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How Chief Information Officer Drives Innovation?

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How Chief Information Officer Drives Innovation?

Short Paper

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Abstract

Owing to today's global digital economy, information technology (IT) executives, namely Chief Information Officers (CIOs), play a crucial role in bridging the business and IT by exploiting IT as a strategic differentiator. Equipped with technical background, CIOs are well-positioned to help the firm to gather and utilize information to explore and exploit innovation. The study aims to investigate whether CIOs contributes to a firm's innovative search. We examine the long-term effects of CIO appointment on the return on innovation investment through research and development (R&D) activities. By employing patent data and a matched sample of U.S. firms between 1995 and 2010, we show that CIO appointment is positively associated with future innovation efficiency. In particular, we find that CIOs in IT firms exerts a stronger influence on the pursuit of innovation. Taken together, our results shed light on the strategic role of CIO in cultivating firm's innovation capability.

Keywords: Chief Information Officer, Innovation capability, R&D investment

Introduction

Owing to today's global digital economy, how to utilize information technology (IT) for value creation is of utmost importance for firm executives, in particular, IT leaders. Sitting at the intersection of the business and IT, Chief Information Officer (CIO)'s role involves a broader managerial perspective of IT management that needs to be aligned with organizational strategic goals for coping with the changing environment (Griffin 2015; Grover *et al.* 1993; Raghunathan and Raghunathan 1989). Aside from the traditional role that emphasizes on cost efficiency and IT management, CIOs play a significant role in preparing firms for better responding to information needs arising from a changing business reporting environment (Liu *et al.* 2018). CIOs are expanding their roles by putting innovation as one of the top priorities to help firm sharpen its business strategies (CIO 2019; Deloitte 2016). They are becoming more strategic and active in immersing themselves in driving the firm's digital capabilities for exploring new business opportunities (CIO 2019). In this study, we aim to investigate the value of CIO by examining whether appointing a CIO in the C-suite contributes to a firm's innovative search capability. We empirically examine the association between CIO appointment and the return of innovation investment measured as future innovation efficiency.

An effective IT strategy is found to be associated with product innovation performance (Chen *et al.* 2015). Being the senior executive who manages IT strategy and investment, CIO's roles are evolving. CIO's role shifts from protecting the status quo to embracing and extending new innovative capabilities (Burrus 2013). This is because CIOs recognize the importance of 'helping in business innovation' as a core

expectation of the IT organization (Deloitte 2016). Anecdotal evidence suggests that since CIO manages IT assets and appreciates what value of IT can bring to the firm, CIO is well-positioned to steer the business towards corporate innovation and to help the company reap the benefits of technological changes (CIO 2019).

The market has found to react positively when a firm announces a CIO appointment (Khallaf and Skantz 2015). Such reaction suggests the expectation of CIOs to be able to develop and deliver IT strategies that not only optimize the performance of business operations but also help to furnish relevant, timely information to support the pursuit of innovation for future growth. Given the fact that modern business reporting and management information systems have been digitalized, CIO leadership is becoming more valuable as an effective CIO leader needs to know how to communicate and collaborate with executives from non-IT function (Liu *et al.* 2018). CIOs with good leadership and talent management skills help to address technology challenges. IT function led by a successful CIO helps a firm to be more customer-centric, which in turn leads to the growth of firm value (Cammarata 2017).

This study draws on the business value of IT and strategy management literature to explore the impact of CIO position on firm's value growth. We attempt to answer an important question regarding the value of the CIO: Does CIO appointment have an impact on the outcome of a firm's innovation investment? We focus on the long-term effects of CIO appointment on the return of innovation investment by employing patent data and a total of 3,022 firm-year observations from 1995 to 2010. Our empirical results show a significant, positive impact of CIO appointment on future innovation efficiency. The results further reveal the incremental value of CIOs in IT firms as there exists a stronger CIO impact on IT firm's future innovation outcomes. The findings shed light on the information systems research stream in IT capabilities by exploring the strategic value of the CIO with regard to corporate innovation capability.

Literature Review and Hypothesis Development

The resource-based theory recognizes the value of intangible organizational resources that drive superior firm performance (Barney 1991; Teece 1997). One important intangible organizational resource is firm's IT capability (Bharadwaj 2000). IT facilitates exploring and exploiting new business opportunities (Benitez *et al.* 2018). Literature in the business value of IT suggests that IT capabilities have a significant impact on product innovation performance (Bharadwaj 2000). In particular, information management capability, a specific dimension of IT capability, is found to influence other firm capabilities such as customer management, process management, and performance management (Mithas *et al.* 2011). In a dynamic business environment characterized by rapid technological changes, product innovation is the key to a firm's competitive advantages (Damanpour 1991).

Innovation outcomes rely on a firm's IT capabilities that are under CIO's watch (Griffin 2015). The value of the CIO is that it is a crucial position that helps to integrate IT with firm strategy (Khallaf and Skantz 2011). CIOs are in a unique position that manages and leverages IT capabilities to improve firm operations. CIOs play a strategic role as they can serve as a process innovator (Luftman and Kempaiah 2008). CIO literature indicates that the reporting structure and the interaction between CIO with other top management team members affect firm's value creation and performance (Banker *et al.* 2011; Karahanna and Preston 2013). With good leadership to bridge the coordination between IT and non-IT business functions, CIOs are expected to exploit IT as a strategic differentiator which contributes to the growth of the firm value (Chen and Wu 2011). More importantly, CIOs can act as a catalyst for change management, such as providing relevant information to address emerging managerial challenges.

The performance of the CIO is found to be conditioned on his/her IT management capability (Chen and Wu 2011). A skilled CIO managing a firm's IT resources effectively to support strategic initiatives can benefit the firm by retaining its competitive advantages (Chun and Mooney 2009). CIO appointment is found to be associated with research growth and organizational relationship management (Nicolaou 2008). The positive effects of CIO appointment on market reaction and accounting-based performance have found in the prior CIO literature (Khallaf and Skantz 2011). The value of IT with the appointment of CIO is expected to affect firm performance through the improvements in research and development (R&D) activities. Khallaf and Skantz (2015) suggest that first-time CIO appointment signals a significant strategic change in firms' management practice. They find that CIO appointments in firms with superior IT capability have a positive impact on R&D productivity, measured by aggregate accounting-based

performance measures, such as return on assets (ROA) or return on equity (ROE). Aggregate accounting-based performance measures show the bottom-line result of cross-function collaboration in a firm. The innovation based on R&D activities may result in the growth of ROA, but the promotion efforts of the marketing function or the improved productivity of production function could also lead to a better ROA.

To directly measure the return of innovation investments, prior literature documents that innovation efficiency, the ratio of patents or citations to R&D spending, can be employed as a strong predictor of future returns of innovation investments, after controlling for firm characteristics and risk (Hirshleifer *et al.* 2013). Using U.S. patents data from 1926 to 2010 and considering the stock market response to news about patents, Kogan *et al.* (2017) develop a new patent-level measure which can better reflect the scientific value of the patent based on the number of citations the patent received in the future. The measure is associated with substantial growth, reallocation, and creative destruction. To investigate the direct contribution of CIO's influence on the return of innovation creation activities such as R&D, we follow the concept of Hirshleifer *et al.* (2013) to construct the innovation efficiency measure that is scaled by prior R&D investments. Given the strategic influence of CIO, a position that is crucial to firm's IT capabilities, we expect that CIO appointments help to leverage IT capital more effectively for creating future economic value through the investments in R&D. Accordingly, we hypothesize the relationship between CIO position and innovation efficiency as follows:

H1: CIO appointment is positively associated with a firm's future innovation efficiency.

Research Methodology

To examine the effects of CIO appointment on future innovation success, we estimate the following model and control factors affecting a firm's R&D investment and innovation strategies, such as resource allocation, financial performance, or growth potential. The main regression model is as follows:

$$IE_{it+2} = \beta_0 + \beta_1 CIO_{it} + \beta_2 SIZE_{it} + \beta_3 ROA_{it} + \beta_4 TOBINQ_{it} + \beta_5 LEV_{it} + \beta_6 CAPX_{it} + \beta_7 TENURE_{it} + \beta_8 EMPG_{it} + \beta_9 INDQ_{it} + \varepsilon_{it} \quad (1)$$

where IE_{it+2} represents alternative innovation efficiency measures in the future, including $IENPAT_{it+2}$, $IENLPAT_{it+2}$, $IECWPAT_{it+2}$, and $IEMVPAT_{it+2}$. The innovation measures capture whether a firm is efficient in pursuing innovation by investing in innovation search activities such as R&D. Alternative innovation measures developed in the study are the ratios of different numerators in year $t+2$ to the sum of adjusted R&D expenditure in the past 5 years from year $t-4$ to year t. We follow prior innovation literature (Hirshleifer *et al.* 2013; Kogan *et al.* 2017) to consider patent data that can reflect the economic value of patent as alternative numerators of innovation measures. The numerators of $IENPAT_{it+2}$, $IENLPAT_{it+2}$, $IECWPAT_{it+2}$, and $IEMVPAT_{it+2}$ are raw patent numbers, the logarithm of patent numbers, citation frequency of patents, and total market value of patents for firm i in year $t+2$. For the denominator of the measures, we follow prior literature to consider 5-year cumulative R&D expenditure with the assumption of 20% depreciation rate (Chan *et al.* 2001; Lev *et al.* 2005) ending in the year t since the average time for the US Patent and Trademark Office (USPTO) to grant a patent is two years (Hall *et al.* 2001; Hirshleifer *et al.* 2013). CIO_{it}, the main variable of interest, is the indicator of CIO appointment, which equals 1 if firm i has CIO in its top management team in year t, and 0 otherwise. Prior literature suggests bigger firms with more resources, fast-growing firms, prior firm performance, firm risk or executive tenure may affect firm's investment decisions (Chae *et al.* 2014; Hoitash et al. 2016; Kogan *et al.* 2017; Mao and Zhang 2018). We therefore control for the following variables that may have a confounding effect on our innovation measures: firm size ($SIZE_{it}$) is the logarithm of total assets at the beginning of year t. Return on assets (ROA_{it}) and Tobin's Q ($TOBINQ_{it}$) as the market-to-book ratio measure for firm performance and growth potential, respectively. To capture the level of business risk due to financing strategies that may affect a firm's investment in R&D projects, leverage (LEV_{it}) is measured as the total debt-to-equity ratio at the beginning of year t. Capital expenditure ($CAPX_{it}$), defined as capital expenditure to total assets at the beginning of year t, is measured for capturing a firm's investment in long term capital infrastructure. To account for the experience and knowledge of CIO regarding the firm's operations, we control for CIO tenure ($TENURE_{it}$), defined as the logarithm of total number of years a CIO has worked for firm i. Knowledge resides in human resources is critical to a firm's innovation capability. We thus control for employee growth ($EMPG_{it}$), defined as the ratio of annual change in total employee number to total assets, to reflect the change of human capital investment. Industry growth may intensify the competition and put

the pressure on firms to be innovative. We thus control for the industry growth ($INDQ_{it}$), with the use of the industry-level Tobin's q ratio. We include fixed effects of industry and year in the model. Industry classification is based on two-digit SIC code.

Table 1. Variable Definitions	
Variable	**Definition**
$IENPAT_{it+2}$	= patent-based measure of innovation efficiency, defined as the number of patents in year *t+2*, divided by the sum of 100%, 80%, 60%, 40%, and 20% of R&D expenses in year *t*, *t-1*, *t-2*, *t-3*, and *t-4*, respectively;
$IELNPAT_{it+2}$	= alternative patent-based measures of innovation efficiency, defined as the log of one plus patent numbers in year *t+2*, divided by the sum of 100%, 80%, 60%, 40%, and 20% of R&D expenses in year *t*, *t-1*, *t-2*, *t-3*, and *t-4*, respectively;
$IECWPAT_{it+2}$	= citation-based measure of innovation efficiency, defined as the log of one plus citation-weighted patent values in year *t+2*, divided by the sum of 100%, 80%, 60%, 40%, and 20% of R&D expenses in year *t*, *t-1*, *t-2*, *t-3*, and *t-4*, respectively;
$IEMVPAT_{it+2}$	= market-based measure of innovation efficiency, defined as the market value of patents in year *t+2*, divided by the sum of 100%, 80%, 60%, 40%, and 20% of R&D expenses in year *t*, *t-1*, *t-2*, *t-3*, and *t-4*, respectively;
CIO_{it}	= the indicator of firm-year having chief information officer (CIO), chief technology officer (CTO) or related executives in the management team;
$SIZE_{it}$	= the logarithm of total assets at the beginning of year *t*;
ROA_{it}	= return on assets;
$TOBINQ_{it}$	= Tobin's Q calculated as the market-to-book ratio at the beginning of year *t*;
LEV_{it}	= leverage at the beginning of year *t*;
$CAPX_{it}$	= capital expenditure to total assets at the beginning of year *t*;
$TENURE_{it}$	= the logarithm of the number of years a CIO has worked for firm *i* in year *t*;
EMPGit	= the ratio of annual change in the number of employees to total assets;
$INDQ_{it}$	= Tobin's Q at the industry level in year t based on two-digit SIC code.

Table 1. Variable Definitions

We collect our sample based on three sources. First, we rely on the Capital IQ database to retrieve CIO information and the patent data provided by Kogan *et al.* (2017) to construct the innovation efficiency measures. We focus on U.S. firms and employ the Compustat North America database to extract corporate financial information. The Capital IQ database provides CIO-related information, including executive title, job description, compensation, and other attributes since 1995. The aforementioned patent dataset provides patent-related information until 2010. We identify CIO observations based on executives' titles, which are classified as CIO or related titles, such as chief technology officer (CTO), and job descriptions. We exclude firms in financial industries (SIC 6000-6999) because such financial firms exhibit significant different capital structures. We merge data from Capital IQ, the patent dataset, and the Compustat North America and make sure sample firms, with or without CIO position during the sample period, exist in all databases.

CIO appointment is not mandatory as it is the firm's choice to decide whether to have such a position within the organizational structure to manage IT assets and strategy. Such choice could be endogenous along with firm operations and the information needs conditioned on the development of technology. Therefore, we follow prior literature (e.g. Hoitash *et al.* 2016) to use a propensity score-matched sample to examine the association between CIO and future innovation efficiency. First, we identify 5,569 firm-year observations with CIO appointment from the initial sample as the CIO sample. Second, we construct a control sample, which includes firm-year observations with similar attributes as the CIO sample, but not hiring CIOs, based on a logistic regression model, as follows:

$$\text{Prob.}\,(CIO_{it+1}=1) = \alpha_0 + \alpha_1 SIZE_{it} + \alpha_2 TOBINQ_{it} + \alpha_3 \Delta SALES_{it} + \alpha_4 R\&D5_{it} + \alpha_5 INTAN_{it} + \alpha_6 EMPI_{it} + \alpha_7 ACC_{it} + \alpha_8 ROA5_{it} + \alpha_9 NSEG_{it} + \alpha_{10} INDQ_{it} + u_{it} \quad (2)$$

where $\Delta SALES_{it}$ represents the ratio of annual change in net sales to total assets at the beginning of year *t*; $\Delta R\&D5_{it}$ is the average research and development expenditure from year *t-5* to year *t-1*, divided by total assets at the beginnings of year *t*; $INTAN_{it}$ is the intangible assets to total assets in year *t*; $EMPI_{it}$ is employee intensity defined as the number of employees to total assets; ACC_{it} is the total accruals deflated by total assets at the beginnings of year *t*; $ROA5_{it}$ is the average return on assets from year *t-5* to year *t-1*; $NSEG_{it}$ is the number of segments as a proxy of business complexity in year *t*. We also include fixed effects of industry and year in the model. Other variables are defined above and documented in Table 1.

We then match each CIO firm-year with a non-CIO firm in the same industry and year (sampling without replacement), based on the closest propensity score within a caliper distance of 0.05. Our final test sample includes 1,511 non-CIO firm-year observations (the control sample) and 1,511 firm-year observations with CIO appointment. Table 2 reports the descriptive statistics based on the propensity score-matched final test sample. The mean (median) estimated propensity scores are 0.0537 and 0.0543 (0.0491 and 0.0495), respectively, for CIO and non-CIO samples (untabulated). On average, firms with CIO have a larger size, better performance, greater capital investments, and greater growth potential at both firm and industry levels than those without CIO appointment. The differences between CIO and non-CIO sample are significant across all innovation efficiency measures at the 0.05 level or better.

Table 2. Descriptive Statistics

	CIO Sample (n=1,511)			Non-CIO Sample (n=1,511)			Difference (p-value)	
	(1)	(2)	(3)	(4)	(5)	(6)	t-test	Wilcoxon test
Variable	Mean	Median	S.D.	Mean	Median	S.D.	(1) vs. (4)	(2) vs. (5)
$IENPAT_{it+2}$	0.059	0.000	0.141	0.043	0.000	0.147	<0.001	<0.001
$IELNPAT_{it+2}$	0.026	0.000	0.090	0.014	0.000	0.051	<0.001	<0.001
$IECWPAT_{it+2}$	0.029	0.000	0.104	0.021	0.000	0.077	0.025	<0.001
$IEMVPAT_{it+2}$	0.025	0.000	0.083	0.013	0.000	0.043	<0.001	<0.001
CIO_{it}	1.000	1.000	0.000	0.000	0.000	0.000		
$SIZE_{it}$	5.062	4.858	2.107	4.933	4.780	2.309	0.107	0.585
ROA_{it}	-0.159	0.012	0.619	-0.162	0.008	0.742	0.145	0.129
$TOBINQ_{it}$	0.683	0.525	0.735	0.678	0.465	0.838	0.170	0.145
LEV_{it}	0.125	0.019	0.208	0.153	0.014	0.217	0.003	0.007
$CAPX_{it}$	0.061	0.034	0.090	0.058	0.030	0.099	0.706	0.381
$TENURE_{it}$	1.659	1.835	0.494	0.000	0.000	0.000	<0.001	<0.001
$EMPG_{it}$	0.009	0.004	0.029	0.007	0.005	0.028	0.112	0.118
$INDQ_{it}$	4.487	4.189	2.944	4.438	4.146	2.384	0.127	0.381

Table 2. Descriptive Statistics

In Table 3, we present the results of Pearson correlations for variables employed in equation (1). We find that alternative measures of innovation efficiency are significantly correlated with each other. In addition, the results show that CIO indicator (CIO_{it}) is more significantly correlated with citation-based and market-based measures of innovation efficiency. This supports the strategic value of the CIO position, that is leveraging IT effectively in exploiting new business opportunities as well as help create value-added products/services.

Table 3. Correlation Matrix

Variables		1	2	3	4	5	6	7
$IENPAT_{it+2}$	1							
$IELNPAT_{it+2}$	2	**0.891**						
$IECWPAT_{it+2}$	3	**0.865**	**0.878**					
$IEMVPAT_{it+2}$	4	**0.821**	**0.857**	**0.858**				
CIO_{it}	5	*0.079*	*0.052*	**0.060**	**0.046**			
$SIZE_{it}$	6	**0.099**	**0.105**	**0.109**	*0.054*	*0.129*		
ROA_{it}	7	*0.040*	0.021	*0.016*	0.033	*0.032*	**0.369**	
$TOBINQ_{it}$	8	**0.080**	**0.085**	**0.089**	**0.123**	*0.031*	**0.152**	**0.369**
LEV_{it}	9	**-0.074**	**-0.083**	**-0.083**	**-0.072**	**-0.065**	**0.201**	*-0.026*
$CAPX_{it}$	10	0.026	0.018	0.029	*0.032*	*0.024*	**0.072**	**0.232**

TENURE$_{it}$	11	0.036	*0.042*	*0.038*	*0.066*	**0.168**	**0.118**	**0.005**
EMPG$_{it}$	12	0.024	0.023	*0.028*	*0.031*	*0.025*	*0.032*	**0.088**
INDQ$_{it}$	13	*0.041*	*0.031*	*0.025*	*0.027*	*0.028*	*0.024*	*0.014*
Variables		*8*	*9*	10	*11*	12		
LEV$_{it}$	9	**-0.057**						
CAPX$_{it}$	10	**0.175**	**0.068**					
TENURE$_{it}$	11	**0.070**	-0.021	**0.059**				
EMPG$_{it}$	12	0.024	**-0.050**	**0.194**	*0.016*			
INDQ$_{it}$	13	**0.052**	-0.005	0.015	0.015	0.026		

This table reports cross-sectional Pearson correlations. Numbers reported in **bold** and *italics* represent strong (p<0.01) or weak (p<0.05 or p<0.1) levels of significance, respectively.

Table 3. Correlation Matrix

Results

Table 4 presents the results for the association between CIO appointment (*CIO$_{it}$*) and alternative innovation efficiency measures in terms of patent numbers, citation frequency, and market value. In column (2), the estimated coefficient on *CIO$_{it}$* of 0.110 is significantly and positively associated with the ratio of two-years-ahead raw patent numbers to past R&D expenditure at the 0.05 level. In columns (3) to (5), the estimated coefficients on *CIO$_{it}$* of 0.059, 0.084, and 0.043, are consistently and positively associated with future innovation efficiency based on transformed patent numbers, citation numbers, and total market value of patents, respectively, at the 0.01 significance level or better. The results, therefore, support the notion that CIOs, which lead the IT strategy and manages IT capital, can contribute to firms' innovation strategy as well as facilitate the realization of R&D investment by improving the success rate of R&D projects (number of patents registered), the usefulness of R&D outcomes (citation frequency), and the intangible values of the firm (total market value of patents).

Most of the control variables are consistent with our expectations and prior literature (e.g. Hirshleifer *et al.* 2013; Kogan *et al.* 2017). Firm size (*SIZE$_{it}$*), return on assets (*ROA$_{it}$*), and Tobin's Q measure (*TOBINQ$_{it}$*) are positively associated with future innovation efficiency measures, implying that firms with more resources and better past performance are more capable and willing to place emphasis on innovation activities such as R&D in order to retain their competitive advantages. Leverage (*LEV$_{it}$*) is negatively associated with future innovation efficiency, suggesting that firms with higher financial leverage are constrained by their resources that could be devoted to uncertain R&D projects. Capital expenditure (*CAPX$_{it}$*) is positive but insignificant. CIO tenure (*TENURE$_{it}$*) is positively associated with innovation efficiency. CIOs with longer work experience (longer tenure) have more in-depth knowledge regarding the firm's operations as well as personnel relationship. The positive results suggest that CIOs benefits from such experience while collaborating with others to help the firm achieve its strategic goals such as innovation. The positive effect of employee growth (*EMPG$_{it}$*) on innovation efficiency is consistent with the literature in human capital that addresses the value of human resources. Industry-level growth is positively associated with firm's future innovation efficiency, suggesting that firm invests more in innovation when operating in a growing business environment.

Table 4: The Association between CIO Appointment and Innovation Efficiency				
Variable	*IENPAT$_{it+2}$*	*IELNPAT$_{it+2}$*	*IECWPAT$_{it+2}$*	*IEMVPAT$_{it+2}$*
CIO$_{it}$	0.110 (2.13)**	0.059 (3.26)***	0.084 (3.13)***	0.043 (2.82)***
SIZE$_{it}$	0.059 (7.18)***	0.069 (2.79)**	0.085 (2.31)**	0.012 (5.51)***
ROA$_{it}$	0.112 (3.77)***	0.038 (3.42)***	0.054 (3.15)***	0.044 (4.39)***
TOBINQ$_{it}$	0.027 (6.78)***	0.094 (6.64)***	0.014 (6.63)***	0.011 (8.36)***
LEV$_{it}$	-0.042 (-4.11)***	-0.114 (-3.20)***	-0.168 (-3.18)***	-0.094 (-2.86)***
CAPX$_{it}$	0.039 (1.41)	0.018 (1.59)	0.018 (1.35)	0.006 (1.53)
TENURE$_{it}$	0.016 (2.05)**	0.098 (1.49)	0.018 (1.77)*	0.021 (2.01)**
EMPG$_{it}$	0.955 (2.08)**	0.335 (1.76)*	0.370 (2.16)**	0.265 (1.67)*
INDQ$_{it}$	0.016 (1.46)	0.007 (2.66)***	0.010 (2.94)***	0.024 (1.33)

Fixed Effects	Industry & Year	Industry & Year	Industry & Year	Industry & Year
Obs.	3,022	3,022	3,022	3,022
Adj-R^2	0.105	0.087	0.085	0.118

***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively. Standard errors are clustered at firm level and the *t-statistics* are reported in parentheses. Variables are defined in Table 1.

Table 4. The Association between CIO Appointment and Innovation Efficiency

We perform additional robustness checks. The matched sample using the propensity score matching method may not eliminate endogeneity concerns when potential hidden bias may exist for the choice of CIO appointment within the matched sample. First, we perform Rosenbaum's (2002) bounds tests to examine the sensitivity of our main results based on the propensity score matching method. We show that the highest Rosenbaum's critical value (*Γ*) is 1.62, suggesting our main findings and inferences are robust. Second, we strictly limit the CIO sample by excluding observations with similar titles, such as CTO, and rerun the analysis. The results remain hold by using such a limited sample. Third, one may suggest that the patent granting process could be completed sooner. Thus, we rerun our analysis by employing the one-year ahead model, which uses dependent variables at year t+1 (IE_{it+1}). The results remain quantitatively similar to the main results in Table 4. Fourth, several major IT-related events causing structural changes of firm practices occurred in the late 1990s, such as the collapse of the internet bubble market and Y2K issues (Khallaf and Skantz 2015). We, therefore, follow Khallaf and Skantz (2015) to use the year 1999 as the breakpoint and rerun our analyses by using two matched samples for pre- and post-1999 periods, respectively. The results remain to hold for both periods.

IT firms are well recognized to be more proactively in the pursuit of technological innovation. To further examine whether IT firms benefit more by appointing a CIO to manage firm's IT capability that's relevant to innovation search, we rerun our model by adding a dummy variable, IT_{it}, for IT firms and constructing the interaction variable, $CIO_{it}*IT_{it}$, to investigate whether there is incremental value of having CIOs within IT firms. For industry classification, we follow Francis and Schipper (1999) by employing 3-digit SIC codes. We present the results in Table 5. Consistent with the main results, the coefficients on CIO_{it} across alternative models are significantly positive. The insignificant coefficients on IT_{it} suggest that the innovation efficiency in IT industries is not significantly better than other industries. Importantly, the results show that the interaction, $CIO_{it}*IT_{it}$, are positively associated with innovation efficiency. Innovation is of utmost importance for IT firm's success and growth. Our results provide empirical evidence to support the value of CIO, especially for IT firms.

Table 5: The Impact of CIO Appointment on Innovation in IT Firms				
Variable	$IENPAT_{it+2}$	$IELNPAT_{it+2}$	$IECWPAT_{it+2}$	$IEMVPAT_{it+2}$
CIO_{it}	0.035 (2.33)**	0.020 (2.60)***	0.026 (2.61)***	0.015 (2.56)**
IT_{it}	0.024 (1.05)	0.015 (1.08)	0.021 (1.21)	0.009 (1.01)
$CIO_{it}*IT_{it}$	0.029 (2.25)**	0.017 (3.99)***	0.022 (4.12)***	0.012 (3.35)***
$SIZE_{it}$	0.056 (3.33)***	0.059 (2.06)**	0.019 (2.05)**	0.028 (1.80)*
ROA_{it}	0.068 (2.05)**	0.031 (2.30)**	0.042 (2.07)**	0.031 (2.73)***
$TOBINQ_{it}$	0.014 (2.74)***	0.043 (2.40)**	0.065 (2.41)***	0.061 (3.75)***
LEV_{it}	-0.046 (-3.69)***	-0.123 (-2.90)***	-0.020 (-3.38)***	-0.098 (-2.28)**
$CAPX_{it}$	0.047 (1.66)*	0.019 (1.43)	0.020 (1.21)	0.019 (0.71)
$TENURE_{it}$	0.084 (3.11)***	0.097 (1.66)*	0.023 (1.60)	0.035 (1.78)*
$EMPG_{it}$	0.475 (1.67)*	0.451 (1.91)*	0.334 (1.85)*	0.366 (1.98)**
$INDQ_{it}$	0.011 (1.00)	0.004 (2.00)**	0.007 (2.28)**	0.034 (1.04)
Fixed Effects	Industry & Year	Industry & Year	Industry & Year	Industry & Year
Obs.	3,022	3,022	3,022	3,022
Adj-R^2	0.127	0.107	0.107	0.138

***, **, and * denote significance at the 0.01, 0.05, and 0.10 levels, respectively. Standard errors are clustered at firm level and the *t-statistics* are reported in parentheses. Variables are defined in Table 1.

Table 5. The Impact of CIO Appointment on Innovation in IT Firms

Conclusion

In today's digital economy, contemporary CIOs should strive to serve as an innovator by strategically aligning IT resources with firm's business goals to help cultivate organizational innovation capabilities, in order to create and maintain the competitive advantages. While prior research has examined and documented the impact of CIO on firm performance, the direct effect of CIO appointment on innovation performance, specifically measured by the outcome of R&D investment, has not yet empirically investigated in the literature. This study investigates whether the appointment of CIO in the top management team, a position to lead IT strategy and management for supporting the pursuit of value creation activities such as R&D, can affect the efficiency of technological innovation in a firm.

We rely on innovation literature to employ patent estimates which incorporate the private economic value of new innovations to measure the return of innovation investment through R&D activities. The empirical results show that CIO appointment contributes to future innovation efficiency. The findings contribute to prior CIO literature by suggesting that the value of the CIO is associated with leveraging IT capital for new business opportunities. An effective CIO leadership is linked with the firm's IT capabilities that in turn affects the ability to explore innovation through value creation activities such as R&D. Compared to CIOs in non-IT firms, CIOs in IT firms exert a stronger influence in the firm's pursuit of innovation. The study not only contributes to the literature in information systems and strategy management by addressing the association between CIO appointment and R&D investment but also supplement practitioners' expectation with empirical evidence showing that firm could benefit from CIO appointment as such position contributes to a firm's future innovation performance.

The study draws on the resource-based view of the firm to explicate the effect of CIO appointment, a critical executive position that affects a firm's IT capability, on the performance of a firm's innovation investment. The empirical findings presented in this short paper show important implications of the value of CIO with regard to innovation search capability. We believe the research addresses the emerging interest of both academia and practitioners regarding the roles of CIO. There are avenues we plan to further enrich the study. To shed more light on the strategic role of CIOs, we plan to explore the moderating effect of CIO appointment on the association between business strategies and innovation performance. We have included CIO tenure in the current model to account for CIO's experience regarding the firm's operations. Drawn on prior CIO literature in examining the leadership of CIO and its interaction within other executives, we plan to further consider various CIO characteristics, such as age, industry experience, or educational background, to investigate what CIO characteristics stimulate effective collaboration across business functions that may lead to a better alignment between the business and IT.

References

Banker, R. D., Hu, N., Pavlou, P. A., and Luftman, J. 2011. "CIO Reporting Structure, Strategic Positioning, and Firm Performance," *MIS Quarterly* (35:2), pp. 487-504.

Barney, J. 1991. "Firm Resources and Sustained Competitive Advantage," *Journal of Management* (17:1), pp.99-120.

Benitez, J., Llorens, J., and Braojos, J. 2018. "How Information Technology Influences Opportunity Exploration and Exploitation Firm's Capabilities," *Information & Management* (55:4), pp. 508-523.

Bharadwaj, A. 2000. "A Resource-based Perspective on Information Technology Capability and Firm Performance: an Empirical Investigation," *MIS Quarterly* (24:1), pp. 169-196.

Burrus, D. 2013. "Today's CIO Needs to be the Chief Innovation Officer," *Harvard Business Review*, available at: https://hbr.org/2013/07/todays-cio-needs-to-be-the-chi.

Cammarata, 2017. "Why the CIO is the Chief Innovation Officer?" Mobile Business Insight, available at: https://www.ibm.com/information-technology/why-cio-chief-innovation-officer.

Chan, L. K. C., Lakonishok, J., and Sougiannis, T. 2001. "The Stock Market Valuation of Research and Development Expenditures," *Journal of Finance* (56:6), pp. 2431-2456.

Chae, H., Koh, C. E., and Prybutok, V. R. 2014. "Information Technology Capability and Firm Performance: Contradictory findings and Their Possible Causes," *MIS Quarterly* (38:1), pp. 305-326.

Chen, Y., Wang, Y., Nevo, S., Benitez-Amado, J., and Kou, G. 2015. "IT Capabilities and Product Innovation Performance: the Roles of Corporate Entrepreneurship and Competitive Intensity," *Information & Management* (52:6), pp. 643-657.

Chen, Y., and Wu, J. 2011. "IT Management Capability and Its Impact on the Performance of a CIO," *Information & Management* (48), pp. 145-156.

Chun, M., and Mooney, J. 2009. "CIO Roles and Responsibilities: Twenty-five Years of Evolution and Change," *Information & Management* (46:6), pp. 323-334.

CIO. 2019. "Winter 2019: State of the CIO," CIO.com, available at: https://www.cio.com/article/3335497/winter-2019-state-of-the-cio.html.

Damanpour, F. 1991. "Organizational Innovation: a Meta-Analysis of Effects of Determinants and Moderators," *Academy of Management Journal* (34:3), pp. 555-590.

Deloitte. 2016. "The CIO's Innovation Agenda," available at: https://www2.deloitte.com/content/dam/Deloitte/us/Documents/about-deloitte/us-cio-insider-role-innovation.pdf.

Francis, J., and Schipper, K. 1999. "Have Financial Statements Lost Their Relevance?" *Journal of Accounting Research* (37:2), pp. 319-353.

Griffin, M. 2015. "The innovative CIO," available at: https://www.cio.com/article/2925992/innovation/the-innovative-cio.html.

Grover, V., Jeong, S., Kettinger, W. J., and Lee, C. C. 1993. "The Chief Information Officer: A Study of Managerial Roles," *Journal of Management Information Systems* (10:2), pp. 107-130.

Hall, B. H., Jaffe, A., and Trajtenberg, M. 2001. "The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools," NBER Working Paper 8498, available at: http://www.nber.org/papers/w8498.

Hirshleifer, D., Hsu, P., and Li, D. 2013. "Innovative Efficiency and Stock Returns," *Journal of Financial Economics* (107:3), pp. 632-654.

Hoitash, R., Hoitash, U., and Kurt, A. C. 2016. "Do Accountants Make Better Chief Financial Officers?" *Journal of Accounting and Economics* (61:2), pp. 414-432.

Karahanna, E., and Preston, D. S. 2013. "The Effect of Social Capital of the Relationship between the CIO and Top Management Team on Firm Performance," *Journal of Management Information Systems* (30:1), pp. 15-56.

Khallaf, A., and Skantz, T. 2011. "Does Long-Term Performance Improve Following the Appointment of a CIO?" *International Journal of Accounting Information System*s (12:1), pp. 57-78.

Khallaf, A., and Skantz, T. 2015. "R&D Productivity Following First-Time CIO Appointments," *International Journal of Accounting Information Systems* (16), pp. 55-72.

Kogan, L., Papanikolaou, D., and Seru, A. 2017. "Technological Innovation, Resource Allocation and Growth," *Quarterly Journal of Economics* (132:2), pp. 665-712.

Lev, B., Sarath, B., and Sougiannis, T. 2005. "R&D Reporting Biases and Their Consequences," *Contemporary Accounting Research* (22:4), pp. 977–1026.

Liu, F., Hsu, H., and Yen, D. C. 2018. "Technology Executives in the Changing Accounting Information Environment: Impact of IFRS Adoption on CIO Compensation," *Information & Management* (55:7), pp. 877-889.

Luftman, J., and Kempaiah, R. 2008. "An Update on Business-IT Alignment: A line Has Been Drawn," *MIS Quarterly Executive* (7:2), pp. 165–177.

Mao, C., and Zhang, Z. 2018. "Managerial risk-taking incentive and firm innovation: Evidence from FAS 123R," *Journal of Financial and Quantitative Analysis* (53:2), pp. 867-898.

Mithas, S., Ramasubbu, N., and Sambamurthy, V. 2011. "How Information Management Capability Influences Firm Performance," *MIS Quarterly* (35:1), pp. 237-256.

Nicolaou, A. 2008. "Research Issues on the Use of ERP in Inter-Organizational Relationships," *International Journal of Accounting Information Systems* (9:4), pp. 216-226.

Raghunathan, B., and Raghunathan, T. S. 1989. "Relationship of the Rank of Information Systems Executive to the Organizational Role and Planning Dimensions of Information Systems," *Journal of Management Information Systems* (6:1), pp. 111-126.

Rosenbaum, P. R. 2002. *Observational Studies*, 2nd ed. Springer Series in Statistics, New York.

Teece, D. J., Pisano, G., Shuen, A. 1997. "Dynamic Capabilities and strategic management," *Strategic Management Journal* (18:7), pp.509-533.