_t)mm+K_t\bar{S}_{t,i,f})}{\sqrt{(\sigma_v^2\sigma_\varepsilon^2)(t\sigma_v^2+\sigma_\varepsilon^2)}}\right)$$

.

Since the variance of $f(\alpha_{i,f}|\hat{\alpha}_{t,i,f})$ declines as tenure increases, the critical value of $\hat{\alpha}_{t,i,f}$ used in the separation decision, Z_t, increases with tenure because the probability an executive is discharged is the constant probability Q^*; the BoD will only dismiss a CEO in an early period if the early signals indicate an extremely poor match because of the high level of uncertainty about true match quality. However, over time the BoD becomes more confident of its estimate of $\alpha_{i,f}$ and the critical value of $\hat{\alpha}_{t,i,f}$ that leads to dismissal increases. This is illustrated in Figure 1A. For the two executive shown in the figure at t_1 and t_2, the probabilities true match quality falls above Z is the same for both executives and an executive is discharged if the $\Pr(\alpha_{i,f} |\hat{\alpha}_{t,i,f}) > 1\text{-}F(Z) = Q^*$. Because Executive B has been in office longer than Executive A, the firm has a more precise estimate of his/her match quality. Therefore, the cut point, $\hat{\alpha}^*_{t=2}$, for executives with tenure equal to t_2 is greater than the cut point, $\hat{\alpha}^*_{t=1}$, for executives with tenure equal to t_1.

Separating CEOs where the probability that true match quality falls below a threshold probability generates positive selection on true match quality, $\alpha_{i,f}$, such that estimated mean match quality over CT is greater for CEOs that serve in the job longer or $E(\alpha_{i,f}|CT = t) < E(\alpha_{i,f}|CT = t+1)$. The strength of this selection bias favoring higher quality matches among longer surviving CEOs depends on the correlation between the signal and $\alpha_{i,f}$. Figure 1B shows results from the model using simulated data (500,000 firm-CEO pairs, 20 periods) with parameter values of mm=0, $\sigma^2_v = 1$, $\sigma^2_\epsilon = 3$, Z = -.1 and

Q^* =.8.[13] The positively sloped line in the bottom of the figure is the critical value of $\hat{\alpha}_t^*$ used in separation decisions and it increases from -.73 in period 1 to -.40 in period 10. The positively sloped line in the top of the figure plots the mean of estimated match quality for the CEOs that survived a certain number of periods. This increases from .05 at the end of period 1 to .50 at the end of period 10. This selection bias generates the first empirical test of the matching theory. If investors observe $\hat{\alpha}_{t,i,f}$or a noisy signal of $\hat{\alpha}_{t,i,f}$ ($\tilde{\alpha}_{t,i,f}$) then mean monthly stock returns calculated over the entire tenure of each CEO in a sample will be positively correlated with CT if match quality affects firm performance.

Because the signals received by the firm are positively correlated with true match quality, the mean of estimated match quality at the end of period t for executives that leave at the end of period t+1 is less than the mean of estimated match quality for executives that leave at the end of period t+2 or $E(\hat{\alpha}_{t,i,f}|CT = t+1) < E(\hat{\alpha}_{t,i,f}|CT = t+2)$ because of the retention rule. The expected value of estimated match quality at time t conditional on CT increases with CT because higher quality matches have a lower probability of dismissal and mean match quality is correlated with the mean of expected match quality. This leads to the second empirical test of the model; mean estimated match quality at the end of period t for a subsample of CEOs that serve the same length of time is greater than mean estimated match quality for a subsample of executives that serve for a shorter time period or $E(\hat{\alpha}_{t,i,f}|CT > t)$ is positively correlated with CT. Figures 2 shows the relationship between the mean of estimated match quality

[13] The values of σ^2_v and σ^2_ϵ imply the correlation between the first period signal and true performance is .5. This is a plausible value given the industrial psychology literature on the validity measures used in selecting managers.

in period t conditional on how long a CEO will survive beyond period t using the simulated data. Each downward sloping line in Figure 2 connects the values of $E(\hat{\alpha}_{t,i,f}|CT = T)$ as current tenure (t) increases from one to CT. For example, at period 4 estimated mean match quality for CEOs that will serve 5 periods is about -.48 and less than the estimated mean match quality for CEOs that serve for 5 periods (~-.32).

If investors receive valid signals of match quality each month ($\tilde{\alpha}_{t,i,f}$) and match quality affects the future cash flows of the firm, market efficiency predicts that after the period t signal stock prices will adjust based on the market's estimate of how the *change* in estimated match quality affects future profitability. In other words, returns in period t are not equal to $\tilde{\alpha}_{t,i,f}$. After conditioning on other factors that affect monthly stock returns, the expected changes in firm value at the end of period t for the subsample of CEOs that have not departed by the end of period t will equal the expected impact on firm value of the mean change in expected match quality or $\beta\{E(\tilde{\alpha}_{t,i,f}|CT > t) - E(\tilde{\alpha}_{t-1,i,f}|CT > t)\} = \beta(\Delta\tilde{\alpha}_{t,i,f}|CT > t)$ where β is a parameter that describes how the change in mean expected match quality from period t-1 to period t affects the market's estimate of firm value. In the empirical analysis β is not identified because $\Delta\tilde{\alpha}_{t,i,f}$ is not observed or measured. However, insight about $(\Delta\tilde{\alpha}_{t,i,f}|CT > t)$ is provided by Eq. 3. The change in match quality from t=0 to t=1 or $(\Delta\tilde{\alpha}_{t=1,i,f}|CT > 1)$ equals the difference between the period 1 signal and the uniformed prior estimate of match quality or

$$(\Delta\tilde{\alpha}_{t=1,i,f}|CT > 1 =) = (1 - K_1)mm + K_1(S_{1,i,f}|CT > 1) - \text{mm}$$

$$= K_1((S_{1,i,f}|CT > 1) - \text{mm})$$

In the simulated data mm is set equal to zero, so ($\Delta\widetilde{\alpha}_{t=1,i,f}|CT = t'$) = K_1 ($S_{1,i,f}|CT > 1$). Since $S_{1,i,f}$ is correlated with true firm-CEO match quality and CEOs are dismissed after the period 1 signal is observed if $\hat{\alpha}_{1,i,f} < \hat{\alpha}_1^*$, E($K_1$ ($S_{1,i,f}|CT > 1$)) > 0 ~ .5.

The values for ($\Delta\widetilde{\alpha}_{t,i,f}|CT > t$) from the simulated data are shown in Figure 3. These data points show a strong positive correlation between CT and the expected change in estimated match quality in the simulated data for t=2, 3, 4,…10. Note, however, that for periods 3-6 the changes in mean estimated match quality are very similar for higher values off CT. Figure 1 supports the second empirical prediction of the matching model; for plausible parameter values for investor learning about CEO-firm match quality, mean returns observed in a period will be positively related with CT for surviving CEOs provided firm-CEO match quality affects the value of the firm.

Data, Sample and Econometric Methods

The sample of firm-CEO pairs needed to test the matching model requires data on the total time a CEO served in this position in a single firm. For this reason, the sample used in this study comes from Standard and Poor's ExecuComp database (accessed through WRDS) that reports the date CEOs in the sample began their tenure as CEO and the date they left the firm if they left office before the end of the study period. Since completed CEO tenure is a critical variable for this analysis, the subsample of CEOs from ExecuComp includes executives that completed their tenure as CEO by the end of

2008.[14] From this universe a small number of CEOs were excluded who worked for firms that did not have monthly stock return data for the executive's entire tenure in the CRSP dataset. The final sample includes 1579 completed CEO spells where the CEOs were employed at 989 different firms. The median (mean) number of CEOs per firm in the sample was 3 (2.84) and the maximum number was 7; five firms had seven different CEOs that completed their tenures as CEO by 2008.

Table 1 reports descriptive statistics for the sample. The 1579 firm-CEO pairs fall into two subsamples based on whether they began their role as CEO before or after January 1, 1992. 1160 CEOs were hired after 1991 and had mean (median) completed tenure of 4.33 (3.75) years and 419 CEOs were hired before 1992 and had mean (median) tenure of 11.65 (10.68) years. The difference in mean tenure for these two groups of CEOs occurs because executives are excluded from the study if they are still in office at the end of 2008. For CEOs hired after 1991 the maximum possible value for CT is 17 years, whereas for CEOs included in ExecuComp and hired prior to 1991 the maximum value for completed tenure is 17 plus the tenure of the CEO in 1992. The CEOs in ExecuComp that were matched to CRSP and not included in our study sample were executives with unobserved completed tenure because they were still serving as a CEO at the end of 2008. There were 1753 firm-CEO pairs in this excluded sub-sample of ExecuComp.

The sample of CEOs used in this study is not perfect ideal because of the limited time frame (1992-2008) covered by ExecuComp and the requirement that completed

[14] This study was begun in 2009 and the latest version of ExecuComp available at that time reported separation dates to the end of 2008.

tenure is observed within this time frame. The sample of CEOs where completed tenure is observed is composed of two distinct groups, those that were appointed prior to 1992 and those that came to office in 1992 or later. The subsample of CEOs that took office after 1991 and are included in the study is not a random sample of all CEOs in the ExecuComp database because executives with longer completed tenures are under-sampled as they are more likely to still be in office at the end of 2008. The severity of this under-sampling increases with completed tenure. For example, no CEO in this sub-sample could have served for more than 17 years and the only CEOs with 15-17 years of completed tenure had to have begun their tenure sometime in the 1/1/1992 – 1/1/1994 interval.

The set of CEOs in our sample that were hired prior to 1992 and left the position by the end of 2008 provide data on longer serving CEOs that are under-represented among the post 1991 hires. However, CEOs hired before 1992 are also not a random sample of CEOs that began their careers prior to 1992 because shorter tenured CEOs are under-represented in this subsample because they are less likely to be in office when ExecuComp began. For example, the only CEOs that started their tenure as CEO on January 1, 1982 that are also included in ExecuComp had to have had 10 years of tenure on January 1, 1992 and will, therefore, have at least 10 years of completed tenure. Equivalently, no CEO starting on January 1, 1982 with completed tenure of less than 10 years is included in the ExecuComp sub-sample. Thus, there are two sampling problems for the sample of CEOs that ended their tenure by the end of 2008. The executives with shorter completed tenures come disproportionately from the post-1991 appointees and as completed tenure increases the sample is increasingly dominated by pre-1992

appointees.[15] Figure 4 shows the proportion of CEOs appointed before January 1, 1992 as a function of completed tenure.[16] At four years of completed tenure over 90 percent of the sample were hired after 1991, while at 14 years of completed tenure about 80 percent of the CEOs took office before 1992. This feature of our sample could affect our estimates if, for example, there are economy-wide factors affecting CEO survival that are correlated with calendar time. To partially control for this a complete set of calendar year indicators were included in the model. I suspect the potential impact of this sampling process may have its largest impact on the results for CEOs with longer completed tenures. This issue is evaluated later in the paper where the robustness of our results is evaluated using only executives with 10 or fewer years of completed tenure. For CEOs that were still in office at the end of 2008, weaker versions of our hypotheses are tested by examining the relationship between returns at the censoring point and current CEO tenure at the censoring point.

Measuring and Estimating Firm Performance

Firm performance over an executive's tenure was measured using monthly firm stock returns, including dividends ($lnRet_{t,i,f} = ln((P_{t,f}+Div_{t,f}-P_{t-1,f})/P_{t-1,f})$), for each month

[15] One might be tempted to try and use the results in Figure 4 to weight the data. Unfortunately, the data in Figure 4 cannot be used for this purpose because the shape of the underlying completed tenure distribution for all CEOs appointed on or after a particular date is unknown. The completed tenure distribution for those appointed after 1991 is unobserved because completed tenure is unobserved for those in office at the end of 2008. The completed tenure distribution of CEOs appointed before 1992 is also unobserved because shorter serving CEOs are under-represented among the CEOs in office in 1992.

[16] The line in Figure 4 is based on a probit model predicting the probability a firm-CEO match in the sample began after 1/1/1992 as a function of 3rd order polynomial in completed tenure. A linear probability model gives identical predictions. The horizontal line at zero probability and completed tenure greater than 17 is not estimated because the sampling frame prevents any executive hired since 1/1/1992 who will eventually serve more than 17 years from having their completed tenure observed by the end of 2008.

an executive was in office.[17] The following basic regression model was estimated by pooling the monthly data across firm-CEO pairs:

$$(7)\ \ln(1+Ret_{t,i,f}) = \beta_0 + \beta_1\ln(1+RF_t) + \beta_2(\ln(1+MKT_t)) + \beta_3(SMB_t) + \beta_4(HML_t) + \beta_5(MOM_t) + f(\text{Current Tenure}_{t,i,f}\ \text{Complete Tenure}_{t,i,f}) + g(\text{Year indicators}_{t,i,f}) + \epsilon_{t,f}$$

The first set of variables is the four financial market factors identified by Fama & French (1993) and a fifth factor identified by Carhart (1997).[18] The four Fama-French factors are: the risk free return (RF_t), the return to the market portfolio of stocks (MKT_t), the difference in returns between a portfolio of large firms and small firms (SMB_t) and the difference in the returns between a portfolio of high book-to-market and low book-to-market ratio (HML_t) firms. [19] The fourth factor captures market momentum (MOM_t) which has been found to be a significant predictor of returns after controlling for the Fama-French factors (Carhart 1997). These variables are now often used to model abnormal returns in event studies (Greenstone, Oyer & Vissing-Jorgensen 2006). A model based solely on the CAPM that only includes MKT_t and RF_t was also estimated.[20] The estimated effect on returns that reflect learning by the market about match quality are

[17] These data were obtained from the CRSP dataset (University of Chicago) that was accessed through WRDS (The Wharton School, University of Pennsylvania).

[18] Fama and French report a model with three factors where RF and MKT are combined in a single variable equal to $MKT_t - RF_t$. I estimate the less constrained model that allows the absolute values of the coefficients on these variables to differ. Data for these four factors were downloaded from Kenneth French's web page at mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html on February 5, 2010.

[19] Risk free returns were measured using the yield on a 3 month U.S. Treasury bill in month t and RF_t equals ln(1+ T-bill yield).

[20] The estimates from this specification are very similar to the reported results and are available from the author.

captured by functions of current and completed CEO tenure. The year dummies denote the calendar year for an executive's t^{th} month and capture unobserved calendar year effects on returns that may not be captured by the market factors.

To make the tenure parameters easier to interpret, all of the non-tenure exogenous variables were transformed by deviating the value for each variable for each observation from the overall sample mean for each variable. This "centering" of the data means the predicted estimated returns for an "average" firm-CEO pair where average is defined as an observation with mean values for the five market model variables and the year dummies and equals the estimated intercept term plus the estimated tenure coefficients times the values for current and completed tenure. In a model that includes only the CT tenure variable, $\hat{\beta}_0 + \hat{\beta}_{CT} CT_{i,f}$ is an estimate of $\ln(1+Ret_{t,i,f})$ or $(\exp(\hat{\beta}_0 + \hat{\beta}_{CT} CT_{i,f})) - 1)*100$ is the estimated mean percentage change per month in the firm's stock price over an executive's entire tenure as CEO where the values for ln(1+MKT), ln(1+RF), SMB, HML and MOM and the year dummies are all equal to their sample.[21] Similarly, since CT is measured in years, $(\exp(12*CT_{i,f}*(\hat{\beta}_0 + \hat{\beta}_{CT} CT_{i,f})) -1)*100$ equals the estimated percentage change in firm value over the tenure of firm-CEO pairs where $CT = CT_{i,f}$.

Estimating Eq. 7 using OLS on the pool sample of firm-CEO pairs constrains the coefficients on ln(1+MKT), SMB, HML and MOM to be the same across all firms which

[21] The estimate for this "average" CEO can be thought of as the mean weighted estimate for a CEO with mean values for the five market variables plus a weighted mean of the calendar year coefficients where the weights are equal to the fraction of the total number of observations in each of the calendar years. I could have chosen an arbitrary base year when reporting the predicted effects which would simply change the constant or the predicted level of returns but would not change the estimated relationship between returns and CT.

is inconsistent with theoretical models of firm returns and empirical evidence showing that the effects of these variables differ across firms.[22] For example, constraining β_2 to a single value is inconsistent with the CAPM because β_2 in the CAPM for a particular firm measures the price of risk associated with investing in the particular firm relative to investing in the overall market. Constraining the coefficients on these four variables across firms also reduces the precision of the estimated tenure effects. Two alternative estimation methods were used that relax these constraints. First, a random coefficient model was estimated where β_2 - β_5 are allowed to vary across firm-CEO pairs. In this model the coefficients on these variables for each firm-CEO pair are assumed to have been drawn from normal distributions:

$B_{j,i,f} = \beta_j + \nu_{t,i,f}$ and $\nu_{t,i,f} \sim N(0, \sigma^2_{t,i,f})$ and j = ln(1+MKT_t), SMB_t, HML_t, MOM_t.

The second estimation method relaxes the normality constraint on the four financial market variables by adding to Equation 7 a complete set of firm-CEO specific dummy variables that are each interacted with each of the four market factors. In this model the standard errors were clustered on the calendar month to account for common unobserved market shocks correlated with calendar time. This model will be referred to as the fixed effect model.[23] The fixed effect model estimates are less efficient than the

[22] The coefficient on the risk free return is constrained to be the same across firms because the market requires each firm earn a firm specific premium above the constant risk-free returns investors have as an alternative to investing in the stock market.

[23] This is not the usual fixed effect model because the set of firm dummy variables were not included separately in the model because the financial models supporting these variables predicts $E(\epsilon_{f,t}) = 0$ for all firms. Separate firm intercept terms were also excluded to reduce the number of parameters that had to be estimated. The 1578 indicator variables denoting a unique firm-CEO pair were interacted with the four market variables or a total of 6312 parameters for just the four market variables - Ln(1+Mkt), BmS, HmL and Mom. The model was estimated using Stata on a 64 bit dual processor desktop with 32G of memory and there were no problems estimating these fixed effect models.

random coefficient model if the normality assumptions of the random coefficient are met. However, in the random effect model the standard errors are not clustered on the calendar day of the return. [24] Results for all three statistical models are reported. However, most of the discussion will refer to the random coefficient estimates because the results are virtually identical across the three statistical models.

CT and Stock Returns

The first results reported are from simple tests of the relationship between mean monthly stock returns calculated over the completed tenures of CEOs and CT. Three different methods that imposed different levels of structure on the relationship between returns and completed tenure were estimated. The first method imposes very little structure and provides a very transparent graphical presentation of the relationship between the two variables. For each firm-CEO pair the average monthly firm risk premium was calculated over an executive's tenure as CEO by calculating:

$$AVG(RET - RF)_{i,f} = \frac{\sum_{t=1}^{12*CT_{i,f}} (\ln(1 + RET_{t,i,f}) - (\ln(1 + RF_t))}{12 * CT_{i,f}}$$

The mean of AVG(RET-RF) was then calculated over all the firm-CEO pairs in each one month interval of completed tenure. The individual data points (+) in Figure 5a plot these cell means for each monthly intervals of CT. The figure shows a very strong positive linear relationship up to about 8-10 years of completed tenure and then no

[24] The procedure in Stata v 13.1 (xtmixed) to estimate the random coefficient models does not allow standard errors to be cluster by calendar month.

relationship between the variables beyond about 10 years. The line in the graph is an OLS regression line with a 4^{th} order polynomial through the mid-point of each one month time interval where each monthly data point is weighted by the number of CEOs in the cell.

The second semi-parametric method plots the mean conditional returns in each one month interval of completed tenure after conditioning on a set of year dummies and the five financial market variables in Equation 7. All of the market factors except ln(1+Rf) were allowed to vary across firms in a random coefficient model that also included a set of completed tenure dummies ($I_{k,i,f}$) where $I_{k,i,f}$ was set equal to "1" if the CEO served for a total of K months, otherwise $I_{k,i,f} = 0$. The estimation equation was then:

(8) $\ln(1+Ret_{t,i,f}) = \beta_0 + \beta_1 \ln(1+RF_t) + \beta_{2,i,f}(\ln(1+MKT_t)) + \beta_{3,i,f}(SMB_t) + \beta_{4,i,f}(HML_t) + \beta_{5,i,f}(MOM_t) + \Sigma\beta(I_{k,i,f}) + \epsilon_{t,f}$

The coefficient on each of the $I_{k,i,f}$ dummies is an estimate of the mean monthly returns for the firm-CEO pairs where $CT_{i,f}$ is in the k^{th} completed one month tenure interval relative to an excluded bin and conditional on the year indicators and the market controls. Since all of the market financial variables and year dummies were deviated from their sample means, the estimate mean monthly returns for firms in each interval where all the other variables are set equal to their sample means is simply β_0 for the "excluded" bin and and $(\beta_0 + \beta_k)$ for each of the other 246 bins. The data points (+) in Figure 5b plot the estimated mean return for each bin. The variability in these data points conditional on CT is less in Figure 5b compared to Figure 5a because conditioning on the four additional financial market controls and year indicators increases the precision of the estimated tenure effects. Overall, however, the pattern of data points is very similar to Figure 5a; a

strong positive relationship between CT and mean returns over an executive's CT up to about 8-10 years.

The third statistical model used to test H_1 is a standard parametric regression model where monthly returns are estimated to be a function of the market variables, the year dummies and polynomial terms in completed tenure. A fourth order polynomial in completed tenure best describes the data; the completed tenure coefficients were individually significant and a fifth order CT term was not significant. The estimated mean career monthly return for an "average" CEO from this model is shown by the line in Figure 5b. The shaded area shows the 95 percent confidence intervals around each of the estimated conditional means. Again, the estimates show a strong positive relationship between mean returns and completed tenure up to about 8-10 years and then the relationship goes to zero.

The differences in estimated mean monthly returns based on completed tenure through about 8-10 years that are shown in Figures 5a and 5b are economically significant. Using the estimates from the polynomial model, the estimated mean of ln(1+Ret) for a firm with a CEO that serves for 8 years is .00956 (SE=.00045) or an annual return of 12.15 percent (exp(12*.00956)-1). This compares to an expected return of .00211 (SE=.0005) or 2.58 percent per year for a CEO that serves for 4 years.[25]

The results reported Figures 5a and 5b provide strong support for the first prediction from the matching model; firms are learning about match quality and longer serving executives earned higher monthly returns compared to CEOs that had shorter

[25] The difference in mean monthly returns for these two values of CT is .0074 and highly significant with a standard error of .0005.

tenures up to about 8-10 years. Beyond 8-10 years there is neither a positive nor a negative relationship between CT and average career monthly returns.

Do Returns Predict Completed Tenure?

The matching model predicts expected returns in month t for firms where the CEO serves t+k months are smaller than the returns for a firm where the CEO will serve for t+k+j months where j >0.[26] This prediction implies returns in period t predict, with error, the length of time an executive will serve as CEO.[27] Very simple semi-parametric tests of this hypothesis that are comparable to Figure 5b were constructed. Figures 6a-6e report the relationship between completed tenure and estimated mean monthly returns (ln(1+Ret)) calculated over different time intervals of CEO tenure ending with month t for executives that serve through at least month t. The data in these figures were constructed using the same methods used to construct Figure 5b. For example, Figure 6a uses the sample of CEOs that served for more than 12 months and shows the relationship between mean returns over the first 12 months of CEO tenure and the length of time these executives ultimately served as CEO. Each individual data point is the mean conditional return over the first 12 months of tenure for executives in one month intervals of CT greater than a year. Like in Figure 5b, these conditional means were estimated from a random coefficient model of returns for the first 12 months of an executive's tenure that included a set of dummy variables for each one month interval of completed tenure

[26] As noted earlier, this assumes investors observe a noisy signal of match quality in period t.

[27] See Figure 2; at any value of current tenure mean match quality is larger for CEOs that will ultimately have longer tenures.

greater than 1 year. The line and the 95 percent confidence interval around the line are the predictions from a random coefficient model with polynomials in completed tenure. Figure 6a suggests firm returns in the first 12 months of an executive's tenure can discriminate between executives that serve up to about 6 years. The estimated difference in average monthly returns over the first 12 months of tenure between executives that will ultimately serve 8 years versus those that will serve 3 more years (CT=4) is .0051 (.01312-.0080) with a standard error of .0017 (p-value=.003).[28]

Figures 6b-6e show the relationship between completed tenure and mean returns over different time intervals up to 36 months of tenure. The conclusions drawn from these figures are similar to the results suggested by Figure 6a; mean returns through month t are positively related to completed tenure for 4-6 years beyond month t. Table 2 presents the differences in mean monthly returns for CEOs serving 8 versus 4 years for each of the different time intervals described by the Figures 6a-6f using the models with polynomial terms in CT. Over all five time intervals mean estimated returns in each time interval are statistically and economically greater for the executive that serves for 8 years. I take these data to be very consistent with the predictions of the matching model; even in the third year of tenure (Figures 6d), the market is still learning about match quality of surviving CEOs and differentiating between executives that will turnover within a year versus those that stay in office for another 4-5 years.

While the results shown in Figures 6a-6f show returns in through period t are correlated with later returns, the estimates are not inconsistent with market efficiency

[28] These estimates are based on the model with the polynomial terms in CT.

because the figures use knowledge available in 2008 about the completed tenure of CEOs in the sample that leave their position sometime after period t; information unknown to the market at time t.

The Relationship Between Returns, Tenure and Completed Tenure

While the results shown in Figures 6a-6e provide a very transparent test of an implication of the matching model, these tests do not fully exploit the monthly return data for returns, tenure and completed tenure. Tables 3-5 report estimates of monthly returns based on Equations 7 and 8 where current tenure and CT are parameterized several different ways. Table 3 reports the OLS models, Table 4 reports the fixed effect models and Table 5 reports the random coefficient estimates. Each specification for each statistical model includes the five financial market controls and the set of calendar year dummy variables.

Before the estimated tenure effects are discussed, it is worth noting some of the differences and similarities across the three statistical models. The OLS model that constrains the coefficients on four of the market model variables to be the same across firms is clearly the poorest fitting model. The R^2s for the FE specifications are almost twice the size of the OLS specifications and a likelihood ratio test comparing the OLS estimates with the random coefficient estimates decisively rejects the OLS model across all specifications with p-values less than .0001.

When comparing the random coefficient model with the FE model, recall that the FE model does not assume the market model coefficients are normally distributed and the standard errors in the FE model are clustered on the calendar month while the random

coefficient standard errors are not. However, if the market model coefficients are normally distributed then the random coefficient estimates are more precisely estimated compared to the FE model.

The normality assumptions regarding the distributions of $f(\beta_{j,i,f})$ for the four market model variables in the random coefficient model was evaluated by comparing the estimated distributions of $f(\beta_{j,i,f})$ from the random coefficient model with the estimated distribution of the coefficients on the firm by market interaction terms from the fixed effect model. These comparisons are shown in Figures 7a-7d. Each figure refers to the parameters for a different market factor. The normal distribution plotted in each figure is a normal distribution with parameters that match the estimated means and standard deviations of the distributions reported in Table 5. For example, the normal distribution of the estimated effects of market returns on firm returns shown Figure 7a comes from model 6 and has a mean of 1.17 and a SD of .469. The "nearly" normal distribution in Figure 7a is a kernel density estimate of the vector of coefficients on the interactions between the set of firm dummies and ln(1+Mkt).[29] Figures 7b-7d were constructed for the other three market variables using the same method. While formal tests reject the hypothesis that the coefficients from the fixed effect model are normally distributed for all four variables, a visual inspection of the pair of densities in each figure shows the FE

[29] In the model with the complete set of firm-CEO indicators interacted with the four market factors the estimated impact of MKT for the "excluded" CEO-firm is equal to the coefficient on MKT and each of the coefficients on the firm dummy by MKT interaction terms estimates the difference between the effect of MKT for the CEO-firm identified by the dummy variable relative to the effect of MKT for the "excluded" CEO-firm. Thus, the distribution of CEO-firm effects for MKT was obtained by plotting the distribution of following data points: β_{MKT},($\beta_{MKT} + \beta_{MKTxI(2)}$), ($\beta_{MKT} + \beta_{MKTxI(3)}$ .....($\beta_{MKT} + \beta_{MKTxI(N)}$) where N is the total number of firm-CEO pairs in the sample. The figure shows a kernel density estimate of the distribution of firm MKT effects using these N data points.

distribution overlap substantially with the estimated distribution from the random coefficient model.

These comparisons suggest either the random coefficient or the fixed effect models are plausible statistical models for estimating the relationship between monthly returns, tenure and completed tenure. This conclusion is further confirmed by the very similar coefficients on the tenure variables in the two statistical models across each of the models.[30] For this reason, the remaining discussion of the results is based on the random coefficient results reported in Table 5.

Although the specifications with just completed tenure reported in Figure 5 are consistent with the matching model, the data support a much richer specification that includes current tenure and completed tenure as predicted by the matching model. Current tenure and completed tenure (CT) are individually and jointly significant across all three statistical models and the data support a quartic term in completed tenure. [31]

The simplest way to interpret these coefficients is to construct figures that summarize predicted returns for hypothetical "average" CEOs that have different values for current and completed tenure.[32] Since market efficiency implies returns each month reflect the new information learned by investors that is thought to influence future

[30] There are some differences in estimated standard errors across the three models, but none of the differences are sufficient to lead to different conclusions for key null hypotheses using conventional levels of significance (.05).

[31] CT^5 is not statistically significant when added to Model 6 in Table 5. Models 5 and 6 were preferred to Model 4 that includes $Tenure^2$ because in Model 4 this variable was not significant at the .10 level in the FE model and just barely significant at the .10 level in the random coefficient model.

[32] As was done for earlier calculations, the values for the five market variables were set equal to their sample averages in all of these calculations.

profitability, the returns in a month reflect the impact on firm value of the changes in estimated match quality or $\beta\{E(\tilde{\alpha}_{t,i,f}|CT = T, \tilde{S}_t) - E(\tilde{\alpha}_{t-1,i,f}|CT = T, \tilde{S}_{t-1})\}$.

Figure 8 shows estimates of mean returns as current tenure varies for integer values of CT from 2 to 10 years using the random coefficient estimates for Model 6 reported in Table 5. Although the estimates in Figure 8 do not show the nonlinear relationship between returns and current tenure observed in the simulated data (See Figure 3), the estimates do show that at any level of current tenure up to 10 years predicted returns are larger for surviving CEOs that will eventually serve a longer time period than for CEOs that will serve for a shorter length of time. For example, the mean monthly return in month 36 for CEOs that will leave office one year later was -0.0004, while the estimated return for a CEO with CT equal to 8 years was .0106.

Ignoring dividends, each monthly predicted value of $\ln(1+Ret_{t,i,f})$ plotted in Figure 8 for month "t" equals the estimated value of $\ln(P_t / P_{t-1})$ where P_t is the firm's stock price at the end of month t in a CEO's tenure. The predicted total expected change in a firm's stock price over the tenure of a CEO that serves CT years is:

$$CAR_{CT} = \ln\left(\frac{P_{CT*12}}{P_0}\right) = \ln\left(\frac{P_1}{P_0}\right) + \ln\left(\frac{P_2}{P_1}\right) + \ln\left(\frac{P_3}{P_2}\right) + \ln\left(\frac{P_4}{P_3}\right) + \cdots \ln\left(\frac{P_{CT*12}}{P_{CT*12-1}}\right)$$

Based on the results in the last column of Table 5 (Model 6), CAR_{CT} is equal to sum of the monthly data points along the line in Figure 8 for an executives that serves for CT years, or:

$$CAR_{CT} = \ln(\frac{P_{CT}}{P_0}) = \sum_{t=1}^{CT*12}(\hat{\beta}_0 + \hat{\beta}_{Tenure}(t/12) + \hat{\beta}_{CT}(CT) + \hat{\beta}_{CT^2}\left(\frac{CT^2}{1000}\right) +$$

$$\hat{\beta}_{CT^3}\left(\frac{CT^3}{100000}\right) + \hat{\beta}_{CT^4}\left(\frac{CT^4}{1000000}\right) + \hat{\beta}_{Tenure\ x\ CT}(\frac{(\frac{t}{12})*CT}{1000})),$$

Since the market models are estimated using monthly data, t in the preceding equation denotes month t in an executive's tenure and predicted returns over a CEO's entire tenure is a function of the estimated monthly price changes over CT*12 months where CT is completed CEO tenure measured in years.

Figure 9 plots CAR_{CT} and its 95 percent confidence interval for different values of completed tenure. The figure shows that cumulative average returns for CEOs that serve four years is .056 or a 5.8 percent ($(e^{.056}-1)*100$) increase in firm value over the four year period. In contrast, CAR_8 is .883 or a 142 percent ($(e^{.883}-1)*100$) increase in firm value. To illustrate the economic significance of these point estimates, I calculated the predicted impact on firm value over an 8 year period for two hypothetical firms that had a market value of $4 billion at the start of an 8 year period. One firm has two CEOs that each served for 4 years and the other firm had a single executive that served for the entire 8 years. For the firm with two CEOs their estimated market value after 8 years was $4.47 billion or an 11.85 percent change over the entire 8 years.[33] In contrast, the predicted firm value for the firm with a CEO that served the entire 8 years is $9.67 billion or a 142 percent increase in firm value.[34] These estimates show the value to shareholders from a high quality firm-CEO match are substantial!

Figure 9 does not clearly show the strength of the relationship between match quality and completed tenure because the larger values of CAR_{CT} for longer tenured CEOs confounds the effects of longer tenure and the average returns each month

[33] The $4.47 billion equals 4*(1+(exp(.056)-1)) *(1+(exp(.056)-1))

[34] The $9.67 billion equals 4*(1+(exp(.883)-1)).

conditional on completed tenure. To adjust for the differences in the total time served as CEO and to produce estimates comparable to Figure 5, the expected average monthly return for CEOs that served CT years was calculated:

$$AR_{CT} = CAR_{CT}/(12 * CT).$$

These estimates and their 95% confidence intervals are shown in Figure 10. This figure shows average monthly returns increase with CT up to about CT=10. For example, the average monthly percentage change in the stock price for an executive that serves for 8 years is over 7 times larger (.0092/.0012) than the average monthly return for a CEO that serves for four years.

Robustness Checks

The key piece of data about CEOs required to perform the tests in this study data on the total length of time an executive served as CEOs. As discussed earlier, this requirement restricts the sample to CEOs in ExecuComp that ended their tenure by the end of 2008. Among CEOs appointed since 1992, CEOs with longer completed tenure are under-represented relative to CEOs with short completed tenures because longer tenured CEOs are more likely to still be in office at the end of 2008. Also, short-tenured CEOs that came to office prior to 1992 are under-sampled in the sample because they are more likely to have left office by 1992.[35] The usual potential biasing effect of an unobserved factor that is correlated with both completed tenure and returns is potentially

[35] See Figure 4.

more complicated because of this sampling process. I conducted several supplementary analyzes to assess the potential impact of these features of the sample.

The first robustness check excluded from the sample all CEOs with CT > 10 years. Figure 4 shows that this produces a sample of CEOs approximately equally split between CEOs that came to the position before and after 1992. For this subsample, I first estimated the preferred model based on the full sample that included current tenure, a 4th order polynomial in CT and current tenure x CT and found the coefficients on CT^3 and CT^4 were statistically insignificant. These higher order terms were dropped and Table 6 shows the key parameter estimates from a random coefficient model with CT, CT^2, current tenure and CT x current tenure. Figure 11 shows the estimated values of ln(1+Ret) as current tenure changes for integer values of CT from 2 to 10 years and Figure 12 shows the estimated mean monthly career values of ln(1+Ret) for executives that serve as CEO for different time periods. These estimates can be compared to estimates from the full sample shown in Figures 8 and 10. The estimates from the restricted sample are very similar to the full sample up to CT = 8. For example, the difference in mean career monthly returns between an executive that serves 8 years and an executive that serves 4 years is .008 in the full sample and .0085 for the restricted to CEOs with CT $\leq$ 10 years. These results suggest that for CT up to about 10 years, the estimates using the entire sample are not seriously affected by the inclusion of longer tenured CEOs that came to office prior to 1992.

I cannot estimate the impact of CT on executives still in office at the end of 2008 because CT is unobserved. However, data from CEOs still in office at the end of 2008 can be used to test a weaker implication of the matching model. The matching model

implies that mean monthly returns calculated over a CEO's tenure up to the censoring point (the end of 2008) are larger for CEOs that have greater tenure at this point in time because longer serving executives in office at the end of 2008 have higher expected match quality and longer expected completed tenure than executives with less tenure at the end of 2008. For example, a CEO that has been in his/her position for 6 years at the end of 2008 has higher expected match quality compared to the CEO that has 3 years of service at the censoring point because the latter CEO has a non-zero probability of leaving the job before her sixth year because her expected match quality is lower than the expected match quality for the CEO that has completed 6 years. This implies mean monthly returns up to the censoring point should be correlated with observed tenure at the censoring point.

To test this hypothesis the random coefficient model was estimated using the five market model variables, year dummies and functions of an executive's tenure at the censoring point, December 2008, or "Max Tenure". A quartic function of "Max Tenure" provided the best fit to the data the estimates on these variables are reported in Table 7. Figure 13 plots the predicted relationship between E(ln(1+ret)| Max Tenure) and Max Tenure along with the 95 percent confidence interval. The point estimates are significantly different from zero at the .05 level using a 2-tail test after executives have served for four years and up to about 12 years of tenure a statistically significant positive relationship exists between mean monthly career returns and tenure at the censoring point. The point estimate for E(ln(1+ret)| MaxT = 4) = .0011 (SE= .0004) and E(ln(1+ret)| MaxT = 8) = .0034 (SE=.0004) and the difference is .0023 (SE= .0005). The fact that these two point estimates are statistically different from one another is

consistent with the matching model; the expected match quality for the executive in her eighth years is greater than the match quality for a CEO in her fourth year.

Discussion and Summary

There is a large literature showing a negative relationship between *recent* firm returns and the probability an executive is fired (Weisbach 1988, Jenson & Murphy 1992, Murphy & Zimmerman 1993, Parrino 1997, Brickley 2003, Taylor 2010, Kaplan & Minton 2012). This paper extends previous research and views firm performance and the total time an executive serves as CEO as joint outcomes of the quality of the match between the firm and the CEO and the process by which firms learn about match quality and make retention decisions based on estimated match quality.[36] The main innovation in this study is the use of the total length of time an executive serves as CEO as an indicator of match quality. This follows directly from a modify a simple Bayesian normal learning model where the firm's BoD make a CEO retention decision based on a new signal of match quality and its updated estimate of firm-CEO match quality based on the history of signals observed by the BoD. The CEO if its estimate of estimated match quality falls below a threshold match quality level with a probability greater than a threshold probability. This CEO discharge rule produces a sample of surviving CEOs that are positively selected on match quality at each point in CEO tenure. As a result of this selection effect, expected average monthly firm stock returns calculated over a

[36] Since CEO retention decisions are a function of corporate governance, this study is in the spirit of Hermalin & Weisbach (1998) and Hermalin (2005) where corporate governance is a function of match quality.

CEO's tenure are predicted to be positively correlated with the total time an executive serves as CEO if investors are also learning about firm-CEO match quality. The model also predicts expected monthly stock returns in period t for CEOs still in office in period t will be positively correlated with the total length of time an executive serves as CEO. In other words, returns in period t predict, with error, the total time the surviving CEOs will remain in their jobs.

The empirical results using data from ExecComp for CEOs that had left office by the end of 2008 are consistent with the predictions of the model. The results reported in Figures 5a and 5b that impose little structure on the data show mean monthly stock returns over a CEO's time in the position increase up to about 8-10 years of completed tenure and remains relatively constant thereafter. These estimates suggest investors continue to learn about CEO match quality over this 8-10 year period. Estimates from models that impose more structure and include both current and completed tenure continue to suggest investors continue to learn about firm-CEO match quality through at least 10 years of tenure (see Figure 10). Predicted average monthly returns over the career for an executive that serves for 8 years is over seven time greater than the CEO that mean monthly returns over the career of a CEO that serves for four years.

The increase in mean career monthly returns up to 10 years of tenure and constant mean monthly returns for CEOs that serve longer than 10 years is inconsistent with models where entrenched (long-tenured) CEOs profit at the expense of shareholders (Bebchuk & Fried 2004). The differing predictions from matching theory and the theory of entrenched CEOs merits additional research using samples where the censoring of long-tenured CEOs (> 10 years) is less severe than in this study.

The estimates summarized in Figure 8 show monthly returns in month t for a sample of executives that have survived to period t are positively correlated with the length of time they will eventually serve as CEO. At month 36 of current tenure, estimated return is zero (-.0004) for a CEO that will serve a total of 48 months. In contrast, the estimated monthly return in month 36 for an executive that will serve for 8 years is 1.06 percent. Because monthly returns in period t for surviving CEOs are correlated with CT and returns reflects the impact of new information on the value of the firm, the results are evidence of continued investor learning about match quality by investors up to about 10 years of tenure.

The estimated effects of firm-CEO match quality on firm value that are implied by this study are economically significant. The value of CEO-firm match quality based on the estimates reported in Figure 10 can be illustrated by applying these estimates to the experience at Hewlett-Packard (HP) over the period from July 1999 when Carly Fiorina became CEO through September 2011 when Leo Apotheker was fired after serving for less than 11 months. Over this 12+ year time period Hewlett-Packard had 5 different CEOs, including 2 interim CEOs that served 2-3 months following the departure of two non-interim CEOs.[37] This experience suggests HP had great difficulty finding a high quality firm-CEO match. The estimates reported here can put a cost on this experience to HP shareholders. The preferred estimates from the random coefficient

[37] ExecuComp reports Carly Fiorina served from July 17, 1999-February 8, 2005; Robert Paul Wayman served from February 9, 2005-March 1, 2005; Mark Hurd served from April 1, 2005-August 1, 2010; Catherine Lesjak served from August 6, 2010-November 1, 2010 and Leo Apotheker served from November 1, 2010-September 22, 2011.

model predicts HP's market value should have increased just 48.7 percent over the 147 month period from July 1999-September 2011.[38] Alternatively, if HP had found a single executive of much higher match quality that could have served as CEO for the entire 147 month period, the estimate suggest this higher match quality would have caused HP's market value to increase by a factor of 4.4. At the end of fiscal year 1999 HP had a market value of $76 billion. These estimates suggest poor firm-CEO match quality cost HP shareholders $221 billion relative to the firm value that would have been expected with one high quality CEO that served the full 147 months.

This study included all CEOs in ExecuComp where completed tenure was observed and no effort was made to try and distinguish between dismissals and voluntary (from the CEO's perspective) retirements or departures. The strong relationship between returns and completed tenure across all CEOs suggests that even departures labelled as "voluntary" may be influenced by match quality; the utility of retiring to an executive versus the utility of continuing as CEO is likely affected by standard labor supply variables such as CEO wealth, health and age but also the intrinsic benefits the CEO receives from not retiring – benefits that are is likely to be a function of match quality. Thus, while accounting for other factors that might be related to CT may increase the precision of the tenure effects reported here, it's unlikely the substantive conclusion about the importance of CEO-firm match quality will change using more restricted samples and/or additional covariates.

[38] HP actually did much worse than predicted from our model. At the end of 2011 HP's market value had declined to $52.9 billion from $76 billion at the end of FY 1999. There was considerable conflict within the BoD over this period which is not part of the matching model.

The results reports in this study suggest CEO quality, as reflected in the firm-CEO match, has an important impact on firm value that may be at least as important as the efforts by BoDs to provide compensation contracts that align the interests of the CEO with the interests of the firm. The monitoring of CEOs by BoDs may be more important as a mechanism for assessing match quality than as a mechanism for managing the firm's agency problem.

A variety of questions are suggested from these results. How do the firm's corporate governance features affect the rate at which the firm learns about match quality? Do BoDs and the market learn about match quality faster when the CEO is an internal candidate versus an outside hire? Are the signals investors receive about match quality stronger or more valid based on characteristics of the industry? Does the positive relationship between firm stock returns and completed tenure lead to a positive relationship between CT and realized CEO compensation as firms and the CEOs split the rents generated by a high quality match? Are the rents of a high quality CEO-firm match shared with other executives and lower level employees in the firm? More generally, this study illustrates the value of using data available to researchers that is not available to the market to help our understanding of firm behavior and performance.

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Table 1

Descriptive Statistics on Firm-CEO Pairs in ExecuComp, 1992-2008
(SD in parentheses)

	CT observed, hired before or after 1992	CT observed, hired after 1991	CT observed, hired before 1992	CT is censored, hired after 1991	CT is censored, hired before 1992
Unique Firm-CEO Pairs:					
No of observations	1579	1160	419	1583	170
Mean CT (years)	6.27 (5.070)	4.328 (3.009)	11.648 (5.698)	NA	NA
Median CT	5.005	3.751	10.677	NA	NA
CT interquartile Range	6.055	4.267	7.674	NA	NA
Monthly Market Data:					
No of observations	119985	60993	58992	103464	29447
Mean Ln(1+ret)	0.0069 (0.017)	0.003 (0.022)	0.011 (0.007)	0.001 (0.021)	0.01 (0.008)
Mean Ln(1+mkt)	0.0092 (0.005)	0.008 (0.007)	0.011 (0.002)	0.002 (0.007)	0.009 (0.003)
Mean Ln(1+Rf)	0.0039 (0.001)	0.003 (0.001)	0.005 (0.001)	0.003 (0.001)	0.004 (0.001)

(Table 1 Continued)	CT observed, hired before or after 1992	CT observed, hired after 1991	CT observed, hired before 1992	CT is censored, hired after 1991	CT is censored, hired before 1992
Mean SmB	0.1334 (0.370)	0.261 (0.458)	0.002 (0.163)	0.248 (0.306)	0.261 (0.458)
Mean HmL	0.387 (0.381)	0.458 (0.504)	0.314 (0.146)	0.372 (0.349)	0.458 (0.504)
Mean Mom	0.889 (0.375)	0.867 (0.506)	0.916 (0.142)	0.864 (0.506)	0.864 (0.506)

Table 2

Estimates of the Impact of Completed Tenure on Mean Monthly Returns Over an Earlier Period

Prediction Period (months)	Estimated Difference in Returns CT=8 v CT=4
1-12	0.0051
	(0.0017)
13-24	0.0104
	(0.0017)
1-24	0.0073
	(0.0012)
25-36	0.0146
	(0.0020)
1-36	0.0090
	(0.0010)

Standard errors in parentheses.

Table 3

OLS Estimates of CEO Tenure and Completed Tenure on Monthly Stock Returns

Constant	0.0020	-0.0024	-0.0074***	-0.0152***	-0.0150***	-0.0230***
	(0.0013)	(0.0019)	(0.0023)	(0.0032)	(0.0032)	(0.0043)
Ln(1+Rf)	0.5396	0.5549	0.5411	0.5588	0.5580	0.5721
	(1.4233)	(1.4240)	(1.4249)	(1.4253)	(1.4256)	(1.4262)
Ln(1+Mkt)	1.1292***	1.1290***	1.1292***	1.1293***	1.1292***	1.1292***
	(0.0199)	(0.0200)	(0.0200)	(0.0200)	(0.0200)	(0.0200)
SmB	0.0038***	0.0038***	0.0038***	0.0038***	0.0038***	0.0038***
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
HmL	0.0046***	0.0046***	0.0046***	0.0046***	0.0046***	0.0046***
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
MOM	-0.0016***	-0.0016***	-0.0016***	-0.0016***	-0.0016***	-0.0016***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Complete_tenure	0.0005***	0.0012***	0.0034***	0.0061***	0.0060***	0.0099***
	(0.0001)	(0.0002)	(0.0004)	(0.0008)	(0.0008)	(0.0013)
Complete_tenure^2/1000			-0.1226***	-0.3554***	-0.3399***	-0.8869***
			(0.0165)	(0.0486)	(0.0482)	(0.1384)
Complete_tenure^3/100000				0.5301***	0.5295***	3.2811***
				(0.0913)	(0.0911)	(0.5853)
Complete_tenure^4/1000000						-0.4426***
						(0.0867)
Tenure		-0.0001	-0.0021***	-0.0021***	-0.0019***	-0.0019***
		(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Tenure^2/1000			-0.0479**	-0.0485**		
			(0.0196)	(0.0196)		
Complete_tenure x Tenure/1000		-0.0383***	0.1380***	0.1414***	0.0839***	0.0790***
		(0.0134)	(0.0298)	(0.0296)	(0.0150)	(0.0149)
R^2	0.1584	0.1590	0.1597	0.1601	0.1600	0.1602

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

N= 119,985

Table 4

Market Fixed Effect Estimates of CEO Tenure and Completed Tenure on Monthly Stock Returns

Constant	0.0031***	-0.0009	-0.0055***	-0.0125***	-0.0124***	-0.0201***
	(0.0009)	(0.0013)	(0.0015)	(0.0022)	(0.0022)	(0.0031)
Ln(1+Rf)	0.0818	0.0977	0.0658	0.0723	0.0694	0.0799
	(1.1110)	(1.1078)	(1.1083)	(1.1083)	(1.1082)	(1.1094)
Ln(1+Mkt)	1.0966***	1.1004***	1.0953***	1.0939***	1.0944***	1.0973***
	(0.0884)	(0.0875)	(0.0888)	(0.0892)	(0.0891)	(0.0884)
SmB	0.0011	0.0010	0.0009	0.0009	0.0008	0.0008
	(0.0017)	(0.0017)	(0.0017)	(0.0017)	(0.0017)	(0.0017)
HmL	0.0023	0.0024	0.0023	0.0023	0.0022	0.0023
	(0.0018)	(0.0018)	(0.0018)	(0.0018)	(0.0018)	(0.0018)
MOM	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
	(0.0014)	(0.0014)	(0.0013)	(0.0014)	(0.0014)	(0.0013)
Complete_tenure	0.0004***	0.0011***	0.0030***	0.0053***	0.0052***	0.0088***
	(0.0001)	(0.0002)	(0.0003)	(0.0006)	(0.0006)	(0.0011)
Complete_tenure^2/1000			-0.1022***	-0.2921***	-0.2822***	-0.7593***
			(0.0151)	(0.0410)	(0.0402)	(0.1228)
Complete_tenure^3/100000				0.4241***	0.4235***	2.7702***
				(0.0809)	(0.0808)	(0.5414)
Complete_tenure^4/1000000						-0.3720***
						(0.0819)
Tenure		-0.0004	-0.0020***	-0.0020***	-0.0019***	-0.0019***
		(0.0002)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Tenure^2/1000			-0.0300	-0.0307		
			(0.0196)	(0.0197)		
Complete_tenure x Tenure/1000		-0.0274***	0.1095***	0.1127***	0.0762***	0.0725***
		(0.0098)	(0.0310)	(0.0309)	(0.0156)	(0.0155)
R^2	0.3153	0.3162	0.3167	0.3169	0.3169	0.3171

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

N= 119,985, Number of unique firm-CEO pairs = 1579

Table 5

Random Coefficient Model Estimates of CEO Tenure and Completed Tenure on Monthly Stock Returns

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	β	SD	β	SD	β	SD	β	SD	β	SD	β	SD
Constant	0.0022		-0.0022**		-0.0070***		-0.0144***		-0.0143***		-0.0219***	
	(0.0007)		(0.0009)		(0.0011)		(0.0015)		(0.0015)		(0.0020)	
Ln(1+Rf)	0.2725		0.2778		0.2496		0.2616		0.2590		0.2720	
	(0.5520)		(0.5523)		(0.5521)		(0.5520)		(0.5520)		(0.5519)	
Ln(1+Mkt)	1.1684	0.4715***	1.1692***	.4708***	1.1699***	0.4704***	1.1701***	0.4698***	1.1699***	0.4697***	1.1701***	0.4693***
	(0.0159)	(0.0156)	(0.0159)	(0.0156)	(0.0159)	(0.0156)	(0.0159)	(0.0156)	(0.0159)	(0.0156)	(0.0159)	(0.0156)
SmB	0.0049	0.0067***	0.0049***	0.0067***	0.0049***	0.0067***	0.0049***	0.0067***	0.0049***	0.0067***	0.0049***	0.0067***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
HmL	0.0039	0.0069***	0.0038***	0.0069***	0.0038***	0.0069***	0.0038***	0.0069***	0.0038***	0.0069***	0.0038***	0.0069***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
MOM	-0.002	0.003***	-0.0019***	0.0030***	-0.0019***	0.003***	-0.0020***	0.0030***	-0.0020***	0.0030***	-0.0020***	0.003***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Complete_tenure	0.0004		0.0013***		0.0033***		0.0058***		0.0058***		0.0095***	
	(0.0001)		(0.0001)		(0.0002)		(0.0004)		(0.0004)		(0.0008)	
Complete_tenure^2/1000					-0.1135***		-0.3288***		-0.3174***		-0.8334***	
					(0.0122)		(0.0320)		(0.0314)		(0.1002)	
Complete_tenure^3/100000							0.4878***		0.4873***		3.0716***	
							(0.0671)		(0.0671)		(0.4815)	
Complete_tenure^4/1000000											-0.4144***	
											(0.0765)	

Random Coefficient Model Estimates of CEO Tenure and Completed Tenure on Monthly Stock Returns

Table 5 (Continue)

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	β	**SD**	**β**	**SD**	**β**	**SD**	**β**	**SD**	**β**	**SD**	**β**	**SD**
Tenure			-0.0002		-0.0021***		-0.0021***		-0.0020***		-0.0020***	
			(0.0002)		(0.0003)		(0.0003)		(0.0003)		(0.0003)	
Tenure^2/1000					-0.0351*		-0.0357*					
					(0.0199)		(0.0199)					
Complete_tenure x			-0.0354***		0.1201***		0.1234***		0.0810***		0.0765***	
Tenure/1000			(0.0088)		(0.0278)		(0.0278)		(0.0146)		(0.0147)	
R^2	0.2912		0.2922		0.2928		0.2930		0.2930		0.2931	

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

N= 119,985, Number of unique firm-CEO pairs = 1579

The R2 is from a regression of ln(1+ret) on the predicted ln(1+ret) that includes the random components for the four market variables.

Table 6

Coefficients on CEO Tenure Variables in a RC Model of Monthly Firm Stock returns (ln(1+ret)) For CEOs Where Completed Tenure

Constant	-.0205***
	(0.0026)
Completed Tenure	.0114***
	(0.0010)
Completed Tenure^2 /1000	-.8496***
	(0.1021)
Tenure	-.0082***
	(0.0011)
Complete Tenure x Tenure/1000	.8380***
	(0.1362)

Standard errors in parentheses.
*** p <.01, ** p <.05, p < .10

Table 7

Coefficients on CEO Tenure Variables in a RC Model of Monthly Firm Stock returns (ln(1+ret))

For CEOs Where Completed Tenure is Censored

Constant	-.0032***
	(0.0015)
Max Tenure	.0014***
	(0.0004)
Max Tenure^2 /1000	-.0796***
	(0.0288)
Max Tenure^3 /1000	.0013***
	0.0011

Standard errors in parentheses.
*** p <.01, ** p <.05, p < .10

Figure 1a

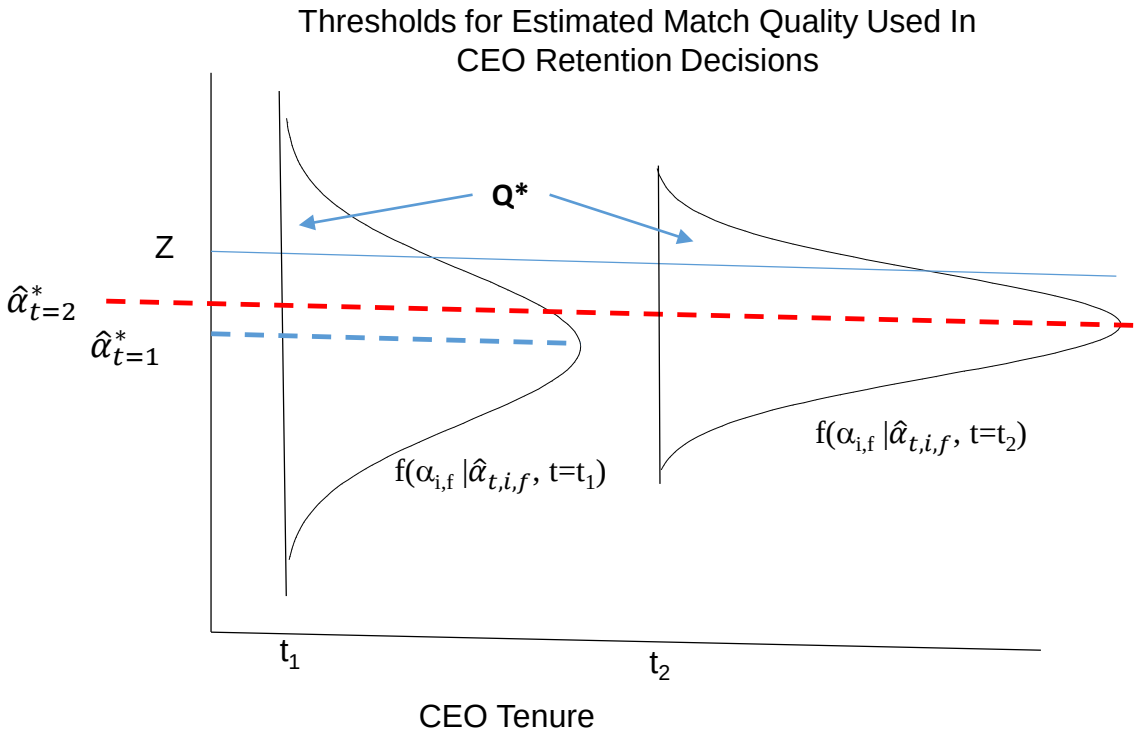


Figure 1b

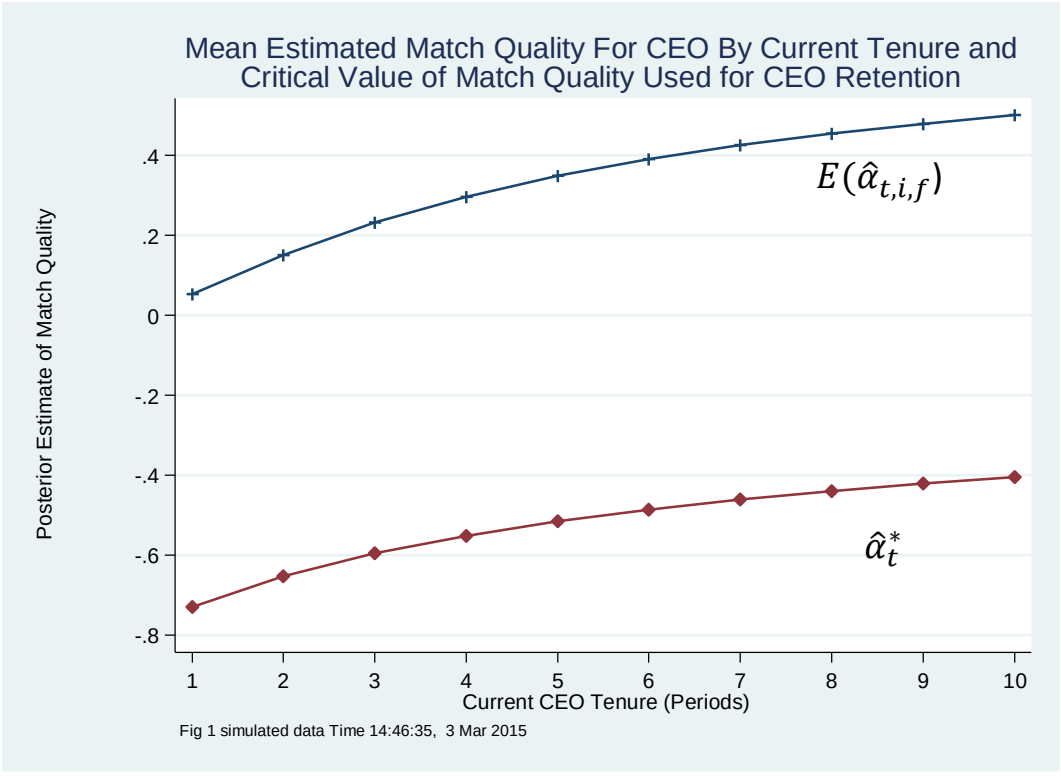


Figure 2

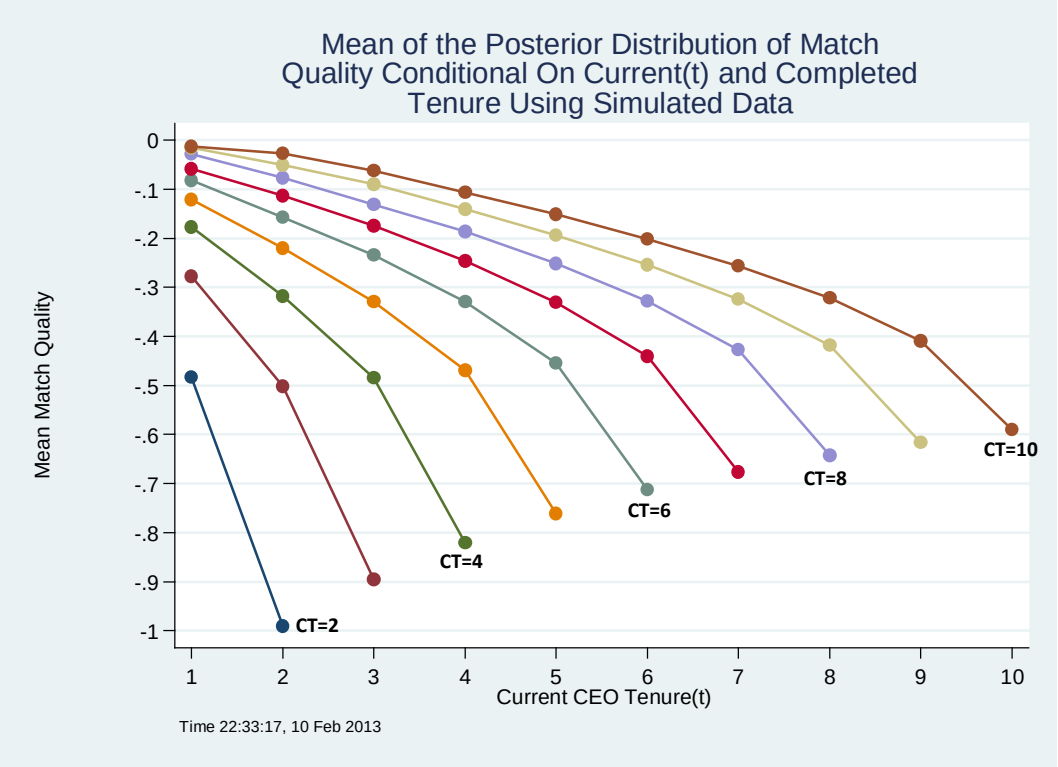


Figure 3

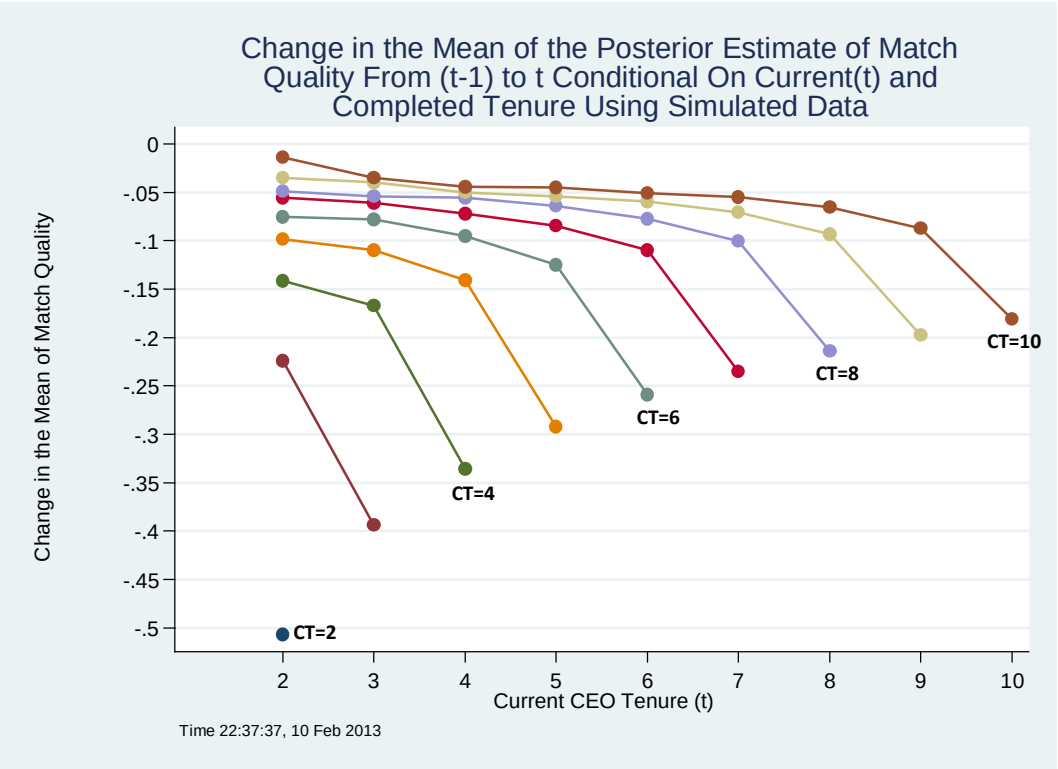


Figure 4

Probability the CEO in a Firm-CEO Pair Was Hired After Jan 1, 1992
Probability
1
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
0
2
4
6
8
10
12
14
16
18
20
Completed Tenure as CEO (years)
Time 13:26:29, 24 Mar 2013 prob_post92_hire.gph

Figure 5a

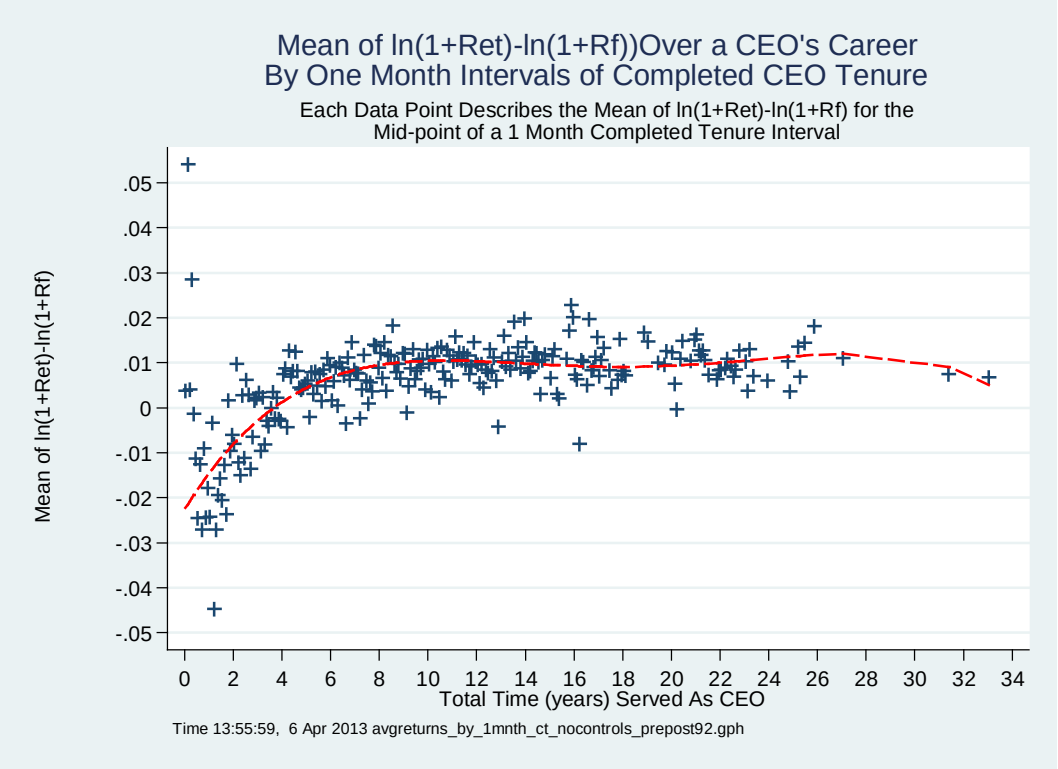


Figure 5b

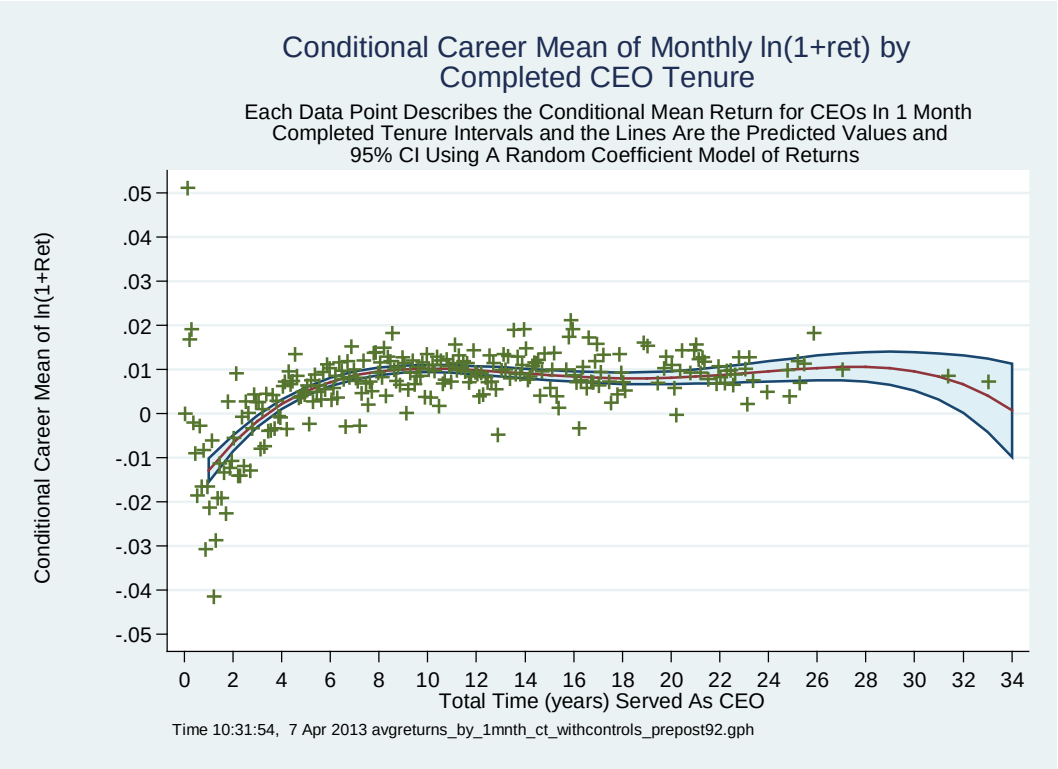


Figure 6a

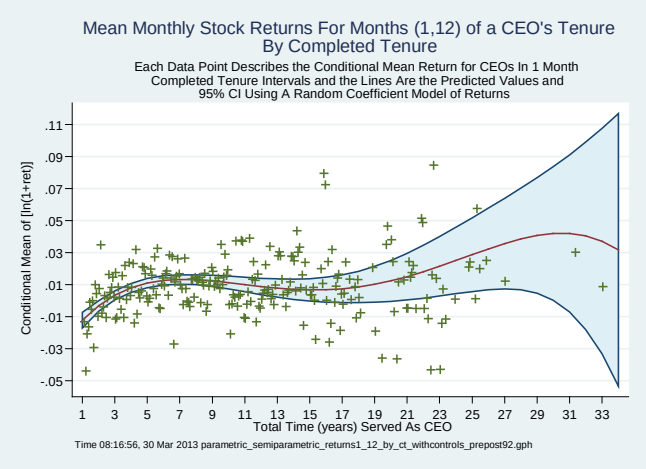


Figure 6b

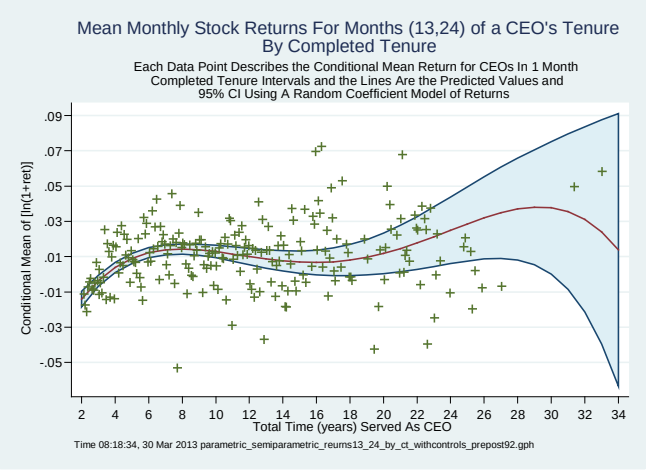


Figure 6c

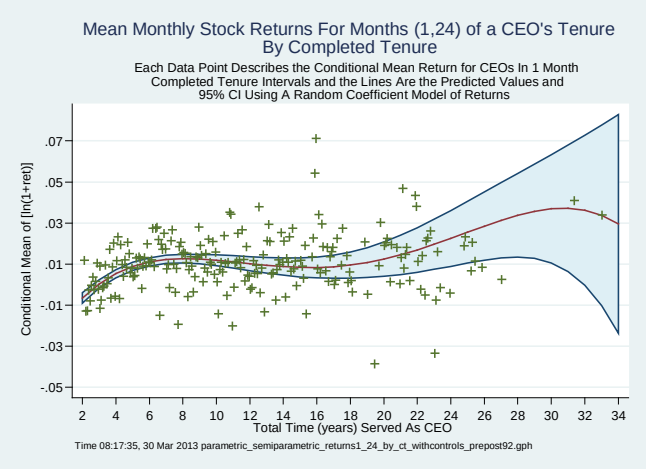


Figure 6d

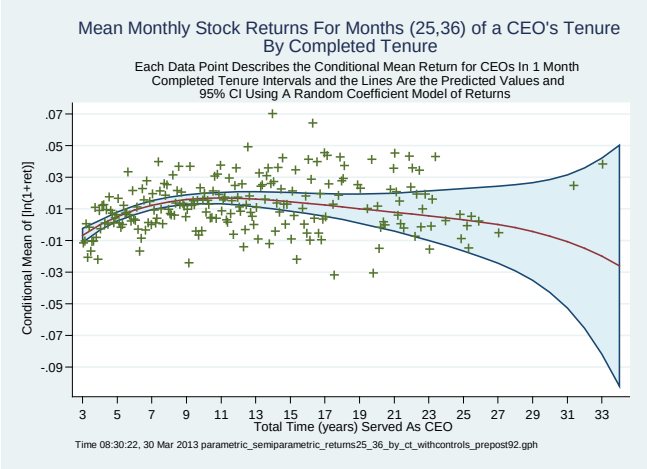


Figure 6e

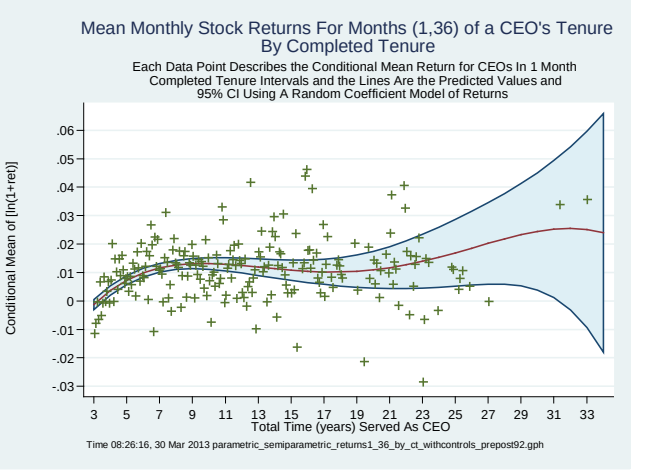


Figure 7a

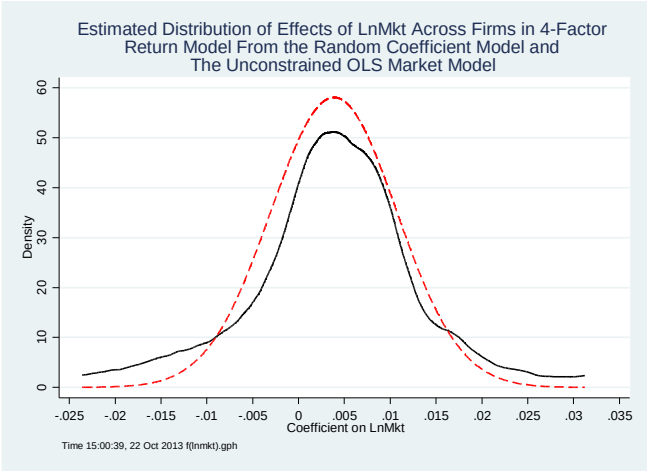


Figure 7b

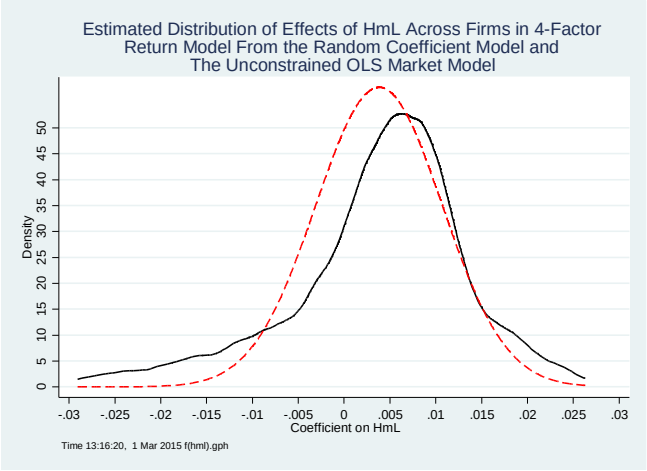


Figure 7c

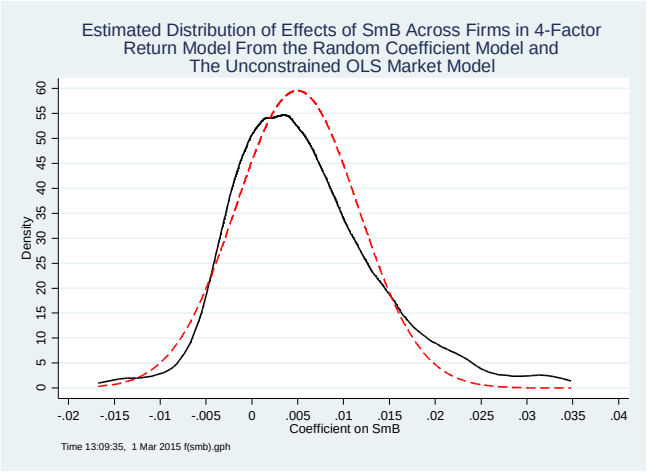


Figure 7d

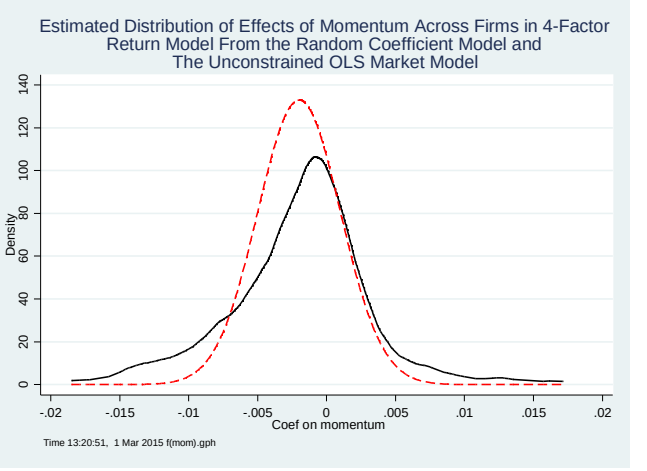


Figure 8

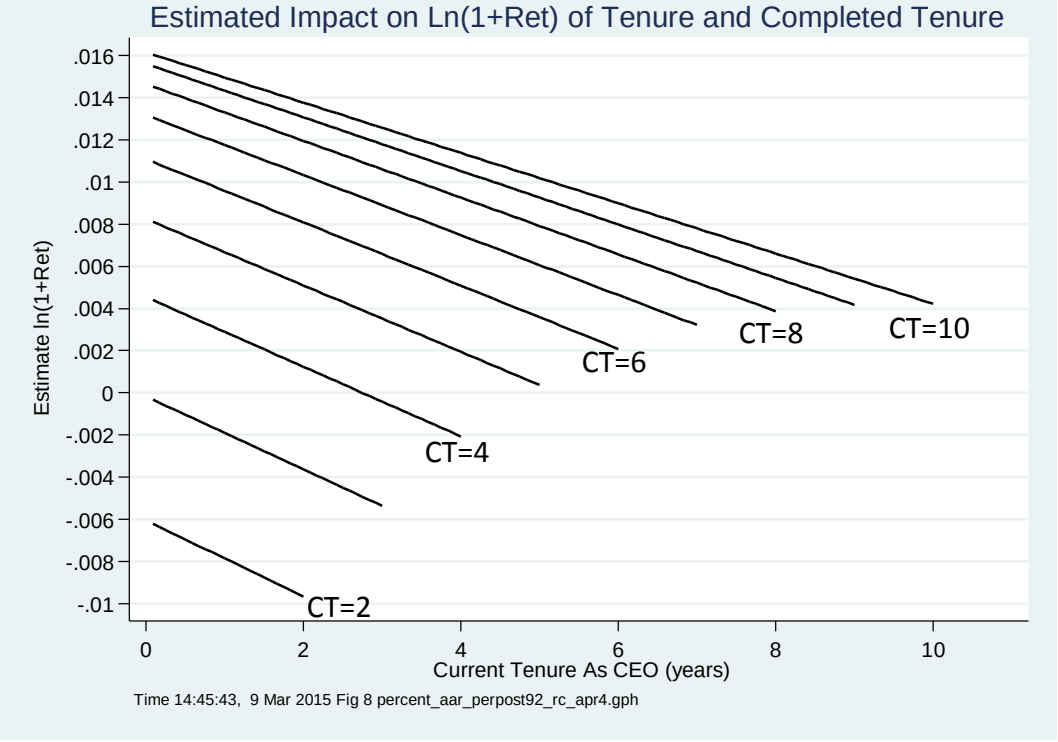

Estimated Impact on Ln(1+Ret) of Tenure and Completed Tenure
Estimate ln(1+Ret)
.016
.014
.012
.01
.008
.006
.004
.002
0
-.002
-.004
-.006
-.008
-.01
CT=2
CT=4
CT=6
CT=8
CT=10
0
2
4
6
8
10
Current Tenure As CEO (years)
Time 14:45:43, 9 Mar 2015 Fig 8 percent_aar_perpost92_rc_apr4.gph

Figure 9

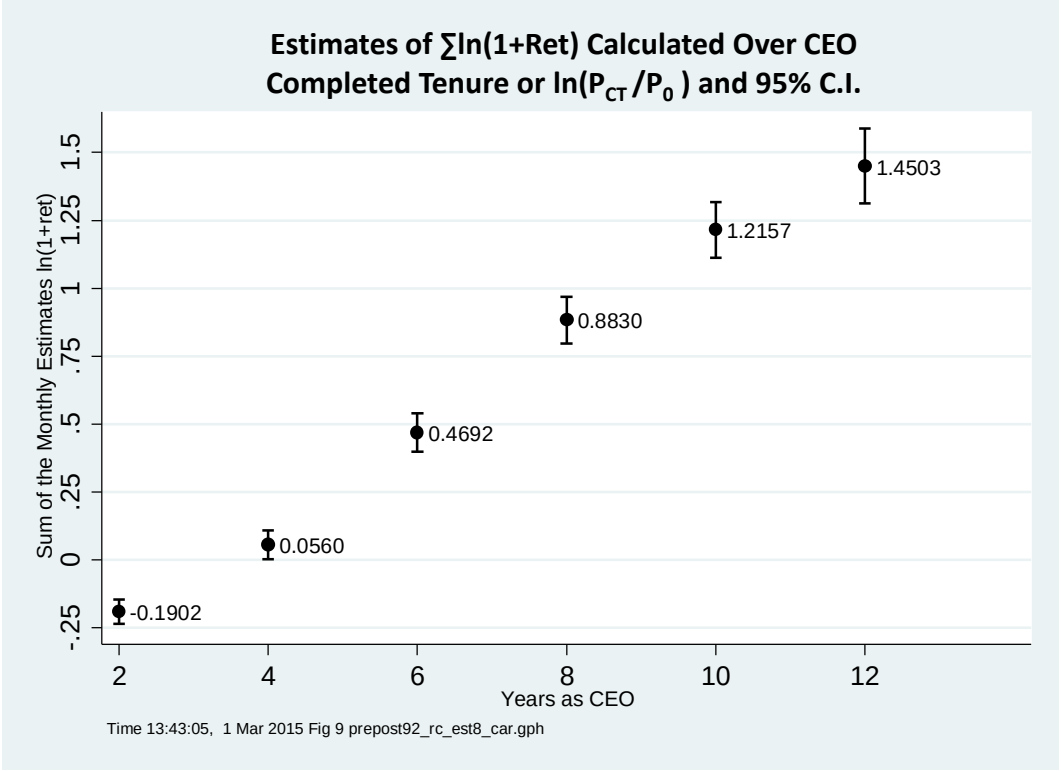


Figure 10

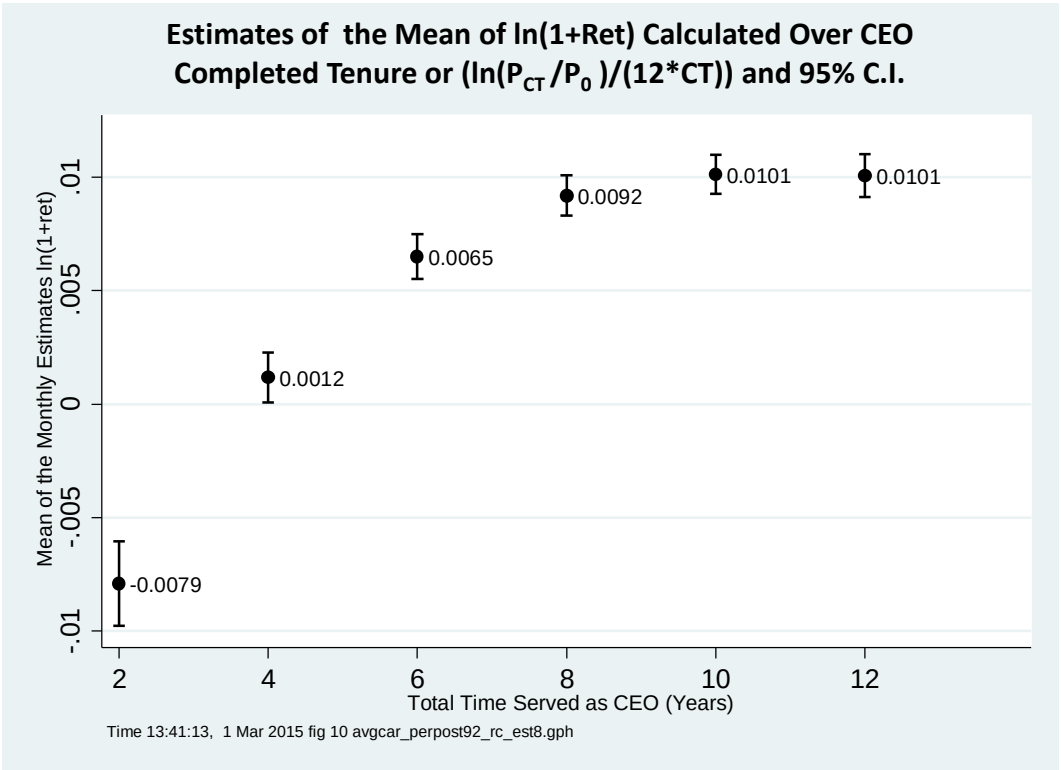


Figure 11

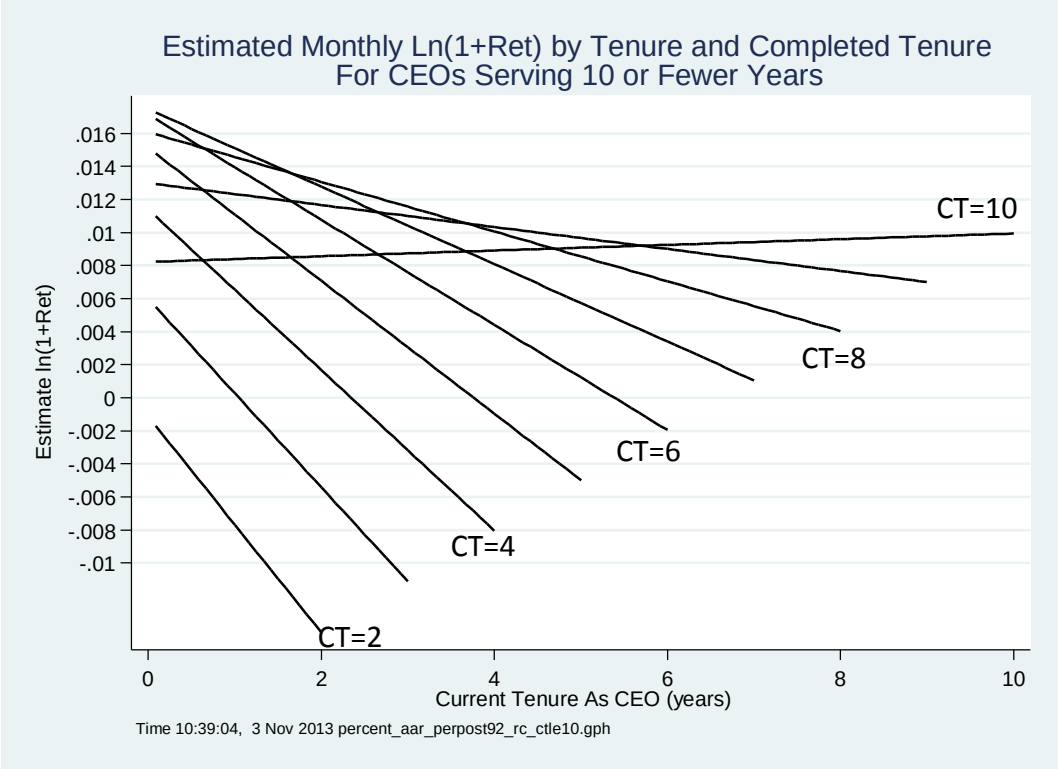


Figure 12

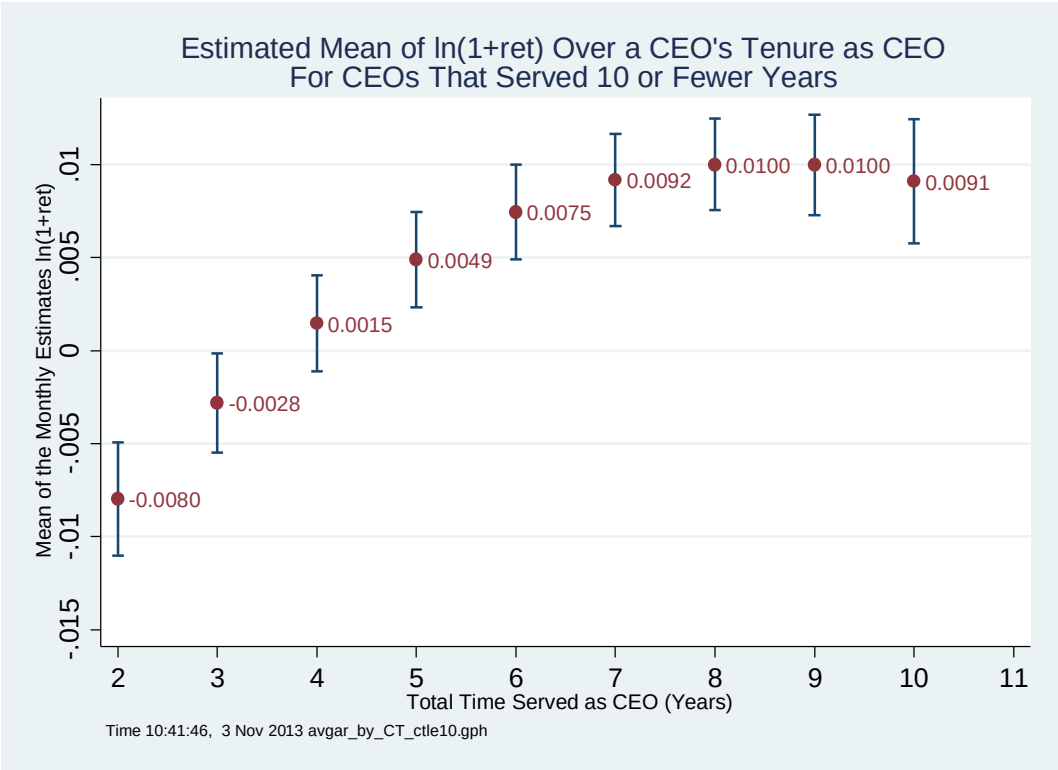
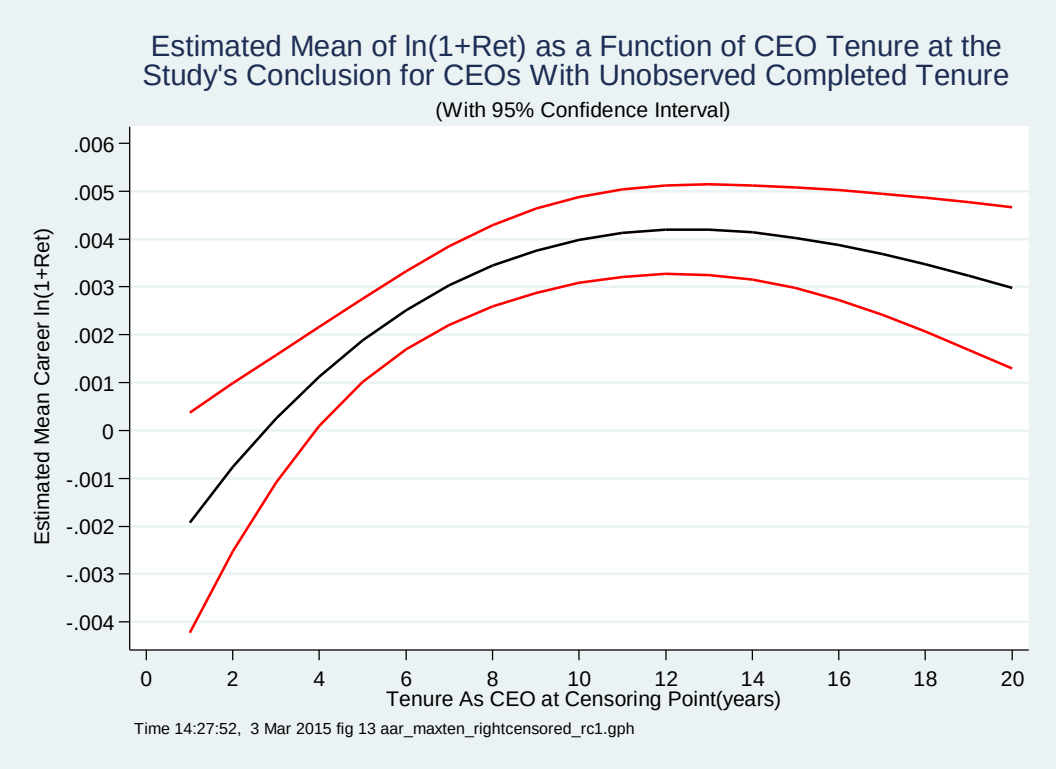


Figure 13


Estimated Mean of ln(1+Ret) as a Function of CEO Tenure at the Study's Conclusion for CEOs With Unobserved Completed Tenure
(With 95% Confidence Interval)
Estimated Mean Career ln(1+Ret)
.006
.005
.004
.003
.002
.001
0
-.001
-.002
-.003
-.004
0
2
4
6
8
10
12
14
16
18
20
Tenure As CEO at Censoring Point(years)
Time 14:27:52, 3 Mar 2015 fig 13 aar_maxten_rightcensored_rc1.gph