Process Institutionalization Crowds Out Innovativeness? An Empirical Analysis on the Relationships Between ISO 9000 Adoption and R&D Expenditure

L. M. Daphne Yiu

School of Business, Macau University of Science and Technology, Taipa, Macau, China

Email address: lmyiu@must.edu.mo

Hugo K. S. Lam

Management School, University of Liverpool, Liverpool, United Kingdom

Email address: hugolam@liverpool.ac.uk

Andy C. L. Yeung (corresponding author)

Faculty of Business, The Hong Kong Polytechnic University, Kowloon, Hong Kong, China

Email address: andy.yeung@polyu.edu.hk

Biographical notes: L. M. Daphne Yiu is Assistant Professor in School of Business, Macau University of Science and Technology; Hugo K. S. Lam is Senior Lecturer in Management School, University of Liverpool; and Andy C. L. Yeung is Chair Professor in Faculty of Business, The Hong Kong Polytechnic University.

Process Institutionalization Crowds Out Innovativeness? An Empirical Analysis on the Relationships Between ISO 9000 Adoption and R&D Expenditure

Abstract

Much research from an organizational perspective suggests that process certifications such as ISO 9000 constrain firms' explorative capability, crowding out Research and Development (R&D) activities. Yet, from an operations management (OM) perspective, process certifications like ISO 9000 should provide a well-established system, strengthening firms' capabilities for both exploration and exploitation. In this research, we examine the impact of ISO 9000 certifications on R&D expenditure of firms and investigate how such an impact is moderated by different operating environments. We find that firms actually increase their R&D expenditure after ISO 9000 certifications. Our results further indicate that ISO 9000-certified firms are more responsive to the changing operating environments for their R&D investments. ISO 9000 certifications reduce R&D expenses more swiftly under turbulence but expand more significantly with operational slack. Our research indicates that ISO 9000-certified firms seem to be more responsive to external environments in controlling their R&D expenditure.

Keywords: ISO 9000; R&D expenditure; recession; market fluctuation; operational slack

1. Introduction

The ISO 9000 quality management standards require firms to develop a persistent effort to improve the quality of goods, services and processes (Ataseven et al., 2013; Singh et al., 2011). Proponents of ISO 9000 certification (e.g., Corbett et al., 2005; Terziovski and Guerrero, 2014) believe that the standards enable firms to develop and implement formalized procedures for reducing variation and waste. Singh et al. (2011) highlighted that ISO 9000 practices focus on internal as well as external processes through coordination with suppliers and customers. ISO 9000 certification is focused on leadership, staff members' participation and process improvement. Process documentation and systems audits are carried out to ensure that organizational routines are systematically developed and reliably executed (Naveh and Erez, 2004; Singh et al., 2011). In addition, ISO 9000-certified firms codify knowledge and update their procedure manuals for their staff members. Regular process reviews are required to identify what should be kept or eliminated in the current routines. Modifying routines enables firms to be more compatible with their exploitation of existing expertise and exploration of new opportunities (Feldman et al., 2019; Pentland and Feldman, 2008). In fact, many researchers consider ISO 9000 adoption as a process of organizational learning (Gray et al., 2015), enhancing the exploration capability of firms (Shi et al., 2019). Through ISO 9000 implementation, firms enhance their process management, routines and information flows to be more flexible and adaptable.

However, some authors (e.g., Benner, 2009; Ratnasingam et al., 2013; Wei, 2010) suggest that ISO 9000 has a negative impact on innovation. In their view, ISO 9000 implementation increases bureaucracy and reduces the flexibility and innovation of firms (Gotzamani and Tsiotras, 2002). The requirements and procedures of ISO 9000 are often highly stringent and inflexible, hindering organizational creativity (Benner and Tushman, 2002; Collis, 1996). More specifically, organizational routines required by ISO 9000 lead to inertia and

rigidity, impeding organizational innovativeness (Benner and Tushman, 2002, 2003; Kuo et al., 2009). Although institutionalized process systems enable firms to develop standardized and documented routines that stabilize organizational activities and reduce variation and uncertainty, the continuous improvement mechanism of ISO 9000 also causes firms to narrowly focus on existing processes for immediate performance benefits, thus losing sight of future technology development opportunities. As a result, institutionalized organizational routines developed through ISO 9000 favor exploitation at the expense of exploration (Adler et al., 2009).

We focus on ISO 9000 because it is an internationally recognized standard for the promotion of good quality management practices (Shafiq et al., 2014). Unlike Total Quality Management (TQM) and Six Sigma practices, ISO 9000 stipulates specific guidelines and documentary requirements for certification. By being certified for ISO 9000, firms not only need to fulfill the general system requirements to run business, but also have to take periodically review on the system's effectiveness. Furthermore, ISO 9000 standards require the documentation of the operational routines for performance improvement (Singh et al., 2011). Among available process improvement techniques such as TQM and Six Sigma, ISO 9000 provides the most systematic and specific requirements to integrate quality management practices into processes, exploiting the current systems for operational and organizational improvements. Paradoxically, ISO 9000 standards require rigid and formalized operational practices in their actual implementation (Terziovski and Guerrero, 2014), which could potentially be in conflict with innovation requirements, making the research on the relation between ISO 9000 and R&D expenditures more interesting. Overall, considering the specific requirements of ISO 9000 certifications on organizational-wide exploitative activities, this study examines the impact of ISO 9000 certifications on firms' innovation activities.

We examine the impact of ISO 9000 certifications on the R&D expenditure of firms

and investigate how such an impact is moderated by different operating environments. Our results show that firms actually increase their R&D expenditure after ISO 9000 certifications. Our analyses further indicate that ISO 9000-certified firms are more responsive to the changing operating environments for their R&D investments. Specifically, ISO 9000-certified firms reduce R&D expenditure more significantly during recession and under high market uncertainty (as approximated by sales fluctuations) but increase R&D expenditure more significantly under high operational slack. Overall, ISO 9000-certified firms reduce R&D expenses more swiftly during turbulence but make better use of buffering resources. Our research indicates that the certified firms appear to be more responsive to external environments in controlling their R&D expenditure. Our results support an operations management (OM) perspective, showing that R&D activities are likely to be underpinned by stable and formalized organizational routines such as those required by ISO 9000. In contrast to an organizational behavior perspective which suggests that process management crowds out explorative capability, we argue that process institutionalizations may serve as high-level premises that constitute enabling organizational structures, supporting R&D investments and new product developments (Farjoun, 2010; Swift, 2016).

The paper is organized as follows. Section 2 provides the research background and discusses the research gap between ISO 9000 certification and R&D, followed by the development of research hypotheses. Section 3 describes the research methods, including a description of the data and fixed-effect regression analysis. Section 4 presents the test results. Section 5 discusses the theoretical and managerial implications. Section 6 concludes our study and discusses its limitations and issues for future research.

2. Research Background and Hypotheses Development

2.1 Exploration and Exploitation

According to March's (1991) exploration and exploitation framework, exploration implies an organizational activity that involves search, discovery, innovation, experimentation, variation and risk-taking, while exploitation implies an activity that is related to refinement, control, production, standardization and efficiency improvement. Exploration leads to uncertain outcomes but with the potential to benefit a firm in the long run, while exploitation provides predictable results that benefit the firm immediately.

In this study, a firm's expenditure in R&D is viewed as an organizational investment in exploratory activity. R&D projects involve a significant amount of resources and capital to develop novel technologies, carry out experiments and search for new product opportunities. However, the outcome is often difficult to control and highly uncertain (Stockstrom and Herstatt, 2008). On the other hand, ISO 9000 implementation is considered as an exploitative practice in operational and efficiency enhancements (Sfreddo et al., 2019). The ISO 9000 quality management standards focus on refinements of organizational systems through a recurring process, reducing variations and leading to a reliable organizational routine.

2.2 ISO 9000, Operational Routines and Organizational Learning

An organizational routine is a repetitive pattern of interdependent organizational actions that use a bundle of resources to accomplish a task (e.g., Dosi et al., 2001; Parmigiani and Howard-Grenville, 2011; Teece, 2007; Zollo and Winter, 2002). Firms are likely to enhance their operational capabilities through ISO 9000 adoption. The ISO 9000 quality management standards emphasize structured processes and standardized procedures. The standards require top management leadership and employee engagement for continuous improvement. ISO 9000 provides well-established routines whereby employees follow systematic procedures for interactions and complete their tasks through predefined mechanisms (Naveh and Erez, 2004). By documenting and auditing routines, procedures and guidelines are created to ensure that

quality objectives are met (Singh et al., 2011). Through ISO 9000 systems, firms accumulate experience and develop knowledge, further enhancing organizational routines, reducing mistakes and improving efficiency. As firms accumulate knowledge and improve organizational routines, operational systems become more reliable, stable and predictable (Adler et al., 2009).

Firms are likely to enhance their organizational learning capability through ISO 9000 adoption. Zollo and Winter (2002) emphasized the importance of firms' learning mechanisms through accumulation and articulation of tacit knowledge and codification of repetitive tasks. Through a deliberate learning process, firms articulate and convert tacit knowledge from organizational members into explicit skill sets embedded in the organization, creating shared values and common understanding. In addition, stable organizational routines, standardized procedures, and accumulated knowledge and resources provide an environment for research and experiments, enhancing firms' explorative capability and leading to a more conducive environment for R&D (Ataseven et al., 2013; Benner and Tushman, 2003; Zollo and Winter, 2002). Overall, ISO 9000-certified firms are likely to have a higher learning orientation, which is compatible with the strong absorptive capability required in high-tech companies, facilitating their organizational exploration and enhancing their innovative activities (Anand et al., 2009; Aoki and Wilhelm, 2017; Wangwacharakul et al., 2020).

2.3 Research Gap between ISO 9000 Certification and R&D Expenditure

There is much controversy about the impact of ISO 9000 on innovation initiatives of firms. ISO 9000 focuses on continuous improvement in operational processes and reduction of the associated operational risks (Terziovski and Guerrero, 2014). ISO 9000 aims to coordinate and streamline organizational activities continuously, enhancing operational consistency and reducing process variations. On the other hand, R&D activities require major modifications or

disruptive changes of existing process routines, entailing flexible procedures and process variations. Accordingly, the adoption of ISO 9000 could lead to organizational rigidity and inertia, impeding innovative activities (Benner and Tushman, 2002). Also, process standardization is carried out under the compliance culture of ISO 9000, limiting the creativity of employees (Manders et al., 2016; Santos-Vijande and Alvarez-Gonzales, 2007). Firms adhering to rigid operational routines may find it difficult to carry out organizational explorations such as R&D (Santos-Vijande and Alvarez-Gonzales, 2007). On one hand, ISO 9000 adoption may enhance firms' quality management capability, enhancing firms' efficiency (Li et al., 2010; Tan et al., 2004). On the other hand, the development of new products through innovation and R&D is also important for long-term development of firms (Calantone et al., 2010). Thus, it is necessary to understand the relationship between ISO 9000 certification and R&D expenditure, and further look into the circumstances in which ISO 9000 certification is supportive to R&D activities.

2.4 Research Hypotheses

2.4.1 ISO 9000 certification and R&D expenditure

ISO 9000 practices involve a continuous plan-do-check-act cycle that entails developing an ongoing process to streamline organizational activities. ISO 9000 quality standards enforce a persistent and repetitive approach to strengthen organizational processes, leading to continuous improvement of operational systems. Through ISO 9000 adoption, a set of policies and procedures is established and regularly enhanced. In addition, firms conduct internal and external audits to ensure the policies and procedures are comply with ISO 9000 principles, enabling firms to continuously review and improve the existing operational practices (Ataseven et al., 2013; Singh et al., 2011). A routine-based learning process through ISO 9000 enhances organizational adaptation, creating an environment compatible with

organizational exploration (Benner and Tushman, 2003; Zollo and Winter, 2002).

Recent research (e.g., Farjoun, 2010; Koryak et al., 2018; Zimmermann et al., 2015) suggests that exploratory activities and exploitative routines are not mutually exclusive but supportive of each other as two crucial organizational functions, particularly for effective new product developments. Technological advancements and R&D activities require well-established organizational routines, disciplined rules and highly reliable operations such as those advocated by ISO 9000 principles. Organizational innovations and novel product developments require strong operational capability and well-developed quality management systems as their base. Accordingly, R&D investments and ISO 9000 are likely to reinforce each other in an organization (Smith et al., 2017). In fact, research in OM points to both quality management and organizational innovation as a set of highly related organizational routines and capabilities that support each other. To facilitate R&D activities, firms require well-established organizational routines and well-defined operational systems (Aoki and Wilhelm, 2017). From this perspective, we develop our first hypothesis:

H1*: The R&D expenditure of firms is enhanced after ISO 9000 certification.*

2.4.2 Impact of ISO 9000 during recession periods

Recession increases environmental complexity (Lome et al., 2016) and significantly intensifies the risks of R&D investments. During a recession, market opportunities of firms are limited, incomes are reduced and firms are thus under pressure to manage liquidity and control costs (Henry, 2013). As such, firms need to significantly control their budgets for R&D activities (Hud and Hussinger, 2015; Srinivasan and Lilien, 2009; Yunlu and Murphy, 2012). Prior studies (e.g., Gretz and Highfill, 2010; Raghavendra et al., 2012) have shown that market uncertainty in a recession period significantly amplifies the risk of R&D projects, undermining the chance of their success in new product launches. Overall, recession periods create an

unfavorable environment for R&D and new product development, and firms need to carefully control their R&D expenditure to regulate their risk exposure (Barlevy, 2007).

Although ISO 9000 adoption provides a more favorable environment for R&D investments as a whole, ISO 9000-certified firms may also be more conservative during the recession period. ISO 9000 standards are developed based on the principle of "systems approach to management", which emphasizes that quality management systems are part of the organization-wide management systems. This suggests that ISO 9000 systems need to be integrated into internal organizational processes as well as external economic environments. Also, ISO 9000 standards apply the principle of "fact-based decision-making", taking the information and data of process output into consideration in making operational decisions. With factual data in operations, firms' capability to make fast and reliable decisions in response to the external environment is improved. Through the development and improvement of organizational systems, ISO 9000-certified firms are likely to nurture strong self-regulatory organizational policies and processes for allocating their R&D investments (Singh et al., 2011). With robust self-discipline and regulatory mechanisms, ISO 9000-certified firms are likely to control their R&D expenditure more carefully during recession periods. In addition, process management systems facilitate information flow across various functional areas and different supply chain partners (e.g., customers and suppliers), allowing companies to monitor business information efficiently (Naveh and Erez, 2004; Singh et al., 2011) and making them more sensitive to external environments. Accordingly, we develop our second hypothesis, which is related to the moderating effect of the external environment on the R&D expenditure of ISO 9000-certified firms:

> ***H2****: ISO 9000-certified firms reduce R&D expenditure to a greater extent during recession periods.*

2.4.3 Impact of ISO 9000 under market fluctuation

In many technology sectors, consumer requirements change and innovative products become obsolete quickly, leading to high industry dynamism and market fluctuation. Under higher market fluctuations, firms find it more difficult to forecast the demand for new products and predict the profitability of their R&D projects (Pérez-Luño et al., 2019). Such an operating environment puts R&D investments at extremely high risk. In a dynamic environment, it is important for companies to respond to uncertain demands and adjust their strategy and budgets to reduce risk and maintain competitiveness (Arvanitis and Woerter, 2013)

ISO 9000 standards enable firms to develop stronger operational capabilities through a documented and formalized framework to regulate their activities and functions (Singh et al., 2011). Specifically, the standards emphasize the management of customers and suppliers (Prajogo et al., 2012; Singh, 2008). The ISO 9000 framework enables firms to develop stronger capabilities in supply chain coordination and to communicate with customers and suppliers more effectively. ISO 9000-certified organizations are likely to have a stronger customer focus and to more closely monitor customer feedback and market requirements. The principles of quality management, including customer focus, supplier partnerships and a systematic approach to management, allow firms to keep track of the external operating environment more carefully and adjust their internal activity plans more responsively (Flynn et al., 2010; Martinez-Costa et al., 2009; Prajogo et al., 2012; Singh, 2008). In addition, ISO 9000-certified firms emphasize information sharing in their supply chain networks (Das et al., 2006; Zhao et al., 2011), making them more sensitive and conservative under market fluctuations:

> ***H3****: ISO 9000-certified firms reduce R&D expenditure to a greater extent under high market fluctuation.*

2.4.4 Impact of ISO 9000 under operational slack

Operational slack can accrue as a result of a firm exceeding its performance target or plans and obtaining more resources as a buffer (Nohria and Gulati, 1996; Voss et al., 2008). In general, slack resources enhance a company's flexibility, giving it more autonomy and resources for exploration (Kim et al., 2008). R&D investments often adopt long investment horizons, and their outcomes are highly uncertain (Kim et al., 2008). As a result, R&D-intensive firms require additional buffering resources for experimentation, trials and expansions of new product lines (Greve, 2003; Lee and Wu, 2016). In particular, extra operational slack implies that firms have additional assets, machines and equipment to try out new ideas and carry out new experiments. Accordingly, firms with operational slack provide a favorable organizational environment for R&D investments.

As we have mentioned, through ISO 9000 principles such as fact-based decision-making and a systematic approach to management, certified firms are likely to develop a more disciplined approach and stronger regulatory mechanism in their organizational activities (Anand et al., 2009; Singh et al., 2011). Through the adoption of ISO 9000, firms develop stable routines, standardized procedures and accumulated knowledge, leading to stronger internal resource allocation and management capability (Ataseven et al., 2013; Benner and Tushman, 2003; Zollo and Winter, 2002). Due to stronger process systems and routines, ISO 9000-certified firms are likely to detect and monitor internal resources more closely and make better use of buffering operational resources for R&D investments (Anand et al., 2009; Aoki and Wilhelm, 2017). Thus we argue that certified firms can better use their slack resources for organizational exploration and innovation activities:

> ***H4****: ISO 9000-certified firms increase R&D expenditure to a greater extent under operational slack.*

3. Research Methods

3.1 Data Collection

We collected and combined longitudinal secondary data from multiple sources to measure the variables investigated in this research and to test the proposed hypotheses. First, similar to prior research based on secondary data (e.g., Cai, 2007; Uotila et al., 2009), we focused on firms included in the S&P 500 Index. This is because these firms are more visible and widely covered by news media and other public sources, enabling us to identify whether and when they received their first ISO 9000 certifications. Moreover, these firms are publicly listed on the stock markets, making their financial and accounting data available for us to measure the relevant variables, such as R&D intensity and operational slack, investigated in this research. Because ISO 9000 was first published by the International Organization for Standardization (ISO) in 1987 (ISO, 1987), we started with a list of 500 firms included in the S&P 500 Index in that year. This approach enabled us to conduct a more rigorous longitudinal analysis to examine how ISO 9000 certification affects R&D expenditure over time. As ISO 9000 has been more commonly adopted by firms in the manufacturing industries than other industries, we focused on those S&P 500 companies with Standard Industrial Classification (SIC) codes between 2000 and 3999 (Lo et al., 2013). As a result, 266 manufacturing firms were retained for this research.

For each of these 266 firms, we identified whether and when they obtained their first ISO 9000 certifications via searches of various sources including company reports, ISO 9000-related websites and Factiva, a database containing news and information articles from different media sources such as *The New York Times* and *The Wall Street Journal* that has been widely used in prior research on firm strategies and practices (e.g., Lam et al., 2019; Lo et al., 2014; Swink and Jacobs, 2012). Specifically, our search keywords included the names of the firms concerned and relevant terms such as ISO 9000 and ISO 9001. To enable a more comprehensive view on firms' ISO 9000 certifications, our searches covered a 30-year period

from 1987 to 2017. We were able to identify 123 out of the 266 manufacturing companies that had ISO 9000 certifications based on our searches of these sources. The distribution of the 123 firms' first ISO 9000 certifications across the 30-year period are shown in Table 1, suggesting that about 50% of these companies obtained their first certifications between 1993 and 1996, although we can still see some sample firms obtaining their first certifications in more recent years (e.g., 2015–2017). We also present the distribution of these ISO 9000-certified firms across different industries in Table 2. It shows that most such firms are in the chemical and allied products industry (18.7%), followed by the industrial machinery and equipment industry (17.9%). Finally, the characteristics of these 123 sample firms in terms of market value, sales, total assets, number of employees, R&D expense, cash dividends, total debt, and property, plant and equipment (PPE) are shown in Table 3.

-----Table 1 about here-----

-----Table 2 about here-----

-----Table 3 about here-----

We also obtained relevant annual accounting data (e.g., R&D expense, sales, PPE) of these sample firms from Compustat to measure other research variables such as R&D intensity and operational slack. Specifically, to measure market fluctuation (also known as industry dynamism), we collected annual sales data of all manufacturing firms from Compustat to compute industry sales. We relied on data from the National Bureau of Economic Research (NBER) to determine the recession years during our investigation period of 1987–2017. Finally, we collected additional accounting and financial data from Compustat and the Center for Research in Security Prices (CRSP) to measure the control variables to be included in our regression analysis. Table 4 summarizes the data sources and measurements of these research variables; a more detailed discussion of the measurement procedures is shown below.

-----Table 4 about here-----

3.2 Variable Measurements

ISO 9000 certification. After identifying the year in which a firm obtained its first ISO 9000 certification, we coded its certification as 1 for all years starting from this certification year and 0 for all years before this year. For example, if a firm had been ISO 9000-certified since 2000, we coded 2000–2017 as 1 for this firm and 1987–1999 as 0 for the same firm. This coding approach enabled us to conduct a firm-level fixed-effect analysis as discussed in the regression analysis section to examine the impact of ISO 9000 certification on R&D expenditure over time. It should also be noted that all firms included in our analysis are ISO 9000-certified because a firm-level fixed-effect analysis removes firms without ISO 9000 certification.

R&D intensity. In line with prior research (e.g., Lam et al., 2019; Yiu et el., 2020), we computed a firm's R&D intensity as its R&D expense divided by sales in each year. We displayed R&D intensity in terms of percentage to ease the interpretation of our regression results. As we maintained a one-year lag between the dependent variable (i.e., R&D intensity) and other independent variables in the regression analysis, our measure of R&D intensity was based on the R&D expense and sales data for 1988–2018.

Recession period. In line with prior research (e.g., Bannier and Hirsch, 2010; Srinivasan et al., 2011), we determined whether a particular year could be viewed as a recession year based on the NBER's classification. Over the 30-year sample period (1987–2017), 4 years – 1990, 2001, 2008 and 2009 – met the NBER's classification and thus were coded as 1 for the recession period variable; other years were coded as 0.

Market fluctuation. We relied on the variation of sales in an industry over a several-year period to determine its market fluctuation (Lam et al., 2019; Wiengarten et al., 2017). Specifically, we first computed industry sales by adding the sales of all firms with the same

four-digit SIC code in each year. We then regressed the industry sales over a five-year period. The market fluctuation was measured as the standard error of slope coefficient in the regression model, divided by the average industry sales over the same five-year period. For example, to measure the market fluctuation of an industry in 2000, we regressed the sales of this industry over 1996–2000 (a five-year period) to obtain the standard error of slope coefficient and then divided it by the average sales of the same industry over 1996–2000.

Operational slack. Following prior research (e.g., Wiengarten et al., 2017; Wood et al., 2017), we computed a firm's operational slack as its PPE divided by sales. As our research is focused on firms' internal practices or strategies such as ISO 9000 adoption and R&D investment, we used an internal measure of operational slack based on PPE rather than some more external-oriented measures such as supply chain slack based on cash conversion cycle.

Control variables. We added five firm-level control variables, including firm size, firm age, firm leverage, labor intensity and dividend payout, in the regression analysis. We measured firm size as natural logarithm of market value (Anderson et al., 1999; Lam et al., 2019), firm age as natural logarithm of number of years since Initial Public Offering (IPO) (Li et al., 2010; Wu et al., 2015), firm leverage as total debt divided by total equity (Kashmiri et al., 2017; Yiu et al. 2020), labor intensity as number of employees divided by sales (Lo et al., 2014; Swink and Jacobs, 2012) and dividend payout as cash dividends divided by market value (Lam, 2018; Tuli and Bharadwaj, 2009).

3.3 Fixed-Effect Regression Analysis

This research was aimed at investigating the direct impact of ISO 9000 certification on R&D expenditure and the moderating effects of several relevant factors including recession period, market fluctuation and operational slack. Although we controlled for several firm-level variables such as firm size, firm age, firm leverage, labor intensity and dividend payout that

may be related to R&D expenditure, some other unobservable firm characteristics such as corporate culture and managerial ability may also be related to companies' decisions to adopt ISO 9000 and invest in R&D, leading to possible endogeneity issues (Lu et al., 2018). Moreover, because our research covered a 30-year period from 1987 to 2017, some unobservable time-specific effects such as economic conditions and industry trends may also have explained firms' variation in R&D investments over time. Finally, although we hypothesized the impact of ISO 9000 certification on R&D expenditure, firms' R&D investments may also affect their decision to adopt ISO 9000, leading to possible reverse causality (Wooldridge, 2010).

We took several steps to address these concerns. First, in line with prior research based on panel data (e.g., Bockstedt et al., 2015; Shan and Zhu, 2013), we adopted a fixed-effect regression approach to analyze our data and test the proposed hypotheses. This approach, by including a firm-level fixed-effect estimation, could help remove any unobservable time-invariant effects that were relevant to firm characteristics such as corporate culture and managerial ability. Our approach also included a year-level fixed-effect estimation to remove any unobservable time-specific effects. This fixed-effect approach thus enabled us to provide a more accurate estimation of how a firm's ISO 9000 certification affects its decision to invest in R&D (i.e., the within-firm effect; Wooldridge, 2010). In our estimation, we also maintained a one-year lag between the dependent variable (i.e., R&D intensity, measured in year $t+1$) and other independent variables such as ISO 9000 certification and operational slack (measured in year t) to ensure the direction of causality under test. This fixed-effect regression model is shown in the following equation (1):

$$
\begin{aligned}
&R\&D\ Intensity_{i(t+1)} \\
&= \beta_0 + \beta_1 Firm\ Size_{it} + \beta_2 Firm\ Age_{it} + \beta_3 Firm\ Leverage_{it} + \beta_4 Labor\ Intensity_{it} \\
&+ \beta_5 Dividend\ Payout_{it} + \beta_6 Recession\ Period_{it} + \beta_7 Market\ Fluctuation_{it} \\
&+ \beta_8 Operational\ Slack_{it} + \beta_9 ISO\ 9000\ Certification_{it} \\
&+ \beta_{10} ISO\ 9000\ Certification_{it} \times Recession\ Period_{it}
\end{aligned}
$$

$$+ \beta_{11} ISO\ 9000\ Certification_{it} \times Market\ Fluctuation_{it}$$

$$+ \beta_{12} ISO\ 9000\ Certification_{it} \times Operational\ Slack_{it} + \alpha_i + \delta_t + \varepsilon_{it}\ , \quad (1)$$

where *i* and *t* are firm and year indices, respectively; α_i and δ_t represent firm-level and year-level fixed effects, respectively; and ε_{it} is the error term. We relied on β_9 to estimate the impact of ISO 9000 certification on R&D expenditure (H1), while the moderating roles of recession period (H2), market fluctuation (H3) and operational slack (H4) were indicated by β_{10}, β_{11} and β_{12}, respectively. It should be noted that our firm-level fixed-effect estimation helped remove any industry-level effects and ensure our results would not be influenced by industry heterogeneity. Therefore, we didn't control for industry-level effects in our regression model, which is consistent with prior research adopting the same estimation strategy.

4. Test Results

Table 5 shows the correlations, means and standard deviations of all variables included in equation (1), while the test results based on the fixed-effect regression analysis are presented in Table 6, which includes five regression models. Model 1 contains all control variables as well as firm-level and year-level fixed effects. Model 2 adds the main effect of ISO 9000 certification, while the moderating effects of recession period, market fluctuation and operational slack are included sequentially in Models 3 to 5. All five models are statistically significant ($p < 0.01$) based on *F*-tests, with *R*-squared ranging from 0.068 to 0.076. The number of firms included in the fixed-effect analysis was reduced from 123 to 114 because the data used for measuring certain firm-level variables such as firm age were missed for several firms. The number of firm-year observations was 3,172, suggesting that there were about 28-year observations for each firm (unbalanced panel).

-----Table 5 about here-----

-----Table 6 about here-----

Three control variables, including firm size, firm age and labor intensity, remained

significant ($p < 0.05$) across the five models. Specifically, firm size and firm age are positively related to R&D intensity, while labor intensity has a negative relationship with R&D intensity. In other words, our results show that larger, older but less labor-intensive firms invest more in R&D.

The coefficient of ISO 9000 certification is significantly positive ($p < 0.1$) across Models 2 to 5, suggesting that firms increase R&D investments following their ISO 9000 certifications. H1 thus is supported. On the other hand, the interaction between ISO 9000 certification and recession period is significantly negative ($p < 0.1$), as shown in Models 3 to 5. This means that when a recession occurs, ISO 9000 certification enables firms to reduce their investments in R&D, supporting H2. Similarly, we also found a significant and negative interaction between ISO 9000 certification and market fluctuation ($p < 0.05$) in Models 4 and 5, indicating that the impact of ISO 9000 certification on R&D intensity is lower when firms' market environments become more fluctuating. H3 is also supported. Finally, Model 5 shows a significant and positive moderating role of operational slack ($p < 0.05$), suggesting that ISO 9000-certified firms invest more in R&D when they have more operational slack. H4 is supported.

Besides the moderating roles, the direct impacts of recession periods and operational slack on R&D intensity remained significant across the five models ($p < 0.01$). Specifically, while a recession period was negatively related to R&D intensity, operational slack had a positive impact on R&D intensity. These results suggest that although firms are more likely to reduce their R&D investments during recession periods, they tend to invest more in R&D if their operational slack is high.

To check the robustness of our findings, we performed several sensitivity tests with alternative measures of the control variables used in our research. In particular, we measured firm size as the natural logarithm of a firm's sales, firm age as the natural logarithm of number

of years since a firm has been founded, firm leverage as a firm's long-term debt divided by its total equity, labor intensity as a firm's number of employees divided by its total inventory, and dividend payout as a firm's total dividends divided by its market value, resulting in Models 1 to 5, respectively. The test results based on these alternative measures remain significant and consistent as shown in Table 7, demonstrating the robustness of our research findings.

-----Table 7 about here-----

5. Discussion

The adoption of ISO 9000 quality management systems leads to the reduction of variations in operating processes, achieving continuous improvement of quality and process. On the other hand, firms renew themselves, explore new opportunities and gain unique competitive advantages for products through investing in R&D (Danneels, 2002; Kyrgidou and Spyropoulou, 2013). Both exploitation and exploration are important organizational functions. Yet, a paradox exists regarding the effect of exploitative ISO 9000 practices on explorative R&D activities. In our research we examined the impact of ISO 9000 certifications on R&D expenditures of firms and investigated how such an impact is influenced in an environment with uncertainties such as during recession periods and under high market fluctuation. Our results show that ISO 9000 certifications enhance R&D expenditure in general. However, during recession periods or in a highly fluctuating industrial environment, ISO 9000 certifications reduce R&D expenditures more significantly. In addition, ISO 9000-certified firms with more slack resources in their operational systems increase their R&D expenditure to a greater extent. Overall, this study suggests that ISO 9000 certifications not only do not reduce R&D activities but also make firms more responsive to the changing operating environment and able to manage R&D-associated risks more prudently. It is possible that the systematic and standardized routines required by ISO 9000 make firms more alert to

uncertainties, more sensitive to external environments and more conservative in their explorative R&D activities. From this perspective, process institutionalization only makes firms more conservative for their R&D expenditures under high environmental uncertainty but it does not appear to be contradictory with organizational exploration.

5.1 Theoretical Implications

A possible explanation for ISO 9000 systems facilitating organizational exploration is that process certifications enhance a firm's organizational learning capability. Through repetitive routines for continuous improvement, companies develop problem-solving skills and accumulate knowledge, leading to reliable and streamlined operations. ISO 9000 emphasizes employee participation and values employees' ideas and suggestions, enabling firms to develop a culture of open communication and a learning mechanism for continuous exploration. In addition, through process routines and articulation and codification of tacit knowledge, ISO 9000-certified firms are more sensitive and adaptable to changing external environments. As a result, these certified firms appear to have a stronger capability to regulate themselves and control R&D expenditure prudently based on the operating context.

ISO 9000 standards not only enhance process improvements and develop dynamic capabilities through knowledge articulation and codification (Zollo and Winter, 2002), but also contribute to organizational renewal (Danneels, 2002; Zollo and Winter, 2002). Organizational renewal is an evolutionary process to exploit and improve firms' quality management and product innovation capabilities, thus modifying their core competencies (Floyd and Lane, 2000; Tinoco, 2014). It is particularly critical in a dynamic environment because an ongoing renewal of firms' core competencies enhances organizational agility to deal with uncertainty in product innovations (Danneels, 2002; Tinoco, 2014). We contribute to the theory by demonstrating that ISO-certified firms are more adaptable and flexible to manage R&D and new product

development in a standard quality management system. Firms with ISO 9000 certifications are in a better position to carry out R&D activities.

We have shown that ISO 9000 certifications encourage firms to pursue more exploratory activities, as indicated by increased R&D expenditure. We have also shown that ISO 9000-certified companies reduce their R&D investments more significantly as the operating environment becomes less favorable and expand more aggressively with internal resources. We contribute to the understanding of quality management by demonstrating that ISO 9000 enhances the control mechanism of firms in response to external environments. Consistent with previous research, we have shown that process certification enhances the self-regulatory mechanism of firms (King et al., 2005; Levine and Toffel, 2010; Short and Toffel, 2010), which does not necessarily need to conflict with organizational exploratory activities. Short and Toffel (2010) considered process certification as a self-regulatory mechanism that leads to a self-disciplinary system, enhancing internal control capabilities of firms. Our research supports this perspective.

5.2 Managerial Implications

We have shown that firms actually increase their R&D expenditure after ISO 9000 certifications. The adoption of ISO 9000 leads to well-established systems, improves organizational routines, stabilizes operating processes and enhances information flow, which generally provides firms with stronger management capabilities. Firms with ISO 9000 may develop a strong capability to continuously assess and monitor their operating contexts. Companies that invest heavily in R&D often face many uncertain factors as a result of changes in external environments, amplifying their risk exposure. With ISO 9000 adoption, they might be able to develop more robust organizational routines that help them detect unfavorable factors, respond more swiftly and more carefully control their R&D expenditure according to the

internal and external factors. Managers may make use of the process routines and structured organizational mechanism to enhance their firms' self-regulatory capabilities, enabling them to be more responsive and risk sensitive. This is particularly important for businesses that invest heavily in organizational exploration and innovation.

Policymakers should encourage manufacturing firms and highly innovative firms to adopt ISO 9000. Policymakers and firms should be aware that ISO 9000 can be a mechanism for controlling R&D activities under environmental uncertainty. For example, the principles of ISO 9000 help firms establish some appropriate mechanisms in deciding on R&D expenditure, which may in turn provide better risk management in their new product development during recession periods or in a highly fluctuating market environment. Other external stakeholders such as industrial customers and buyers should also encourage their suppliers to adopt ISO 9000, including suppliers in the high-tech sectors, which operate in a fast-changing business environment (Castelló et al., 2017).

6. Conclusions

Many studies from an organizational perspective suggest that ISO 9000 certification may reduce firms' explorative capability. These authors believe that the requirements and procedures of ISO 9000 certification are rigid and inflexible, leading to organizational bureaucracy and inertia and hindering exploration. However, from the OM perspective, ISO 9000 helps firms develop structured organizational systems and routines, promotes organizational learning and enhances firms' capability in both exploration and exploitation. Very few studies have been carried out to examine the impact of ISO 9000 certification on R&D expenditure. Based on an analysis of ISO 9000 certification in the U.S. context, we have found that ISO 9000 certifications facilitate R&D expenditure. However, ISO 9000-certified firms are more sensitive to recessions and market fluctuations. In addition, ISO 9000-certified

firms with slack resources expand their R&D investments more aggressively, indicating that they may be more responsive to the availability of resources for organizational exploration. We have provided empirical evidence that ISO 9000 certifications are not necessarily in conflict with R&D exploration. Instead, the certifications might provide better systems that regulate R&D expenditure in response to operating environments. ISO 9000 implementations lead to a stronger regulatory capability for responding to changes and reducing the risks for firms from organizational exploration.

The current research has some limitations, which provide some possible directions for future study. In this research, we considered R&D expenditure as a proxy for organizational exploration. Although R&D expenditure is commonly considered an important indicator for organizational innovation, firms vary in the effectiveness of their R&D activities. Future researchers may also consider using the patent data as a measure of organizational exploration. Moreover, we only considered operational slack, which indicates the extra operational resources of firms in terms of property, plant and equipment. Also, we studied firms included in the S&P 500 Index so the results of this research are not generalizable to small and medium-sized enterprises (SMEs). Further studies may look into the impact of ISO 9000 certifications on R&D investments of SMEs (Putri et al., 2016). Future research can be conducted by considering other factors in additional to internal operational resources such as human capital, technology competence and supply chain capability (Hanlon and Saunders, 2007; Ismail, 2018). The types of competences and resources may influence a firm's decisions on its resource allocation and make firms' R&D activities more effective.

Acknowledgments

We thank Prof. Angappa Gunasekaran (Editor-in-Chief) and two anonymous referees for their many helpful comments on an earlier version of our paper. This research was supported in part by the Research Grants Council of Hong Kong under grant number PolyU 155226/16B.

References

Adler, P. S., Benner, M., Brunner, D. J., MacDuffie, J. P., Osono, E., Staats, B. R., . . . Winter, S. G. (2009). Perspectives on the productivity dilemma. *Journal of Operations Management*, *27*(2), 99–113.

Anand, G., Ward, P. T., Tatikonda, M. V. & Schilling, D. A. (2009). Dynamic capabilities through continuous improvement infrastructure. *Journal of Operations Management*, *27*(6), 444–461.

Anderson, S. W., Daly, J. D. & Johnson, M. F. (1999). Why firms seek ISO 9000 certification: Regulatory compliance or competitive advantage? *Production and Operations Management*, *8*(1), 28–43.

Aoki, K., & Wilhelm, M. (2017). The role of ambidexterity in managing buyer-Supplier relationships: The Toyota case. *Organization Science*, *28*(6), 1080–1097.

Arvanitis, S., & Woerter, M. (2013). Firm characteristics and the cyclicality of R&D investments. *Industrial and Corporate Change*, *23*(5), 1141–1169.

Ataseven, C., Prajogo, D. I. & Nair, A. (2013). ISO 9000 internalization and organizational commitment: Implications for process improvement and operational performance. *IEEE Transactions on Engineering Management*, *61*(1), 5–17.

Bannier, C. E. & Hirsch, C. W. (2010). The economic function of credit rating agencies: What does the watchlist tell us? *Journal of Banking & Finance*, *34*(12), 3037–3049.

Barlevy, G. (2007). On the cyclicality of research and development. *American Economic Review*, *97*(4), 1131–1164.

Benner, M. J. (2009). Dynamic or static capabilities? Process management practices and response to technological change. *Journal of Product Innovation Management*, *26*(5), 473–486.

Benner, M. J. & Tushman, M. (2002). Process management and technological innovation: A

longitudinal study of the photography and paint industries. *Administrative Science Quarterly*, *47*(4), 676–707.

Benner, M. J. & Tushman, M. L. (2003). Exploitation, exploration, and process management: The productivity dilemma revisited. *Academy of Management Review*, *28*(2), 238–256.

Benner, M. J. & Veloso, F. M. (2008). ISO 9000 practices and financial performance: A technology coherence perspective. *Journal of Operations Management*, *26*(5), 611–629.

Bockstedt, J., Druehl, C. & Mishra, A. (2015). Problem-solving effort and success in innovation contests: The role of national wealth and national culture. *Journal of Operations Management*, *36*, 187–200.

Cai, J. (2007). What's in the news? Information content of S&P 500 additions. *Financial Management*, *36*(3), 113–124.

Calantone, R. J., Harmancioglu, N., & Droge, C. (2010). Inconclusive innovation "returns": A meta-analysis of research on innovation in new product development. *Journal of Product Innovation Management, 27*(7), 1065-1081.

Collis, D. (1996). *Organizational capability as a source of profit in organizational learning and competitive advantage.* Betrand Moingeon and Amy Edmondson.

Corbett, C. J., Montes-Sancho, M. J. & Kirsch, D. A. (2005). The financial impact of ISO 9000 certification in the United States: An empirical analysis. *Management Science*, *51*(7), 1046–1059.

Castelló, J., Llach, J., & Castro, R. D. (2017). Evidence for quality management systems being instrumental in improving supplier performance: the case of the wind power sector. *International Journal of Productivity and Quality Management*, *22*(4), 427-450.

Danneels, E. (2002). The dynamics of product innovation and firm competences. *Strategic Management Journal*, *23*(12), 1095–1121.

Das, A., Narasimhan, R. & Talluri, S. (2006). Supplier integration: Finding an optimal

configuration. *Journal of Operations Management*, *24*(5), 563–582.

Dosi, G., Marengo, L., & Fagiolo, G. (2001). *Learning in evolutionary environments* (No. 2003/20). LEM Working Paper Series.

Farjoun, M. (2010). Beyond dualism: Stability and change as a duality. *Academy of Management Review*, *35*(2), 202–225

Feldman, M. S., Pentland, B. T., D'Adderio, L. & Lazaric, N. (2019). Beyond routines as things: Introduction to the special issue on routine dynamics. *Organization Science*, *27*, 505–513.

Floyd, S. W., & Lane, P. J. (2000). Strategizing throughout the organization: Managing role conflict in strategic renewal. *Academy of Management Review, 25*(1), 154-177.

Flynn, B. B., Huo, B., & Zhao, X. (2010). The impact of supply chain integration on performance: A contingency and configuration approach. *Journal of Operations Management*, *28*(1), 58–71.

Gotzamani, K. D. & Tsiotras, G. D. (2002). The true motives behind ISO 9000 certification: Their effect on the overall certification benefits and long-term contribution towards TQM. *International Journal of Quality & Reliability Management*, *19*(2), 151–169.

Gray, J. V., Anand, G. & Roth, A. V. (2015). The influence of ISO 9000 certification on process compliance. *Production and Operations Management*, *24*(3), 369–382.

Gretz, R. T. & Highfill, J. (2010). Recession, R&D spending, and the current account: Bad news, bad news, and a little encouragement. *Global Economy Journal*, *10*(1), 1850192.

Greve, H. R. (2003). A behavioral theory of R&D expenditures and innovations: Evidence from shipbuilding. *Academy of Management Journal*, *46*(6), 685–702.

Hanlon, D. & Saunders, C. (2007). Marshaling resources to form small new ventures: Toward a more holistic understanding of entrepreneurial support. *Entrepreneurship Theory and Practice*, *31*(4), 619–641.

Henry, L. (2013). Intellectual capital in a recession: Evidence from UK SMEs. *Journal of Intellectual Capital*, *14*(1), 84–101.

Hud, M. & Hussinger, K. (2015). The impact of R&D subsidies during the crisis. *Research Policy*, *44*(10), 1844–1855.

Ismail, R. (2018). The impact of human capital and innovation on labour productivity of Malaysian small and medium enterprises. *International Journal of Productivity and Quality Management*, *25*(2), 245-261.

ISO. (1987). *ISO 9000:1987: Quality management and quality assurance standards – Guidelines for selection and use.* Retrieved from https://www.iso.org/standard/16529.html

Kashmiri, S., Nicol, C. D. & Hsu, L. (2017). Birds of a feather: Intra-industry spillover of the Target customer data breach and the shielding role of IT, marketing, and CSR. *Journal of the Academy of Marketing Science*, *45*(2), 208–228.

Kim, H., Kim, H. & Lee, P. M. (2008). Ownership structure and the relationship between financial slack and R&D investments: Evidence from Korean firms. *Organization Science*, *19*(3), 404–418.

King, A. A., Lenox, M. J. & Terlaak, A. (2005). The strategic use of decentralized institutions: Exploring certification with the ISO 14001 management standard. *Academy of Management Journal*, *48*(6), 1091–1106.

Koryak, O., Lockett, A., Hayton, J., Nicolaou, N., & Mole, K. (2018). Disentangling the antecedents of ambidexterity: Exploration and exploitation. *Research Policy*, *47*(2), 413–427.

Kuo, T., Chang, T. J., Hung, K. C. & Lin, M. Y. (2009). Employees' perspective on the effectiveness of ISO 9000 certification: A Total Quality Management framework. *Total Quality Management*, *20*(12), 1321–1335.

Kyrgidou, L. P. & Spyropoulou, S. (2013). Drivers and performance outcomes of innovativeness: An empirical study. *British Journal of Management*, *24*(3), 281–298.

Lam, H. K. (2018). Doing good across organizational boundaries: Sustainable supply chain practices and firms' financial risk. *International Journal of Operations & Production Management*, *38*(12), 2389–2412.

Lam, H. K., Ding, L., Cheng, T. C. E. & Zhou, H. (2019). The impact of 3D printing implementation on stock returns: A contingent dynamic capabilities perspective. *International Journal of Operations & Production Management*, *39*(6/7/8), 935–961.

Lee, C. L. & Wu, H. C. (2016). How do slack resources affect the relationship between R&D expenditures and firm performance? *R&D Management*, *46*(S3), 958–978.

Levine, D. I. & Toffel, M. W. (2010). Quality management and job quality: How the ISO 9001 standard for quality management systems affects employees and employers. *Management Science*, *56*(6), 978–996.

Li, S., Shang, J. & Slaughter, S. A. (2010). Why do software firms fail? Capabilities, competitive actions, and firm survival in the software industry from 1995 to 2007. *Information Systems Research*, *21*(3), 631–654.

Lo, C. K., Pagell, M., Fan, D., Wiengarten, F. & Yeung, A. C. (2014). OHSAS 18001 certification and operating performance: The role of complexity and coupling. *Journal of Operations Management*, *32*(5), 268–280.

Lo, C. K., Wiengarten, F., Humphreys, P., Yeung, A. C. & Cheng, T. C. E. (2013). The impact of contextual factors on the efficacy of ISO 9000 adoption. *Journal of Operations Management*, *31*(5), 229–235.

Lome, O., Heggeseth, A. G. & Moen, Ø. (2016). The effect of R&D on performance: Do R&D-intensive firms handle a financial crisis better? *The Journal of High Technology Management Research*, *27*(1), 65–77.

Lu, G., Ding, X. D., Peng, D. X. & Chuang, H. H. C. (2018). Addressing endogeneity in operations management research: Recent developments, common problems, and directions for future research. *Journal of Operations Management*, *64*, 53–64.

Manders, B., de Vries, H. J., & Blind, K. (2016). ISO 9001 and product innovation: A literature review and research framework. *Technovation, 48*, 41-55.

March, J. G. (1991). Exploration and exploitation in organizational learning. *Organization Science*, *2*(1), 71–87.

Martínez-Costa, M., Choi, T. Y., Martínez, J. A., & Martínez-Lorente, A. R. (2009). ISO 9000/1994, ISO 9001/2000 and TQM: The performance debate revisited. *Journal of Operations Management*, *27*(6), 495–511.

Naveh, Eitan, Marcus, Alfred, & Moon, Hyoung Koo. (2004). Implementing ISO 9000: performance improvement by first or second movers. *International Journal of Production Research, 42*(9), 1843–1863.

Naveh, E. & Erez, M. (2004). Innovation and attention to detail in the quality improvement paradigm. *Management Science*, *50*(11), 1576–1586.

Nohria, N. & Gulati, R. (1996). Is slack good or bad for innovation? *Academy of Management Journal*, *39*(5), 1245–1264.

Parmigiani, A., & Howard-Grenville, J. (2011). Routines revisited: Exploring the capabilities and practice perspectives. *Academy of Management annals*, *5*(1), 413–453.

Pentland, B. T. & Feldman, M. S. (2008). Designing routines: On the folly of designing artifacts, while hoping for patterns of action. *Information and Organization*, *18*(4), 235–250.

Pérez-Luño, A., Alegre, J., & Valle-Cabrera, R. (2019). The role of tacit knowledge in connecting knowledge exchange and combination with innovation. *Technology Analysis & Strategic Management*, *31*(2), 186–198.

Prajogo, D., Huo, B. & Han, Z. (2012). The effects of different aspects of ISO 9000

implementation on key supply chain management practices and operational performance. *Supply Chain Management: An International Journal*, *17*(3), 306–322.

Putri, N. T., Retha, F., & Yusof, S. R. M. (2016). Design of quality system documentation in hydrotiller production unit as improvement of quality management system in small and medium enterprise. *International Journal of Productivity and Quality Management*, *19*(1), 116-138.

Raghavendra, M. S., Raj, J. R. & Seetharaman, A. (2012). A study of decrease in R&D spending in the pharmaceutical industry during post-recession. *International Journal of Academic Research*, *4*(5) 29–47.

Ratnasingam, J., Yoon, C. Y. & Ioras, F. (2013). The effects of ISO 9001 quality management system on innovation and management capacities in the Malaysian furniture sector. *Bulletin of the Transilvania University of Brasov. Forestry, Wood Industry, Agricultural Food Engineering. Series II*, *6*(1), 63.

Santos-Vijande, M. L., & Álvarez-González, L. I. (2007). Innovativeness and organizational innovation in total quality oriented firms: The moderating role of market turbulence. *Technovation, 27*(9), 514-532.

Sfreddo, L. S., Vieira, G. B., Vidor, G., & Zin, R. A. (2019). Systematic literature review of ISO 9001 and process management. *International Journal of Productivity and Quality Management*, *26*(3), 330-352.

Shafiq, M., Mirza, K., Abid, K., & Naeem, M. A. (2014). Effect of ISO 9000 Certification on TQM Implementation. *Journal of Quality and Technology Management, 5*(2), 01–26.

Shan, J. & Zhu, K. (2013). Inventory management in China: An empirical study. *Production and Operations Management*, *22*(2), 302–313.

Shi, Y., Lin, W., Chen, P. K. & Su, C. H. (2019). How can the ISO 9000 QMS improve the organizational innovation of supply chains? *International Journal of Innovation*

Science, *11*(2), 278–298.

Short, J. L. & Toffel, M. W. (2010). Making self-regulation more than merely symbolic: The critical role of the legal environment. *Administrative Science Quarterly*, *55*(3), 361–396.

Smith, K. W., Erez, M., Jarvenpaa, S., Lewis, M. W., & Tracey, P. (2017). Adding complexity to theories of paradox, tensions, and dualities of innovation and change: Introduction to organization studies special issue on paradox, tensions, and dualities of innovation and change. *Organization Studies*, 38 (3-4), 303–317.

Singh, P. J. (2008). Empirical assessment of ISO 9000 related management practices and performance relationships. *International Journal of Production Economics*, *113*(1), 40–59.

Singh, P. J., Power, D. & Chuong, S. C. (2011). A resource dependence theory perspective of ISO 9000 in managing organizational environment. *Journal of Operations Management*, *29*(1–2), 49–64.

Srinivasan, R. & Lilien, G. L. (2009). R&D, advertising and firm performance in recessions. *ISBM report*, *3*, 1–26.

Srinivasan, R., Lilien, G. L. & Sridhar, S. (2011). Should firms spend more on research and development and advertising during recessions? *Journal of Marketing*, *75*(3), 49–65.

Stockstrom, C., & Herstatt, C. (2008). Planning and uncertainty in new product development. *R&D Management*, *38*(5), 480–490.

Swift, T. (2016). The perilous leap between exploration and exploitation. *Strategic Management Journal*, *37*(8), 1688–1698.

Swink, M. & Jacobs, B. W. (2012). Six Sigma adoption: Operating performance impacts and contextual drivers of success. *Journal of Operations Management*, *30*(6), 437–453.

Tan, K. C., Kannan, V. R., Jayaram, J., & Narasimhan, R. (2004). Acquisition of operations capability: a model and test across U.S. and European firms. *International Journal of*

Production Research, 42(4), 833-851.

Teece, D. J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal*, *28*(13), 1319–1350.

Terziovski, M. & Guerrero, J. L. (2014). ISO 9000 quality system certification and its impact on product and process innovation performance. *International Journal of Production Economics*, *158*, 197–207.

Tinoco, J. K. (2014). Double dealing: the influences of diverse business processes on organizational ambidexterity. *Academy of Strategic Management Journal, 13*(2), 87.

Tuli, K. R. & Bharadwaj, S. G. (2009). Customer satisfaction and stock returns risk. *Journal of Marketing*, *73*(6), 184–197.

Uotila, J., Maula, M., Keil, T. & Zahra, S. A. (2009). Exploration, exploitation, and financial performance: Analysis of S&P 500 corporations. *Strategic Management Journal*, *30*(2), 221–231.

Voss, G. B., Sirdeshmukh, D. & Voss, Z. G. (2008). The effects of slack resources and environmental threat on product exploration and exploitation. *Academy of Management Journal*, *51*(1), 147–164.

Wangwacharakul, P., Berglund, M., & Harlin, U. (2020). Quality management to facilitate product introduction across borders. *International Journal of Productivity and Quality Management*, *29*(2), 268-283.

Wei, W. C. (2010). From mediate and moderate view to untangle the relationship among product innovation performance, cross-functional cooperation and quality practices. *International Journal of Information and Management Sciences*, *21*(4), 365–390.

Wiengarten, F., Fan, D., Lo, C. K. & Pagell, M. (2017). The differing impacts of operational

and financial slack on occupational safety in varying market conditions. *Journal of Operations Management*, *52*, 30–45.

Wood, L. C., Wang, J. X., Olesen, K. & Reiners, T. (2017). The effect of slack, diversification, and time to recall on stock market reaction to toy recalls. *International Journal of Production Economics*, *193*, 244–258.

Wooldridge, J.M. (2010). *Econometric analysis of cross section and panel data*. Cambridge, Massachusetts: MIT Press.

Wu, Q., Luo, X., Slotegraaf, R. J. & Aspara, J. (2015). Sleeping with competitors: The impact of NPD phases on stock market reactions to horizontal collaboration. *Journal of the Academy of Marketing Science*, *43*(4), 490–511.

Yiu, L. M., Lam, H. K., Yeung, A. C., & Cheng, T. C. E. (2020). Enhancing the financial returns of R&D investments through operations management. *Production and Operations Management*, in press.

Yunlu, D. G. & Murphy, D. D. (2012). R&D intensity and economic recession: Investigating the moderating role of CEO characteristics. *Journal of Leadership & Organizational Studies*, *19*(3), 284–293.

Zimmermann, A., Raisch, S., & Birkinshaw, J. (2015). How is ambidexterity initiated? The emergent charter definition process. *Organization Science*, *26*(4), 1119–1139.

Zhao, X., Huo, B., Selen, W. & Yeung, J. H. Y. (2011). The impact of internal integration and relationship commitment on external integration. *Journal of Operations Management*, *29*(1–2), 17–32.

Zollo, M., & Winter, S. G. (2002). Deliberate learning and the evolution of dynamic capabilities. *Organization Science*, *13*(3), 339–351.

Table 1
Distribution of Sample Firms' First ISO 9000 Certifications Across Years.

Year	Frequency	Percentage
1987	1	0.8
1988	1	0.8
1990	2	1.6
1991	2	1.6
1992	9	7.3
1993	18	14.6
1994	16	13
1995	15	12.2
1996	12	9.8
1997	7	5.7
1998	7	5.7
1999	3	2.4
2000	3	2.4
2001	1	0.8
2002	5	4.1
2003	5	4.1
2004	2	1.6
2005	2	1.6
2007	2	1.6
2008	3	2.4
2010	2	1.6
2015	1	0.8
2016	2	1.6
2017	2	1.6
Total	123	100

Table 2
Distribution of ISO 9000-Certified Firms Across Industries.

Two-Digit SIC Code	Industry	Frequency	Percentage
28	Chemical & Allied Products	23	18.7
35	Industrial Machinery & Equipment	22	17.9
36	Electronic & Other Electric Equipment	13	10.6
37	Transportation Equipment	11	8.9
38	Instruments & Related Products	10	8.1
26	Paper & Allied Products	8	6.5
34	Fabricated Metal Products	7	5.7
20	Food & Kindred Products	6	4.9
33	Primary Metal Industries	6	4.9
24	Lumber & Wood Products	4	3.3
Other SIC Codes	Other Industries	13	10.6
Total		123	100

Table 3
Characteristics of ISO 9000-Certified Firms.

Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Market Value	Millions of dollars	14273.6	25450.4	15.1	150744.8
Sales	Millions of dollars	11501.6	22573.3	112.0	168919.0
Total Assets	Millions of dollars	13889.5	31702.7	239.0	237545.0
Number of Employees	Thousands	44.5	68.1	1.0	608.0
R&D Expense	Millions of dollars	494.7	1077.1	5.0	8200.0
Cash Dividends	Millions of dollars	359.4	807.5	0.0	5348.0
Total Debt	Millions of dollars	4545.1	14879.6	0.0	132835.0
Property, Plant and Equipment	Millions of dollars	4131.7	9281.7	33.0	67869.0

Table 4
Variable Descriptions.

Variables	Measurements	Data Sources	References
ISO 9000 Certification	Search Factiva to identify the year in which a firm obtains its first ISO 9000 certification and code all years starting from the certification year as 1 and all years before the certification year as 0	Factiva, company reports, ISO 9000-related websites	Levine and Toffel (2010), Swink and Jacobs (2012)
R&D Intensity	A firm's R&D expense divided by sales, measured in terms of percentage	Compustat	Lam et al. (2019), Yiu et el. (2020)
Recession Period	For the sample period 1987–2017, code years classified by the National Bureau of Economic Research as recessions (i.e., 1990, 2001, 2008 and 2009) as 1 and other years as 0	National Bureau of Economic Research	Bannier et al. (2010), Srinivasan et al. (2011)
Market Fluctuation	Standard error of slope coefficient obtained by regressing industry sales (four-digit SIC codes) over the past five years, divided by the average industry sales over the same five-year period	Compustat	Lam et al. (2019), Wiengarten et al. (2017)
Operational Slack	A firm's property, plant and equipment (PPE) divided by sales	Compustat	Wiengarten et al. (2017), Wood et al. (2017)
Firm Size	Natural logarithm of a firm's market value of equity	CRSP	Anderson et al. (1999), Lam et al. (2019)
Firm Age	Natural logarithm of the number of years since a firm's IPO	Compustat	Li et al. (2010), Wu et al. (2015)
Firm Leverage	A firm's total debt divided by total equity	Compustat	Kashmiri et al. (2017), Yiu et el. (2020)
Labor Intensity	A firm's number of employees divided by sales	Compustat	Lo et al. (2014), Swink and Jacobs (2012)
Dividend Payout	A firm's cash dividends divided by its market value of equity	Compustat, CRSP	Lam (2018), Tuli and Bharadwaj (2009)

Table 5
Correlations and Descriptive Statistics.

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. R&D Intensity (%)	1									
2. Firm Size	0.307***	1								
3. Firm Age	-0.029	0.435***	1							
4. Firm Leverage	-0.017	0.007	0.020	1						
5. Labor Intensity	-0.052***	-0.504***	-0.585***	-0.014	1					
6. Dividend Payout	-0.029	-0.041**	-0.032*	0.000	0.022	1				
7. Recession Period	0.010	-0.029	0.062***	-0.012	-0.061***	0.001	1			
8. Market Fluctuation	-0.068***	-0.163***	-0.112***	-0.014	0.058***	0.008	0.027	1		
9. Operational Slack	0.027	0.079***	-0.028	0.004	-0.058***	0.018	-0.008	0.098***	1	
10. ISO 9000 Certification	0.070***	0.367***	0.638***	-0.002	-0.534***	-0.042**	0.040**	-0.054***	-0.048***	1
Mean	4.319	8.805	3.583	1.008	5.248	0.027	0.119	0.023	0.319	0.600
Standard deviation	4.802	1.591	0.302	24.262	3.169	0.132	0.324	0.018	0.228	0.490

Notes: $^{*}p<0.1$, $^{**}p<0.05$, $^{***}p<0.01$ (two-tailed tests).

Table 6

Fixed-Effect Test Results.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	-8.056***	-7.652***	-7.654***	-8.431***	-8.953***
	(2.608)	(2.608)	(2.607)	(2.633)	(2.639)
Firm Size	0.175***	0.172***	0.175***	0.168***	0.171***
	(0.053)	(0.053)	(0.053)	(0.053)	(0.053)
Firm Age	3.490***	3.358***	3.358***	3.574***	3.821***
	(0.846)	(0.846)	(0.846)	(0.852)	(0.857)
Firm Leverage	-0.001	-0.001	-0.001	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Labor Intensity	-0.062***	-0.058**	-0.060***	-0.058**	-0.061***
	(0.022)	(0.022)	(0.022)	(0.022)	(0.023)
Dividend Payout	0.272	0.255	0.254	0.276	0.280
	(0.256)	(0.255)	(0.255)	(0.255)	(0.255)
Recession Period	-3.062***	-3.321***	-2.801***	-2.889***	-3.117***
	(0.697)	(0.701)	(0.759)	(0.760)	(0.765)
Market Fluctuation	3.282	3.260	3.345	8.181**	8.717***
	(2.183)	(2.180)	(2.180)	(3.221)	(3.224)
Operational Slack	2.141***	2.109***	2.111***	2.109***	1.418***
	(0.296)	(0.296)	(0.296)	(0.296)	(0.401)
ISO 9000 Certification		0.412***	0.465***	0.647***	0.368*
		(0.135)	(0.138)	(0.165)	(0.197)
ISO 9000 Certification × Recession Period			-0.634*	-0.622*	-0.610*
			(0.356)	(0.356)	(0.356)
ISO 9000 Certification × Market Fluctuation				-8.400**	-9.350**
				(4.120)	(4.133)
ISO 9000 Certification × Operational Slack					0.883**
					(0.346)
Firm-Level Fixed Effects	Included	Included	Included	Included	Included
Year-Level Fixed Effects	Included	Included	Included	Included	Included
Number of Firms	114	114	114	114	114
Number of Observations	3172	3172	3172	3172	3172
F-statistic	5.68***	5.79***	5.73***	5.69***	5.72***
R-squared	0.068	0.071	0.072	0.074	0.076

Notes: $^{*}p<0.1$, $^{**}p<0.05$, $^{***}p<0.01$ (two-tailed tests); Standard errors are in parentheses; One-year lag between the dependent variable and all independent variables.

Table 7

Sensitivity Test Results.

Variables	Model 1 Measure Firm Size as the natural logarithm of sales	Model 2 Measure Firm Age as the natural logarithm of number of years since being founded	Model 3 Measure Firm Leverage as long-term debt divided by total equity	Model 4 Measure Labor Intensity as number of employees divided by inventory	Model 5 Measure Dividend Payout as total dividends divided by market value
ISO 9000 Certification	0.347*	0.410**	0.368*	0.339*	0.367*
	(0.196)	(0.197)	(0.197)	(0.197)	(0.197)
ISO 9000 Certification × Recession Period	-0.563*	-0.616*	-0.609*	-0.585*	-0.607*
	(0.340)	(0.356)	(0.356)	(0.355)	(0.356)
ISO 9000 Certification × Market Fluctuation	-9.471**	-6.820*	-9.348**	-8.939**	-9.351**
	(4.100)	(4.104)	(4.133)	(4.127)	(4.133)
ISO 9000 Certification × Operational Slack	0.880**	0.730**	0.882**	0.864**	0.883**
	(0.345)	(0.344)	(0.346)	(0.345)	(0.346)
Number of Observations	3200	3187	3172	3172	3172
F-statistic	5.60***	5.20***	5.72***	5.98***	5.72***
R-squared	0.073	0.069	0.076	0.079	0.076

Notes: *p<0.1, **p<0.05, ***p<0.01 (two-tailed tests); Standard errors are in parentheses; One-year lag between the dependent variable and all independent variables. All control variables, firm-level and year-level fixed effects are included.