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HOW QUICKLY DO CEOs BECOME OBSOLETE? INDUSTRY DYNAMISM, CEO TENURE, AND COMPANY PERFORMANCE

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Scholars have characterized CEO tenures as life cycles in which executives learn rapidly during their initial time in office, but then grow stale as they lose touch with the external environment. We argue, however, that the opportunities for adaptive learning are limited because (1) a CEO assumes office with a relatively fixed paradigm that changes little thereafter; (2) inertia limits the speed at which an organization can align itself with a new CEO's paradigm; and (3) for any within-paradigm learning to occur, the external environment must be stable enough so that the cause–effect relationships that CEOs glean today remain relevant tomorrow. In a longitudinal study of 98 CEOs in the relatively stable branded foods industry and 228 CEOs in the highly dynamic computer industry, we found results that strongly supported our hypotheses. In the stable food industry, firm-level performance improved steadily with tenure, with downturns occurring only among the few CEOs who served more than 10–15 years. In contrast, in the dynamic computer industry, CEOs were at their best when they started their jobs, and firm performance declined steadily across their tenures, presumably as their paradigms grew obsolete more quickly than they could learn. Copyright © 2006 John Wiley & Sons, Ltd.

In recent years, a significant body of research has focused on the ways that top executives influence strategic choices and organizational performance. Based on the premise that organizations are susceptible to the actions of their uppermost managers, but that managers are only boundedly rational, researchers have found that organizations become reflections of their top executives (Cyert and March, 1963; Hambrick and Mason, 1984). Studies have found, for example, that CEO personalities and functional backgrounds predict strategic actions and orientations (Gupta and Govindarajan, 1984; Miller, Kets de Vries, and Toulouse, 1982).

Most research linking executive characteristics to organizational outcomes, however, has been cross-sectional in design and static in its logic. Apart from studies of CEO succession, it has been rare to dynamically model executive orientations and firm performance, with time playing a central theoretical role (e.g., Gabarro, 1987; Miller, 1991).

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Yet from literatures on organizational evolution (Nelson and Winter, 1982), human factors in decision making (Rubin and Brockner, 1975; Staw and Ross, 1987), and executive cognition (Hambrick, Geletkanycz, and Fredrickson, 1993), it appears likely that senior executives, including CEOs, do not think, behave, or perform uniformly over their tenures.

A few papers have examined how the impact of CEOs varies over their time in office. Hambrick and Fukutomi (1991) proposed that new CEOs begin with a knowledge deficit but steadily learn about their jobs, organizations, and environments. After some point, though, CEOs are thought to become insular and overly wedded to their early formulas, resulting in an inverted U-shaped relationship between tenure and firm performance. In line with this model, Miller and Shamsie (2001), in a longitudinal study of the film industry, found that firm performance increased for the first 8–10 years of CEOs' tenures and then began to fall. Pointing to the same pattern, Miller (1991) found that the environment–organization alignments prescribed by contingency theory (e.g., Lawrence and Lorsch, 1967) were indeed observed for companies whose CEOs had been in office for a brief or moderate period; but those alignments were not observed when CEOs had been in office for 10 years or more, resulting in lower company performance. Miller concluded that CEOs are alert to the environment during their early years in office, but then lose touch and become 'stale in the saddle.'

These three works are strikingly consistent in their portrayals of CEO tenures, as each argues that CEOs pass through two phases during their time in office. The first is an initial period of adaptive improvement, in which CEOs learn by doing and gradually implement a strategic orientation that fits the firm to its environment. Eventually, though, a second tendency takes hold that causes performance to decline. CEOs become overly committed to their earlier formulas, and their organizations become so tightly aligned with the status quo that change becomes difficult to consider and even harder to execute. The result is an inverted-U relationship between CEO tenure and firm performance.

Such a relationship may generally occur, but an important contingency has yet to be considered. If we assume that CEOs often arrive at their jobs with paradigms that are well-suited to current conditions, yet also relatively fixed, then the dynamism of the external environment determines how quickly these paradigms become obsolete. CEOs who operate in relatively stable environments will enjoy long periods of effectiveness with only delayed downturns. On the other hand, CEOs who operate in highly dynamic environments will tend to peak very early, and the performance of their firms will begin to drop after only a brief time in office. This paper explores that contrast.[1]

CEO PARADIGMS AND FIRM PERFORMANCE

Our core premise is that each CEO has a finite and relatively fixed paradigm, consisting of an interconnected worldview and a repertoire of skills for applying it. Such a paradigm includes a bounded model of how the environment behaves, what options are feasible, and how the organization should be run (Miller and Dröge, 1986; Miller *et al.*, 1982). Although a CEO's paradigm may show some elasticity when faced with the need for change, it will be the rare executive who can greatly transform his or her mindset, aptitudes, and skills. For example, a CEO who has risen and thrived in an efficiency-driven industry, and who is a talented cost cutter, will struggle if customers begin to favor luxury features. Even if the CEO recognizes the new requirement for luxury, he or she will have great difficulty putting in place all the organizational elements necessary to execute a strategy consistent with those demands, because such actions would contradict prior decisions and undermine the executive's cost-cutting skills.

In selecting a new CEO, a board of directors attempts to find someone whose competencies and experience align with conditions facing the firm at the time and into the foreseeable future (Finkelstein and Hambrick, 1996; Vancil, 1987). Although alignment is seldom perfect, boards are likely to exhibit at least some facility in assessing current leadership needs and extrapolating future ones, particularly in environments that change slowly

[1] In this paper, performance refers to organizational outcomes, which are influenced both by CEOs and by factors outside their control. A different aspect of performance exists at the individual level and involves how CEOs function in their various roles, which boards of directors might judge, for instance, by assessing a CEO's integrity or communication skills. Our data, though, capture only organizational outcomes, not individual-level measures of job fulfillment.

and incrementally. As a result, a new leader will typically have a paradigm that is more appropriate than a randomly selected executive (Finkelstein and Hambrick, 1996). The duration of the new leader's fit, however, will depend on the degree to which the external environment remains stable or evolves in ways that the board of directors can anticipate.

CEOs take office with some awareness of why they were selected for the job, often perceiving a mandate to mold their firms in ways that align with their personal paradigms (Finkelstein and Hambrick, 1996). As a result, new CEOs will have fairly clear ideas about what they have been tasked to do and how they should proceed. Yet their ability to execute strategies consistent with their paradigms is limited by organizational inertia, which constrains the rate at which firms can change (Hannan and Freeman, 1984). Some early initiatives may yield quick improvements to firm performance, but it will take time both to assemble an executive team whose mindsets and assumptions match the CEO's and to fully implement policies that bring the organization's activities into alignment with the CEO's paradigm (Hambrick and Fukutomi, 1991; Miller, 1993; Siggelkow, 2002).

If CEOs take office with paradigms that change only modestly over time, yet organizations need time to fully align themselves with those worldviews, then the CEO tenure clock will pace two simultaneous yet countervailing processes. The first is adaptive. To the extent that a board can foresee a company's future environment and select a CEO whose paradigm matches it, performance will improve with tenure as the firm's strategy more fully manifests the CEO's paradigm. If the environment is stable enough so that the refinements made today remain useful tomorrow, the CEO may also engage in some within-paradigm learning (cf. Argote, Beckman, and Epple, 1990; Argote and Epple, 1990). After initially rising, the rate of performance increase will slow, as the easiest opportunities for within-paradigm refinements are exhausted and the paradigm itself constrains major change. Thus, some combination of gradual implementation of the CEO's paradigm and learning by doing will improve firm performance, but at a slower rate as CEO tenure lengthens.

In contrast, a second and concurrent process, involving growing mismatches between the CEO's paradigm and the external environment, will diminish firm performance at an increasing rate. Long-tenured CEOs become increasingly committed to their earlier policies (Staw and Ross 1987). And through time, CEOs increasingly surround themselves with like-minded executives who reinforce the CEO's entrenched point of view (Hambrick, 1995). While new CEOs are highly attuned to the external environment (having been selected specifically for their fit with current conditions), longer-tenured executives are increasingly isolated from it (Hambrick and Fukutomi, 1991). Over time, mismatches between the CEO's paradigm and the environment tend to mount at an increasing rate due to a compounding process: with each passing year, environmental conditions move further away from those that the CEO was initially equipped to face; at the same time, the CEO becomes increasingly inattentive to those developments.

HYPOTHESES

If the CEO tenure clock paces two processes, one adaptive and involving the implementation of a CEO's initially suitable paradigm, the second maladaptive and involving the growing mismatch between a CEO's paradigm and the environment, what are the net effects on firm performance? The answer, we propose, is contingent on the dynamism of the external environment. Figure 1(a, b) depicts—for stable and dynamic settings, respectively—how the benefits of internal alignment with a CEO's paradigm and the penalties of its external misfit change over the course of a CEO's tenure, and what the resultant effects on firm performance are likely to be.

A stable industry is one in which customer preferences, technologies, and competitive dynamics change little. There, as Figure 1(a) indicates, the benefits of internal fit and learning accrue steadily over a relatively long period, and the penalties for external mismatches accumulate slowly, becoming substantial only for CEOs who remain in office for extraordinary lengths of time. In stable settings, boards can select CEOs whose paradigms provide reasonable matches to both present and future conditions. Such foresight is possible because historical conditions are strongly correlated with future ones, and boards can observe alternative CEO candidates and project with some accuracy how

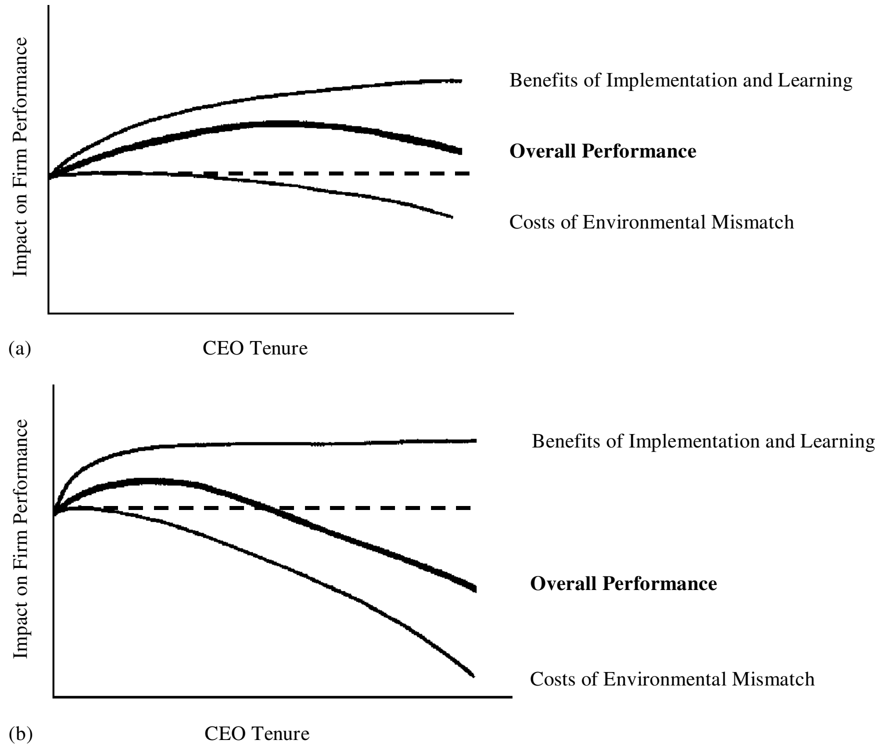

Figure 1. Predicted effects of CEO tenure on firm performance. (a) Effects in stable environments. (b) Effects in dynamic environments

their paradigms will serve in coming years. In stable settings, the potential for steady improvement is considerable, since knowledge acquired today will, to a fair degree, also apply tomorrow (March, 1991; Weick, 1991). Therefore, even if CEOs' paradigms evolve very little, they can gradually discern how to better implement their ideas, resulting in steady improvements over long periods. Later improvements will be smaller than earlier ones, as the limitations of a given paradigm are reached, but the overall trend is favorable.

Figure 1(a) further indicates that, even in stable settings, there is at least some penalty to be paid for the growing mismatch between a CEO's paradigm and the environment, which arises from the accumulated effects of environmental drift, coupled with the tendency for long-tenured executives to lose touch with their external settings. While those hazards are relatively small and mount very gradually in stable settings, we expect they will become noticeable among the longest serving CEOs, resulting in an inverted U-shaped relationship. Most CEOs in stable industries will therefore leave office while their company's performance is still on the rise, but the few who stay in office the longest will eventually exhibit declining performance.

In comparison, Figure 1(b) depicts the scenario typical of dynamic industries in which the long-range benefits of internal fit are limited, and the penalties imposed by external mismatches mount quickly. In these settings, the potential for early improvement is sizeable because the predecessor's paradigm is likely to have grown severely obsolete, giving the board an opportunity to appoint a successor whose worldview is much better aligned with current environmental conditions. Moreover, dynamic industries are characterized by an ongoing barrage of external jolts that disrupt the status quo and allow top executives to make major strategic alterations (Hambrick and Finkelstein, 1987; Tushman and Romanelli, 1985). As a result, new CEOs in dynamic environments can align their firms with their paradigms fairly quickly, which Figure 1(b) reflects in the rapid initial rise of its internal fit curve.

While near-term benefits can be grasped quickly in dynamic settings, two factors limit long-term improvements. First, accurate long-range prediction is all but impossible in dynamic settings, so boards are generally unable to appoint new CEOs whose paradigms will remain appropriate far into the future. Second, learning requires an environment that is simple enough to comprehend and stable enough so that knowledge can accumulate in a coherent body rather than being rendered obsolete by external change. Dynamic settings lack those prerequisites: environmental feedback is noisy and confusing, so cause-and-effect relationships are difficult to discern (Levinthal and March, 1993; Lounamaa and March, 1987), and environmental upheaval is often so great as to make yesterday's knowledge useless (March, 1991; Miller and Shamsie, 2001). Executives may try to cope by acting quickly and learning fast on the basis of minimal data, but such an approach is hazardous. As Levinthal and March (1981: 323) have observed: 'Fast learners adapt quickly to correct signals; [but] they also adapt quickly to false signals.' CEOs in turbulent settings often make new discoveries, but this amounts to swimming upstream against repeated surges of environmental change, so their net progress is minimal. The potential for *cumulative* adaptive learning is therefore limited when many external changes call for fresh starts from blank slates rather than the reuse of existing knowledge.

Correspondingly, mismatches between CEOs' paradigms and external conditions accrue rapidly in dynamic settings. New CEOs arrive with fresh and generally appropriate ideas, because boards select leaders whose worldviews fit current conditions. Yet those individuals will begin to lose their suitability soon after they take office, as their paradigms become outdated. Even as external cause–effect relationships change, CEOs will be seduced by their initial successes and strengthen their convictions regarding the correctness of their paradigms (Staw and Ross, 1987; Weick, 1991).

In summary, CEO effectiveness will increase initially but then decline in both stable and dynamic settings, but obsolescence will manifest itself much more rapidly in turbulent environments. We therefore predict:

Hypothesis 1: There will be an inverted U-shaped relationship between CEO tenure and company performance. Performance will initially increase, but then later decrease.

Hypothesis 2: Peak firm-level performance will occur earlier in CEOs' tenures in a dynamic industry than in a stable one.

METHODOLOGY

We drew samples from the computer and branded foods industries, selected for their widely contrasting degrees of dynamism. Prior research suggests that the factors affecting environmental dynamism include degrees of innovation, technological change, supply instability, competitive rivalry, and market growth (Aldrich, 1979; Dess and Beard, 1984). Over the study period, 1955–94, these two industries differed dramatically on all those dimensions. The computer industry was characterized by rapid technological change, much innovation, volatile growth, and unstable demand (Brown and Eisenhardt, 1997). In contrast, the food industry was much more stable, with slower and more consistent growth, and little technological or competitive change (Geletkanycz and Hambrick, 1997).

For the computer industry, we examined all companies with a primary SIC code of 3570, 3571, or 3572 that were listed in COMPUSTAT in any year from 1955 through 1994. We then searched major public sources (*Wall Street Journal Index, NEXIS, Standard and Poor's Register of Directors and Executives*) and company filings to identify the year that each CEO began and ended his or her tenure. Tenures that continued beyond 1994 were treated as right-censored. We considered the company's highest-ranking executive (typically the chairman) to be the CEO, unless another executive expressly held the CEO title. In all, the computer sample included 228 CEO tenures, ranging from 1 to 36 years. The median tenure was 4 years, and 15 percent were longer than 10 years. The total number of CEO-years was 1397.

For the food industry, we examined companies with a primary two-digit SIC code of 20 (excluding those that were involved principally in agricultural commodities). The sample consisted of firms that were listed on the New York or American Stock Exchange in any year from 1955 to 1994. We used the same public sources noted above to identify the dates that CEOs started and completed their tenures. Again, tenures that continued beyond 1994 were treated as right-censored. The food industry sample included 98 CEO tenures, ranging from 1 to 36 years. The median was 6 years, and one-fourth were greater than 10 years. In all, there were 847 CEO-years.

Measures

Dependent variable

To assess firm performance, we examined three annual measures of profitability: (1) return on sales = net $\text{income}_t/\text{sales}_t$; (2) return on assets = net $\text{income}_t/\text{net assets}_t$; and (3) return on invested capital = net $\text{income}_t/(\text{shareholders equity}_t + \text{debt}_t)$. All financial data were taken from COMPUSTAT. Within each industry, those measures were highly correlated, so we used weights from factor analyses to extract a unified construct. In the computer sector, that analysis yielded a one-factor weighted average of *profitability* with an eigenvalue of 2.28 that explained 76.1 percent of the total variance in return of sales, assets, and invested capital. The food industry analysis also yielded a one-factor solution. Its eigenvalue was 2.52, and it explained 84.1 percent of total variance.

Independent variables

CEO tenure was measured by counting the years a chief executive had been in office. We also calculated the square of tenure and included it where it was significant. Unless otherwise noted, all predictors were updated annually and lagged by 1 year.

Organizational controls

To control for economies of scale, we measured *firm size* by taking the natural log of the number of employees. Because performance may exhibit path dependencies due to organizational learning, inertia, or the development of firm-specific capabilities (e.g., Barney, 1991; Teece, Pisano, and Shuen, 1997), we controlled for prior performance, as measured by $profitability_{t-1}$. Similarly, we controlled for *firm age*, measured in years. Its square was not significant in any analyses.

Changes in strategy may affect firm performance, so we assessed year-to-year adjustments in four key resource allocations: (1) expenditures on property, plant, and equipment (PP&E); (2) R&D expenditures; (3) advertising expenditures; and (4) the number of employees. If a firm were maintaining the status quo, these quantities would be similar across years; conversely, large changes (positive or negative) in these measures would signal important alterations to a firm's resource deployments. Next, we calculated the natural logarithms of the absolute values of their differences between the prior and current year. For example, $\Delta\text{R\&D} = \ln(|\text{R\&D}_t - \text{R\&D}_{t-1}|)$. Logarithms were used to reduce skewness. Data were obtained from COMPUSTAT, and all dollar values were deflated using a GNP index. These measures have the advantages of objectivity and widespread availability—both over time and across industries. They have been used in prior research to characterize similarity among firms' strategic profiles (Geletkanycz and Hambrick, 1997) and changes in firm profiles over time (Westphal, Seidel, and Stewart, 2001).

Because strategic changes typically span across a firm's activities (Tushman and Romanelli, 1985), we used factor analysis to extract an index, *strategic change*, comprised of ΔPP&E, ΔR&D, Δadvertising, and Δemployees. In the computer industry, this yielded a one-factor solution with an eigenvalue of 2.80 explaining 70.0 percent of the variance in the four change components. There was also a one-factor solution in the food industry, with eigenvalue of 2.16 and explaining 53.9 percent of variance. Since CEOs' abilities to make changes may vary across their tenures (Miller and Shamsie, 2001), we also examined the interaction of CEO tenure and strategic change and included it where it was significant.

Two dummy variables accounted for a limitation in public reporting of data on R&D and advertising. When firms spend immaterial amounts on these activities, they are not required to report them, and COMPUSTAT lists them as missing. Rather than exclude those observations, we used a common econometric technique. All missing values for R&D and advertising were treated as zero expenditures, and the *R&D missing* or *advertising missing* dummies were coded 1. This preserves observations yet removes any bias associated with assigning a zero value (Greene, 1993).

Industry controls

Using COMPUSTAT data, we controlled for several differences within each industry across time. *Industry profitability* equaled the mean, excluding the focal firm, for each industry in each year of the three-item index described earlier. To assess rivalry, we measured *industry density*, as done in many ecological studies (e.g., Hannan and Carroll, 1992). It equaled the number of firms in an industry that were listed in COMPUSTAT in a given year. Its square was not significant.

Both the need for and ease of strategic change may shift across time. For instance, invention of new technologies may cause many firms to make major shifts in R&D spending that are largely independent of a CEO's influence. We therefore controlled for the total amount of strategic change by *other* firms in the same industry. Such measures are comparable to measures of population mass used by ecologists (Barnett and Amburgey, 1990; Baum and Mezias, 1992). For each industry, we calculated:

$$\text{industry change mass}_{i,t,t-1} = \ln\left(\Sigma_j \text{ strategic change}_{j,t,t-1}\right), \text{ for } j \neq i$$

Here, i represents the focal firm, t is the current year, $t-1$ is the prior year, and j indexes across all firms in the industry. Since contingency theory suggests that performance is enhanced when firms change their operations to match changes in the environment (Lawrence and Lorsch, 1967), we also assessed the interaction of strategic change and industry change mass and included it where it was significant.

To account for other within-industry differences across time, we coded four period-specific dummies that identified the 1950s, 1960s, 1970s, and 1980s. The 1990s were the omitted category. Results were unchanged using dummies that identified 5-year rather than 10-year periods.

CEO controls

As CEOs accumulate tenure, they grow older, which may affect their abilities (Walsh, 1995), so we controlled for *CEO age*, measured in years. Its square was not significant. Left-censoring occurred among CEOs who (a) were in office prior to 1955, the start of the sample window, or (b) were already in office when their firm went public and first entered COMPUSTAT. To control for that, the *left-censored CEO* dummy variable was coded 1 across the entire time-series of those CEOs who were not observed from their first year in office, and 0 otherwise (cf. Haveman, 1992). Unlike our other variables, this dummy did not vary with time.

Modeling and estimation

We analyzed annual profitability using generalized estimating equations (GEEs), an extension of the family of generalized linear models, which are designed to handle longitudinal data (Liang and Zeger, 1986; Lipsitz *et al.*, 1994). GEEs derive maximum likelihood estimates from models with four parts: (1) a linear component, $\eta_i = \beta \boldsymbol{x}_i$; (2) a link function, g, which may be nonlinear, that describes how the means of observed values are related to the linear component: $g(\mu_i) = \eta_i = \beta \boldsymbol{x}_i$; (3) a specification of the distribution from which μ_i is drawn; and (4) a specification of the correlation structure among time-series outcomes. All models had a first-order autoregressive correlation structure, corrected for under- and overdispersion, and provided robust variance estimates (White, 1980) to account for heteroscedasticity and unobserved differences across firms and CEOs. We assessed the overall goodness of fit of each model by calculating minus two times its log likelihood score. Differences in that quantity across nested models have a chi-squared distribution.[2]

We estimated separate models for the food and computer industries rather than pooling them and using interactions to test cross-industry differences. Although pooling increases statistical power, it is problematic when the variance of the disturbance terms, $\sigma_\varepsilon{}^2$, differs substantially across groups (Greene, 1993: 236). That was clearly the case here since error variances were over 10 times larger in the dynamic computer industry than in the stable food sector.

[2] To avoid confounding the effects of CEO tenure with other processes, we did not use fixed-effects models. Most CEOs had a short time-series of data, so there were not enough observations to use CEO-based dummy variables to implement fixed effects. Alternatively, we could have mean-deviated each CEO's observations (Greene, 1993), but that would have confounded the effects of CEO tenure, CEO age, and firm age. To illustrate, suppose a CEO was in office for 3 years, beginning at age 49 in an 84-year-old firm. When the within-CEO mean of each of those variables (2, 50, and 85 respectively) is subtracted from its corresponding observation, all three variables have a time-series of -1, 0, 1. As a result, they could not be modeled together. GEE models allowed us to include all three variables while controlling for unobserved differences across CEOs via the autocorrelation correction and robust variance estimators, which together, provide very conservative results (Liang and Zeger, 1986; Lipsitz *et al.*, 1994).

Correcting for sample selection bias

If boards tend to weed out incompetent CEOs, then inferior managers would have relatively short stays in office and capable CEOs would have long tenures. To correct for that problem, we used the technique described by Lee (1983). This approach, which is more robust than the two-step procedure described by Heckman (1979), first uses predictors measured at $t-1$ to estimate the likelihood that a CEO will leave office in year t. We did that using an accelerated failure time (AFT) model with an exponential distribution. Next, we calculated:

$$\lambda_{i,t} = \frac{\phi[\Phi^{-1}(F(i,t))]}{1-F(i,t)}$$

where i indexes CEOs, t indexes time, $\phi(x)$ is the standard normal density function, $\Phi^{-1}(x)$ is the functional inverse of the standard normal distribution, and $F(i,t)$ is the cumulative hazard function obtained from the AFT model. Once calculated, $\lambda_{i,t}$ was controlled in all analyses.

RESULTS

Tables 1 and 2 provide descriptive statistics for the branded foods and computer industries. We assessed multicollinearity using condition indices (Belsley, 1991). The only problematic collinearity was between industry density and industry change mass in the computer sample, ($r = 0.96$). The effects of change mass mediated those of density, so we dropped density from the computer industry analyses.

Models 1 and 2 of Table 3 report profitability analyses for the highly stable food industry. Model 1 contains the controls, and Model 2 adds CEO tenure. Since CEOs' abilities to make changes may evolve across their time in office (Miller and Shamsie, 2001), we also assessed the interaction of tenure and strategic change. It was significant for the food industry, so Model 2 includes that term. (The tenure^2 × strategic change interaction was not significant.) To interpret Model 2, Figure 2 graphs the statistically significant effects of tenure and tenure^2 on profitability for three values of strategic change: 'small' = $\mu - \sigma$; 'medium' = μ; and 'large' = $\mu + \sigma$, where μ and σ are the mean and standard deviation of the strategic change measure.

As Figure 2 shows, there was an inverted U-shaped relationship between tenure and profitability for all three levels of strategic change, which is consistent with Hypothesis 1. That pattern was driven by the positive and significant effect of tenure, and the negative and significant effect of tenure^2. To determine if that result held across the entire observed range of strategic change, we

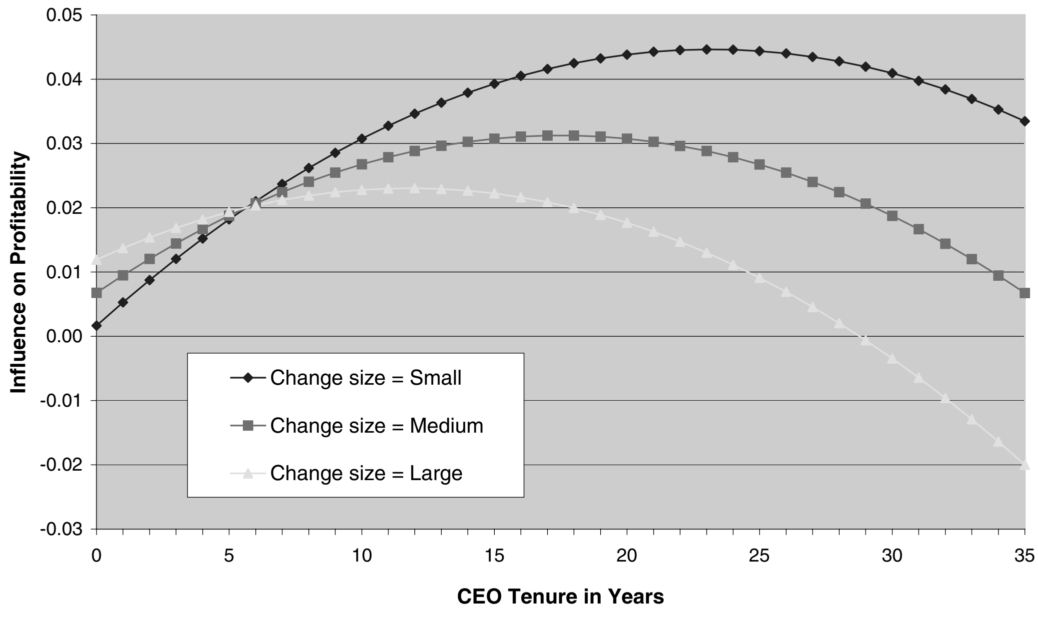

Figure 2. Effects of CEO tenure on profitability in the food industry at three levels of strategic change

Table 1. Means, standard deviations, and correlations of food industry variables

Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Profitability	0.08	0.04																
2. CEO tenure	7.82	6.59	0.11															
3. Firm size	2.48	1.36	−0.01	−0.19														
4. Firm age	71.02	25.98	0.30	0.05	−0.04													
5. Strategic change	2.73	2.08	0.07	−0.06	0.71	0.05												
6. R&D missing	0.49	0.50	−0.06	−0.01	−0.10	−0.29	−0.15											
7. Advertising missing	0.30	0.46	−0.10	−0.30	−0.26	−0.34	−0.29	0.48										
8. Industry profitability	0.08	0.02	0.18	0.05	−0.02	0.02	−0.07	0.22	0.24									
9. Industry density	160.52	20.55	−0.12	0.06	0.03	−0.01	0.08	−0.25	−0.30	−0.58								
10. Industry change mass	10.49	2.39	−0.13	0.20	0.06	0.20	0.20	−0.36	−0.56	−0.58	0.46							
11. The 1950s	0.01	0.04	0.03	−0.03	−0.01	−0.02	−0.05	0.04	0.06	0.03	−0.16	−0.16						
12. The 1960s	0.15	0.36	0.08	−0.21	−0.11	−0.22	−0.25	0.39	0.64	0.58	−0.43	−0.67	−0.02					
13. The 1970s	0.37	0.48	−0.20	−0.19	−0.07	−0.22	−0.06	−0.11	0.06	−0.66	0.66	0.30	−0.03	−0.32				
14. The 1980s	0.29	0.46	0.09	0.13	0.09	0.18	0.21	−0.11	−0.37	0.15	−0.26	0.21	−0.02	−0.27	−0.50			
15. CEO age	56.82	9.39	0.15	0.58	−0.26	0.12	−0.21	−0.08	−0.06	0.08	0.00	−0.04	0.03	0.02	−0.08	−0.06		
16. Left-censored CEO	0.04	0.21	0.04	−0.01	−0.03	−0.19	−0.16	0.18	0.34	0.27	−0.29	−0.49	0.16	0.43	−0.12	−0.14	0.26	
17. Lambda	0.14	0.16	0.17	0.18	0.27	0.19	0.24	−0.37	−0.16	−0.14	0.39	0.18	−0.03	−0.23	0.09	−0.17	0.38	−0.03

$N = 847$ CEO-years

Table 2. Means, standard deviations, and correlations of computer industry variables

Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Profitability	−0.08	0.51																
2. CEO tenure	6.59	5.85	−0.02															
3. Firm size	1.50	1.60	0.27	0.14														
4. Firm age	19.89	20.73	0.10	0.03	0.66													
5. Strategic change	2.78	3.02	0.26	0.11	0.79	0.56												
6. R&D missing	0.05	0.21	−0.00	−0.09	0.00	0.04	−0.06											
7. Advertising missing	0.50	0.50	−0.01	0.01	0.05	0.05	−0.01	0.09										
8. Industry profitability	−0.11	0.14	0.17	−0.04	0.06	−0.01	−0.05	0.07	−0.02									
9. Industry density	68.24	22.15	−0.19	0.04	−0.11	−0.01	0.02	−0.14	−0.12	−0.75								
10. Industry change mass	13.14	2.42	−0.19	0.03	−0.17	−0.04	−0.03	−0.17	−0.14	−0.74	0.96							
11. The 1950s	0.01	0.05	0.03	−0.02	0.05	0.06	0.00	0.11	0.05	0.12	−0.16	−0.23						
12. The 1960s	0.04	0.19	0.09	0.02	0.14	0.04	0.04	0.13	0.20	0.36	−0.52	−0.64	−0.01					
13. The 1970s	0.18	0.38	0.15	−0.08	−0.01	−0.04	−0.05	0.05	−0.03	0.56	−0.65	−0.52	−0.02	−0.09				
14. The 1980s	0.44	0.50	0.02	0.01	−0.06	−0.02	−0.01	−0.05	−0.14	0.08	0.32	0.26	−0.05	−0.17	−0.42			
15. CEO age	51.09	8.34	0.03	0.23	0.39	0.42	0.32	−0.08	−0.01	0.00	0.01	−0.02	−0.02	0.03	−0.02	−0.00		
16. Left-censored CEO	0.26	0.44	0.08	0.48	−0.05	−0.21	−0.00	−0.04	−0.04	−0.05	0.05	0.04	0.01	0.01	−0.07	0.04	−0.28	
17. Lambda	0.28	0.11	−0.20	0.16	−0.02	0.16	−0.02	−0.11	0.01	−0.43	0.46	0.46	0.10	−0.26	−0.29	0.01	0.54	−0.27

$N = 1397$ CEO-years

Table 3. GEE models of food company and computer company profitability

Predictor variables	Food industry		Computer industry	
	(1)	(2)	(3)	(4)
CEO tenure$_{t-1}$		0.020***		−0.029**
		(0.006)		(0.011)
CEO tenure$^2_{t-1}$		−0.001**		
		(0.000)		
CEO tenure$_{t-1}$ × Strategic change$_{t,t-1}$		−0.002*		
		(0.001)		
Firm size$_{t-1}$	0.001	0.008	0.169**	0.254***
	(0.015)	(0.014)	(0.062)	(0.067)
Profitability$_{t-1}$	0.181***	0.180***	0.622***	0.607***
	(0.010)	(0.010)	(0.054)	(0.056)
Firm age$_{t-1}$	0.002***	0.002**	−0.004	−0.005
	(0.001)	(0.001)	(0.003)	(0.003)
Strategic change$_{t,t-1}$	−0.003	0.012	0.050*	0.002
	(0.007)	(0.010)	(0.026)	(0.027)
R&D missing$_{t-1}$	−0.044	−0.042	0.022	−0.002
	(0.027)	(0.026)	(0.316)	(0.298)
Advertising missing$_{t-1}$	−0.071	−0.060	0.095	0.114
	(0.071)	(0.064)	(0.117)	(0.122)
Industry profitability$_{t-1}$	−0.029*	−0.032*	−0.447**	−0.432**
	(0.013)	(0.013)	(0.167)	(0.163)
Industry density$_{t-1}$	−0.000	−0.001		
	(0.001)	(0.001)		
Industry change mass$_{t,t-1}$	−0.032***	−0.034***	0.041	−0.053
	(0.009)	(0.009)	(0.069)	(0.082)
Industry change mass$_{t,t-1}$ × Strategic change$_{t,t-1}$				0.029**
				(0.009)
The 1950s	−0.063	−0.003	1.891*	1.733*
	(0.142)	(0.138)	(0.838)	(0.832)
The 1960s	0.099	0.120	1.595*	1.595*
	(0.118)	(0.121)	(0.708)	(0.669)
The 1970s	0.113*	0.134*	1.525***	1.453***
	(0.053)	(0.060)	(0.381)	(0.377)
The 1980s	0.167***	0.160**	0.689***	0.692***
	(0.049)	(0.053)	(0.190)	(0.189)
CEO age$_{t-1}$	−0.001	−0.003	0.002	0.006
	(0.002)	(0.002)	(0.010)	(0.010)
Left-censored CEO	0.065	0.036	0.131	0.379*
	(0.058)	(0.052)	(0.156)	(0.189)
Lambda$_{t-1}$	0.154	0.189	−1.974*	−1.564
	(0.089)	(0.098)	(0.902)	(0.957)
−2* log likelihood	2346.724***	2335.320***	4359.546***	4349.036***
Δ fit from prior model (χ^2)	n.a.	11.404**	n.a.	10.510**

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; two-tailed tests. $N = 847$ CEO-years for the food industry; $N = 1397$ CEO-years for the computer industry

used Model 2 to calculate the partial derivative, ∂ profitability/∂ tenure. That quantity changed from positive to negative for each observed value of strategic change, so Hypothesis 1 was supported.

Models 3 and 4 of Table 3 analyze profitability in the dynamic computer industry. Model 3 contains the controls, and Model 4 adds CEO tenure and the significant interaction of industry change mass and strategic change. (Here, neither tenure^2 nor the interaction of tenure and strategic change was significant.) As Model 4 shows, CEO tenure had a negative and significant effect on profitability. We had envisioned a brief period of improvement for computer CEOs, followed by steep deterioration, but, instead, profitability declined immediately and steadily throughout a CEO's tenure.

Computer CEOs may have improved their firms' performance *within* their first year in office before declining, but our annual data precluded our detecting that. Results, then, for the computer industry did not support the predicted inverted U-shaped relationship between tenure and company performance. Instead, those executives were at their best at the outset of their tenures and then steadily worsened.

Hypothesis 2 predicted that performance would peak earlier in a dynamic industry than a stable one, and our results support that expectation. Peak performance occurred in year 1 of the tenures of computer industry CEOs. In comparison, as Figure 2 indicates, performance peaked much later among chief executives in the stable food industry. Indeed, the peak occurred at about 11 years of tenure among food executives making large strategic changes, at about 17 years for those making medium-size changes, and at about 23 years for those making small changes. Notably, about three-fourths of food industry CEOs exited before 11 years, so very few stayed in office long enough to see their performance drop; in contrast, according to our estimates, virtually all CEOs in the dynamic computer industry served long enough to see their early successes followed by performance deterioration.

DISCUSSION

Prior research suggests that CEOs adaptively learn for a decade or more of their tenures before firm performance suffers (Miller, 1990; Miller and Shamsie, 2001). In comparison, we find that the potential for any performance improvements is contingent on the dynamism of the external environment. Among firms in the stable branded foods industry, and consistent with current theory, firm performance increased for at least ten years of a CEO's tenure before declining. Yet in the turbulent computer industry, we could find no evidence of time-related performance improvements. There, CEOs were at their best during their first year in office and worsened steadily thereafter.

The early onset of CEO obsolescence in dynamic settings contrasts sharply with prior research, which has emphasized adaptive learning over extended periods. An immediate and steady decline *is* consistent, though, with our premise that CEOs assume office with relatively fixed paradigms. When a board hires a CEO, it tries to find someone whose worldview and capabilities are reasonably suited to current conditions, yet that new leader's paradigm may begin to obsolesce almost immediately. From Figure 1(a, b) we see that the timing of peak firm-level performance depends on the relative impact of two evolving processes: (1) the degree of internal fit between a firm's strategy and its CEO's paradigm; and (2) the degree of external mismatch between that paradigm and the environment. As the second dynamic becomes more pronounced, the time to a CEO's peak performance shortens. In fact, it can move so close to the start of a CEO's tenure that performance, as measured by annual data, will appear to decrease monotonically, which accords with our finding among computer industry CEOs.

In comparison, firm-level performance increased for the first 10–20 years of CEOs' tenures in the branded foods industry. It is interesting to speculate about what portion of that improvement was due to CEO learning and what part was a byproduct of the slow, gradual rate at which a firm can implement a CEO's paradigm. Prior research suggests that general managers typically instigate major changes in their first 6–18 months in office (Gabarro, 1987; Kotter, 1982), and that it takes 2–4 years for a firm to align itself with a new CEO's paradigm (Kao, 1985; Miller and Shamsie, 2001). If such figures apply here, then inertia might account for a 3- to 5-year lag in implementing a CEO's paradigm, which is well short of the 10–20 years of increasing performance that we observed in the food industry. Since performance improvements appear to extend far beyond the time it takes to implement a new paradigm, it seems that CEOs in stable settings exhibit beneficial learning over a long period. Future research is needed to determine just what and how CEOs learn in stable settings, why those lessons fail to accumulate in more dynamic ones, and which of a CEO's assumptions and behaviors are most and least open to change.

In closing, we have argued that although CEOs are capable of learning, such a process requires an environment stable enough so that the cause–effect relationships discovered today will still be useful tomorrow. While research on dynamic capabilities (Teece *et al*., 1997), organizational ecology (Hannan and Carroll, 1992), and organizational learning (Levinthal and March, 1993) has considered the constraints and capacities that entire organizations exhibit as they try to cope with environmental change, that work has devoted little attention to the role of key individual decision makers. This study contributes to that discussion by shedding light on the role that CEOs play as their organizations evolve and try to adapt to external change.

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