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# Seeking Value through Deviation? Economic Impacts of IT Overinvestment and Underinvestment

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***Abstract:*** This study addresses the economic impacts of information technology (IT) overinvestment and underinvestment decisions. Based on the view of Red Queen competition in conjunction with institutional theory, we hypothesize that overinvestment and underinvestment in IT have nonlinear performance impacts. Drawing on the idea of management control mechanisms, we further hypothesize that the performance impacts are conditional on ownership concentration. Using a sample of S&P 500 firms, we find that, on average, there is a positive relationship between a firm's overinvestment in IT and Tobin's q, although that relationship attenuates at higher levels of overinvestment. However, there is, on average, no relationship between a firm's underinvestment in IT and its Tobin's q. Importantly, the payoff for underinvestment becomes positive for companies with founding-family ownership. Implications for research and practice are discussed.

***Key words***: IT investment, firm performance, deviation, overinvestment, underinvestment, Red Queen, concentrated ownership

## 1. Introduction

Information technology (IT) investment decisions are of continuing strategic importance to firms (Mithas and Rust 2016). Different levels of IT investment can significantly expand or constrain the set of a firm's competitive actions (Mithas et al. 2013; Rai and Tang 2014). In practice, firms making IT investment decisions often use an industry benchmark (Nolan and McFarlan 2005). Our study uses the lens of Red Queen competition[1] to address the performance implications of getting closer to or further from the industry benchmark. The view of Red Queen competition depicts performance differences among firms as a function of competitive race (Barnett 2008: 72; Barnett and Hansen 1996). When a firm acts to gain a competitive edge, this may trigger reactions among its

[1] Barnett (2008: 2) describes Red Queen competition with a reference to a scene in Lewis Carroll's *Through the Looking Glass* in which Alice asks the Red Queen why she is running but remaining in the same place. The Red Queen responds, "A slow sort of country [you must come from]! Now, here, you see, it takes all the running you can do, to keep in the same place… to get somewhere, you must run at least twice as fast."

rivals. Firms in the same competitive cohort then find themselves in a competitive race. Under Red Queen competitive pressures, each firm's performance depends on exceeding the actions of its rivals. This logic is useful but underresearched in the context of IT investment and its economic impacts (Agarwal and Tiwana 2015). We therefore find it theoretically intriguing to shed new light on firm IT investment through the lens of Red Queen competition. At first glance, that lens would suggest that for a firm to outperform its rivals, its IT investment must exceed theirs. IT investment, however, consumes resources that can be used for other competitive actions (Mithas et al. 2013). Institutional theory also suggests that making the same amount of IT investment that rivals do can bring the benefits of having a "legitimate" amount of investment (DiMaggio and Powell 1983). Each of these perspectives suggests that a firm's deviation from the industry benchmark affects its performance, but they predict impact in different directions. We therefore ask: *How does a firm's IT investment deviation from the industry benchmark affect firm performance*?

Following prior research using industry average as an industry benchmark for a firm's IT investment decision making (Mithas et al. 2013), we define a firm's IT investment deviation as:

$$Deviation = \begin{cases} overinvestment\ (\equiv IT\ investment - industry\ average), if\ IT\ investment > industry\ aveage; \\ underinvestment\ (\equiv industry\ average - IT\ investment), if\ IT\ investment \leq industry\ aveage. \end{cases}$$

According to this definition, both high overinvestment and high underinvestment are forms of moving further from the industry average.

Further, we investigate management control mechanisms that can moderate the performance implications of IT investment deviation. Such research may offer insights into how firms can compete by investing in IT under Red Queen competitive pressures. Evidence suggests that IT investment deviation may not always be a reaction to Red Queen competition in order to pursue a competitive advantage. For example, when making large-scale IT investment decisions, "CEOs consider several personal and firm-level financial factors, including factors unrelated to IT cost and performance" (Hall and Liedkta 2005: 193). Scholars suspect that during the late 1990s, CEOs invested excessively in Internet technologies to increase their own benefits from stock options (Bolton et al. 2006). It has long been noted that IT managers tend to overinvest in IT—the so-called "empire-building" syndrome (Dewan et al. 1998). All these cases may manifest themselves in overinvestment in IT but may not do anything to increase competitive advantage. There may also be shirkers who tend to underinvest in IT (Aggarwal and Samwick 2006). If managers lack knowledge and skills to manage certain technologies, they may choose to bypass good investment opportunities that would have created value for their firms (Li 2009). These observations from practice show the need to enrich thinking from the Red Queen logic by considering management control mechanisms that can mitigate managers' self-dealing. Starting from the seminal work by Berle and Means (1932: 113-114) on management control, there is mounting evidence that concentrated corporate ownership—for example, founding-family ownership (Ali et al. 2007; Anderson and Reeb 2003, 2004)—is a control mechanism that can mitigate managers' self-interested activities (La Porta et al. 1999). It is associated with owners having both the power and the incentive to monitor managerial behaviors. We extend this strand of research on management control to research on IT investment deviation and ask: *How does concentrated ownership moderate payoff to IT investment deviation?*

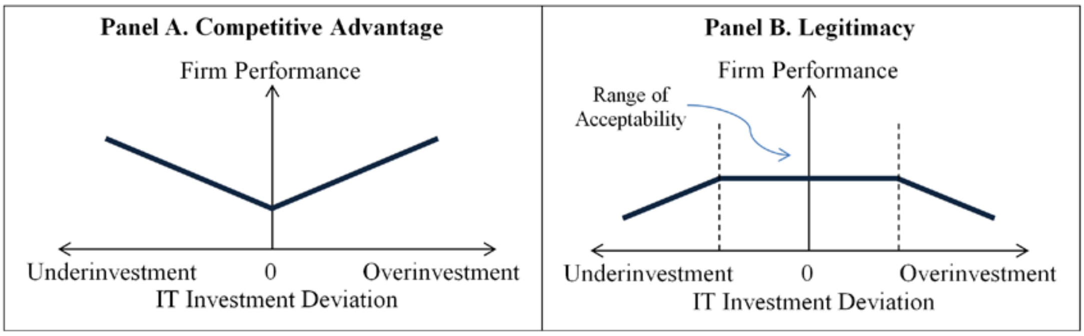
To answer our two research questions, we use IT investment data from the Computer Intelligence (CI) database and hand-collect information about concentrated ownership (family ownership) following prior research (Anderson and Reeb 2003, 2004). Our sample covers Standard & Poor's (S&P) 500 firms during 2001-2006. We find that, on average, there is a positive relationship between a firm's overinvestment in IT (more than industry average) and Tobin's q, although that relationship attenuates at higher levels of overinvestment. However, there is, on average, no relationship between a firm's underinvestment in IT (less than industry average) and its Tobin's q. Importantly, the payoff for underinvestment becomes positive for firms with founding-family ownership.

This study contributes to the literature in three ways. First, it is one of the first studies to answer the call to examine the economic impact of information systems through the lens of Red Queen competition (Agarwal and Tiwana 2015). It builds explicitly on Red Queen rationales and provides empirical evidence of the relationship between a firm's IT investment deviation and its Tobin's q. Second, a finer-grained result shows that a firm can improve performance by distinguishing itself from rivals through deviation *in either direction* from industry average IT investment, contrary to the inference from the view of Red Queen competition that a firm gains competitive advantage by investing *more* than its rivals. Our finding thus points to two different avenues towards outperforming competitors through IT investment, extending the sole focus on competitive race under Red Queen competitive pressures. The payoff for underinvestment, however, relies on an effective management control mechanism. This is related to our third contribution. We examine concentrated ownership as a management control mechanism that can enhance the payoff of IT investment deviation. While the view of Red Queen competition theorizes that managers will rationally pursue a competitive edge by taking more competitive actions than their rivals, we argue and find evidence that, at least in the context of IT investment decisions, this is not always the case, which is where management control comes in. Our findings enrich theory-building for Red Queen competition by suggesting the joint impact of firm deviation from industry average and an effective management control mechanism.

## 2. Hypotheses

Our hypothesis development draws on the view of Red Queen competition in conjunction with institutional theory. They constitute a theoretical tension, as illustrated in Figure 1.

**Figure 1. Rationales Underlying Hypothesis Development**




***Effect of deviation on competitive advantage*****.** Red Queen competition theory considers a firm to be an adaptive learning system to search for competitive advantage. IT can improve a firm's capability to compete (e.g., Bharadwaj et al. 1999; Sambamurthy et al. 2003); for example, by embedding digital features in products and services (Agarwal and Tiwana 2015), enabling new business models (Rai and Tang 2014), or streamlining business processes (Bharadwaj et al. 2007; Rai et al. 2012). But leveraging IT will trigger competitors' responses and, as a result, "an entity…must evolve progressively faster just to keep up with its cohort of rivals" (Agarwal and Tiwana 2015: 473). If a firm wants to gain a competitive advantage, it must, according to this Red Queen logic, do more than its competitors. By our definition, overinvestment in IT allows the firm to leverage IT more than its competitors do. We thus expect overinvestment to lead to a competitive advantage (Figure 1, Panel A). Underinvestment, as the other form of deviation, may also confer competitive advantage. Saved resources can be used for such non-IT approaches to competitive advantage as marketing, research and development, and building up production capacity (Miller et al. 2012). Mithas et al. (2013) offer a hypothetical example: An airline, rather than trying to match its competitors' advanced flight-routing information systems, may instead focus on premium services such as larger leather seats and gourmet meals. To the extent that underinvestment in IT is a firm's rational attempt to reallocate resources to non-IT-based competitive approaches (Mithas et al. 2013), we expect an associated improvement in performance (Figure 1, Panel A).

It is worth noting that Red Queen theory assumes that the firm's managers are working rationally for the firm's interests (Barnett 2008: 4), but this is not always true (He et al. 2009; Hoskisson et al. 1999). In reality, different levels of IT investment could be the result of decisions made in a particular manager's self-interest, such as empire-building and shirking (Aggarwal and Samwick 2006; Li 2009). Empire-building here refers to a manager's intention to overconsume firm resources to make excessive IT investments; shirking refers to a manager's failure to make good IT investments because they require him or her to spend more effort acquiring relevant technical and managerial knowledge and overseeing more IT projects. Such self-interested decisions may do nothing to improve firm performance. Hence, whether firms can improve performance through IT investment deviation (Figure 1, Panel A) is an empirical question—and one well worth testing.

***Effect of deviation on legitimacy.*** Institutional theory contends that, when evaluating technologies with uncertain outcomes,[2] decision makers may follow others' choices to economize on search costs and to minimize the experimentation costs and risks incurred by first-movers (DiMaggio and Powell 1983). If industry peers converge to a certain amount of IT investment, stakeholders (including business partners and market investors) may take it for granted that the amount is legitimate. If a firm chooses that amount, its stakeholders consider its choice to be rational. A firm that differs significantly is subject to questions and actions challenging its legitimacy (DiMaggio and

[2] There is evidence that outcomes of IT investment are subject to high uncertainty (Dewan et al. 2007).

Powell 1983); following Hirsch and Andrews (1984), these questions and actions are called *legitimacy challenges*. In the context of IT investment, legitimacy challenges can influence firm performance in three ways.

First, legitimacy challenges can directly influence the operation of IT applications that span business boundaries. Partner support is instrumental in ensuring that cross-business IT applications operate effectively and improve firm performance (Yao and Zhu 2012). However, if business partners do not identify with a firm's choices, they may not want to commit to working with the firm on those IT applications (Teo et al. 2003). We expect this effect to be particularly salient nowadays, as IT applications increasingly transcend business boundaries (Tambe et al. 2012). Second, IT investment can enhance the digital features of a firm's product and service offerings (Agarwal and Tiwana 2015; Setia et al. 2013). Too many or too few digital features relative to competitors may entail legitimacy challenges. For instance, when pioneer firms in the media industry started to offer digital content over wide area networks, they faced legitimacy challenges because customers were unfamiliar with this new method of consumption and questioned its value (Jarvenpaa and Leidner 1998). Third, if market stakeholders (investors and business partners) do not comprehend a firm's IT investment decision, they may perceive it as a red flag signaling that the firm is being irrational. This may make the firm less attractive to investors, increase its costs of capital, and reduce its business opportunities and thus its growth opportunity (Miller et al. 2012).

The above discussion leads us to expect IT investment deviation to adversely influence firm performance. As a qualification to that expectation, the literature does note a "range of acceptability" (Reger and Huff 1993) within which firms can differ from an industry benchmark without losing legitimacy; it recognizes the reality that firms cannot be exactly alike. As illustrated in Panel B of Figure 1, firms can stay in that range without sacrificing performance. Those outside it, however, face challenges of illegitimacy, leading to reduced performance.

***Firm performance and IT investment deviation***. Combining the expected effects of IT investment deviation as shown in Panels A and B of Figure 1, we expect a nonlinear relationship between firm performance and over- or underinvestment, consistent with recommendations of Haans et al. (2016) in which we consider the benefits and costs of overinvestment (underinvestment). Firm performance is hypothesized to increase with overinvestment (that is, pursuing competitive advantage), but when investment moves out of the range of acceptability, legitimacy challenges set in and escalate rapidly, weakening its positive relationship with firm performance. We expect the same pattern for the relationship between underinvestment and firm performance. Our first hypothesis is therefore:

*H1a: There is a positive relationship between firm performance and overinvestment in IT, with the relationship attenuating at higher levels of overinvestment.*

*H1b: There is a positive relationship between firm performance and underinvestment in IT, with the relationship attenuating at higher levels of underinvestment.*

***Concentrated ownership.*** For two reasons, we expect concentrated ownership to play a moderating role in the relationships proposed in H1a and H1b. First, as discussed above, a counterargument to the hypothesized positive relationship between deviation and competitive advantage is managers' agency problems such as empire-building and shirking (Aggarwal and Samwick 2006). Concentrated ownership has long been viewed as an effective management control mechanism to mitigate agency problems (Shleifer and Vishny 1986), as owners with large shares of ownership have both the incentive and the power to monitor managers. For example, the literature documents cases in support of the high incentive and power of founding-family owners, who possess a large share and concentrated ownership, to closely monitor IT decision making. During an interview, a manager of a family-owned firm suggested the economic incentive for family owners to closely monitor IT money (Bruque and Moyano 2007: 246): "They know they're risking their own homes.… They're all going 100 per cent here because it's their money on the line in any decisions taken … you know it's your share, it's your firm.'' In another interview, family owners clearly stated the power they had when leading IT projects (Bruque and Moyano 2007).[3]

Second, concentrated owners, such as founding-family owners, generally have a long-term investment horizon (Zellweger et al. 2012). A sustained presence allows them to acquire more firm-specific knowledge (Ali et al. 2007; Beckman and Burton 2008), one reason being that they take part

[3] Bruque and Moyano (2007: 245) interviewed a general manager and owner of a family-owned firm, who said: "Well, the driving force for that, it's us really. We're three brothers, one is here, another's in production in charge of this area, and there's another person in the office, and then there's me, who is sort of above everybody. …my brother who's in production and me who perhaps really push for this thing and who ask for things, you know? The ones who are pushing for change."

in management or monitor the firm throughout its existence: "[Founding] families potentially provide superior oversight because their lengthy tenure permits them to move further along the firm's learning curve" (Anderson and Reeb 2003: 1305). To the extent that concentrated owners have gained firm-specific knowledge, they can steer an IT investment decision—be it for underinvestment[4] or overinvestment[5]—towards improving the firm's performance. Based on the above discussion, we expect a greater payoff for IT investment deviation for firms with concentrated ownership.

*H2a: Overinvestment in IT is associated with greater firm performance for firms with concentrated ownership.*

*H2b: Underinvestment in IT is associated with greater firm performance for firms with concentrated ownership.*

## 3. Method

### 3.1 Sample and Data

We use the Computer Intelligence (CI) database to develop our measure for IT investment. The CI database provides information about IT stock and has been widely used in research on IT investment and payoff (e.g., Dewan et al. 2007; Xue et al. 2012). In this study, we measure concentrated ownership with *founding-family ownership* ("*family ownership*" for short, following the literature). It is the most common type of concentrated ownership (Gomez-Mejia et al. 2010); globally, about one-third of public firms are controlled by their founding families (La Porta et al. 1999). Among S&P 500 firms, 19 percent have the founding family as the largest shareholder (Villalonga and Amit 2006). Prior studies identify the control effect of founding-family ownership (Anderson and Reeb 2003, 2004; Villalonga and Amit 2006; Wang 2006). Following the procedure used in Anderson

[4] An illustrative case is Jondim & Sons, a family firm that controlled 10 percent of the UK paint market. Firm-specific knowledge in its business led Jondim & Sons to curtail the company's IT investment when "the family members seriously contemplated the adoption of information technology" (Ogbonna and Harris 2005: 7). More specifically, in interviews with family owners and top management, one stated: "We are not a high-tech company; it is not something our industry values and I don't think we should try to pretend otherwise…. We are essentially a tradesman's centre and our main business is to satisfy the tradesman by giving him what he wants at a price he is prepared to pay. I don't think that paying for fancy gizmos and computer whizz-kids are part of the service package that they would be prepared to pay for" (Ogbonna and Harris 2005: 11-12).

[5] An illustrative case is the founder of the Mexican Information Group (Jarvenpaa and Leidner 1998). He has reformed the company's business models since its inception, thereby gaining a deep understanding of the firm's strengths and weaknesses and its opportunities and challenges. When Mexico's weak national infrastructure hindered rollout of the company's information products, he led the company to pioneer the development of private networks in Mexico, allowing the release of wide-area-network versions of its products. When he found that the company's business partners lacked technical skills, he re-allocated resources from technology innovation to customer service, providing nearly unlimited training to partners. As one executive remarked, "he is always there intellectually challenging how things could be improved" (Jarvenpaa and Leidner 1998: 354).

and Reeb (2003), we hand-collect information about the fraction of a firm's common stock owned by its founding family. Collecting such information is a lot of work, so we follow prior research (Anderson and Reeb 2003) in focusing on the S&P 500 firms. A detailed description of our method is provided in subsection 3.2.2 below. We retrieve firms' financial information from Compustat, corporate governance data from RiskMetrics, compensation data from ExecuComp, and stock return data from the Center for Research in Security Prices (CRSP).

After combining these data sources, our final sample consists of 1,603 firm-year observations from 2001 through 2006. Panel A of Table 1 shows the industry distribution. Sample firms are in a wide range of industries; manufacturing companies account for 54.1 percent. This is similar to the industry distribution documented in prior studies examining family ownership and firm performance (e.g., Anderson and Reeb 2003). Panel B of Table 1 reports summary statistics of IT investment made by our sample firms year by year; measurement is discussed in detail in subsection 3.2.2 below. Overall, we see that the mean IT investment remained stable during our sample period.[6]

**Table 1. Sample Characteristics**

Panel A: Industry Distribution

| Industry | # of observations | Percent |
|---|---|---|
| Agriculture, Mining and Construction (SIC 01-19) | 87 | 5.4% |
| Manufacturing (SIC 20-39) | 867 | 54.1% |
| Transportation, Communications and Utilities (SIC 40-49) | 172 | 10.7% |
| Wholesale and Retail (SIC 50-59) | 175 | 10.9% |
| Finance (SIC 60-69) | 131 | 8.2% |
| Services (SIC 70-89) | 141 | 8.8% |
| Others (SIC 91-99) | 30 | 1.9% |
| Total | 1,603 | 100.0% |

Panel B: IT Investment Scaled by Total Assets (%) by Year

| Year | # of obs. | Mean | Median | S.D. |
|---|---|---|---|---|
| 2001 | 251 | 0.33 | 0.20 | 0.38 |
| 2002 | 259 | 0.33 | 0.19 | 0.40 |
| 2003 | 275 | 0.30 | 0.17 | 0.37 |
| 2004 | 265 | 0.28 | 0.17 | 0.34 |
| 2005 | 268 | 0.32 | 0.20 | 0.34 |
| 2006 | 285 | 0.30 | 0.19 | 0.33 |

### 3.2 Variables

#### 3.2.1 Dependent Variable

[6] This is consistent with evidence in prior literature. For instance, the average IT spending of a sample of large global firms documented in Mithas et al. (2012) remained stable during 2001-2003, with a slight drop in 2003.

*Firm performance (Tobin's q).* The literature uses *Tobin's q* as the dependent variable to assess the economic impact of family ownership (Anderson and Reeb 2003) and IT payoff (Bharadwaj et al. 1999; Brynjolfsson et al. 2002; Xue et al. 2012). It is measured as firm value scaled by the book value of total assets, adjusted by industry (less industry average *Tobin's q*) so as to capture competitive advantage (Bebchuk et al. 2011; Villalonga and Amit 2006).

### 3.2.2 Independent Variables

*Firm IT investment deviation* (*Overinvestment*/*Underinvestment*). To define IT investment deviation, we first estimate IT capital investment. We follow Chwelos et al.'s (2010) procedure to estimate a firm's IT capital stock (*IT capital*). *IT capital* represents the market value of a firm's IT in five classes: personal computers, mainframes, minicomputers, networking equipment, and computer peripherals (Chwelos et al. 2010). The industry level of IT investment (*Industry IT*) is the average IT investment made by peers in the same SIC two-digit industry. Following Mithas et al. (2013), firm IT investment deviation is the difference between a firm's *IT capital* and *Industry IT*. In our empirical tests, we separate such deviation into (a) IT overinvestment (*Overinvestment*), which is the difference between *IT capital* and *Industry IT* if a firm's *IT capital* is greater than *Industry IT* and zero otherwise, and (b) IT underinvestment (*Underinvestment*), which is the difference between *Industry IT* and *IT capital* if *Industry IT* is greater than or equal to *IT Capital,* and zero otherwise. (Recall our definition of IT investment deviation given in the Introduction.)

*Founding-family ownership.* We use the percentage of common stock held by founding-family members to proxy for concentrated ownership. We use ExecuComp and RiskMetrics databases to identify key executives and directors for each firm-year, then read the proxy statement and corporate history (from the Hoover's and EDGAR databases and the firm's website) for each firm-year to identify the founder and his or her family members and determine whether any of them are key executives, directors, or block holders. If so, we collect information about their share ownership.

### 3.2.3 Control Variables

Since there are incentive effects on performance (Bergstresser and Philippon 2006), we include executives' equity holdings (*Executive holding*) and equity-based pay (*Equity pay* ) to control for managerial incentives to work for the firm's best interests and managers' freedom to pursue their own objectives without fear of reprisal, even though prior empirical studies have found the relationships of *Executive holding* and *Equity pay* with firm performance to be inconclusive (Denis and McConnell 2003). Since a firm's board may affect its strategies and performance (Dalton et al. 1998), we—like many others—use the proportion of outside directors (*Outside directors*) as a measure of board independence. Although outside directors can strengthen the monitoring system, their relationship with firm value is found to be inconclusive empirically (Dalton et al. 1998). R&D spending (*R&D*) generates intangible and long-term benefits (Bharadwaj et al. 1999); we measure it by dividing R&D expenses by annual sales. Prior studies report that there is a negative relationship between stock-return volatility and firm value and that larger and older firms have lower values of *Tobin's q* (Anderson and Reeb 2003). We therefore control for stock-return volatility (*Volatility*), firm size measured by the natural logarithm of the number of employees (*Employee*), market value (*Market value*), and the natural logarithm of firm age (*Age*). We also include the ratio of long-term debt to total assets (*Leverage)* to control for variations in capital structure, both because it may influence a firm's financial performance (Opler and Titman 1994) and because the use of debt is arguably a monitoring mechanism to mitigate the conflict between managers and owners (Jensen 1989). We also include industry and year dummies in the regression to control for industry and year fixed effects and a dummy variable indicating overinvestment rather than underinvestment to allow for different intercepts for over- and underinvesting firms.

Table 2 presents definitions of the variables. Table 3 shows descriptive statistics.

In Figure 2, we explore the data by examining the longitudinal trends of Tobin's q and overinvestment (Panel A) and underinvestment (Panel B). In Panel A, we select firms that overinvested in IT in each of our sample years and plot the average overinvestment and average Tobin's q of these firms. Similarly, in Panel B we select firms that underinvested in IT in each of our sample years and plot the average underinvestment and average Tobin's q of these firms. We can eyeball the associations of IT deviation with Tobin's q, suggesting that IT investment deviation creates value.

**Table 2. Definitions of Variables**

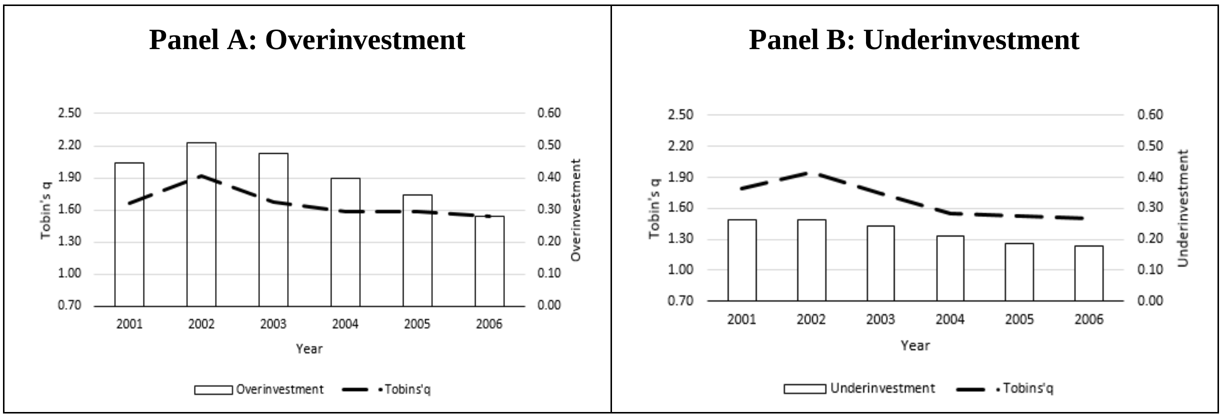
| Variable | Definition | Data source |
|---|---|---|
| *Tobin's q* | **Tobin's q**, measured as the market value of common stock plus the book value of preferred stock and long- and short-term debt, divided by the book value of total assets, adjusted for the industry average Tobin's q at the SIC two-digit level. | Compustat |
| *Overinvestment* | **IT overinvestment relative to industry peers**, measured as the difference between *IT capital* and *Industry IT* if a firm's *IT capital* is greater than the industry average IT investment and zero otherwise. *IT capital* is estimated using the hedonic-price method and taking into consideration personal computers, mainframes, minicomputers, networking equipment, and computer peripherals owned by a firm, divided by total assets (Chwelos et al. 2010). *Industry IT* is measured as the average of *IT capital* in the firm's SIC two-digit industry. | Computer Intelligence |
| *Underinvestment* | **IT underinvestment relative to industry peers,** measured as the difference between *Industry IT* and *IT capital* if a firm's *IT capital* is smaller than or equal to the industry average IT investment and zero otherwise. | Computer Intelligence |
| *Family ownership* | **Founding-family ownership**, measured as the percentage of common stock outstanding held by founding-family members. | ExecuComp, RiskMetrics |
| *Executive holding* | **Executive holding**, proxied by the equity holding of the chief executive officer. | ExecuComp |
| *Outside directors* | **Outside directors**, measured as the number of independent directors serving on the board divided by the size of the board. | RiskMetrics |
| *Equity pay* | **Executives' equity-based pay**, proxied by the chief executive officer's option pay plus other equity rewards, divided by his or her total compensation. | ExecuComp |
| *R&D* | **Research and development expenditure**, measured as annual research and development expenditure divided by annual sales. | Compustat |
| *Leverage* | **Financial leverage**, measured as long-term debt divided by total assets. | Compustat |
| *Volatility* | **Stock return volatility**, measured as the standard deviation of stock returns in the previous 60 months. | Center for Research in Security Prices |
| *Employee* | **Number of employees**, measured as the natural logarithm of the number of employees a firm has. | Compustat |
| *Market value* | **Firm size**, measured as the natural logarithm of a firm's equity market value. | Compustat |
| *Age* | **Firm age**, measured as the natural logarithm of a firm's age in years. | Compustat |

**Table 3. Descriptive Statistics**

| | Mean | S.D. | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* | *11* | *12* | *13* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *1. Tobin's q* | 0.03 | 0.99 | 1 | | | | | | | | | | | | |
| *2. Overinvestment* | 0.10 | 0.30 | -0.04 | 1 | | | | | | | | | | | |
| *3. Underinvestment* | 0.10 | 0.22 | 0.05 | **-0.15** | 1 | | | | | | | | | | |
| *4. Family ownership* | 2.97 | 8.27 | 0.05 | **-0.06** | **0.10** | 1 | | | | | | | | | |
| *5. Executive holding* | 0.84 | 2.82 | **0.08** | -0.03 | **0.12** | **0.37** | 1 | | | | | | | | |
| *6. Outside directors* | 72.50 | 15.06 | **-0.1** | 0.03 | **-0.07** | **-0.29** | **-0.22** | 1 | | | | | | | |
| *7. Equity pay* | 0.52 | 0.27 | **0.06** | -0.03 | **0.06** | **-0.08** | **-0.13** | **0.05** | 1 | | | | | | |
| *8. R&D* | 0.04 | 0.07 | **0.11** | -0.02 | **0.18** | -0.03 | -0.04 | 0.04 | **0.22** | 1 | | | | | |
| *9. Leverage* | 0.19 | 0.13 | **-0.19** | -0.03 | **-0.17** | -0.03 | **-0.13** | **0.08** | **-0.13** | -0.27 | 1 | | | | |
| *10. Volatility* | 0.11 | 0.04 | **-0.09** | 0.03 | **0.25** | 0.03 | 0.05 | **-0.10** | **0.14** | **0.45** | **-0.12** | 1 | | | |
| *11. Employee* | 3.07 | 1.23 | **-0.13** | 0.00 | 0.02 | 0.00 | **-0.11** | **0.12** | **0.07** | **-0.19** | 0.03 | **-0.22** | 1 | | |
| *12. Market value* | 9.29 | 1.12 | **0.28** | **-0.19** | **0.12** | -0.02 | -0.01 | **0.07** | **0.15** | **0.12** | **-0.21** | **-0.26** | **0.54** | 1 | |
| *13. Age* | 3.44 | 0.60 | **-0.12** | 0.01 | **-0.14** | **-0.08** | **-0.10** | **0.22** | **-0.14** | **-0.19** | **0.25** | **-0.44** | **0.30** | **0.15** | 1 |

*Note.* Correlation figures are boldfaced if significant at the 5% level. See Table 2 for definitions of variables. *Overinvestment* and *Underinvestment* are multiplied by 100 for illustrative purposes.

**Figure 2. Tobin’s q and IT Investment Deviation over Time**




*Note.* In the figure above, in order to remove the variance in Tobin’s q caused by the control variables discussed in section 3.2.3, we run a regression of Tobin’s q on these control variables and use the regression residual (plus sample average Tobin’s q for illustrative purpose).

## 4. Empirical Results

### 4.1 Empirical Models

Our empirical models have the following features:

***Curvilinear relationship***. Because we expect a curvilinear relationship between firm performance and IT investment deviation (H1a/b), we include square terms of overinvestment and underinvestment. To test the moderating role of concentrated ownership (H2a/b), we multiply the IT investment deviation variables (overinvestment and underinvestment and their square terms) by concentrated ownership as proxied by family ownership.

***Garen approach***. We start with OLS regression and then address the possible endogeneity of IT investment. Prior research (Mitra 2005) shows that a focal firm increases its investment if it has greater growth options and simultaneously more free cash flows, after controlling for industry average IT investment (which is exogenous to the focal firm’s investment decisions). We use Garen’s (1984) two-stage approach to model the possible endogeneity. In the first stage, we define a continuous variable, *DEV*, which is the difference between a firm’s *IT capital* and the *Industry IT*, and explain *DEV* based on Mitra’s (2005) model. We choose Mitra (2005) as our base model because it allows us to derive a model for explaining *DEV* and because its parsimony is appropriate to the Garen approach (Semadeni et al. 2014). In the second stage, we calculate $\hat{\mu}$, which is the difference between the actual *DEV* and the predicted *DEV* from the first-stage regression. The Garen approach also includes the interaction term $DEV \times \hat{\mu}$ to account for unobserved heterogeneity over the range of the continuous selection variable (*DEV*, in our case). We report the details of the Garen approach and the first-stage regression results in Appendix B in the online supplement.

***Partial adjustment model.*** A partial adjustment model can help address the dynamics of IT investment (Mithas et al. 2013). Specifically, it uses the Mitra model to determine the "expected" IT deviation and then incorporates the process by which a firm may gradually adjust its IT investment from an initial deviation toward the expected level of deviation. Furthermore, following prior studies (e.g., Kobelsky et al. 2008), we extend the partial adjustment model by including uncertainty, profitability, leverage, and related diversification as additional explanatory variables for IT investment. Having more explanatory variables helps control for more observable factors but also reduces the sample size. We must take this tradeoff into account because our regressions include fixed effects, so the degree of freedom is an empirical issue to consider. With this concern, we present the empirical results of all three models.

**4.2 Results of Hypothesis Testing**

Table 4 shows the results of OLS regression in Column (1) and the second-stage regressions of the Garen approach in Columns (2) through (4). The first stage of the Garen approach uses Mitra's model in Column (2), the partial adjustment model in Column (3), and the extended partial adjustment model, as discussed in section 4.1 above, in Column (4).

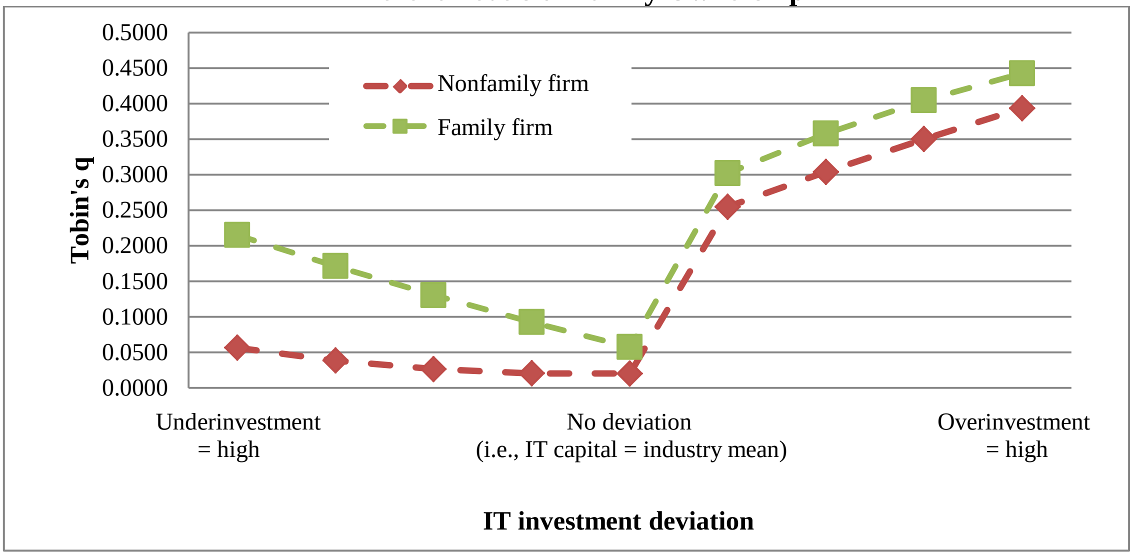
Columns (1) through (4) consistently show that the relationship between *Overinvestment* and *Tobin's q* is significant and positive. The coefficient on *Overinvestment*$^2$ is significant and negative in all four columns. These results, indicating a curvilinear relationship between *Tobin's q* and overinvestment, support H1a that the performance implication of overinvestment attenuates at higher levels of overinvestment. Table 4 shows that the coefficients on *Underinvestment* and *Underinvestment*$^2$ are not significant in Columns (1)-(4). Thus, we find no support for H1b. A possible explanation is that underinvestment may be attributable to managers' shirking rather than to their efforts to differentiate from competitors. Another possible explanation is that, while underinvesting in IT saves resources, whether those resources are then used to gain competitive advantage through some non-IT approach would depend on the effectiveness of management control systems such as concentrated ownership.

The coefficient on *Overinvestment×Family ownership* is positive in Columns (1)-(4) and is marginally significant in Columns (1) and (2), where t-stat equals 1.71 and 1.78, respectively. The coefficient on *Overinvestment*$^2$×*Family ownership* is negative and significant in Columns (1) and (2) but becomes insignificant in Columns (3)-(4). A negative coefficient on *Overinvestment*$^2$×*Family ownership* differs from our *ex ante* expectation that concentrated ownership is an effective management control mechanism. This unexpected result may be attributed to an idea found in the literature on the cost side of concentrated ownership: "entrenched" control associated with concentrated ownership (e.g., Bebchuk and Cohen 2005; Bebchuk et al. 2000). That is, owners with concentrated ownership may expropriate minority shareholders by making investments in their own interests. Morck et al. (1988) document an inverse-U-shaped relationship between managerial equity ownership and firm value and argue that owners with a large share of ownership become entrenched and pursue their own benefits at the expense of other investors; for example, through tunneling by means of merger-and-acquisition ventures that do not increase firm value. The possible expropriation associated with concentrated ownership may offset its constructive role as a management control mechanism. Overall, we do not see clear evidence of the moderating role of family ownership for overinvestment (H2a); family ownership moderates the impact of underinvestment, as the coefficient on *Underinvestment×Family ownership* is positive and significant (supporting H2b).

To illustrate the results, we draw an interactive diagram in Figure 3 using regression results in Column (1), showing how the association between *Tobin's q* and IT investment deviation (*Overinvestment*/*Underinvestment*) differs across levels of concentrated ownership (*Family ownership*). For illustrative purposes, we show two levels of *Family ownership*: (a) *Family ownership* equal to zero, indicating nonfamily firms, and (b) the sample mean level of *Family ownership*, representing average family firms. Figure 3 shows that the curve of firm performance (*Tobin's q*) and IT investment deviation (*Overinvestment*/*Underinvestment*) for family firms (that is, mean *Family ownership*) is above the curve for nonfamily firms. The difference between the two curves appears to be particularly salient on the underinvestment side. From Figure 3 and the results in Table 4, we thus find strong evidence supporting the moderating role of family ownership for the payoff to underinvestment.

Regarding control variables, the positive coefficient on *Dummy indicating overinvestment* suggests that, everything else being equal, overinvestment in IT is associated with higher firm performance than underinvestment is. The positive coefficient on *Family ownership* suggests that family firms outperform nonfamily firms in general, consistent with prior research (Anderson and Reeb 2003). Several variables related to management control (*Executive holding*, *Outside directors*, and *Equity pay*) turn out to be insignificant, which is not surprising given the mixed findings in prior literature (Dalton et al. 1998; Denis and McConnell 2003). The coefficient on *R&D* is insignificant, largely consistent with results reported by Bharadwaj et al. (1999) and Chari et al. (2008). Other control variables (*Leverage*, *Volatility*, *Employee*, *Market value*, and *Age*) have significant coefficients with the same signs as found in prior research relating these variables to *Tobin's q* (e.g., Anderson and Reeb 2003; Bharadwaj et al. 1999).

**Figure 3. Iteractive Diagram of Tobin's q and IT Investment Deviation across Firms with Different Levels of Family Ownership**




*Note.* "High" underinvestment/overinvestment represents deviation from the industry mean by one standard deviation of *IT capital*. "Nonfamily firms" are those whose *Family ownership* is zero. "Family firms" are those whose *Family ownership* is the sample average value.

**Table 4. Results of Hypothesis Testing**

| | Dependent variable = *Tobin's q* | | | |
|---|---|---|---|---|
| | (1) OLS | (2) Garen method + Mitra model | (3) Garen method + partial adjustment model | (4) Garen method + extended partial adjustment model |
| Deviation on the overinvestment side | | | | |
| *Overinvestment* | 68.31** | 73.75** | 73.08** | 83.05** |
| | (3.78) | (3.82) | (4.02) | (3.82) |
| *Overinvestment*$^2$ | -4,367.81** | -4,302.60* | -4,418.06* | -5,248.71* |
| | (-2.99) | (-2.30) | (-2.19) | (-2.13) |
| *Overinvestment* × *Family ownership* | 5.06 | 5.29 | 3.68 | 3.21 |
| | (1.71) | (1.78) | (1.49) | (1.29) |
| *Overinvestment*$^2$ × *Family ownership* | -991.59* | -958.36* | -714.09 | -661.41 |
| | (-2.23) | (-2.15) | (-1.51) | (-1.48) |
| Deviation on the underinvestment side | | | | |
| *Underinvestment* | 33.80 | 30.67 | 37.78 | 31.51 |
| | (1.16) | (1.05) | (1.32) | (1.07) |
| *Underinvestment*$^2$ | 1,383.68 | 451.83 | 5,291.29 | 3,871.25 |
| | (0.21) | (0.07) | (0.66) | (0.47) |
| *Underinvestment* × *Family ownership* | 12.37** | 13.30** | 7.88** | 7.98** |
| | (3.03) | (3.27) | (2.60) | (2.63) |
| *Underinvestment*$^2$ × *Family ownership* | -524.21 | -495.79 | -764.78 | -773.91 |
| | (-1.16) | (-1.09) | (-1.39) | (-1.40) |
| Controls | | | | |
| *Dummy indicating overinvestment* | 0.18** | 0.20** | 0.17* | 0.16* |
| | (2.70) | (2.84) | (2.36) | (2.20) |
| *Family ownership* | 0.01* | 0.01* | 0.01 | 0.01 |
| | (2.21) | (2.30) | (1.79) | (1.75) |
| *Executive holding* | -0.01 | -0.01 | -0.01 | -0.01 |
| | (-1.32) | (-1.42) | (-0.82) | (-0.92) |
| *Outside directors* | 0.00 | 0.00 | -0.00 | -0.00 |
| | (0.07) | (0.02) | (-0.26) | (-0.40) |
| *Equity pay* | -0.05 | -0.06 | -0.05 | -0.03 |
| | (-0.71) | (-0.82) | (-0.63) | (-0.45) |
| *R&D* | -0.48 | -0.45 | -0.61 | -0.60 |
| | (-0.67) | (-0.63) | (-0.86) | (-0.84) |
| *Leverage* | -0.66* | -0.68* | -0.72* | -0.85** |
| | (-2.20) | (-2.31) | (-2.35) | (-2.83) |
| *Volatility* | -3.24** | -3.23** | -2.92** | -3.13** |
| | (-3.42) | (-3.47) | (-3.17) | (-3.42) |
| *Employee* | -0.53** | -0.54** | -0.52** | -0.51** |
| | (-10.83) | (-10.80) | (-10.83) | (-10.76) |
| *Market value* | 0.65** | 0.65** | 0.61** | 0.60** |
| | (13.44) | (13.30) | (12.97) | (12.79) |
| *Age* | -0.26** | -0.25** | -0.21** | -0.20** |
| | (-3.67) | (-3.59) | (-3.00) | (-2.86) |
| Industry and year effects | Included | Included | Included | Included |
| *DEV* × $\hat{u}$ | | 448.18 | 1,775.40 | 2,390.16 |
| | | (0.20) | (0.90) | (1.13) |
| $\hat{u}$ | | -23.32* | -18.43 | -26.12 |
| | | (-2.54) | (-1.97) | (-1.95) |
| N | 1,603 | 1,602 | 1,314 | 1,270 |
| $R^2$ | 0.531 | 0.534 | 0.539 | 0.535 |

*Note.* We cluster standard errors by firm and use heteroscedasticity-consistent estimation. ** and * denote significance at the 1% and 5% levels, respectively; t-stats are in parentheses. *DEV* and $\hat{\mu}$ are defined in the description of the first-stage model in Appendix B. See Table 2 for definitions of variables.

### 4.3 Alternative Model Specifications

We tested alternative model specifications, including (a) fixed effects models, (b) controlling for the lagged dependent variable, and (c) using a different set of control variables, all of which give consistent results. Statistical details are presented in Appendix C.

It is worth noting that by including firm fixed effects, we can rule out unobserved firm-level confounding factors. The results show that the interaction of family ownership and overinvestment becomes insignificant. This may be attributed to the fact that family ownership changes slowly; the correlation of current and lagged family ownership is as high as 0.93. Therefore, including firm fixed effects may "wash out" the role of family ownership. In other words, given the stability of family ownership over time, the results reported in Table 4 basically identify cross-sectional variation regarding the impact of family ownership. Other than this, the results are similar to those reported in Table 4 regarding the association between firm performance and over- or underinvestment in IT. In line with prior research examining firm performance and family ownership (e.g., Anderson and Reeb 2003; Bennedsen et al. 2007; Villalonga and Amit 2006), we report regressions controlling for industry and year fixed effects—but not firm fixed effects—as the main results.

## 5. Discussion

### 5.1 Summary of Results, Contributions, and Implications for Research

We have hypothesized and tested how firm deviation from industry average in making IT investment decisions is related to firm performance (H1a/b) and how concentrated ownership moderates that relationship (H2a/b) and we have demonstrated the robustness of our empirical results by using multiple models. We summarize the results of hypothesis testing and our contributions to research in Table 5.

**Table 5. Summary of Results and Contributions**

| Hypothesis | Result | Contribution |
|---|---|---|
| H1a/b: There is a positive relationship between firm performance and overinvestment/underinvestment in IT, with the relationship attenuating at higher levels of overinvestment/underinvestment. | Supports H1a, in that a firm's Tobin's q is positively related to overinvestment in IT, with the relationship attenuating at higher levels of overinvestment. | Explicitly builds on the view of Red Queen competition to analyze payoff to IT investment decisions, answering the recent call for such research to enrich our understanding of information systems development and economic impacts. |
| H2a/b: Overinvestment/ underinvestment in IT is associated with greater firm performance for firms with concentrated ownership. | Supports H2b, in that family ownership positively moderates the performance impact of underinvestment. | Adds to research on Red Queen competition by suggesting that better firm performance can be derived not only through overinvestment, but also through underinvestment, with the performance impact conditional on family ownership.<br>Introduces concentrated firm ownership as a moderating variable that enhances the payoff for IT investment decisions. |

Our findings have important takeaways for future research. First, they demonstrate the usefulness of the view of Red Queen competition for analyzing the economic impacts of information systems development—including IT investment decisions—answering the recent call for such research by Agarwal and Tiwana (2015). Our work also joins the recent strand of research that introduces the theoretical lens of deviation (from industry peers) to the literature on IT investment (Mithas et al. 2013). We extend this strand by (a) theorizing a tension, based on Red Queen theory and institutional theory, which suggests a curvilinear relationship between deviation and firm performance and (b) providing new evidence for the performance implications of deviation. Our approach differs from the method commonly used in the voluminous literature on IT investment and payoff that relates firm performance to IT investment per se rather than to deviation. We find that deviation does have performance implications (Figure 3), a finding which we hope will encourage more researchers to examine IT investment decisions and payoff through the Red Queen competition perspective. Firms make various decisions related to IT investment, such as outsourcing (Mithas et al. 2013), co-developing with business partners (Rai et al. 2012), and embedding software features in product and service offerings (Agarwal and Tiwana 2015). The continual appearance of new technologies and applications—such as cloud architecture, the Internet of things (IoT), and technologies to enhance IT security—requires firms to keep making new investment decisions. Using a lens of Red Queen competition to examine these decisions can be a promising avenue for future research.

Second, an important implication of our study for research built on Red Queen competition is that either overinvestment *or* underinvestment may improve firm performance. According to the original Red Queen competition logic, firms need to make more and more investment to keep up with industry peers. Our results show that, in the domain of IT investment, investing less may also bring the opportunity to improve firm performance, possibly by saving resources for non-IT approaches to gaining a competitive edge (Mithas et al. 2013). Whether that opportunity is taken is subject to effective management control systems, as illustrated in Figure 3. Although we obtain this finding in the specific domain of IT investment and payoff, we believe that future research on Red Queen competition can examine the impact of deviation—that is, either overinvestment or underinvestment, rather than the sole logic of running in a competitive race—in other domains. This could have widespread implications, given that the view of Red Queen competition can be applied to various types of competitive action (Derfus et al. 2008).

Third, our study shows that concentrated ownership plays a moderating role that enhances the payoff on IT investment deviation. The economics and management literatures have long studied the economic impacts of concentrated corporate ownership; our work extends that line of inquiry to IT investment decisions and payoff. We provide evidence that concentrated ownership, such as founding-family ownership, is an effective ownership structure that leads firm deviation in IT investment toward increasing firm value. Given that ownership structure is a fundamental organizational feature, future research could examine other ownership structures to enhance our understanding of IT investment and payoff. An even broader implication is that future research on the problem of managers' self-interested activities in IT management—for example, earnings management by manipulating IT investment amounts (Xue et al. 2014)—can consider concentrated ownership as a solution.

**5.2 Implications for Practice**

Our work has important messages for practitioners, too. First, consistent with the Red Queen logic, our results show that in making IT investment decisions, simply following industry norms may not improve performance. Furthermore, we find that overinvestment in IT yields on average higher return than underinvestment (see Figure 3), suggesting that managers need to jointly evaluate both IT-enabled and non-IT-enabled competitive moves. Second, although deviation from the industry's average IT investment is a potential approach to value creation, it is more likely to work when there is a strong monitoring mechanism and with overseers who have business-specific knowledge. In particular, underinvestment may not pay off if a firm lacks such control (see Figure 3). Although we focused on family ownership concentration, there may well be other effective management control mechanisms, such as establishing dedicated committees and/or task forces. Third, the curvilinear relationship between overinvestment and firm performance implies that firms at high levels of overinvestment may face challenges which, looking through an institutional lens, are due to lost legitimacy. One solution is better communication with stakeholders regarding the details of IT investment, which may mitigate concerns that the firm is running unnecessary risks by experimenting with technologies.

**5.3 Limitations and Future Research**

This study has the following limitations. First, our analysis examines only the total capital invested in IT. Future research could investigate investment decisions for specific applications, such as computer systems used in specific business processes. Second, our analysis (the regressions reported in Table 4) shows cross-sectional relationships among IT deviation, family ownership, and firm performance. To tell a story of Red Queen competition, it would be desirable to better research the "causal" impact of deviation and family ownership on firm performance. Given that family ownership typically remains quite stable, we need a long series of longitudinal data that document changes in family ownership. Another research design that can be considered for future research is to collect firm announcements of major IT projects, identify the associated change in firm deviation (for example, from underinvestment to overinvestment), and then quantify stock market reaction to the change. This kind of event study produces a market-based estimate of the impact of deviation. In addition, researchers can try to identify exogenous shocks to corporate ownership and leverage such shocks to better tease out the “causal” impact of ownership (e.g., Chen et al. 2016; Crane and Koch 2014). Third, we operationalize ownership concentration by using founding-family ownership as a proxy, but future research could take advantage of other ways to measure it. Fourth, our sample is limited to S&P 500 firms; whether our results can be generalized to smaller firms deserves further research.

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