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Determinants and consequences of chief information officer equity incentives

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ABSTRACT

The chief information officer (CIO) is responsible for bridging the gap between two critical domains—technology and business, making the CIO's job uniquely different from other executives. As digital technologies become increasingly important to firms' competitive success, boards of directors and senior executives seek to align the CIO role with overall firm's objectives. Agency theory suggests that one way to create the alignment between an executive's efforts and firm performance is to implement appropriate equity compensation incentives (i.e., those resulting from stock and stock options) tying the executive's wealth to firm value. To date, research does not address what factors a firm should consider when designing CIO incentives and how these incentives influence firm performance. To address this major gap, we examine both the antecedents and performance consequences of CIO equity incentives. We assess organizational, environmental, and individual factors that influence CIO equity incentives and find that environmental and organizational factors are more important than individual CIO characteristics in the determination of CIO equity incentives. We also find that firms that create higher CIO equity incentives realize greater subsequent accounting and market performance. Our research contributes to the IT personnel literature by showing how firms can use compensation policies to leverage the CIO role to enhance overall business performance.

1. Introduction

Previous research suggests that alignment of business and IT strategies creates superior business value (Chan et al., 1997; Sabherwal and Chan, 2001). Chief information officers (CIOs) are the senior executives directly responsible for bridging that gap between technology and business (Orlikowski, 2000; Groysberg et al., 2011). Effective CIOs champion and implement technology initiatives while aligning IT strategies with the business strategy (Armstrong and Sambamurthy, 1999; Enns et al., 2001, 2003; Preston and Karahanna, 2009). However, some CIOs often have a strong non-business (i.e. technology) background. Because their technical knowledge is anchored in the natural sciences and engineering, CIOs are often outsiders that are indoctrinated into business. In contrast, other executives—such as chief financial officers (CFO) who are responsible for managing the financial aspects of the business and related financial reporting—expertise originates primarily within the business domain. Thus, CIOs present a unique challenge for the board of directors, but relatively little research examines how firms may leverage the CIO function to improve firm performance.

Because of technology's prominent role in business operations, CIOs have critical decision rights. Yet, aligning their behaviors with firm strategy is challenging because the CIO's efforts and actions are often unobservable and therefore not contractible. Agency

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theory advocates aligning executive efforts with business objectives through compensation schemes that tie the executive's wealth to firm value (Jensen and Meckling, 1976; Holmström, 1979; He et al., 2014). Substantial empirical research examines how equity-based compensation (i.e., stock and stock options) motivate firm's top executives to create firm value (e.g., Core and Guay, 1999; Core and Guay, 2002; Hanlon et al., 2003; Coles et al., 2006). Most research focuses, however, on Chief Executive Officer's (CEO's) incentives; there is little research examining non-CEO, especially CIO, incentives.[1]

It is important to examine the antecedents of CIO incentives, because incentivizing CIOs is often challenging. Because the literature is in its infancy, there is little information about factors that boards of directors should consider when setting appropriate CIO compensation. In the only prior study of CIO compensation, Yayla and Hu (2014) examine whether board of directors' IT awareness and industry IT intensity interact to affect CIO compensation. Their study, however, provides little insight into appropriate levels of incentives, since they focus on structural conditions that may have little relationship to the alignment of CIO incentives. For example, their measure of IT awareness is the percentage of directors with IT backgrounds, and their measure of IT intensity is based on industry capital IT investment rather than IT spending. In short, there is no research that identifies antecedents of CIO incentives. We address this gap by examining how CIO incentives are influenced by organizational, environmental, and governance determinants, as well as personal CIO characteristics, such as age, gender, tenure.

Furthermore, we offer a more accurate test of CIO incentives. Previous research on CIO incentives largely focuses on *yearly* CIO compensation flows (Yayla and Hu, 2014). However, prior research on C-level executives' incentives suggests that firms should consider *accumulated* CIO incentives (arising from equity-based compensation) to align the incentives of the CIO (and resulting IS initiatives) with those of the firm's owners (e.g., Core and Guay, 1999; Core and Guay, 2002). To highlight the difference between yearly and accumulated incentives, consider two CIOs both receiving total yearly compensation of $2 million, and that $1 million (or 50%) relates to stock options. These numbers would suggest the two CIOs have the same levels of *yearly* incentives from option compensation. Suppose that one CIO *held* $5 million in company stock and the other CIO *held* only $1 million. It is clear these two executives have different *accumulated* equity incentives, which would trigger different managerial and risk-taking behavior.[2]

Advancing the research on CIO incentives, we address the gaps outlined above, by examining: 1) the factors that a firm should consider while specifying CIO equity compensation incentives and 2) how CIO compensation incentives influence a firm's operating and market performance. Our research focuses on the incentives that arise from the CIO's cumulative holdings of firm-specific equity instruments, such as stock holdings and stock options (see, e.g., Core and Guay, 1999).[3] We use a novel dataset constructed from multiple sources, including Standard and Poor's Execucomp, Compustat, and proxy statements containing biographical data, such as CIO tenure, age, and gender. Guided by agency theory (e.g., Jensen and Meckling, 1976; Coles et al., 2006; Hirshleifer et al., 2013), we identify factors that likely influence the level of CIO equity incentives. We focus our investigation on the organizational attributes, environmental dynamics, and CIO personal characteristics expected to determine CIO equity incentives. Then, we assess whether those incentives are associated with two widely-used measures of overall operational (return on sales (ROS)) and market (Tobin's q) performance. Tobin's q is a market, future-oriented measure that may directly relate to fundamental accounting performance (Blanchard et al., 1993). By also focusing on return on sales, an oft-used accounting performance measure, we present a holistic understanding of how CIO incentives affect major dimensions of firm performance.

Our findings offer insights about different categories of factors. We find that organizational determinants including size, cash flow, sales growth, and R&D intensity, are positively related to CIO equity incentives. These results suggest that more complex, innovative, and risky firms require higher levels of CIO incentives to align IT with business strategy. We find that environmental determinants, industry IT intensity and industry (or peer) level of equity incentives, impact CIO equity incentives, suggesting that CIO incentive levels are influenced by the competitive environment in which the firm operates. Finally, we find that CIO's tenure, age and gender affect the CIO's equity incentives.[4] Also, CIOs that have received a “CIO 100” award—a proxy for CIO competence—receive higher levels of equity incentives. Collectively, our model explains approximately 47% of the variability in CIO equity incentives.

[1] Recent studies, such as Geiger and North (2006), Chava and Purnanandam (2010), Jiang et al. (2010), Wang et al. (2011), and Kim et al. (2011) focus on Chief Financial Officer (CFO) incentives and firm performance, while Nath and Mahajan (2008), Boyd et al. (2010), and Nath and Mahajan (2011) focus on Chief Marketing Officer (CMO) incentives. Other generic studies examining non-CEO incentives are Carpenter and Wade (2002) and Aggarwal and Samwick (2003). We are unaware of any other study examining CIO accumulated incentives and firm accounting and market performance.

[2] Consistent with this notion, Core and Guay (1999) show that board of directors intervene to maintain “optimal equity incentive levels,” so no two grants may be identical even if received in the same year. Because our measure of CIO equity incentives is accumulated, it is “set” at the time CIOs make decisions, so it is less subject to endogeneity concerns (related to firm value).

[3] Our measure of CIO equity incentives (as discussed fully in Appendix A) represents the change in value of CIO cumulative equity holdings with respect to a 1% change in firm stock price (δCIO Firm-Specific Wealth/δFirm Value). Extant research typically refers to this measure as the delta (Core and Guay, 1999, 2002) or pay-performance sensitivity (He et al., 2014). The incentives arising associated with the equity holdings are very strong. In our sample of CIOs, the average delta is approximately $110,000, implying that every time the stock price changes by 1%, the CIO accumulated wealth related to the portfolio value of equity holdings changes by $110,000. Note that equity based incentives help to mitigate the ex post settling up problem (Fama, 1980). To illustrate, if the CIO is granted a cash bonus for completing an IT initiative (e.g., and ERP implementation) and it eventually fails to generate value, recovering the cash bonus would be hard and the shareholders would be worse off. On the other hand, because the payoff related to equity incentives is performance-contingent; if the IT initiative fails, the CIO is not rewarded, but if the initiative is successful and delivers value, the CIO is rewarded accordingly.

[4] In robustness tests, we also consider educational background (e.g., computer science vs. business degree) and degree type (e.g., undergraduate vs. graduate degrees). However, we do not find these variables have any explanatory power.

Regarding the impact of CIO incentives on accounting and market performance, we find that after controlling for important determinants including past performance, firms that offer high levels of equity incentives to their CIOs have higher future ROS and Tobin's *q* relative to firms with low levels of equity incentives. Firms that offer higher levels of incentives also have higher Tobin's *q* relative to a matched sample of non-CIO firms,[5] as well as firms with lower CIO incentives. These results suggest that CIO equity incentives effectively align CIO efforts with firm value objectives.[6]

To provide further insights into the impact of CIO equity incentives on firm performance and to ensure that the results are not due to a correlation between CIO incentives and other C-level executive's incentives, we construct equity incentives for the CEO and CFO, and examine the relative importance of the CIO equity incentives. After considering the incentives of these important executives, we continue to find that CIO incentives are important contributors to firm performance measured with Tobin's *q*. Collectively, these results suggest that sufficiently high levels of CIO equity incentives are significant sources of accounting and market-based performance.

Our research extends the limited IS literature examining the relationship between managerial compensation and firm performance in several ways. First, while extant research has focused on the importance of CEO (e.g., Talmor and Wallace, 1998; Anderson et al., 2000) and CFO (e.g., Chava and Purnanandam, 2010) or the CMO (e.g., Nath and Mahajan, 2011) compensation, little is known about CIO incentives and how those affect performance. We extend the nascent and emerging literature on CIO compensation (Yayla and Hu, 2014). While Yayla and Hu examine the CIO yearly compensation as being directly influenced by the board of directors' IT awareness, we extend the literature by identifying a broader set of key antecedents that influence a firm's choice of accumulated CIO equity incentives.

Previous research has largely ignored the relative effects of various executives' incentives while examining CIO compensations (Yayla and Hu, 2014). We examine CIO equity incentives in concert with CEO and CFO incentives to control for any culture or halo effect, due to the generic incentives to leadership skills that may overlap across other leaders of the C-suite. Finally, our sample is over three times larger than the only other recent study of CIO compensation and employs a sample matched against similar non-CIO firms. Thus, besides presenting a broader test of factors influencing CIO incentives, our study presents a robust test for the effects of CIO incentives on firm performance, a relationship that has not been tested in previous research. In testing the relationship, we focus on both accounting- and market-based measures of future performance. Our study contributes to the literature by providing a robust test of the relationships between CIO incentives and firm performance that will offer a rigorous model for future research to test relationships in this domain.

2. Related literature and theoretical background

2.1. Related literature

Based on agency theory (Jensen and Meckling, 1976) and research in financial economics (e.g., Core and Guay, 1999, 2002; Coles et al., 2006; He et al., 2014), we focus on CIO incentives arising from firm-specific equity compensation instruments, such as shares of stock, restricted and unrestricted, and stock options.[7] Particularly, we measure CIO equity incentives as the change in value of CIO cumulative equity holdings with respect to a 1% change in firm stock price (Core and Guay, 1999, 2002; Coles et al., 2006; He et al., 2014).

Our focus on CIO equity incentives is important and timely. A robust line of literature examines the determinants and firm performance consequences of CEO equity incentives (Guay, 1999; Core and Guay, 1999; Hanlon et al., 2003; Coles et al., 2006, among others).[8] While the research into non-CEO executive equity incentives is generally scant, recent research focusing on non-CEO executives is beginning to examine incentives allocated to specific executives (e.g., CFO or CMO) and the impact of incentives on various aspects of firm performance. For example, studies examine the determinants and consequences of CFO (e.g., Mian, 2001;

[5] Non-CIO firms are selected from firms who do not identify a CIO as part of their top executive team.

[6] We recognize the possibility or reverse causality: that better performing firms hire better CIOs and pay them more. We note, however, that our regression models control for past performance, and our matching process also incorporates past performance. Furthermore, the same argument—that better performing companies hire better people and give them higher pay—can also apply to CFOs. Yet, we did not find a relationship between CFO incentives and future performance.

[7] There is a long history of research addressing agency theory, beginning with the work of Jensen and Meckling (1976). In brief, agency theory argues that the separation of ownership and control in publicly traded firms engenders conflicts of interest between shareholders and managers. Since the agents' actions and efforts are generally unobservable and therefore non-contractible (Holmström, 1979), firms use outcome-based compensation contracts as a mechanism to align the interest of shareholders and managers (Jensen and Meckling, 1976; Murphy, 1999).

[8] The typical compensation contract comprises a fixed salary, a yearly bonus (typically associated with performance in the year), equity grants (in the form of shares and stock options), and other compensation such as an allowance for the lease of a car or the use of a corporate jet for personal purpose, etc. Consistent with prior work, we focus on the performance-based incentives arising from equity-based compensation, since these represent the largest source of incentives in the CIO's compensation package. For example, in our sample, the median equity-based compensation is $285,000, while the median bonus compensation is $77,000. In addition, structuring incentives based on equity compensation mitigates the ex post settling-up problem (Fama, 1980), while cash-based compensation may exacerbate it. For example, if the CIO is granted a cash bonus for completing an IT initiative (e.g., ERP implementation) and it eventually fails to generate value, recovering the cash bonus would be hard and the shareholders would be worse off. On the other hand, because the payoff related to equity compensation is performance-contingent; if the IT initiative fails, the CIO is not rewarded. If the initiative is successful and delivers value, the CIO will be rewarded accordingly.

Geiger and North, 2006; Collins et al., 2009) and CMO (e.g., Nath and Mahajan, 2008; Boyd et al., 2010; Nath and Mahajan, 2011) appointments or terminations. More closely related to our study, several recent papers examine the impact of CFO equity incentives on stock returns (Wang et al., 2011), firm risk (Kim et al., 2011), financial leverage (Chava and Purnanandam, 2010), and earnings management behavior (Jiang et al., 2010). Focusing upon non-CEO executives helps bring out important aspects relevant for setting incentives in that domain, such as finance or information systems. Therefore, we extend the previous literature examining C-level equity incentives, by examining antecedents of CIO equity incentives and their effects on firm's operating and market performance. Before developing arguments for antecedents and consequents of CIO incentives, we review the basic tenets of agency theory, the overarching framework of our analysis.

2.2. Basic tenets of agency theory

In agency relationships, principals (e.g., shareholders or senior management) delegate decision making rights and authority to an agent (e.g., CIO), who is assumed to be self-interested and relatively more risk-averse than the principal (Jensen and Meckling, 1976).[9] The divergence in risk preferences is likely to result in agency costs, which may be reflected in the underinvestment in positive (albeit risky) net present value (NPV) projects (Jensen and Meckling, 1976). Because undertaking, implementing, and managing IT initiatives involve substantial risk and uncertainty (Dewan et al., 2007), CIOs may be deterred from making the business process changes necessary to make IT initiatives successful.

One way to align incentives and mitigate risk-preference differences between the manager and shareholders is to implement compensation schemes that tie the manager's wealth to firm value (Jensen and Meckling, 1976; Core and Guay, 1999, 2002). Such compensation schemes are especially important for managing performance of C-level executives. This expectation follows from the controllability principle which suggests that an executive's pay, pay structure, or the value derived from a given form of pay, should depend on the organizational outcomes the executive controls or influences (Antle and Demski, 1988; Arya et al., 2007). Because the effect of the CIO's development, implementation, and integration of IT initiatives with business strategy is expected to be value enhancing (Chatterjee et al., 2001), it is reasonable for firms to structure CIO incentives in ways that are directly related to firm operating and market performance.

Prior research finds that equity incentives are effective in aligning senior managers' interest to those of the shareholders for two main reasons. First, equity incentives encourage the executive to exert effort, which is expected to translate into firm performance and value. Because equity incentives are tied to share prices, if executive effort translates into performance, then the executive is rewarded accordingly. Second, shares of stock and stock options often vest contingent on future performance (e.g., Murphy, 1999; Perry and Zenner, 2000).[10] Thus, equity incentives may motivate CIOs better to align digital and business strategies and enhance firm performance (Core and Guay, 1999; Coles et al., 2006). For example, as their equity incentives increase, CIOs are more likely to develop an integrated digital business strategy with a goal to maximize firm value (Mata et al., 1995; Sambamurthy et al., 2003).[11] We next use the arguments from agency theory to develop our research model.

3. Hypotheses development

3.1. Antecedents of CIO incentives

CIOs are responsible for the development and implementation of information systems. For example, CIOs can aid an organization's ability to acquire, assimilate and use appropriate IT systems, and design and build IT architectures (Armstrong and Sambamurthy, 1999). CIOs also develop strategic IT plans, influence firms' decisions to adopt advanced information technologies (Enns et al., 2001, 2003), and foster relationships among varied organizational actors, including technology architects, business strategists, and other business partners (Feeny et al., 1992; Chatterjee et al., 2001). Various factors within and outside the firm can influence CIOs' willingness and ability to manage the development and implementation of these information systems (Tornatzky and Fleischer, 1990). Hence, we identify a broad range of antecedents influencing a firm's choice of CIO equity incentives.

To identify these determinants of CIO equity incentives, we draw from the financial economics and organizational literature that explores the determinants of executive compensation. Because the literature on non-CEO compensation is sparse (Aggarwal and Samwick, 2003), we inform our identification of the determinants of CIO equity incentives largely based on prior research examining the determinants of CEO stock-based compensation (Demsetz and Lehn, 1985; Jensen, 1986; Smith Jr. and Watts, 1992; Gaver and Gaver, 1993; Yermack, 1995; Palia, 2001; Himmelberg et al., 1999; Core and Guay, 1999; Hanlon et al., 2003). We argue that when a CIO is among the firm's most highly compensated executives, their pay is likely determined by many of the same factors as other C-suite executives.

Specifically, we identify a broad set of factors that are organizational, environmental, and individual in nature. By focusing on

[9] Relative to managers, shareholders can afford to be more risk-seeking because they are able to diversify unsystematic risk by including various securities in their investing portfolio. On the other hand, managers are risk-averse due to their inability to diversify the unsystematic risk arising to their employment with their current firm (i.e., they cannot diversify their human capital by working in various firms simultaneously).

[10] Managerial equity incentives have also been found to be associated with managerial talent attraction and retention.

[11] While important to firm success, digital strategies may not be sufficient to generate a competitive advantage on their own (e.g., Carr, 2003; Mata et al., 1995).

these three sets of factors, it is our hope to present a holistic view of the determinants of CIO equity incentives. In the sections that follow, we discuss each of the determinants if CIO equity incentives categorized under the following rubrics: organizational determinants, environmental (industry) dynamics and CIO personal characteristics.

3.2. Organizational determinants of CIO equity incentives

Organizational characteristics play an important role in shaping an executive's compensation structure. We examine the impact of size, R&D intensity, earnings uncertainty, and free cash flows on CIO equity incentives offered. The dissemination and adoption of IT innovations often involves various political factors (e.g., resistance to change, territorial boundaries) that may prevail in larger organizations (Markus, 1987). Because of these arguments, CIOs may need to be more creative in their relational and entrepreneurial efforts to manage information systems in larger firms (Enns et al., 2001, 2003). Aligning business and IT in larger firms is challenging, because of the diverse goals of many more constituents. Indeed, larger firms are more complex and involve a broader set of constituencies with competing demands requiring greater managerial talent, ingenuity, and creativity to align the varied interests in a simultaneous fashion (Smith Jr. and Watts, 1992). Further, larger firms use more performance-contingent compensation because the ability to evaluate executives explicitly is more challenging (Demsetz and Lehn, 1985; Core and Guay, 1999). Hence, larger firms are likely to select higher levels of compensation incentives for their CIOs. Overall, the scale and complexity of operations in larger firms encourages a firm to create incentives to strengthen the alignment of CIO with overall economic performance instead of directly monitoring the CIO's efforts in development and implementation of information systems. Therefore, we propose the following hypothesis (in alternate form):

H1a. There is a positive relationship between firm size and CIO equity incentives.

We argue that a firm's risk profile also affects CIO's equity incentives. CIOs in firms with higher risk profiles need to be particularly adept since they may have to undertake IT initiatives consistent with that profile (Dewan et al., 2007; Kobelsky et al., 2008; Henderson et al., 2010). However, direct monitoring of the CIO's actions in dynamic firms with high risk profiles is difficult. Thus, firms resort to equity incentives to mitigate potential monitoring costs (Core and Guay, 1999). Also, to attract and retain highly talented CIOs, riskier firms are likely to grant higher levels of equity incentives. All told, to minimize monitoring costs and to encourage innovative behavior from the CIO, we expect riskier firms to resort to higher levels of equity incentives.[12] We use R&D spending intensity as an indicator of firms' risk profiles. Prior research also finds that high levels of investment in R&D increase the risk profile of a firm. For example, Kothari et al. (2002) find that investments in R&D are all directly correlated with earnings volatility, while Amir et al. (2007) find that R&D contributes to subsequent earnings variability more than capital expenditures in high R&D-intensive industries—industries in which R&D is relatively more intensive than physical capital. More formally, we propose the following hypothesis (in alternate form):

H1b. There is a positive relationship between the risk profile of the firm, indicated by R&D spending intensity, and CIO equity incentives.

CIOs of firms that face rapid growth and that generate relatively high levels of free cash flows might be tempted to invest inefficiently. CIOs in firms that enjoy higher levels of free cash flows may obtain more generous IT budgets (Kobelsky et al., 2008; Henderson et al., 2010) that may lead to inefficient IT investments. This potential problem may be particularly acute now, given that the current magnitude of IT spending is quite large, i.e., prior research shows that IT spending is as large as 50% of capital expenditures for most U.S.-based firms (Epstein and Rejc, 2005; Henderson et al., 2010). To manage the projects, CIOs must be incentivized to invest judiciously. Especially, because IT projects are complex, CIOs must be incentivized to find and implement an efficient investment policy. An investment policy is efficient if positive net present value (NPV) projects are identified, funded and implemented, while negative NPV projects are rejected (Biddle et al., 2009). However, previous theoretical and empirical works show that managers in firms with excess cash flow and large budgets are likely to overinvest, resulting in wasteful spending (Blanchard et al., 1994; Jensen, 1986; Richardson, 2006). Often, firms may mitigate the potential agency costs arising from the "free cash flow problem," by tying free cash flows to equity compensation and ownership (Himmelberg et al., 1999; Jensen and Meckling, 1976; Jensen, 1986; Palia, 2001). Thus, to increase the likelihood that the CIO manages IT budgets in a judicious manner we expect a positive relationship between free cash flows and equity incentives. Formally, we propose the following hypothesis (in alternate form):

H1c. There is a positive relationship between free cash flows and CIO's equity incentives.

[12] An additional purpose of equity-based compensation is to encourage risk-taking behavior by the CIO. Under this argument, we would expect measures of future managerial risk-taking to be a function of CIO equity-based incentives. Our main argument is that firms that are inherently riskier will a) grant decision rights to the CIO and b) will have greater difficulty in monitoring the CIO's actions. Hence, these firms will create higher levels of equity-based incentives. Our results shown in Table 2 show a strong positive relationship between R&D intensity, an indicator of firm risk profile, and CIO equity incentives.

3.3. Environmental determinants of CIO equity incentives

A CIO's efforts in developing and implementing information systems are also influenced by the competitive environment in which the firm operates. We examine the impacts of industry characteristics—industry's IT intensity, industry's compensation incentives and industry concentration—on CIOs' equity incentives. Prevailing industry IT intensity may influence firms' IT intensity, since industry IT intensity can indicate the strategic role of IT in the industry (Kobelsky et al., 2008). For example, CIOs of firms in industries with transformative IT have much greater organizational and leadership responsibilities than firms with membership in industries filling automate IT strategic roles (Dehning et al., 2003).

Greater industry IT intensity may therefore lead a firm to choose higher CIO equity incentives to encourage CIOs' entrepreneurial and risk-taking behaviors. Moreover, firms operating in industries with high IT intensity must manage more complex and potentially risky IT resources, processes, staff and assets (Dewan et al., 2007; Henderson et al., 2010; Kobelsky et al., 2008). As managers of these resources, CIOs have to align the various IT processes, staff and resources continuously with the common goals of the organization. Therefore, we propose the following hypothesis (in alternate form):

H2a. There is a positive relationship between industry IT intensity and CIO equity incentives.

Certain industries, such as those that are R&D or IT-intensive, are more likely to engage in innovative business practices (Anderson et al., 2000). These industries are characterized by rapid changes in technology and competitive forces. Prior research examines the pay practices of “new economy” (Ittner et al., 2003; Murphy, 2003) and “Silicon Valley” firms (Anderson et al., 2000) finding that these firms rely more heavily on equity compensation relative to firms in other industries. Murphy (1999) also finds substantial industry clustering in executive compensation practices, perhaps reflecting competition for human capital and talent in those industries. We expect that CIO compensation contracts will reflect prevailing industry practices. We use average CEO equity incentives to reflect industry practices since CEO incentive information is broadly available. Thus, we propose the following hypothesis (in alternate form):

H2b. There is a positive relationship between the use of equity incentives in the industry, indicated by average CEO equity incentives, and CIO equity incentives.

Finally, we expect that industry concentration also affects the use of CIO equity incentives. The potential business value of IT increases in concentrated industries since those benefits are not competed away (Dewan and Mendelson, 1998). Again, this suggests a greater demand for innovative and entrepreneurial CIOs and corresponding higher use of equity incentives in concentrated industries. As additional evidence of the relationship between IT and industry concentration, Kobelsky et al. (2008) find a positive relationship between industry concentration and level of firm IT budgets. Hence, we propose the following hypothesis (in alternate form):

H2c. There is a positive relationship between industry concentration and CIO equity incentives.

3.4. Individual determinants of CIO equity incentives

Besides organizational and institutional factors, we propose that CIO equity incentives may be influenced by individual characteristics. Specifically, we argue that CIO's tenure with the firm, age, and gender influence CIO equity incentives.[13] Because CIOs are often perceived to lack business experience, tenure plays an important role in their organizational growth. Over time in the position, the CIO gains experience with the firm (its business processes and strategy), the more important it is for the firm to incentivize CIOs through performance-contingent compensation such as stock options. However, an alternative argument may imply that lesser equity incentives with tenure. Organizational theorists contend that executives with long tenure “grow stale in the saddle” (Miller, 1991), ignore the firm's internal and external environment, and ultimately compromise firm performance. However, we argue that there is a positive association between CIO tenure and the levels of equity incentives because tenure offers them greater experience and marketability, due to their additional business experience. Moreover, there is an active labor market for seasoned CIOs, which exerts pressure to pay experienced CIOs higher levels of compensation to retain their services (Palia, 2001; Guay, 1999). Following these arguments, we expect there to be a positive relationship between CIO tenure and equity incentives. More formally we propose the following hypothesis (in alternate form):

H3a. There is a positive relationship between CIO tenure and equity incentives.

While we expect tenure to be positively related to CIO equity incentives, we also expect that relationship to be limited when the CIO approaches the end of their career. Because many technology professionals start their careers early and experience rapid advancement, it becomes imperative to differentiate age with tenure. While, on average, tenure should be positively related to equity incentives, older executives, who may also have longer tenure with the firm, may become increasingly opportunistic, risk-averse, and

[13] In robustness tests, we also considered educational background (e.g., computer science vs. business degree) and degree type (e.g., undergraduate vs. masters degree vs. PhD). Firms may use levels of education as a screening factor when hiring new CIOs, and many firms also encourage executives to obtain post-graduate degrees. More education also can enlighten executives about alternate strategies, potentially encouraging CIOs to implement more innovative and entrepreneurial strategies. Based on these arguments, we expected a positive relation between educational levels and equity incentives; however, we found that educational background offered no explanatory power.

committed to the status quo (Hambrick and Mason, 1984; Hambrick et al., 1993).

For CIOs, age has a different effect. Technology is an ever-changing field that requires senior executives to have an open mind, to learn and adapt to new developments. Prior research documents a propensity of executives to become myopic as they approach the end of their career (e.g., Dechow and Sloan, 1991; Antia et al., 2010). Therefore, older CIOs may be more reluctant to adopt technological changes and become more risk-averse, potentially rendering the CIOs' ability to "catch up" lessening the impact of equity incentives (Hall and Liedtka, 2005). Therefore, the older CIOs may focus on short-term results at the expense of long-term value with a corresponding increase in demand for cash-based (i.e., bonuses) compensation rather than equity-based incentives. Considering these reasons, we propose a negative relationship between equity incentives and CIOs age. Therefore, we present the following hypothesis (in alternate form):

H3b. There is a negative relationship between CIO age and equity incentives offered by the firm.

Relationship between gender and equity incentives is often unclear. While female executives may have shattered the "glass ceiling" in many management positions, these constraints may still exist within the IT function (Daily et al., 1999). In general, there is a growing recognition that an executive's gender affects major corporate decisions. Prior research shows that women tend to be less aggressive or more cautious in various decisions. For instance, it has been argued that female executives tend to be more risk-averse in general (Byrnes et al., 1999), more likely to comply with rules and regulations (Baldry, 1987), and pursue more conservative accounting and financing choices (Huang and Kisgen, 2013; Barua et al., 2010). This suggests that firms may resort to higher levels of equity incentives for female CIOs to offset their risk-aversion. Further, getting women in the STEM disciplines and IS roles is a national level concern. Thus, firms are likely to enhance incentives for female CIOs. On the other hand, female executives in male-dominated positions have strong incentives to demonstrate their superior ability (Eagly and Carli, 2003). Thus, it is possible that female CIOs make riskier investments and undertake initiatives to demonstrate capability, and we should observe that female CIOs receive lower levels of equity incentives. Overall, the relationship between CIO incentives and CIO gender is unclear. To consider both possibilities equally, we offer the following hypothesis in null form:

H3c. There is no relationship between gender and CIO incentives, i.e., both male and female CIOs are awarded similar levels of equity incentives.

Notwithstanding other individual characteristics, individual competence should affect CIO compensation. One important indicator of CIO competence is his or her ability to deliver strategically important projects. As a proxy for the CIO's ability to deliver such projects, we use the annual *CIO Magazine* 100 awards. These awards specifically recognize IT innovations that contribute to business value. In a survey by *PR Week* magazine, CEOs named the CIO 100 award among the top 10 most influential corporate scorecards compiled by any publication or organization (CIO, 2008). Masli et al. (2011) find a link between CIO 100 awards and future operating and market performance. Thus, we argue that the CIO 100 awards clearly demonstrate CIO competence, and we expect that firms that receive CIO 100 awards reward their CIOs with higher equity incentives. Formally, we propose the following hypothesis (in alternate form):

H3d. There is a positive relationship between CIO 100 awards and CIO's equity incentives.

3.5. Governance determinants of CIO equity incentives

Yayla and Hu (2014) show that governance structure is linked to CIO compensation. They argue that boards with greater IT awareness are better able to monitor and incentivize CIOs. Directors with IT backgrounds increase IT awareness, decrease information asymmetry, and can affect CIO compensation decisions. They also argue that board size can affect CIO compensation, since larger boards have more outside directors that may better protect the interest of shareholders. They find evidence that board size and board IT awareness are related to CIO long-term compensation. We also include CEO IT background as a governance factor that affects CIO incentives for many of the same reasons that board IT awareness is relevant. CEOs with IT experience should have a better understanding of possible contributions of IT to firm performance. Therefore, we present the following hypothesis (in alternate form):

H4. There is a positive relationship between IT aware governance, i.e., board IT awareness, CEO IT awareness, and board size, and CIO equity incentives.

3.6. Consequences of CIO incentives

As outlined earlier, theory suggests that equity-based compensation schemes align the incentives of the agent, the CIO, with that of the shareholders. Prior research shows that equity incentives effectively align the interests of the CEO with that of the shareholders, leading to higher firm performance on average. We therefore expect that equity incentives can also effectively align the CIO's efforts with that of the shareholders and the other members of the top management team (TMT) (Enns et al., 2003; Feeny et al., 1992; Groysberg et al., 2011). In that case, the CIO would develop, implement, and manage IT systems to generate business value (Zhu et al., 2006; Zhu et al., 2004; Iacovou et al., 1995; Tornatzky and Fleischer, 1990). The CIO would also coordinate efforts with other members of the TMT to assure that IT resources are used effectively and efficiently within the firm's business processes. To the extent that equity incentives effectively align the CIO's interests with that of the shareholders, the level of CIO equity incentives should be positively related to future firm performance. We measure firm performance using both operating and market performance measures.

We therefore offer our final hypothesis in alternate form:

H5. Current CIO incentives are positively related to firms' future operating (return on sales or ROS) and market (Tobin's *q*) performance.

4. Research design

4.1. Description of sample

We began with all available observations from Standard & Poor's Execucomp for the period 1993 to 2015.[14] We summarized the Execucomp data to form one observation per firm year with CEO, any CFO, and CIO compensation data. We identified the CIO data by executive title information (i.e., the Execucomp TITLEANN field) for 1315 executives with direct responsibility for information systems, e.g., chief information officer, CIO, VP-information systems. We then merged that data with Compustat financial data for the period 1990 to 2016.[15] Additionally, we augmented the Execucomp data with CIO personal characteristics, e.g., age, gender, and tenure, from proxy statements or other databases, such as zoominfo.com, that maintain biographical information for executives. Similarly, we performed manual searches to collect information about firm governance, e.g., the percentage of board members with IT experience, the board size, and whether the CEO had previous IT-related positions.

4.2. CIO firm matching to non-CIO firms

To avoid selection bias and potential endogeneity, we matched CIO firms to non-CIO firms on an array of variables related to firm performance relative to industry performance. Specifically, we compared firms on size (log of revenue), industry pay ratio and the difference between the firm and industry pay ratio (current compensation, salary plus bonus, divided by total compensation), industry R&D intensity and the difference between the firm and industry R&D intensity, industry past cash flow availability and the difference between the firm and industry past cash flow availability. We also controlled for the probability that a firm designates a CIO in the industry and year, since we expect that a firm's decision to designate a CIO is often a function of industry practices. Finally, asset turnover provides information about firm strategy. The matching model is specified below (firm and year subscripts are suppressed for readability):

$$\begin{aligned}\text{CIO Firm} = {} & b0 + b1\ \text{size} + b2\ \text{industry pay ratio top 5} + b3\ \text{difference pay ratio top 5} + b4\ \text{industry R\&D intensity} \\ & + b5\ \text{difference R\&D intensity} + b6\ \text{probability of CIO in industry and year} + b7\ \text{industry past cash flow avail} \\ & + b8\ \text{difference past cash flow avail} + b9\ \text{asset turnover} + e. \end{aligned} \quad (1)$$

To perform the matching, we used the STATA routine *psmatch2* (Leuven and Sianesi, 2003), which performs propensity score matching (Rosenbaum and Rubin, 1983; Heckman et al., 1997, 1998). The *psmatch2* routine identifies the nearest non-CIO neighbor based on propensity score to each of the available 1315 CIO firm years using full Mahalanobis nearest neighbor routine with no replacement. The routine matched 1241 CIO firms to similar non-CIO firms.[16] The results from the matching process are shown in Table 1. The first column, *All Available Observations*, shows results for all available data, i.e., 1315 CIO firm years and 40,082 potential matching firms. All the model variables are significant in the full model, except for size and the difference between the firm and industry past cash flow available. The second column, *After Matching*, in Table 3 applies the *psmatch2* routine to the matched sample and confirms that any substantial differences are eliminated. The pseudo r-squared value is now zero, and only two variables are marginally significant. We dropped any unmatched CIO firms, keeping the CIO firms and their nearest neighbor to obtain our matched sample. Thus, our final matched sample includes 1241 CIO firm years and 1241 non-CIO firm years.

4.3. CIO compensation and characteristics

The CIOs in our sample are highly compensated executives with mean annual salaries of over $320,000, bonuses of almost $115,000, and total compensation including option grants and other incentive pay of more than $1,338,000. On average, CIO current cash compensation (salary plus bonus) is 45% of the corresponding CEO compensation, and CIOs own approximately $2 million of their company's stock.

We focus on CIO equity incentives, which we measure as the change in executive wealth for a 1% change in firm value (Core and

[14] Execucomp data starts in 1992, but equity incentive data is available from 1993. Execucomp tracks executive compensation for up to 11 of the highest paid executives of the firm. For each executive, Execucomp reports the executive's total compensation package, which is typically comprised of annual salary, bonus, and stock option and restricted share grant values. Execucomp collects the executive compensation variables from form DEF14A, which is more commonly known as the annual “proxy” statement.”

[15] We calculate variables for past financial performance that required data for years t-1 to t-3.

[16] The *psmatch2* program uses probit to estimate the propensity score. It also allows users to set the caliper value for the maximum distance between the treatment group and controls. We used the default caliper value, which provided a median difference between the treatment group propensity score (pscore) and the nearest neighbor of approximately 0.3% and a resulting pseudo r-squared value of zero. The process successfully classified 97.9% of the CIO and non-CIO firms and effectively eliminates most of the differences between the treatment and control firms.

Table 1
Matching CIO to non-CIO firms.

	All available observations	After matching
Size	−0.015	0.000
	(1.60)	(0.02)
Industry pay ratio top 5	−0.274	0.414
	(2.59)***	(1.82)***
Difference pay ratio top 5	−0.196	0.114
	(3.24)***	(0.96)
Industry R&D intensity	−0.737	0.072
	(4.37)***	(0.28)
Difference R&D intensity	−0.600	−0.057
	(3.46)***	(0.21)
Probability of CIO in industry and year	21.414	2.122
	(24.27)***	(1.26)
Industry past cash flow avail	−0.797	0.629
	(3.67)***	(1.45)
Difference past cash flow avail	0.103	0.337
	(0.66)	(1.07)
Asset turnover	0.095	−0.054
	(5.98)***	(1.94)*
Constant	−2.035	−0.180
	(22.01)***	(0.97)
Pseudo R-squared	0.08	0.00
Chi-squared	933.05	10.30
N	41,397	2482

CIO firms matched to potential non-CIO firms using the Stata routine psmatch2 (Leuven and Sianesi, 2003). This routine implements full Mahalanobis and propensity score matching. We use all firms with available data to match with 1315 identified firms with designated Chief, Information Officers. After matching, there were 1241 CIO firms with matching non-CIO firms. The matching process successfully classifies 97.9% of the CIO and non-CIO firms. The *After Matching* column confirms that the matching eliminates most of the differences between CIO and non-CIO firms. See Appendix B for Variable definitions.

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Guay, 1999, 2002).[17] This measure reflects the sensitivity of an executive's portfolio of shares and stock options accumulated over his or her tenure to firm performance, and many researchers (Smith and Stulz, 1985; Hemmer et al., 1999; Guay, 1999; Core and Guay, 2002; Core and Guay, 2002; Coles et al., 2006) argue that it provides a better measure of overall compensation-based incentives than annual compensation figures. For our sample of CIO firms, CIO wealth increases approximately $55,000, on average, for a 1% increase in market value, suggesting that CIOs are strongly motivated to improve firm performance.

Table 2 presents descriptive statistics for CIO incentives and personal characteristics, such as age, gender, and tenure, as well as CIO firm characteristics. CIOs in our sample are typically just over 51 years old and have been employed by their firms for over seven years. CIOs are also overwhelmingly (89%) male. On average, 66% of CIO firms' board of directors have an IT background, and 19.5% of their CEOs also have an IT background. This suggests that CIO firm executives recognize the importance of the CIO function. Approximately, 9% of our sample firms received CIO 100 awards for outstanding achievements in the use of technology.[18]

Table 2 also summarizes compensation for male and female CIOs. Although female CIOs represent only 11% of the sample, relative to male CIOs, the female CIOs on average have lower equity incentives, yet higher total compensation and restricted stock grants, and own more their firm's stock. Although not tabulated, we found that female CIOs tend to work for significantly larger firms, although those firms are less likely to earn CIO100 awards. Female CIO age and tenure with their firms is similar to the male CIOs. There are more female CIOs in the period 2004 to 2015 than female CIOs in the previous decade, and their compensation reflects greater use of restricted stock than stock options. Table 2 shows that female CIOs have lower equity incentives, but they hold higher levels of restricted and unrestricted stock.

Table 2 also compares firm, industry, governance and compensation variables for CIO firms to matched non-CIO firms, i.e., those that do not list CIOs among their most highly compensated executives. Prior research suggests that compensation is closely related to

[17] We follow Core and Guay (1999, 2002) and define equity incentives (delta) as follows: $[(e^{-dt} * N(Z) * 1/\text{stock price}) * \text{number of options held by the CEO at each option category (e.g., exercisable or unexercisable)}]$, where d (t) is the dividend yield (life of the underlying asset), N is the cumulative probability function of the normal distribution, Z is evaluated using the Black-Scholes model (Black and Scholes, 1973) adjusted for dividends (Merton, 1973), and stock price is the price of the stock at the end of year t. All the data necessary to estimate delta come from the Execucomp database. Please refer to Appendix A for more details on the calculation of this variable.

[18] *CIO Magazine* recognizes 100 firms each year in this prestigious award. The awards have been given for over 30 years to celebrate 100 organizations and their IT teams for using technology in innovative ways to deliver business value. We expect that the receipt of this award demonstrates a firm's strong commitment to the use of IT.

Table 2
Descriptive statistics.

CIO compensation and related firm characteristics

	Mean	Median	SD	N
Equity incentives	2.893	2.879	1.495	1241
Total compensation	$1339	$841	$1776	1241
Restricted stock grants	$346	$46	$759	1241
Stock ownership	$1915	$416	$9725	1241
Age	51.025	51.000	6.725	1233
Female	0.114	0.000	0.318	1241
Tenure w/firm	7.594	6.000	6.506	679
Firm characteristics				
Board IT background	0.659	1	0.474	610
Board size	9.127	9	2.763	614
CEO IT background	0.195	0	0.396	652
CIO 100 award	0.087	0	0.281	1241
Male CIOs				
Equity incentives	2.911	2.882	1.494	1099
Total compensation	$1302.5	$802.3	$1790.5	1099
Restricted stock grants	$330.5	$28.1	$760.0	1099
Stock ownership	$1814.6	$394.7	$9248.2	1099
Option incentives	2.233	2.232	1.713	1099
Female CIOs				
Equity incentives	2.761	2.832	1.496	142
Total compensation	$1618.7	$1086.0	$1638.2	142
Restricted stock grants	$467.6	$174.3	$692.1	142
Stock ownership	$2691.0	$565.8	$12,847.6	142
Option incentives	1.802	1.510	1.738	142

Comparison of CIO with matched non-CIO firms

	Non-CIO firms				CIO firms				Prob (Diff < > 0)
	Mean	Median	SD	N	Mean	Median	SD	N	
Size	7.509	7.394	1.595	1241	7.470	7.322	1.546	1241	ns
Past cash flow avail	0.097	0.093	0.083	1241	0.100	0.093	0.082	1241	ns
Past R&D intensity	0.026	0.000	0.086	1241	0.019	0.000	0.118	1241	ns
Industry R&D intensity	0.131	0.023	0.302	1241	0.135	0.020	0.344	1241	ns
Industry IT intensity	0.028	0.021	0.019	551	0.033	0.028	0.023	631	***
Industry concentration	0.412	0.375	0.164	1241	0.401	0.363	0.172	1241	ns
Sales growth	0.088	0.070	0.262	1241	0.065	0.058	0.217	1241	**
ROS	0.036	0.043	0.224	1241	0.027	0.049	0.549	1241	ns
Future Tobin's *q*	0.084	0.092	0.768	1241	0.039	0.059	0.814	1241	ns
Future ROS	0.031	0.042	0.255	1241	0.023	0.045	0.399	1241	ns
CEO equity incentives	5.066	5.182	1.775	1241	5.017	5.063	1.953	1241	ns
CFO equity incentives	3.308	3.425	1.437	719	3.164	3.217	1.509	667	*
Pay ratio top 5	0.386	0.313	0.267	1241	0.400	0.345	0.234	1241	ns
CEO total compensation	$4972	$3184	$5927	1202	$4266	$2633	$4606	1220	***
CFO total compensation	$1949	$1410	$1701	717	$1809	$1304	$1586	667	ns

This table presents descriptive statistics: mean, median, standard deviation, and number of observations, regarding CIO compensation, CIO firm characteristics, CIO characteristics, and comparison of CIO and non-CIO firms, and other compensation for firms in the sample. The non-CIO firms are matched to corresponding CIO firms using the matching process described in Table 1. CIO firms are those with designated CIOs shown among each firm's most highly compensated executives as listed in Execucomp. The full sample includes 1241 CIO firms and 1241 matched non-CIO firms. Prob (Diff < > 0) indicates significance of difference between mean values for CIO and non-CIO firms (two-tailed *t*-tests). NS = not significant, See Appendix B for variable definitions.

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

firm size and past firm performance. Table 2 indicates that CIO firms are much like the matched non-CIO firms, attesting to the matching process. Both sets of firms are moderately sized; CIO firms' mean (median) annual sales revenue is $6.1 ($1.5) billion and non-CIO firms' annual sales revenue is $7.1 ($1.6) billion (shown in log form). There is no significant difference in past or future financial performance (cash flow availability, R&D intensity, ROS and Tobin's *q*) for CIO and non-CIO firms, although non-CIO firms have higher sales growth. Both CIO and non-CIO firms compete in industries with similar levels of R&D intensity, but CIO firms compete in industries with higher IT intensity. CEOs of non-CIO firms enjoy marginally higher compensation than CIO firms; the mean (median) CEO total compensation if $4.97 ($3.1) million for non-CIO firms and $4.27 ($2.6) million for CIO firms. In the 667

CIO firms with corresponding CFO data, the CFOs are more highly compensated than the CIOs, considering both total compensation and equity incentives. In short, both CIO and non-CIO firms have highly compensated executives and should therefore be expected to perform well in the future, ceteris paribus. There is no clear reason why some firms place a CIO among their highest paid executives and some do not.

4.4. Econometric considerations

With panel data, observations are often serially correlated, because the samples include multiple observations from each firm. If the analysis does not fully control for firm effects, the standard errors can be biased downward. In a recent study, Petersen (2009) compared the performance of a number of approaches used in the literature to deal with this problem. He found that in the presence of firm effects, standard errors clustered by firm are unbiased and produce correctly sized confidence intervals.[19] Thus, we employ OLS regressions with clustered standard errors to adjust for potential intrafirm correlation.

5. Research design

5.1. Determinants of CIO compensation

A central goal of our study is to document important determinants of CIO incentive compensation. In Table 3 we estimate this basic model:

$$\text{CIO Equity Incentives} = f(\text{organizational determinants}, \text{environmental determinants}, \text{individual determinants}, \text{governance determinants}, \text{controls}) \quad (2)$$

This model examines the organizational, environmental, and individual determinants of CIO equity compensation, controlling for revenue growth, past return on sales, and time trend. Organizational determinants include firm size, past cash flow availability, past return on sales (ROS), past R&D intensity, sales growth, and the pay ratio (current compensation divided by total compensation) for the top 5 most highly compensated executives. Environmental determinants include industry CEO incentives, industry concentration, and industry IT intensity (IT expenditures divided by total revenue). Individual determinants include tenure with the firm, age, gender, and receipt of a CIO 100 award. Governance determinants include whether the board members have IT experience, the size of the board of directors (number of board members), and whether the CEO has IT experience. We control for time trend since the use of incentive pay has generally increased over time. All variables are defined in Appendix B.

5.2. Performance consequences of CIO incentives

Next, we examine whether CIO incentives positively affect firm performance. We use a two-step approach to compare the performance consequences of CIO incentives against similar firms that do not separately identify their CIO's compensation. In step one we form predicted CIO incentives based on the determinants of CIO incentives model shown in column (1) of Table 3.[20] We calculate the residual values as the difference between actual *CIO incentives* and the predicted value. We divide residual CIO incentives into two portfolios, where one portfolio includes positive residual incentives and the other portfolio includes negative residual incentives. We form two dummy variables to indicate low residual high residual incentive portfolio. We set these dummy variables to zero for non-CIO firms. We also form dummy variable for non-CIO firms. This allows us to compare performance among CIO firms with higher than average incentives and CIO firms with lower than average incentives, as well as comparing non-CIO firms against CIO firms with both high and low CIO equity incentives.

Then, we regress future performance indicators on two of the three dummy variables described above, dropping one to avoid perfect collinearity. We control for predicted incentives, past firm performance, compensation structure, and other factors expected to affect future performance, such as R&D and capital intensities as specified in the following model:

$$\text{Future perf} = b0 + b1\ \text{high/low CIO incentives} + b2\ \text{non} - \text{CIO firm} + b3\ \text{past performance} + b4\ \text{pay ratio top 5} + b5\ \text{r\&d intensity} + b6\ \text{capex intensity} + b7\ \text{total assets} + e \quad (3)$$

or

$$\text{Future perf} = b0 + b1\ \text{low CIO incentives} + b2\ \text{high residual incentives} + b3\ \text{past perf} + b4\ \text{pay ratio top 5} + b5\ \text{r\&d intensity} + b6\ \text{capex intensity} + b7\ \text{total assets} + e. \quad (4)$$

Future performance is measured as either average return on sales or Tobin's *q* over years t to t + 2. Eq. (3) tests whether high CIO

[19] More recently, Gow et al. (2010) asserted that researchers should control for both firm and year to account for cross-sectional and time-series dependency. In our tests, controlling for both made little difference in the reported standard errors and corresponding *t*-statistics.

[20] We also used column (2) to compute predicted and residual incentives with similar results. The correlation between predicted values (and corresponding residuals) from models 1 and 2 in Table 2 is 0.99. We could not use predicted and residual values from columns 3 and 4 because observations are unavailable for matched non-CIO firms.

Table 3
Determinants of CIO equity incentives.*

	CIO equity incentives			
	(1)	(2)	(3)	(4)
Organizational determinants				
Size	0.401	0.424	0.386	0.391
	(16.25)***	(13.18)***	(11.09)***	(9.64)***
Past cash flow avail	3.203	2.308	1.635	1.409
	(7.07)***	(4.17)***	(3.04)***	(2.49)**
Past R&D intensity	3.696	4.341	4.041	3.463
	(7.49)***	(5.85)***	(5.75)***	(4.69)***
Past ROS	1.152	0.991	0.777	0.734
	(5.86)***	(3.71)***	(3.05)***	(2.84)***
Sales growth	1.093	1.003	0.788	0.693
	(6.65)***	(5.44)***	(4.44)***	(3.68)***
Pay ratio top 5	−1.320	−0.794	−0.859	−0.935
	(7.62)***	(4.16)***	(4.66)***	(4.77)***
Environmental determinants				
Industry CEO equity incentives		0.569	0.589	0.624
		(7.11)***	(7.56)***	(7.63)***
Industry concentration		−0.287	0.030	−0.116
		(1.00)	(0.11)	(0.39)
Industry IT intensity		7.914	9.064	8.836
		(3.76)***	(4.47)***	(4.01)***
CIO characteristics				
CIO 100 award			0.595	0.559
			(3.71)***	(3.71)***
CIO tenure with firm			0.046	0.046
			(7.22)***	(7.22)***
CIO age			−0.021	−0.021
			(3.44)***	(3.44)***
CIO female			−0.362	−0.362
			(2.40)**	(2.40)**
Governance determinants				
Board IT background				0.143
				(1.47)
Board size				−0.017
				(0.86)
CEO IT background				0.246
				(2.03)**
Other controls				
Trend	−0.040	−0.043	−0.041	−0.042
	(6.41)***	(3.78)***	(3.66)***	(3.53)***
Constant	0.657	−2.615	−1.809	−2.106
	(2.50)**	(5.28)***	(3.24)***	(3.48)***
Adjusted R-squared	0.32	0.40	0.47	0.47
N	1241	631	608	573

This table examines the organizational, environmental, personal, and firm governance determinants of CIO equity incentives. Available data for industry IT intensity, personal characteristics, and firm governance limits the sample size in columns (3) and (4). See Table 1 for the number of available observations for each variable. See Appendix B for variable definitions.

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

incentive firms perform better in the future compared to firms without designated CIOs, and Eq. (4) tests performance differences for high and low CIO incentives. Also, note that we control for past performance to control for an endogenous relationship between incentives and past performance, i.e., the "halo effect" (Santhanam and Hartono, 2003). All variables are defined in Appendix B.

6. Results

6.1. Determinants of CIO equity incentives (H1 to H4)

Table 3 presents the multivariate analysis of the determinants of CIO equity incentives. Column (1) examines the impact of organizational determinants and other control variables on CIO incentives. In conjunction with the *Trend* variable, these variables explain 33% of the variance in CIO equity incentives; while organization determinants alone explain 31% of that variance. CIO incentives are significantly positively related to size, past cash flow availability, past earnings (*ROS*), R&D intensity (*R&D intensity*),

and sales growth. Larger firms with greater past performance, higher R&D spending, more sales growth, and more commitment to technology excellence create more equity incentives for their CIOs. Conversely, CIO incentives are significantly negatively related to the *Pay Ratio Top 5* variable, so firms that favor salaries and bonuses in their pay structures have lower CIO equity incentives. These results suggest a strong link between organizational characteristics and CIO equity incentives, confirming hypotheses H1a, H1b, and H1c.

Column (2) adds environmental determinants: industry CEO equity incentives, industry concentration, and industry IT intensity. Industry CEO incentives are strongly positively related to firm CIO incentives, suggesting that the propensity to use equity incentives in the industry strongly influences CIO incentives. Industry concentration is negatively but not significantly related to CIO incentives. The relationships between CIO incentives and organizational determinants introduced in column (1) remain generally unchanged. The IT data is limited to 2008 or earlier, but it is strongly positively related to CIO equity incentives. This suggests that CIO incentives are higher when the competition in the industry depends on IT. Overall, these results are consistent with hypotheses regarding the relationship between industry IT intensity H2a, the use of equity incentives in the industry H2b and CIO equity incentives. The results do not support a relationship between industry concentration H2c and CIO equity incentives.

Column (3) adds CIO individual determinants to the model. Since personal information for all CIOs is limited, including these predictors also limits the number of available observations. Nevertheless, the relationship between CIO incentives and the other variables (included in columns (1) and (2)) remains consistent. Of the individual determinants, CIO tenure is significantly related to CIO incentives, confirming hypothesis H3a. The CIO age variable is significantly negatively related to CIO equity incentives, suggesting that older CIOs receive lower equity compensation, consistent with our prediction. The gender (female) variable is also significantly negatively related to CIO incentives, suggesting that after controlling for other factors, female CIOs receive lower levels of incentives than male counterparts. Thus, hypothesis H3b regarding the impact of age on equity incentives is confirmed, while hypothesis H3c that male and female CIOs receive similar levels of equity incentives is rejected. The CIO 100 Award variable is strongly related to CIO incentives, suggesting that CIO competence—demonstrated by their recognized ability to implement projects that deliver business value—has substantial impact on CIO compensation. Hypothesis H3d regarding the impact of a CIO 100 award on CIO equity incentives is confirmed.

Column (4) adds governance characteristics. When the board and CEO have IT experience, CIO equity incentives increase, but only the *CEO IT background* variable is significant. When we omit the *CEO IT background* variable, the *Board IT background* variable becomes significant. This further suggests that firms with senior IT experience tend to award higher equity incentives to their CIOs, generally consistent with hypothesis H4. In untabulated results, we limited observations to those 573 available in column (4). Using that subset, the r-squared values increase from 0.28 in column (1) to 0.35 in column (2) to 0.43 in column (3) to 0.47 in column (4). Thus, organizational characteristics most strongly affect the fit of the model, but the environmental and personal characteristics variables add significantly to the fit as well.

6.2. Relationship between CIO incentives and future return on sales (H5)

Table 4 presents the multivariate analysis of the relationship between predicted and residual CIO incentives and future earnings, i.e., earnings before extraordinary items scaled by total sales revenue (ROS). Column (1) includes a dummy variable to differentiate CIO firms from the matched non-CIO firms. That variable is not significantly related to future ROS, indicating that simply including the CIO among the senior executives has no effect on performance, consistent with the univariate analysis in Table 2. It also confirms the quality of our matching process. Columns (2) to (4) examine the impact of the residual incentive portfolios on performance. Column (2) shows the comparison between low and high CIO residual incentives using the model in Eq. (4). The coefficient on the low residual incentives portfolio is significantly negatively related to future ROS, but the coefficient on the high residual incentives portfolio is essentially zero. The difference between the two coefficients is significant (F-test, Prob > F = 0.003), indicating that firms in the low residual incentives portfolio have lower future ROS than firms in the high residual incentives portfolio. Columns (3) and (4) compare non-CIO firms with the high residual incentive firms (column (3)) and the low residual incentive firms (column (4)) using the model in Eq. (3). In column (3), the difference between the coefficient on *High CIO incentives* is not significantly different from the coefficient on *Non-CIO firm* (F-test, Prob > F = 0.47). In column (4), however, the coefficient on *Low CIO incentives* is significantly lower than the coefficient on *Non-CIO firm* (F-test, Prob > F = 0.001).

For all columns *past return on sales* is strongly related to *future return on sales*, reflecting the serial correlation in earnings. R&D intensity (*R&D intensity*) and *Pay Ratio Top 5* are significantly negatively related to future performance. Capital expenditure intensity (*Capex intensity*) and firm size (*Total Assets*) are generally not related to future performance. Overall, the results suggest that low residual incentives adversely affect future performance, although CIO firms in general do not outperform non-CIO firms. The results in Table 4 support the argument that firms offering CIOs higher equity incentives have higher future earnings (*ROS*) than firms offering their CIOs lower equity incentives, consistent with hypothesis H5.

6.3. Relationship between CIO incentives and future Tobin's q (H5)

Tobin's *q* is a widely-used financial market-based measure of firm performance that reflects the markets' perceptions of the firm's future performance. Bharadwaj et al. (1999) ably describe the origins and prior research involving Tobin's *q*. In summary, Tobin's *q* provides a forward-looking measure of firm performance, often used to indicate the firm's intangible value. Bharadwaj et al. (1999) also argue that Tobin's *q* better reflects IT's true contribution to firm value. They test and find a significant positive relationship between IT spending and Tobin's *q* values for the period 1988 to 1993. The CIO is the senior executive with direct responsibility for

Table 4
Regression analysis of the relation between residual CIO incentives and future earnings.*

	Future earnings			
	(1)	(2)	(3)	(4)
CIO firm	−0.015			
	(1.51)			
Low CIO incentives		−0.039		−0.049
		(3.31)***		(3.00)***
High CIO incentives		0.010	0.049	
		(0.74)	(3.00)***	
Non-CIO firm			0.039	−0.010
			(3.31)***	(0.74)
Control variables				
Past ROS	0.045	0.045	0.045	0.045
	(3.75)***	(3.78)***	(3.78)***	(3.78)***
Pay ratio top 5	−0.057	−0.058	−0.058	−0.058
	(2.45)**	(2.48)**	(2.48)**	(2.48)**
R&D intensity	−2.315	−2.318	−2.318	−2.318
	(7.07)***	(7.17)***	(7.17)***	(7.17)***
Capex intensity	0.077	0.077	0.077	0.077
	(0.79)	(0.79)	(0.79)	(0.79)
Total assets	−0.005	−0.005	−0.005	−0.005
	(1.00)	(1.17)	(1.17)	(1.17)
Constant	0.135	0.140	0.102	0.150
	(3.06)***	(3.22)***	(2.24)**	(3.22)***
Industry controls	Yes	Yes	Yes	Yes
Adjusted R-squared	0.596	0.599	0.599	0.599
N	2482	2482	2482	2482

This table examines the relation between CIO incentives and future earnings (measured as ROS [Compustat ib./Compustat revt] in years t to t + 2), controlling for past ROS (ROS in years t-1 to t-3) and Fama-French (Fama and French, 1997) industry categories.
Tests of equality of coefficients:
Column (2) Low CIO incentives = High CIO Incentives, F(1, 1169) = 9.02, Prob > F = 0.003 ***.
Column (3) High CIO incentives = Non-CIO firm, F(1,1669) = 0.55, Prob > F = 0.47.
Column (4) Low CIO incentives = Non-CIO firm, F(1, 1169) = 18.93, Prob > F = 0.001 ***.
See Appendix B for variable definitions.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$, clustered standard errors adjust for intrafirm correlation.

effective use of the firm's IT resources to improve future firm performance. We therefore expect that companies will seek to align CIO incentives with Tobin's *q* values. We follow Bharadwaj et al. (1999) to calculate Tobin's *q*[21]:

$$q = (\text{MVE} + \text{Preferred Stock} + \text{Debt})/\text{Total Assets} \quad (5)$$

where *MVE* is the market value of equity, *Preferred Stock* is the liquidating value of outstanding preferred stock, *Debt* equals current liabilities minus current assets plus the book value of inventories plus long-term debt, *Total Assets* is the book value of assets. Firm and year subscripts are suppressed for readability. All values are measured at the end of the fiscal year. We measure future Tobin's *q* by taking the average value of the log of Tobin's *q* for years t to t + 2.

The structure of Table 5 follows Table 4 implementing Eqs. (3) and (4). As in Table 4, the *CIO firm* dummy in column (1) is not significant, indicating no difference between the CIO firms and the matched non-CIO firms. Columns (2) to (4) examine the impact of the residual incentive portfolios on future Tobin's *q*. Column (2) shows that firms in the high residual incentives portfolio have significantly higher future *q* than the low residual incentive portfolio firms (F-test, Prob > F = 0.000). In column (3), the coefficient on *High CIO incentives* is significantly greater that the coefficient on the *Non-CIO firm* dummy (F-test, Prob > F = 0.005), whereas in column (4), the non-CIO dummy is significantly negatively related to future q, but the coefficient on *Low CIO incentives* is significantly more negative (F-test, Prob > F = 0.001). Past Tobin's *q* is significantly related to future Tobin's *q*, consistent with the earnings relationship in Table 4. Although R&D intensity is not significantly related to future Tobin's *q*, *Pay Ratio for Top 5*, *Capex intensity*, and *Total assets* are all negatively related to future Tobin's *q*. Overall, these results strongly suggest that high CIO residual incentive firms perform better in the future than both non-CIO firms and low CIO residual incentive firms, again confirming hypothesis H5.

In untabulated tests, we also examined the direct relationship between CIO incentives and future performance using the continuous measure of incentives rather than the three portfolios. These tests, of course, limited the sample to those firms with identifiable CIOs in Execucomp. Nevertheless, CIO incentives remained significantly positively related to future performance after controlling for past performance and other variables expected to affect future performance identified in Eqs. (2) and (3). That

[21] Bharadwaj et al. (1999) use Chung and Pruitt's (1994) approximation of Tobin's *q*.

Table 5
Regression analysis of the relation between residual CIO incentives and future Tobin's *q*.*

	Future Tobin's *q*			
	(1)	(2)	(3)	(4)
CIO firm	−0.008			
	(0.35)			
Low CIO incentives		−0.086		−0.159
		(3.26)***		(5.25)***
High CIO incentives		0.074	0.159	
		(2.83)***	(5.25)***	
Non-CIO firm			0.086	−0.074
			(3.26)***	(2.83)***
Control variables				
Past Tobin's *q*	0.787	0.777	0.777	0.777
	(35.89)***	(35.61)***	(35.61)***	(35.61)***
Pay ratio for top 5	−0.141	−0.147	−0.147	−0.147
	(2.71)***	(2.89)***	(2.89)***	(2.89)***
R&D intensity	0.079	0.073	0.073	0.073
	(0.71)	(0.62)	(0.62)	(0.62)
Capex intensity	−0.219	−0.216	−0.216	−0.216
	(2.44)**	(2.47)**	(2.47)**	(2.47)**
Total assets	−0.023	−0.026	−0.026	−0.026
	(2.51)**	(2.90)***	(2.90)***	(2.90)***
Constant	0.229	0.256	0.170	0.330
	(2.64)***	(3.00)***	(1.98)**	(3.71)***
Industry controls	Yes	Yes	Yes	Yes
Adjusted R-squared	0.706	0.711	0.711	0.711
N	2482	2482	2482	2482

This table examines the relation between CIO incentives and future Tobin's *q* values (q values in years t to t + 2), controlling for past Tobin's *q* (q values in years t-1 to t-3), and Fama-French industry categories.
Tests of equality of coefficients:
Column (2) Low CIO incentives = High CIO Incentives, F(1, 1169) = 27.54, Prob > F = 0.000 ***.
Column (3) High CIO incentives = Non-CIO firm, F(1,1669) = 8.03, Prob > F = 0.005.
Column (4) Low CIO incentives = Non-CIO firm, F(1, 1169) = 10.65, Prob > F = 0.001 ***.
See Appendix B for variable definitions.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$, Clustered standard errors adjust for intrafirm correlation.

relationship persisted when we also included CEO incentives in the model.[22]

6.4. Comparing CIO incentives against other senior executive incentives

Next, we compare CIO incentives against incentives for other senior executives in the CIO and non-CIO firms, i.e., those for chief financial officers (CFO) and chief executive officers (CEO). Panel A of Table 6 presents mean values of future earnings and Tobin's *q* and changes in those measures for portfolios based on high and low CIO incentives and high and low CFO incentives. Future earnings are significantly higher for firms with higher CIO or CFO incentives than firms with low CIO or CFO incentives; however, the change in earnings is not significantly different. Future Tobin's *q* is also significantly higher for high CIO or CFO incentive firms than for low incentive firms. The change in Tobin's *q* is only significantly higher for high CIO incentive firms than for low CIO incentive firms (one-tailed *t*-test, $p < 0.01$).

Table 6 Panel b presents a multivariate analysis of the relationship between executive incentives and future performance, applying Eqs. (3) and (4) but adding the equity incentives for the CEO and CFO. Columns (1) and (2) examine the relation to future ROS and columns (3) and (4) examine the relation to future Tobin's *q*. Since there is limited overlap between CIOs and CFOs, we form portfolios of high and low residual CFO incentives in the same manner as we formed the CIO portfolios, i.e., based on the model in Table 3 column (1) but without the CIO 100 award variable. We use the actual CEO equity incentives since we have complete information about CEOs.

First, we use CIO and CFO indicators to test whether including a CIO or CFO among the firm's most highly compensated executives affects future performance. Not surprisingly, columns (1) and (3) indicate that CIO (and CFO) firms in general do not perform better; there is no impact on future performance. Comparing incentive portfolios in column (2), *Low CIO incentives* is significantly negatively

[22] In untabulated additional tests, we further examine alternate measures of CIO incentives, i.e., options delta, restricted stock grants, and vega incentives, and their relation to future Tobin's q. All these incentive measures are highly correlated and the relationships to future performance are qualitatively similar to those reported for CIO equity incentives.

Table 6
Analysis of the relative impact of different officer incentives on future performance.

Panel A: comparison of mean values

Incentives level	Future earnings	Change in earnings	Future Tobin's *q*	Change in Tobin's *q*
Low CIO	0.000	−0.031	−0.077	−0.099
High CIO	0.045[b]	−0.001	0.156[a]	0.018[a]
Low CFO	0.014	0.065	−0.129	−0.022
High CFO	0.061[a]	−0.002	0.199[a]	−0.018
Average	0.027	0.028	0.062	−0.034

Panel B: multivariate analysis

	Future earnings		Future Tobin's *q*	
	(1)	(2)	(3)	(4)
CIO firm	−0.014		−0.004	
	(1.45)		(0.20)	
CFO firm	0.009		0.009	
	(0.84)		(0.37)	
Low CIO incentives		−0.025		−0.061
		(2.22)**		(2.31)**
High CIO incentives		−0.000		0.055
		(0.01)		(2.12)**
Low CFO incentives		−0.008		0.005
		(0.68)		(0.18)
High CFO incentives		0.029		0.018
		(2.30)**		(0.67)
CEO equity incentives	0.017	0.014	0.051	0.045
	(6.91)***	(5.62)***	(7.18)***	(6.16)***
Control variables				
Past ROS/Tobin's *q*	0.044	0.044	0.738	0.735
	(3.78)***	(3.78)***	(31.31)***	(31.38)***
Pay ratio top 5	−0.039	−0.044	−0.124	−0.129
	(1.45)	(1.64)	(2.15)**	(2.28)**
R&D intensity	−2.322	−2.328	0.090	0.084
	(7.20)***	(7.29)***	(0.85)	(0.75)
Capex intensity	0.064	0.063	−0.227	−0.223
	(0.67)	(0.66)	(2.49)**	(2.48)**
Total assets	−0.010	−0.010	−0.045	−0.046
	(2.18)**	(2.26)**	(4.72)***	(4.81)***
Constant	0.080	0.099	0.132	0.164
	(1.82)*	(2.24)**	(1.41)	(1.77)*
Industry controls	Yes	Yes	Yes	Yes
Adjusted R-squared	0.60	0.61	0.72	0.72
N	2482	2482	2482	2482

Panel A shows mean values of selected financial performance variables for firms with high and low levels of CIO and CFO incentives.
Panel B examines the relation between CIO incentives and future earnings (ROS) or Tobin's *q* values (q values in years t to t + 2), controlling for past ROS (columns 1 and 2) or Tobin's *q* (columns 3 and 4) and Fama-French industry categories.
Tests of equality of coefficients:
Column (1) CIO firm = CFO firm, F(1, 1169) = 1.95, Prob > F = 0.16.
Column (2) Low CIO incentives = High CIO incentives, F(1, 1169) = 27.54, Prob > F = 0.000 ***.
Low CFO incentives = High CFO incentives, F(1, 1169) = 8.96, Prob > F = 0.003 ***.
Column (3) CIO firm = CFO firm, F(1, 1169) = 1.95, Prob > F = 0.18, Prob > F = 0.67.
Column (4) Low CIO incentives = High CIO Incentives, F(1, 1169) = 14.54, Prob > F = 0.000 ***.
Low CFO incentives = High CFO incentives, F(1, 1169) = 0.23, Prob > F = 0.635.
See Appendix B for variable definitions.
[a] Indicates that the difference between high and low incentives for this officer is significant at the 1% level.
[b] Indicates that the difference between high and low incentives for this office is significant at the 5% level, one-tailed *t*-tests. Allocation to high and low incentive portfolios based on residuals from regressions based on model (1) in Table 3.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$, clustered standard errors adjust for intrafirm correlation.

related, and the *High CFO incentives* is significantly positively related to future earnings. The difference between coefficients on Low CIO incentives and High CIO incentives is significant (F-test, Prob > F = 0.000), consistent with results in Table 4. Similarly, the difference between Low CFO incentives and High CFO incentives is also significant (F-test, Prob > F = 0.003).

Column (4) shows that *Low CIO incentives* is negatively related to future q and *High CIO incentives* is significantly positively related to future Tobin's *q* even after controlling for other executives' incentives. Again, the difference between coefficients is significant (F-test, Prob > F = 0.000). Neither *Low CFO incentives* nor *High CFO incentives* is related to future Tobin's *q*. The difference between coefficients for high and low incentives portfolios is substantially greater for CIOs than CFOs. CEO incentives are consistently significantly positively related to both future earnings and Tobin's *q*. R&D intensity (*R&D intensity*) is negatively related to future return on sales, as in Table 4, but not significantly related to Tobin's *q*, as in Table 5. Both capital expenditure intensity (*capex intensity*) and the pay ratio for the top 5 executives are significantly negatively related to future q but unrelated to future ROS. Size (*Total assets*) is consistently negatively related to both future performance measures. In all columns, past performance strongly predicts future performance. In sum, CIO incentives remain an important predictor of future performance after controlling for the incentives of other senior C-level executives, although CIO incentives contribute less to future ROS than to future Tobin's *q* performance. CFO incentives seem to drive earnings performance more while CIO incentives drive growth more. CEO equity incentives impact both earnings performance and growth.

Throughout this paper, we proceed under the belief that accumulated incentives provide a better measure of CIO incentives than annual compensation. Core and Guay (1999) argue that firms set optimal incentive levels and then grant new incentives to adjust compensation to optimal levels. Thus, annual grants may not be consistent with the actual level of CIO incentives. Nevertheless, we performed sensitivity tests using annual CIO (and CFO) option grants and total annual long-term compensation. Those results were not consistent with and were sometimes opposite our expectations for incentives. Neither annual option grants nor total long-term compensation was significantly related to future Tobin's *q* or future earnings.

7. Summary and conclusions

In this research, our objective was to assess the antecedents and consequents of CIO equity incentives (those resulting from stock and employee stock options). Our results imply that CIOs represent critical IT leadership, and firms aligning their incentives appropriately realize greater operational and market performance. Results suggest ways to structure equity incentives to align CIOs efforts with the firm's objective of developing and sustaining an IT competitive advantage. Our findings are important for firms that seek to set appropriate levels of equity incentives for their CIOs. Because elevation of CIO position to the forefront of firm strategy is a newer business development, there is sparse literature studying factors firms use to determine appropriate compensation incentives for the CIOs. Previous research examines how CIOs champion IS goals and aid the firm's ability to acquire, assimilate and leverage appropriate IT systems (Armstrong and Sambamurthy, 1999), to design and build IT architectures and value net of relationships among varied organizational actors including technology architects, and business strategists (Chatterjee et al., 2001), to influence peers' decisions regarding adoption of advanced information technologies (Enns et al., 2001, 2003), and to develop strategic IS plans and enhance IS–business partnership (Feeny et al., 1992). Despite the literature identifying the importance of their role in the organization, CIO's compensation has gained little attention in prior research. Our study presents evidence of the impacts of organizational, environmental, and individual (CIO) characteristics influencing CIO equity incentives, extending the literature examining strategic IS issues.

In terms of equity-based incentives, non-IS researchers have studied the impacts of CFO's equity incentives on firm risk (Kim et al., 2011), financial leverage (Chava and Purnanandam, 2010), and earnings management behavior (Jiang et al., 2010). With a growing interest in examining links between the CIO position and organizational performance (e.g., Chatterjee et al., 2001; Banker et al., 2011), this study extends the prior literature by showing the impacts of CIO equity incentives—a mechanism that may be used by a firm to harness the potential of its CIOs—for enhanced firm performance. Specifically, CIO incentives are an important mechanism for firms to align their IS strategies with the business goals. Different from other domains, aligning IS and business has been a continual concern for the firms. Even though the CIO incentives play an important role, previous research offers little guidance about the strategies firm may use to align its top IS executives' incentives to further the alignment between technology and business (Yayla and Hu, 2014). Therefore, by studying a comprehensive set of factors to achieve this alignment, we add to the previous literature studying business-IT alignment and IS leadership (Armstrong and Sambamurthy, 1999; Chan et al., 1997; Enns et al., 2001, 2003; Sabherwal and Chan, 2001). Further, our research is likely to offer a robust platform for future research on the topic. Specifically, future research may examine whether the salience of factors varies across the type of firm or in certain environments. For example, do organizational or individual characteristics become a stronger influence when environmental uncertainty is higher or within industries with greater clock speed?

Unlike other executives, such as the CFO, information systems professionals stand out in the firm because the nature of their activities is often different from all other business activities. Because of their greater familiarity and experience with technology than business, CIOs assimilation with the top management is often a concern. Therefore, previous research examining CIO compensation has emphasized the role of awareness about IT among the board of directors as a crucial antecedent to CIO incentives (Yayla and Hu, 2014). However, there is a considerable concern for business-savvy CIOs that can champion growth (Groysberg et al., 2011). For the CEOs and other board members, the way to harness the potential of the CIO is by aligning incentives, tying their wealth to firm performance. Using this approach, we extend the previous research, as our study offers the firm (and its board of directors) the mechanisms for making strategies regarding CIO incentives. Our analysis also extends the previous research that has emphasized awareness about IT among the board (Yayla and Hu, 2014), by highlighting factors that the board may consider while deciding about incentives. Further, our research is likely to encourage future research that will examine when and how firms may leverage these factors to create specific strategies for incentivizing CIOs.

Finally, our study makes several methodological advancements in the domain of research examining CIO incentives. First, we go

beyond the measure of *yearly* CIO compensation used in previous research (for example, Yayla and Hu, 2014). Instead, our focus in in examining determinants of *accumulated* CIO incentives as well as the performance consequences of those incentives. Further, we focus on both the operational (return on assets or ROS) and market (Tobin's *q*) based measure of firm performance. The perceptual and accounting based measures also offer a more robust test. Further, whether the markets are more efficient at valuing CIO incentives than the operational measures is an empirical question that may be examined in future research. The answer to the question will help us better understand whether the returns to CIO incentives accrue in the short-term or long-term. Finally, we make another methodological advancement, by highlighting the need to control for incentives of other top executives, such as the CFO. Firm offering high incentives to these executives may have a culture of offering high incentives. Previous research has not controlled for this effect. By examining CIO equity incentives, while controlling for the CEO and CFO incentives, we offer a more robust test and a foundation model that can be used for future research to examine other research questions related to CIO compensation. Our study makes important contributions to a broader literature examining organizational impacts of IS, highlighting the use of compensation incentives to align the interests of firm's managerial IS resources with overall firm performance. Overall, we hope that our research will give an impetus to more future research about ways to create and leverage IS leadership.

Appendix A. Stock option valuation and option delta calculations

Stock option valuation

Stock option values are computed based on the Black-Scholes (Black and Scholes, 1973) formula for valuing European call options, modified by Merton (1973) to take into account dividend payouts:

$$\text{Option value} = [Se^{-dT}\,N(Z) - Xe^{-rT}\,N(Z - \sigma T^{(1/2)})]$$

where:

$$Z = [\ln(S/X) + T(r - d + \sigma^2/2)]/\sigma\ T^{(1/2)}$$

N = cumulative probability function for the normal distribution
S = price of the underlying stock
X = exercise price of the option
σ = expected stock-return volatility over the life of the option
r = natural logarithm of risk-free interest rate
T = time-to-maturity of the option in years
d = natural logarithm of expected dividend yield over the life of the option

The six inputs required to estimate the Black-Scholes model (stock price, exercise price, time-to-maturity, expected stock-return volatility, expected dividend yield, and risk-free rate) are available for options granted during the current year only in Execucomp. Thus, without estimating, one would have to examine several previous firm financial statements in order to form one executive's total option portfolio value – a taxing manual process. To estimate the value of previous years' grants, we follow Core and Guay's (2002) "one year approximation" (OA) process.

In order to estimate the time-to-maturity and the exercise price of previously granted unexercised options, the OA method treats the unexercised options as two separate grants: 1) unexercised unexercisable options and 2) unexercised exercisable options. Because the details of previously granted stock options are not disclosed in the firms' proxy statements, this method assigns a time-to-maturity for previously granted unexercisable options of one year less than the newly granted options. Additionally, it assigns a time-to-maturity for previously granted exercisable options of three years less than newly granted options. If no option grants are granted in the current year, the remaining time before expiration is set to nine and six years for unexercisable and exercisable options, respectively.

To estimate the exercise prices of these options, the options are again viewed as two separate grants. The realizable (in-the-money) values of the previously granted options are reported in Execucomp segregated by exercisability. To estimate the exercise price from this data, the total realizable value is divided by the number of options unexercised. This gives an average value of how far in-the-money each option is. Because the realizable value is the actual stock price minus the exercise price, the average value can be subtracted from the end-of-year stock price to estimate the exercise price. The remaining variables necessary are assumed to be the same. See Core and Guay (2002) for more details.

Option delta calculations

The sensitivity with respect to a 1% change in stock price (option delta) is estimated as follows:

$$[\delta(\text{option value})/\delta(\text{price})] * (\text{price}/100) = e^{-dT}\,N(Z) * (\text{price}/100)$$

where:

N' is the normal density function.

To translate option "delta" incentives into dollars, we multiply the corresponding option delta by the number of options held within each option type (e.g., unexercisable, inclusive of new grants vs. exercisable) and then aggregate these values. We assume that the delta for stock holdings and restricted shares is 1.0 (Core and Guay, 2002). To arrive at incentives coming from stock holdings, we multiply the value of stock and restricted share holdings by price $*$ 100, when estimating the "delta" incentives. We measure the CIO's total portfolio of equity incentives (in dollars) by adding the total option incentives to those corresponding incentives coming from stock and restricted shares.

We note that this measure of equity incentives does not capture the effect of executive endowments or other sources of outside wealth. However, we expect that extensive outside wealth would only act to decrease resulting CIO personal incentive relative to current equity-based compensation and decrease the likelihood of any link to performance. Needless to say, the fact that this measure of equity incentives do not include outside wealth is an inherent limitation of the study.

Appendix B. Variable definitions

Compensation variables

CIO equity incentives = change in CIO wealth for 1% change in firm market value, log transformed;

CIO total compensation = CIO salary plus bonus plus equity compensation (Execucomp tdc1, $000s);

CIO restricted stock grants = CIO restricted stock grants value in year t (Execucomp rstkgrnt, $000s);

CIO stock ownership = CIO stock ownership value in year t (Execucomp stockown, $000s);

CIO option incentives = change in CIO wealth for 1% change in firm market value due to unexercised options only, log transformed;

High CIO incentives = 1 if residual CIO incentives from model shown in col. (1) of Table 3 are above the median, and 0 otherwise;

Low CIO incentives = 1 if residual CIO incentives from model shown in col. (1) of Table 3 are below the median, and 0 otherwise;

CEO/CFO equity incentives = change in CEO/CFO wealth for 1% change in firm market value, log transformed;

CEO/CFO total compensation = total salary, bonus, and equity compensation (Execucomp tdc1) for CEO/CFO in year t.

High CFO incentives = 1 if residual CIO incentives are above the median, and 0 otherwise; CFO residual incentives computed in the same manner as residual CIO incentives using the model shown in col. (1) of Table 3 without the CIO 100 award variable;

Low CFO incentives = 1 if residual CFO incentives are below the median, and 0 otherwise; CFO residual incentives computed in the same manner as residual CIO incentives using the model shown in col. (1) of Table 3 without the CIO 100 award variable;

Matching variables

Asset turnover = total revenue divided by total assets.

Difference past cash flow available = firm past cash flow available minus Industry past cash flow avail;

Difference Pay Ratio Top 5 = ratio of current compensation (salary plus bonus) to total compensation (Execucomp variable tdc1) for the 5 most-highly compensated employees at a firm minus the Industry Pay Ratio Top 5;

Difference R&D intensity = firm R&D intensity (R&D expense divided by total revenue) minus Industry R&D Intensity;

Industry IT intensity = mean IT expenditures divided by total revenue for the industry (Fama-French 48 industry categories) and year;

Industry past cash flow avail = mean past cash flow available for the industry (Fama-French 48 industry categories) and year; past cash flow available equals operating cash flows less cash dividends divided by total assets for years t-1 to t-3;

Industry Pay Ratio Top 5 = mean value of the ratio of current compensation (salary plus bonus) to total compensation (Execucomp variable tdc1) for the 5 most-highly compensated employees for each industry (Fama-French 48 industry categories) and year.

Industry R&D intensity = mean R&D expense divided by total revenue for each industry (Fama-French 48 industry categories) and year;

Probability of CIO in industry and year = the percentage of firms with designated CIOs in Execucomp for each industry and year;

Size = Firm total revenue ($mm) (Compustat revt), log transformed;

Determinants, firm performance, and control variables.

Board IT background = 1 if any board members have IT background/experience, and 0 otherwise;

Board size = count of board members in year t;

Capex intensity = Capital expenditures (Compustat capx) divided by total revenue (Compustat revt):

CEO IT background = 1 if CEO has IT background/experience, and 0 otherwise;

CFO Firm = 1 if the firm designates a CFO (among the highly compensation employees reported in Execucomp), and 0 otherwise;

CIO age = age of CIO in year t;

CIO female = 1 if the CIO is female, and 0 if the CIO is male;

CIO Firm = 1 if the firm designates a CIO (among the highly compensation employees reported in Execucomp), and 0 otherwise;

CIO tenure with firm = number of years CIO employed by the firm;

CIO 100 award = 1 if firm received CIO Magazine CIO 100 award during period beginning one year before CIO tenure to two years after, 0 otherwise;

Future Earnings = Mean firm ROS (ib/revt) for years t, t + 1, and t + 2;

Future Tobin's q = mean Tobin's q values in years t to t + 2; Tobin's q calculated per Chung and Pruitt (1994);

Industry CEO equity incentives = mean CEO equity incentives for each industry (Fama-French 48 industry categories) and year;

Industry concentration = four-firm industry concentration (sales revenue for top 4 firms divided by total revenue) for each industry and year;

Non-CIO Firm = 1 if matched non-CIO firm, and 0 otherwise;

Past Cash Flow Avail = operating cash flows less cash dividends divided by total assets for years t-1 to t-3;

Past ROS = earnings (Compustat ib) divided by total revenue (Compustat revt) for years t-1 to t-3;

Past R&D intensity = R&D intensity for years t-1 to t-3;

Pay Ratio Top 5 = annual ratio of current compensation (Execucomp salary plus bonus) to total compensation (Execucomp

variable tdc1) for the 5 most-highly compensated employees.

R&D intensity = R&D expense (0 if missing) (Compustat xrd) divided by total revenue (Compustat revt);

ROS = earnings before extraordinary items (Compustat ib., $mm) divided by total revenue;

Sales growth = total revenue (Compustat revt, $mm) in year t divided by total revenue in year t-1, log transformed;

Size = Firm total revenue ($mm) (Compustat revt), log transformed;

Total assets = Total assets (Compustat at, $mm), log transformed.

Trend = year – 1990.

All continuous variables not log transformed are winsorized 1% at each end of the distribution.

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