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Does Tight Internal Control Hinder Firm Innovation?*

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Abstract

This paper studies the impact of the strictness of internal control on firm innovation. Innovation activities are characterised by high uncertainty and risk of failure, while internal control focuses on operational efficiency and compliance with applicable laws and regulations. Thus, tight internal control discourages employees from undertaking risky innovation projects. On the basis of the criteria for identifying internal control weaknesses in Chinese listed firms, this paper constructs a proxy for the strictness of internal control. The results show that tighter internal control leads to less innovation input and lower innovation quality. This relation is stronger for firms with more R&D staff and weakens for firms with specialised R&D centres and state-owned firms. In addition, the impact of innovation output on operating performance is weaker in firms with tighter internal control. This paper reveals the negative impact of tight internal control on innovation activities and provides important implications for the implementation of China's innovation strategy.

***Keywords*:** Internal Control Strictness, Negative Incentives, Innovation Input, Innovation Quality

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I. Introduction

This paper studies the impact of the strictness of internal control on firm innovation. Internal control plays a critical role in ensuring the efficient operation of firms. Existing research shows that internal control not only reduces a firm's risk and the possibility of information manipulation (Gao and Jia, 2016; Skaife *et al.*, 2013) but also improves its operating efficiency through enhanced information transmission (Cheng *et al.*, 2018; Liu *et al.*, 2015). These studies mostly focus on internal control quality: that is, the extent to which firms achieve established internal control objectives. In contrast, this paper studies the strictness of the internal control system: that is, the intensity of the firm's control over its activities. In order to develop and retain a competitive edge over their rivals, firms need continual innovation, which is characterised by high uncertainty and risk of failure. Compliance with internal controls imposes a burden on firms engaged in risky innovation activities. Thus, the main research question of this paper is how tight internal control impedes firm innovation.

Tight internal control improves information transmission and reduces agency costs within the firm, but it decreases the flexibility of employee behaviour. By imposing penalties on behaviours that exceed the defined standards, the internal control system creates negative incentives for employees. Under tight internal control, employees need to exert certain efforts to ensure that their behaviours meet the standards, weakening their motivation to participate and cooperate in the innovation process. To deal with the high uncertainty and failure risk embedded in innovation, they tend to choose innovation projects with short-term visible output. Hence, we hypothesise that firms with tighter internal control invest less in innovation and produce patents of lower quality.

On the basis of the criteria for identifying internal control weaknesses in Chinese listed firms, this paper constructs a proxy for the strictness of internal control. *The Basic Standard for Enterprise Internal Control* (hereinafter, the "*Basic Standard*") requires listed firms to establish and maintain adequate internal controls and provide periodic self-evaluations of the adequacy of their internal control system. The identification criteria for internal control weaknesses are disclosed in the internal control self-evaluation reports. Stricter criteria for identifying internal control weaknesses indicate a higher possibility of firm activities being identified as having internal control weaknesses, and thus a tighter internal control system. Taking Chinese A-share listed firms from 2013 to 2017 as the sample, we find that both the innovation input and the proportion of invention patents in total patents decrease with the strictness of internal control. These results imply that relaxing the internal control system is, on average, conducive to innovation.

Cross-sectional tests show that the negative relation between the strictness of internal control and innovation is stronger in firms with more R&D staff and weakens for firms with specialised R&D centres and state-owned firms. These results suggest that tight internal

control stifles firm innovation mainly through creating negative incentives for R&D staff and that the effect of tight internal control is conditional on the strength of firms' implementation of internal control and organisation of innovation activities. In addition, our results indicate that incentivising employees with high compensation cannot alleviate the negative effects of tight internal control on innovation activities. Further results show that firms with tighter internal control are less able to convert their innovation output into improvements in operating performance.

The main contribution of this paper is to study the impact of internal control on firms' activities from the perspective of strictness and add to the literature on internal control. Mixed results have been found in previous studies on the relation between internal control quality and firm innovation. Gao and Zhang (2019) find that an enhanced internal control system imposes a financial burden and litigation risks on firms and decreases the number and quality of patents. The results of Li *et al.*'s (2019) study show that high-quality internal control discourages managers from taking high-risk projects, leading to less innovation, while Zhang *et al.* (2018) find that defective internal control also inhibits innovation. Using public data, this paper measures the strictness of internal control and finds that the strictness of internal control affects firm innovation after controlling for internal control quality. This implies that strictness, as a feature of the internal control system, is an important variable that has been omitted from previous internal control studies.

Second, this paper investigates the impact of negative incentives on innovation. Previous studies mainly focus on the relation between positive incentives for managers and employees and innovation. They find that increasing tolerance for failure and rewards for long-term success, extending the exercise period of equity incentives, and promoting pay equity within the management team motivate managers to pursue innovation (Baranchuk *et al.*, 2014; Ederer and Manso, 2013; Tian *et al.*, 2016). For non-executive employees, providing stock options fosters innovation through enhancing their risk-taking incentives (Chang *et al.*, 2015). This paper clarifies the relation between tight internal control and negative incentives and documents the negative impact of tight internal control on employees' role in innovation. Furthermore, we find that providing employees with positive incentives cannot alleviate the negative impact of tight internal control. These findings contribute to the incentive mechanism and innovation literature.

Third, this paper provides implications regarding the construction of an internal control system. Firms need to balance incentives and controls when constructing their internal control systems. While ensuring the effectiveness and efficiency of internal control, firms should also consider incentives for firm innovation so as to maximise firm value. At the economy level, relaxing control over individuals may contribute to innovation success.

The remainder of this paper proceeds as follows. Section II presents the institutional background, literature review, and hypotheses development. Section III describes the sample

and introduces our research design. The empirical results are presented in section IV, followed by additional results in section V. Finally, section VI concludes the paper.

II. Hypotheses Development

2.1 Institutional Background

The *Basic Standard* was announced jointly by the Ministry of Finance, the China Securities Regulatory Commission, the National Audit Office, the China Banking Regulatory Commission, and the China Insurance Regulatory Commission in June 2008. In April 2010, the ministries further issued the *Application Guidelines for Enterprise Internal Control*, *Guidelines for Assessment of Enterprise Internal Control* and *Guidelines for Audit of Enterprise Internal Control* (collectively, the "*Implementation Guidelines*") as the detailed guidelines for implementing the *Basic Standard*. The *Implementation Guidelines* are effective for companies listed on the main board of the Shanghai Stock Exchange and the Shenzhen Stock Exchange from 1 January 2012.

The *Basic Standard* is intended to increase the effectiveness of internal control in listed Chinese firms and eventually to reduce the risks for firms and their stakeholders. Chinese listed firms are required to conduct a self-assessment of their internal controls and report on that assessment on an annual basis. Within their internal control self-evaluation reports, they disclose the identification criteria for internal control weaknesses: that is, the criteria established by the firm to evaluate the effectiveness of the design and operation of their internal control system. Major weaknesses (重大缺陷), material weaknesses (重要缺陷), and general weaknesses (一般缺陷) are identified accordingly:[5] for example, when the direct damage to property caused by a violation event reaches the lower limit of the identification criteria for a major weakness, it is identified as a major weakness and the relevant unit or person responsible for the major weakness will be punished. When identifying internal control weaknesses, firms distinguish between internal control over financial reporting and non-financial reporting. Internal control over financial reporting is designed and implemented for financial reporting objectives, while internal control over non-financial reporting addresses other objectives, including strategic objectives, asset security, operational objectives, and compliance objectives.

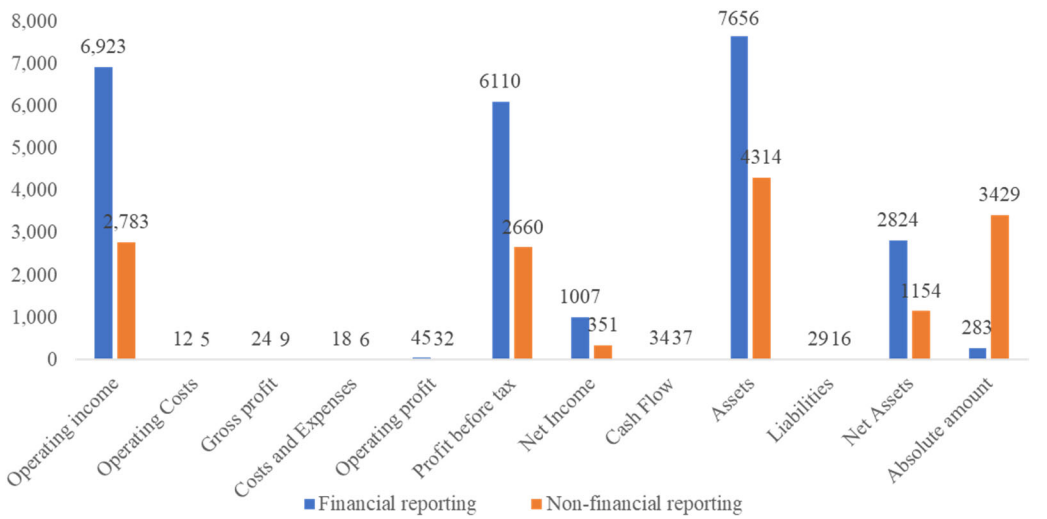
Quantitative and qualitative criteria are established for identifying internal control weaknesses. Qualitative criteria are expressed in words and related to business nature. For example, in its 2017 internal control self-evaluation report, Digital China Information Service

[5] *The Guidance on Evaluation of Internal Control of Enterprises* states that a major weakness is "a combination of one or more control weaknesses that may cause the firm to deviate significantly from the control objectives". A material weakness is "a combination of one or more control weaknesses whose severity and economic consequences are lower than those of a major weakness, but still has the potential to cause the firm to deviate from its control objectives". A general weakness refers to weaknesses other than major and material weaknesses.

Company Ltd. (000555) states that the firm should identify a major weakness if its control environment is ineffective, or managers have engaged in fraud, or its external auditors have detected a material misstatement in financial reporting. Quantitative criteria are divided into absolute value criteria and ratio criteria. The former are based on the absolute amount of direct property damage, while the latter refer to the ratio of direct property damage in financial benchmarks such as total assets and operating income.

Among the ratio criteria for identifying internal control weaknesses, there are seven financial benchmarks related to the income statement (operating income, operating costs, gross profit, costs and expenses, operating profit, profit before tax, and net profit), three financial benchmarks related to the balance sheet (assets, liabilities, and net assets), and one financial benchmark related to the cash flow statement (net cash flow from operating activities). Firms often use one or more financial benchmarks to develop ratio criteria for internal control weaknesses. Among firm-year observations which disclose the identification criteria for internal control weaknesses in financial reporting over the sample period 2013 to 2017, the most commonly used financial benchmark is assets (7,656 observations), followed by operating income (6,923 observations) and pre-tax profit (6,110 observations). Only 283 observations have disclosed absolute value criteria. In contrast, among firm-year observations which disclose the identification criteria for internal control weaknesses in non-financial reporting, there are relatively fewer observations which disclose ratio criteria and more with absolute value criteria (3,429 observations).

Figure 1 Statistics on the Identification Criteria of Internal Control Weaknesses in Listed Firms



R&D activities involve high risks and are a key focus of the internal control. *Application Guidelines for Enterprise Internal Control No. 10-Research and Development* emphasise that

when conducting R&D activities, firms should evaluate the adequacy of internal control in research plan formulation, R&D process management, and R&D output transformation and protection. In disclosed internal control reports, many firms list R&D activities as high-risk areas and elaborate on the internal control process of R&D activities. For instance, Digital China Information Service Company Ltd. (000555) points out in its 2017 internal control self-evaluation report that on the basis of its strategy and technology within the same industry, the firm would improve its R&D processes and formulate project management methods that are conducive to technology development. Some firms disclose internal control weaknesses related to R&D activities. Over the period 2013 to 2017, listed firms disclosed 3,316 internal control weaknesses in total, including 48 internal control weaknesses related to R&D activities.

2.2 Related Literature

2.2.1 Internal control

The existing literature mainly studies how the quality and disclosure of internal control affect a firm's operation as well as external stakeholders. The quality of internal control refers to its effectiveness in realising the firm's internal control objectives. There are three streams of literature regarding the impact of internal control quality on firms' activities. The first stream contends that firms with high-quality internal control effectively control risks. Lower internal control quality leads to higher investor risk expectations and thus more audit workload and higher audit fees (Hogan and Wilkins, 2008). The second stream argues that low-quality internal control reduces the quality of intra-firm information, resulting in inaccurate management forecasts (Feng *et al.*, 2009), inefficient decision-making (Cheng *et al.*, 2018), and supply chain disruption (Bauer *et al.*, 2018). The third stream contends that internal control serves as an important governance mechanism to constrain the management's ability to extract private benefits and expropriate shareholders. In firms with weaker internal control, because self-interested managers are more likely to extract rents from current shareholders, insider trading is more profitable (Skaife *et al.*, 2013) and investors have lower cash flow valuations (Gao and Jia, 2016).

The quality of internal control is affected by multiple factors in the construction and implementation of an internal control system. Some features of an internal control system, including strictness, have important impacts on employees and firm activities. Due to the lack of data on the design of internal control systems, there is limited empirical evidence regarding the relation between the features of internal control and firm activities. Some studies on control systems[6] discuss this topic theoretically. Adler and Borys (1996) propose that a control system with the following features will encourage employees to boost firm value. First,

[6] Compared to internal control system, control system is a much broader concept. Control systems refer to systems of monitoring, sanctioning, and rewarding (Seal *et al.*, 1999).

employees can observe how the control system functions and its subordinate behaviour (internal and global transparency). Second, the control system can be adjusted according to special work needs of employees (flexibility). Third, when the control system is not compatible with the firm's operation, employees can repair it (repair). If the internal control system does not have the above features and only reflects the supervision or control of the decision makers, this formal institution will exert a negative impact on employee behaviour.

Building on prior literature, we focus on the strictness of the internal control system, an underexplored topic in the literature. When a firm constructs a tight internal control system to improve its operating efficiency, it sets limits on the flexibility of employee behaviour.

2.2.2 Employees and innovation

Although it is difficult for employees to participate in innovation decision-making, they contribute an important force in the formation of innovation ideas and the execution of innovation decisions (Chang *et al.*, 2015; Chen *et al.*, 2016). Creative employees with specialised skills are the main source of new ideas and knowledge within the firm. In addition, employees are in charge of the execution of innovation decisions. The individual efforts, teamwork, and stability of employees in innovation activities greatly affect the innovation efficiency of the firm (Dougherty, 1992; Van de Ven, 1986). Information feedback from employees during the execution of innovation decisions helps the management to adjust decisions in a timely manner, thus reducing trial and error costs. Incentives provided by the firm for its employees affect their performance in innovation activities. Positive incentives (or the bonus contract in the literature on contract framework) refer to incentives that encourage employees to behave in line with firm value, while negative incentives (or the penalty contract in the literature on contract framework) refer to penalties on employees' behaviours that harm firm value (Lazear, 1991).

Empirical studies have identified various measures taken by firms to provide positive incentives for employees to motivate them to innovate, such as increasing labour protection (Ballot *et al.*, 2001), providing equity-based incentives (Chang *et al.*, 2015), and offering employee-friendly workplaces (Chen *et al.*, 2016). Our study complements this strand of literature by exploring the negative incentive effect of tight internal control on firm innovation.

2.3 Hypotheses

Innovation is important for establishing firms' competitive advantages. A key input in the innovation process is human capital. The role of managers as decision makers is highlighted in the existing research on innovation, while employees have a unique role different from that of managers. We analyse how the strictness of internal control affects the behaviour of both managers and employees and then the firm's innovation input and innovation quality. Strictness of internal control refers to the intensity of the firm's control over various activities, including innovation.

2.3.1 The agency-behaviour perspective

Firm innovation is affected by the agency behaviour of managers and employees. Stein (2003) divides agency problems that have the most direct implications for investment into four types: empire building, reputational and career concerns, the quiet life, and overconfidence. Here, we focus on agency problems that cause underinvestment.

First, managers and employees have strong incentives to avoid risk in order to protect their under-diversified, firm-specific wealth. Because the innovation process is characterised by the unpredictability of outcomes and high probability of failure (Holmstrom, 1989), risk-averse agents[7] are not willing to engage in innovation activities, thereby hindering firm innovation. Second, agents' preference for the quiet life is another source of agency conflict that results in underinvestment. Managers are prone to excessive inertia when it comes to making tough innovation decisions, and employees may not exert as much effort in innovation activities as they would in other activities. Third, agents concerned with their compensation or labour-market reputations may show short-termism and take actions that boost short-term firm performance at the expense of long-term shareholder value (Narayanan, 1985). When their compensation is associated with accounting profits or market returns, they may decrease innovation investment in pursuit of short-term firm performance.

Tight internal control constrains the above agency behaviours. Tight internal control requires supervision over the entire R&D process and the effective allocation of R&D staff. Tighter standards are adopted to regulate agents' behaviour and ensure that agents act in the interest of shareholders, thereby restraining underinvestment due to agents' risk aversion or preference for the quiet life or to managers' short-termism. Hence, we expect that tight internal control increases firms' investment in innovation.

In addition to decisions on whether to invest in innovation, agency conflicts also affect the selection of innovation projects. The three sources of agency conflicts discussed above explain why some firms tend to choose innovation projects with short-term visible output. Due to adequate prevention and detection mechanisms, tight internal control limits the agency problems during the selection of innovation projects. In firms with tighter internal control, the agents' behaviours are more consistent with the goal of maximising shareholder benefits, and thus the managers are more likely to select high-quality innovation projects and employees work harder in the implementation of high-quality innovation projects. Therefore, we expect that tight internal control improves innovation quality through restricting agency behaviour.

2.3.2 The negative incentive perspective

Tight internal control creates negative incentives for employees. One component of an internal control system is the punishment for non-conforming behaviours. Under tighter

[7] Since both managers and employees are agents within the firm and perform services on behalf of shareholders, we use agents to refer to managers and employees.

internal control, employees are more likely to be punished for not meeting the defined standards.

Innovation is a long-term, multistage, and complex process that requires employee engagement. In firms with tight internal control, it is difficult to pursue innovation activities because uncertainty and failure risks are required to be kept at a low level. This sets high requirements for R&D staff as they need to make more efforts in identifying and controlling potential risks before and during the innovation process. Thus, employees are less motivated to carry out innovation activities. Because successful innovation requires great human capital input from employees, tight internal control hinders firm innovation through discouraging employees from participating in risky activities.

In addition, under tighter internal control, there is more mutual supervision between the upper and lower levels of the firm. It is more difficult for employees to share information and cooperate, hindering firm innovation. In the long run, there is a two-way match between firms and employees. Tight internal control compresses the space for innovation activities by weakening employee autonomy, making it difficult for firms to attract and retain employees with innovative capabilities and willingness and further inhibiting innovation activities.

Similarly, innovation quality is lower in firms with tighter internal control because of the negative incentives it provides. High-quality innovation projects require great resource inputs, information sharing, and teamwork, and the probability of failure is high. When internal control is tighter, employees involved in these projects are more likely to be punished for behavioural deficiencies in the innovation process. Thus, in order to avoid penalties, employees tend to choose innovation projects with visible innovation output in the short term, while ignoring the long-term value of innovation.

To sum up, tight internal control reduces the agency behaviour of management and employees and fosters firm innovation, while weakening employees' motivation to carry out innovation activities, making it difficult for firms to promote large-scale innovation. Hence, we propose hypotheses 1a and 1b as competing hypotheses.

Hypothesis 1a: Strictness of internal control is positively related to investment in innovation.

Hypothesis 1b: Strictness of internal control is negatively related to investment in innovation.

The analysis above shows that tight internal control helps to decrease agency costs within the firm, motivating managers to select high-quality innovation projects and employees to put sufficient efforts into high-quality innovation projects. However, tight internal control leads to lower innovation quality due to the negative-incentive effect on employees. This yields the following competing hypotheses:

Hypothesis 2a: Strictness of internal control is positively related to innovation

quality.

Hypothesis 2b: Strictness of internal control is negatively related to innovation quality.

III. Research Design and Descriptive Statistics

3.1 Sample

The initial sample of this paper is comprised of all the A-share listed firms on the Shenzhen and Shanghai stock exchanges over the period 2013 to 2017. Since 2009, Chinese listed firms have begun to disclose the identification criteria for internal control weaknesses in their internal control self-evaluation reports. In 2012, all firms listed on the main board started the construction of internal control systems. Thus, our sample begins with the fiscal year 2013. From 15,200 firm-year observations, we exclude 53 observations with net assets less than 0, 1,757 observations before or during IPO, 1,137 observations with missing variables for internal control weaknesses, and 584 observations with other missing variables. Our final sample contains 11,669 firm-year observations. Sample-selection procedures are shown in Table 1.

Our primary data source is the China Stock Market and Accounting Research (CSMAR) database, the most commonly used academic database covering Chinese listed firms. We manually collect the criteria for identifying internal control weaknesses from the internal control self-evaluation report and the information about the firm's ultimate controller from the annual report. Data on internal control quality are obtained from the DIB database. The regional per capita salary data come from the website of the National Bureau of Statistics.

Table 1 Sample Selection

Selection criteria	Firm-years
A-share non-financial listed firms from 2013 to 2017	15,200
Less: Observations with negative net assets	(53)
Less: Observations before listing or just listed	(1,757)
Less: Observations with missing variables for internal control weaknesses	(1,137)
Less: Observations with other missing variables	(584)
Final sample	11,669

3.2 Variables and Models

3.2.1 Strictness of internal control

On the basis of the identification criteria for internal control weaknesses, we construct a proxy for the strictness of internal control. We use the quantitative criteria for identifying internal control weaknesses in the financial reporting of listed firms for the following reasons.

First, the identification criteria for internal control weaknesses in financial reporting are highly consistent with those in non-financial reporting.[8] Second, among firm-year observations which disclose the identification criteria for internal control weaknesses over the sample period 2013 to 2017, an average of 2.143 quantitative criteria are used in the identification of internal control weaknesses in financial reporting, and the ratio criteria are more frequently used (as shown in Figure 1). In contrast, an average of 1.368 quantitative criteria are used in the identification of internal control weaknesses in non-financial reporting, and absolute value criteria[9] are more frequently used. Hence, the identification criteria for internal control weaknesses in financial reporting involve more dimensions and are more comparable across firms. Third, compared with quantitative criteria, qualitative criteria define the severity of weaknesses through non-quantitative methods, such as whether or not senior management has committed fraud. To facilitate measurement and testing, this paper uses quantitative criteria.

We manually collect the lower limit of quantitative criteria for major weaknesses in firms' financial reporting,[10] convert each ratio criterion into an absolute value using annual report data, remove the negative value, and take the minimum value among all criteria (including absolute value criteria, if any). We divide this minimum value by current operating income and take the opposite as the measure for strictness of internal control. Since the strictness of a firm's internal control remains consistent over a period, this paper measures strictness of internal control (*Tight*) using the identification criteria for internal control weaknesses first disclosed by the firm. If there is a change in identification criteria, the changed *Tight* is applied for years after the change. In firms with a larger *Tight*, the possibility of employees' behaviour being identified as having internal control weaknesses is higher and the firm's internal control is tighter.[11] Since there may be noise and measurement errors in the proxy for strictness of internal control, we further discuss the rationality of *Tight* in section 4.4.

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[8] We also use the quantitative criteria for identifying internal control weaknesses in non-financial reporting to construct the proxy for strictness of internal control, *Tight_nonfin*. The correlation coefficient between *Tight_nonfin* and *Tight* is 0.569, significant at the 1% level.

[9] The use of absolute value criteria can involve complex conditions. There can be multiple absolute value criteria in one firm-year observation. For instance, Oceanwide Holdings Co. (000046) discloses its identification criteria for internal control weaknesses in financial reporting in the 2013 fiscal year, and the identification of material weaknesses involves two absolute value criteria: (1) when gross profit is not higher than 600 million, the quantitative criteria for material weaknesses is that the misstatement in gross profit should be higher than 30 million and lower than 60 million; (2) the misstatement in operating income should be higher than 50 million and lower than 100 million.

[10] In robustness tests, we use the lower limit of the quantitative criteria for material weaknesses in the firm's financial reporting to measure strictness of internal control (*Tight1*), and control the difference between the lower limit of the quantitative criteria for major weaknesses and that for material weaknesses (*Gap*). The conclusions remain unchanged.

[11] We argue that *Tight* can be used to measure a firm's internal control strictness and exert an impact on the firm's various activities, including R&D. If the internal control system is inconsistent across departments (i.e. if the firm has special internal control systems for the innovation department), its innovation activities should be less or not affected by the firm's internal control standards. This weakens our results. If we obtain significant and robust results in spite of this, our theoretical hypotheses are strongly supported.

We take Xiwang Food (000639) as an example to further illustrate *Tight*. Table 2 shows this firm's identification criteria for internal control weaknesses in financial reporting which are disclosed in its 2013 internal control self-evaluation report. In its identification criteria for internal control weaknesses in financial reporting, the firm discloses two ratio criteria using net profit and net assets as the financial benchmark, respectively, and one absolute value criterion. The lower limits of the criteria for major weaknesses in absolute value are 9.048, 11.583, and 20, respectively. Hence, the minimum absolute value is 9.048. We divide the minimum absolute value by operating income and take the opposite as *Tight*: that is, -0.373%. Xiwang Food experiences changes in identification criteria for internal control weaknesses in both 2014 and 2017. The value of *Tight* after the changes is -0.314% for 2014 and -0.425% for 2017. Thus, the value of *Tight* applicable to the fiscal year 2013 is -0.373%, the value of *Tight* applicable over the period 2014 to 2016 is -0.314%, and the value of *Tight* applicable after 2017 is -0.425%.

Table 2 The Identification Criteria for Internal Control Weaknesses in the Financial Reporting of Xiwang Food (000639) (in millions)

Quantitative criteria	**Amount**	**Identification criteria for internal control weaknesses in financial reporting**	
		Lower limit of criteria for major weaknesses in ratios	Lower limit of criteria for major weaknesses in absolute value
Net profit	180.95	5%	9.048
Net assets	1158.27	1%	11.583
Absolute value			20
		Minimum absolute value	**9.048**
		Operating income	**2427.330**
		Tight	**-(9.048/2427.330) = -0.373%**

Source: Xiwang Food (000639) 2013 Internal Control Self-Evaluation Report.

3.2.2 Innovation

Following existing literature (Chen *et al.*, 2016; Kang *et al.*, 2020), this paper uses R&D input to measure a firm's innovation investment (*Rd*), and patent count (*Ln(1+Patent)*) and invention patent count (*Ln(1+Invent)*) to measure its innovation output. Although innovation output is not directly observable, the patents that firms apply for and are eventually granted offer a good indicator of firms' innovation success.[12] Firm-years with missing R&D input and patent output are assigned the value zero in the main tests.[13]

[12] Patent applications filed in later years of the sample period, such as 2017, are still pending. This affects the comparability of the innovation output measure. To alleviate this problem, we control for the year fixed effect in the baseline regressions. In robustness tests, we use the number of current patent applications and the number of current patent applications granted in the current year to measure innovation output.

[13] In robustness tests, we drop observations with missing R&D input or patent information, and the results are qualitatively the same as our baseline results.

A simple patent count captures innovation performance imperfectly because patents vary considerably in technological and economic significance. An increase in patent count does not necessarily mean a rise in innovation quality. Thus, we measure innovation quality using the proportion of invention patents in total patent grants (*Invr*). Patent law in China divides patents into invention patents, utility model patents, and design patents. As invention patents highlight new technology development beyond existing expertise while the other two categories involve relatively limited technological advancements, this ratio captures innovation quality.

We use equation (1) to examine the relation between strictness of internal control and innovation investment. Equation (2) is used to examine the relation between strictness of internal control and innovation output as well as innovation quality, with *Ln(1+Patent)*, *Ln(1+Invent)*, and *Invr* as the dependent variable, respectively. Following Hirshleifer *et al.* (2012), we control for innovation input measured using *Ln(1+Rd)* in equation (2). In addition, since we focus on the strictness of internal control, we control for the effect of internal control quality (*ICQ*) in equations (1) and (2). *ICQ* is measured using the DIB internal control index.

$$Rd_{i,t} = \beta_0 + \beta_1 \times Tight_{i,t} + \beta_2 \times ICQ_{i,t} + \beta_3 \times Other\ \ Controls_{i,t} + \sum Industry + \sum Year + \varepsilon \quad (1)$$

$$Ln(1+Patent)_{i,t}\ \ or\ \ Ln(1+Invent)_{i,t}\ \ or\ \ Invr_{i,t} = \beta_0 + \beta_1 \times Tight_{i,t} + \beta_2 \times Ln(1+Rd)_{i,t} + \beta_3 \times ICQ_{i,t} + \beta_4 \times Other\ \ Controls_{i,t} + \sum Industry + \sum Year + \varepsilon \quad (2)$$

In all of our regression specifications, we control for the firm's basic characteristics, including profitability (*Roa*), financial leverage (*Lev*), asset size (*Size*), growth (*Btm*), tangible asset intensity (*Tang*), age (*Age*), and non-state ownership (*Nonsoe*). Balsmeier *et al.* (2017) find that firms that transition to independent boards increase innovation investment, but the innovation is concentrated in familiar areas. Aghion *et al.* (2013) find that institutional shareholding reduces management's career risk and thus promotes firm innovation. Hence, attributes of corporate governance, including CEO duality (*Dual*), board independence (*Indratio*), and institutional shareholding (*Inst*), are controlled.

We follow Koh and Reeb (2015) to address the issue of "missing R&D" and add an indicator for missing R&D firms (*Rdmiss*) into our model. In the main tests, we adopt a Tobit regression with the left truncation of 0 and present the results based on standard errors clustered by firm. Year and industry fixed effects are controlled. All continuous variables are winsorised at the 1st and 99th percentiles. Variable definitions are provided in the appendix.

3.3 Descriptive Statistics

Table 3 reports the descriptive statistics for all variables used in the regressions. The minimum value of *Rd* is 0, the median value is 0.027, and the maximum value is 0.231, indicating that most observations have a low level of innovation investment. *Ln(1+Patent)*

has a mean value of 2.193 and *Ln(1+Invent)* has a mean value of 0.893, suggesting that sample firms receive an average of 7.962 patent grants and 1.442 invention patent grants among patent applications in the current year. Since some observations do not disclose patents, the number of observations of *Invr* is 8,693. Its mean value is 0.215, indicating that the average percentage of invention patent grants within all patent grants is 21.5%. *Tight* has a minimum value of -0.100, a median value of -0.008, and a mean value of -0.013. *Tight* presents a negative skewed distribution, and most sample firms have relatively tight internal control.

Among the control variables, *Tightnum* has a mean value of 1.864, suggesting that the sample firms have an average of 1.864 identification criteria for internal control weaknesses in financial reporting. *Rdmiss* has a mean value of 0.214, indicating that 21.4% of firm-year observations do not disclose R&D input. The mean values of *Inddiv* and *Subnum* are 0.456 and 2.414, respectively, showing that the average number of industries the sample firms operate in is 1.578 and they have an average of 11.179 subsidiaries.

Table 3 Summary Statistics

Variable	N	Mean	S.D.	Min	Median	Max
A. Main variables						
Rd	11,669	0.033	0.041	0.000	0.027	0.231
Ln(1+Patent)	11,669	2.193	1.730	0.000	2.303	6.597
Ln(1+Invent)	11,669	0.893	1.215	0.000	0.000	5.043
Invr	8,693	0.215	0.289	0.000	0.091	1.000
Tight	11,669	-0.013	0.016	-0.100	-0.008	0.000
B. Control variables						
ICQ	11,669	0.627	0.147	0.000	0.659	0.809
Tightnum	11,669	1.864	1.225	0.000	2.000	4.000
Rdmiss	11,669	0.214	0.410	0.000	0.000	1.000
Roa	11,669	0.075	0.055	-0.111	0.071	0.245
Lev	11,669	0.181	0.161	0.000	0.153	0.634
Size	11,669	22.220	1.269	19.630	22.060	26.020
Btm	11,669	0.380	0.262	0.027	0.317	1.409
Tang	11,669	0.259	0.190	0.002	0.219	0.788
Inddiv	11,669	0.456	0.617	0.000	0.000	2.079
Subnum	11,669	2.414	0.968	0.000	2.398	4.875
Ceochng	11,669	0.201	0.401	0.000	0.000	1.000
Dual	11,669	0.256	0.436	0.000	0.000	1.000
Indratio	11,669	0.375	0.053	0.333	0.333	0.571
Inst	11,669	0.067	0.068	0.000	0.046	0.318
Age	11,669	2.099	0.859	0.000	2.303	3.296
Nonsoe	11,669	0.612	0.487	0.000	1.000	1.000
C. Other variables						
Rdcenter	11,669	0.141	0.348	0.000	0.000	1.000
Rdstaff	11,669	0.164	0.170	0.000	0.121	0.800
Salary	11,669	0.363	0.452	-0.722	0.329	1.770
Atight	11,669	-0.041	0.030	-0.100	-0.036	-0.001
⊿margin	11,669	-0.025	0.243	-1.562	-0.001	0.843

Table 4 reports the Pearson correlation coefficients among our variables of interest. The correlation coefficient between *Tight* and *ICQ* is significantly positive, suggesting that the strictness of internal control and internal control quality are positively related. The correlation coefficient between *Tight* and *Rd* (*Invr*) is significantly positive, supporting our hypothesis 1b (2b). The correlation coefficient between *ICQ* and *Rd* (*Invr*) is also significantly positive, indicating that high internal control quality contributes to firm innovation.

The coefficients between innovation and other variables suggest that firms with a higher proportion of R&D staff or non-state-owned firms make more innovation investment. Firms with specialised R&D centres have more innovation investment and higher innovation quality. In addition, the correlation coefficient between *Salary* and *Rd* is positive but not significant, while the correlation coefficient between *Salary* and *Invr* is significantly positive. This shows that a high salary encourages high-quality innovation, but excessive salaries decrease the resources available for innovation investment.

Table 4 Correlation Matrix

	Rd	*Invr*	*Tight*	*ICQ*	*Nonsoe*	*Rdcenter*	*Rdstaff*
Invr	0.081***						
Tight	-0.095***	-0.021**					
ICQ	0.034***	0.050***	0.082***				
Nonsoe	0.245***	-0.018*	-0.106***	0.00200			
Rdstaff	0.098***	-0.001	0.005	0.031***	0.044***		
Rdcenter	0.361***	0.165***	-0.043***	0.078***	0.022**	0.032***	
Salary	0.000	0.042***	0.030***	0.054***	-0.265***	-0.021**	0.177***

*, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively.

IV. Results

4.1 Determinants for Strictness of Internal Control

The existing literature on determinants for internal control quality finds that in firms with stronger employee protection (Guo *et al.*, 2016), a more independent board (Goh, 2009), audit committees with more financial and supervision experience (Naiker and Sharma, 2009), audit partners with longer tenure (Fitzgerald *et al.*, 2018), and auditor-provided tax services (De Simone *et al.*, 2015), the quality of internal control is higher. This paper focuses on the strictness of internal control. The above factors affecting internal control quality do not necessarily have an impact on the strictness of internal control. Table 5 reports the results from the regression of *Tight* on the determinants for strictness of internal control.

The results in column (1) are based on the full sample, while column (2) only keeps observations that disclose identification criteria for internal control weaknesses for the first time or change the criteria. Since we measure strictness of internal control on the basis of the

identification criteria for internal control weaknesses first disclosed or changed by the firm, column (2) better reflects the factors considered by a firm when constructing or redesigning its internal control system. In column (1), the regression coefficient on *Tightnum* is significantly positive, indicating that firms with tighter internal control use more criteria for the identification of internal quality weaknesses in financial reporting. *Atight* is the auditors' lower limit of tolerance for strictness of internal control, and its regression coefficient is significantly positive. This validates the influence of auditors on firms' internal control strictness.

We measure firm risk-taking using managers' R&D background (*Mngrd*) and firms' earnings volatility (*SDRoa*). Previous research (Yu *et al.*, 2018; Zhang *et al.*, 2021) shows that firms take more risks when managers have an R&D background. The coefficient on *Mngrd* is negative but not significant, and the coefficient on *SDRoa* is negative, significant at the 1% level. This proves that firms with a higher level of risk-taking adopt looser internal control.

Table 5 Determinants for Strictness of Internal Control

Variable	Full sample (1) *Tight*×100		Subsample (2) *Tight*×100	
	Coefficient	t statistic	Coefficient	t statistic
Tightnum	**0.178*** **	**(10.448)**	**0.212*** **	**(9.241)**
***Atight*×100**	**0.149*** **	**(10.723)**	**0.349*** **	**(13.185)**
Mngrd	-0.074	(-1.240)	-0.085	(-1.164)
SDRoa	**-4.063*** **	**(-3.989)**	**-8.693*** **	**(-4.519)**
Roa	**1.161*** **	**(2.647)**	**2.139*** **	**(3.583)**
Lev	0.193	(0.961)	0.476**	(2.153)
Size	0.101***	(3.102)	0.047	(1.133)
Btm	-0.163	(-1.214)	0.019	(0.116)
Tang	0.533***	(2.697)	0.181	(0.786)
Inddiv	0.049	(1.294)	0.050	(1.106)
Subnum	**0.134*** **	**(4.459)**	**0.099** **	**(2.569)**
Ceochng	0.050	(1.402)	0.071	(1.062)
Dual	-0.004	(-0.075)	0.039	(0.591)
Indratio	-0.424	(-0.990)	-0.512	(-1.029)
Inst	0.053	(0.148)	-0.119	(-0.286)
Age	-0.050	(-1.308)	-0.040	(-1.040)
Nonsoe	**-0.227*** **	**(-3.434)**	**-0.178** **	**(-2.499)**
Constant	-3.602***	(-5.164)	-2.065**	(-2.384)
Industry fixed effects	Yes		Yes	
Year fixed effects	Yes		Yes	
Observations	11,647		2,545	
Adjusted R-squared	0.163		0.336	

*, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. OLS regression is adopted, and standard errors are clustered at firm level.

The coefficients on the control variables show that in firms with higher profitability and more subsidiaries, internal control is tighter. In addition, internal control is tighter in state-owned firms, probably because state-owned firms are more influenced by internal control regulations and assessments. The results in column (2) support the above analysis. It is worth mentioning that the coefficient on *Lev* is significantly positive, suggesting that firms establish or change internal control standards under the influence of creditors.

4.2 Strictness of Internal Control and Innovation Investment[14]

Table 6 reports the results from the regression of innovation investment on strictness of internal control. The regression coefficient on our variable of interest, the strictness of internal control (*Tight*), is -0.188, significant at the 1% level. The coefficient on internal control quality (*ICQ*) is positive but not significant. The results indicate that an increase of one standard deviation in strictness of internal control is associated with 9.115% (=coefficient on *Tight*×S.D. of *Tight* /mean of *Rd* =-0.188×0.016/0.033) less innovation investment. This shows that firms' internal control strictness acts on innovation mainly through creating negative incentives for employees, supporting our hypothesis 1b.

Table 6 Strictness of Internal Control and Innovation Investment

Variable	*Rd*	
	Coefficient	t statistic
Tight	**-0.188*** **	**(-3.337)**
ICQ	0.002	(0.441)
Rdmiss	-0.273***	(-32.226)
Roa	-0.077***	(-6.657)
Lev	-0.034***	(-8.373)
Size	-0.002***	(-2.727)
Btm	-0.007***	(-2.719)
Tang	0.003	(0.751)
Inddiv	-0.003***	(-3.865)
Subnum	0.001	(0.956)
Ceochng	-0.002**	(-2.103)
Dual	0.002*	(1.748)
Indratio	0.028***	(2.600)
Inst	0.025***	(3.321)
Age	-0.004***	(-5.250)
Nonsoe	0.002	(1.087)
Constant	0.072***	(4.320)
Industry fixed effects	Yes	
Year fixed effects	Yes	
Observations	11,669	
Pseudo R-squared	-0.488	

*, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Tobit regression is adopted, and standard errors are clustered at firm level.

[14] We also adopt OLS regression in the baseline results. With *Rd* as the dependent variable, the regression coefficient on *Tight* is -0.113, significant at the 1% level, which also supports our hypothesis that there is a negative relation between strictness of internal control and innovation investment.

The coefficients on the control variables are generally consistent with the prior literature. Firms with a lower debt ratio, higher growth, and a shorter listing period invest more in innovation. The coefficients on the corporate governance variables show that investment in innovation is higher in firms with more independent directors, more institutional ownership, and the CEO chairing the board. The coefficient on *Inddiv* is significantly negative, indicating that more diversified firms invest less in innovation, probably due to the crowding out effect of diversification investment on innovation investment. In addition, CEO change is accompanied by a decline in innovation investment.

4.3 Strictness of Internal Control and Innovation Quality[15]

The dependent variables in columns (1) and (2) of Table 7 are *Ln(1+Patent)* and *Ln(1+Invent)*. The coefficients on *Tight* are not significant in either column (1) or column (2), suggesting that the strictness of internal control does not have a significant impact on patent output. Since patents vary considerably in technological and economic significance, we further examine the impact of tight internal control on innovation quality.

Table 7 Strictness of Internal Control and Innovation Quality

Variable	(1) *Ln(1+Patent)*		(2) *Ln(1+Invent)*		(3) *Invr*	
	Coefficient	t statistic	Coefficient	t statistic	Coefficient	t statistic
Tight	**0.988**	**(0.590)**	**-0.251**	**(-0.153)**	**-0.810****	**(-2.136)**
Ln(1+Rd)	0.337***	(14.036)	0.348***	(13.087)	0.033***	(6.201)
ICQ	0.560***	(4.064)	0.704***	(4.510)	0.087**	(2.322)
Rdmiss	4.050***	(10.095)	4.641***	(10.459)	0.517***	(5.285)
Roa	0.683*	(1.744)	0.291	(0.689)	-0.078	(-0.701)
Lev	-0.548***	(-2.944)	-0.648***	(-3.342)	-0.055	(-1.234)
Size	0.374***	(9.378)	0.369***	(8.558)	0.015*	(1.939)
Btm	-0.103	(-0.848)	-0.415***	(-3.173)	-0.093***	(-3.536)
Tang	-0.170	(-0.976)	-0.136	(-0.799)	-0.001	(-0.031)
Inddiv	0.047	(1.361)	0.011	(0.308)	-0.009	(-1.108)
Subnum	0.256***	(8.541)	0.184***	(6.041)	-0.004	(-0.593)
Ceochng	-0.002	(-0.050)	-0.033	(-0.827)	-0.003	(-0.261)
Dual	0.035	(0.739)	0.015	(0.308)	0.007	(0.562)
Indratio	-0.447	(-1.143)	-0.114	(-0.277)	-0.114	(-1.262)
Inst	0.880***	(2.737)	0.806***	(2.591)	0.056	(0.807)
Age	-0.115***	(-3.748)	-0.107***	(-3.370)	-0.013*	(-1.804)
Nonsoe	-0.129**	(-2.228)	-0.228***	(-3.907)	-0.036***	(-2.677)
Constant	-12.880***	(-18.477)	-13.701***	(-18.662)	-0.462***	(-3.011)
Industry fixed effects	Yes		Yes		Yes	
Year fixed effects	Yes		Yes		Yes	
Observations	11,669		11,669		8,693	
Pseudo R-squared	0.214		0.256		0.376	

*, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Tobit regression is adopted, and standard errors are clustered at firm level.

[15] We also adopt OLS regression in the baseline results. With *Invr* as the dependent variable, the regression coefficient on *Tight* is -0.574, significant at the 5% level, which also supports our hypothesis that there is a negative relation between strictness of internal control and innovation quality.

In column (3), with *Invr* as the dependent variable, the regression coefficient on *Tight* is -0.810, significant at the 5% level. An increase of one standard deviation in strictness of internal control is associated with 6.028% (=coefficient on *Tight*×S.D. of *Tight* /mean of *Invr* =-0.810×0.016/0.215) lower innovation quality. This indicates that when internal control is tighter, employees choose more projects aimed at non-invention patents, supporting hypothesis 2b.

In all columns, the regression coefficients on *ICQ* are significantly positive, indicating that high-quality internal control contributes to a rise in innovation output and innovation quality. Although strictness of internal control is positively related to internal control quality, the mechanism by which strictness of internal control affects innovation activities differs from that of internal control quality. In addition, firms with lower debt ratios, more subsidiaries, and more institutional ownership have more innovation output. These firms' basic characteristics have no significant impact on innovation quality. Moreover, for firms with a larger asset size and shorter history and for state-owned firms, both innovation output and innovation quality are higher.

4.4 Robustness Tests

4.4.1 Measuring strictness of internal control

One of our contributions to the existing literature is measuring the strictness of internal control. In the baseline regressions, we construct a proxy for strictness of internal control based on identification criteria for internal control weaknesses in financial reporting. Table 8 shows the regression results when we use the identification criteria for internal control weaknesses in non-financial reporting to construct the proxy. We still find that with tighter internal control, firms have less innovation investment and lower innovation quality, supporting hypotheses 1b and 2b.

Table 8 Alternative Measures for Strictness of Internal Control: *TIGHT_NONFIN*

Variable	(1) *Rd*	(2) *Ln(1+Patent)*	(3) *Ln(1+Invent)*	(4) *Invr*
Tight_nonfin	**-0.075****	**-0.290**	**-0.693**	**-0.454****
	(-2.489)	**(-0.384)**	**(-1.571)**	**(-2.254)**
ICQ	0.006**	0.309***	0.189***	0.041*
	(2.411)	(3.046)	(2.842)	(1.930)
Ln(1+Rd)		0.334***	0.212***	0.014***
		(17.389)	(15.270)	(3.931)
Constant	0.061***	-10.265***	-6.995***	0.157
	(4.489)	(-17.496)	(-15.877)	(1.463)
Other controls	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	11,003	11,003	11,003	8,175
Pseudo R-squared	-0.182	0.208	0.191	1.052

All regressions are Tobit regressions with robust standard errors clustered by firm, and t-statistics are reported in parentheses. All control variables are included but not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively.

Firms usually use multiple financial benchmarks when establishing identification criteria for internal control weaknesses. In the calculation of the main proxy, we convert each ratio criterion into an absolute value using annual report data and take the minimum value. To eliminate the scale effect, we divide it by the operating income. This calculation process may result in a biased measure of internal control strictness for some firms. To avoid measurement bias, we also adopt the lower limit of the ratio criteria for identifying major weaknesses in financial reporting and take their opposite as direct measures of internal control strictness. *Tight_sale*, *Tight_ebt*, and *Tight_ta* take the opposite of the lower limit of the ratio criteria based on operating income, operating profit, or total assets, respectively. Table 9 reports the regression results, and the conclusions remain unchanged.

Table 9 Alternative Measures for Strictness of Internal Control: *TIGHT_SALE*, *TIGHT_EBT,* and *TIGHT_TA*

Variable	(1) *Rd*	(2) *Invr*	(3) *Rd*	(4) *Invr*	(5) *Rd*	(6) *Invr*
Tight_sale	**-0.094***	**-0.937****				
	(-1.897)	**(-2.397)**				
Tight_ebt			**-0.014**	**-0.028**		
			(-0.322)	**(-0.088)**		
Tight_ta					**-0.103**	**-1.076****
					(-1.575)	**(-2.006)**
ICQ	0.016***	0.097**	0.007	0.131**	0.015***	0.106**
	(3.062)	(1.972)	(1.179)	(2.280)	(3.049)	(2.288)
Ln(1+Rd)		0.006***		0.004***		0.006***
		(3.639)		(2.596)		(3.718)
Constant	0.005	-0.413**	0.033	-0.171	-0.007	-0.374*
	(0.203)	(-1.964)	(1.295)	(-0.773)	(-0.330)	(-1.912)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,171	4,659	5,233	3,814	6,719	5,067
Pseudo R-squared	-0.294	0.389	-0.342	0.393	-0.293	0.393

All regressions are Tobit regressions with robust standard errors clustered by firm, and t-statistics are reported in parentheses. All control variables are included but not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively.

To control for the effect of firm-level characteristics on the strictness of internal control, we regress *Tight* on *ICQ* and other firm-level characteristics, including *Tang*, *Inddiv*, *Subnum, Ceochng*, *Age*, and *Nonsoe*, as shown in equation (3). We estimate equation (3) for each industry-year with at least 20 observations and take the residual, *Resi_tight*, as an alternative proxy for strictness of internal control. *Resi_tight* is larger in firms with tighter internal control.

$$\begin{aligned} Tight_{i,t} = {} & \beta_0 + \beta_1 \times ICQ_{i,t-1} + \beta_2 \times Tang_{i,t-1} + \beta_3 \times Inddiv_{i,t-1} \\ & + \beta_4 \times Subnum_{i,t-1} + \beta_5 \times Ceochng_{i,t-1} + \beta_5 \times Age_{i,t-1} \\ & + \beta_5 \times Nonsoe_{i,t-1} + \varepsilon \end{aligned} \quad (3)$$

Table 10 reports the results with *Resi_tight* as the independent variable. When the dependent variable is *Rd* or *Invr*, the regression coefficients on *Resi_tight* are significantly negative, consistent with our main findings.

Table 10 Alternative Measures for Strictness of Internal Control: *RESI_TIGHT*

Variable	(1) *Rd*	(2) *Ln(1+Patent)*	(3) *Ln(1+Invent)*	(4) *Invr*
Resi_tight	**-0.192*** **	**-0.159**	**-1.278**	**-0.919** **
	(-3.292)	**(-0.087)**	**(-0.725)**	**(-2.236)**
ICQ	0.001	0.566***	0.707***	0.087**
	(0.380)	(4.118)	(4.534)	(2.304)
Ln(1+Rd)		0.338***	0.349***	0.033***
		(14.077)	(13.102)	(6.179)
Constant	0.078***	-12.921***	-13.701***	-0.438***
	(4.730)	(-18.576)	(-18.680)	(-2.883)
Other controls	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	11,669	11,669	11,669	8,693
Pseudo R-squared	-0.488	0.214	0.256	0.376

All regressions are Tobit regressions with robust standard errors clustered by firm, and t-statistics are reported in parentheses. All control variables are included but not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively.

The number of identification criteria for internal control weaknesses may reflect the firm's internal control strictness. Firms with more identification criteria for internal control weaknesses have tighter internal control, as shown in Table 5. In the baseline regressions, with *Rd* and *Invr* as dependent variables, if we control *Tightnum*, we find that the regressions coefficients on *Tightnum* are not significant while the regression coefficients on *Tight* are significantly negative. This indicates that the strictness of internal control reflected in the identification criteria for internal control weaknesses plays a more fundamental role in firm innovation.

Moreover, in the baseline regressions, we use the lower limit of the identification criteria for the firm's major weakness when measuring *Tight*. If we use the lower limit of the quantitative criteria for material weaknesses in the firm's financial reporting to measure strictness of internal control (*Tight1*) and control the difference between the lower limit of the quantitative criteria for major weaknesses and that for material weaknesses (*Gap*), the conclusions remain unchanged.

4.4.2 Measuring innovation

To alleviate the endogeneity and mechanical correlation issues, we use *Rd* and *Invr* in the next period as the dependent variable, and the conclusions remain unchanged. Following existing literature (Ju *et al.*, 2013; Quan and Yin, 2017), we also use the increase in intangible assets to measure the firm's innovation investment and the proportion of invention patents in

total patent applications or total patents granted in the current period to measure the firm's innovation quality. The conclusions remain unchanged using alternative measures of innovation.

In the baseline regressions, we assume missing R&D input and patent output to be zero. If we follow Koh and Reeb (2015) to add indicators for pseudo-blank R&D firms (which report no R&D input but file patents) into our model, the coefficients on *Tight* are still significantly negative. If we drop all observations with missing R&D input and patent output and keep the remaining 8,342 observations, the results are qualitatively the same as our baseline results.

4.4.3 Measuring internal control quality

To control for the effect of internal control quality, we control *ICQ*, the DIB internal control index, in equations (1) and (2). Following previous research (Li *et al.*, 2011; Liu *et al.*, 2015), we also measure internal control quality using whether or not the firm has internal control weaknesses (*ICW_dummy*), and the number of internal control weaknesses (*ICW* or *ICW1*). *ICW_dummy* is an indicator for firms which have weaknesses in internal control; 746 observations within our sample have internal control weaknesses. *ICW* is the natural logarithm of total number of internal control weaknesses. For *ICW1*, we assign weights 3:2:1 to the number of major weaknesses, material weaknesses, and general weaknesses and take the natural logarithm of the sum. Higher *ICW* and *ICW1* suggest lower internal control quality. If these measures of internal control quality are controlled, the conclusions remain unchanged. Moreover, if we exclude observations with internal control weaknesses, the results are qualitatively the same.

4.4.4 Tests on non-linear relation

We further test whether there is a non-linear relation between *Tight* and *Rd* or *Invr*. The results of a quantile regression show that the negative effect of tight internal control on innovation activities dominates. As the quantile increases, the negative impact of *Tight* on *Rd* shows a significant upward trend and there is no significant change in the negative impact on *Invr*.

V. Further Analysis

5.1 Tests on Cross-sectional Variation

Our baseline results show that both the innovation input and the proportion of invention patents in total patents decrease with the strictness of internal control, indicating that the negative-incentive effect dominates. In this section, we examine cross-sectional variation in the relation between strictness of internal control and innovation. Specifically, we analyse how the relation varies with the implementation strength of internal control, staff composition,

other incentives, and the organisation of innovation activities.[16]

5.1.1 Adequacy of Implementation of internal control

The negative relation between strictness of internal control and firm innovation varies with the adequacy of implementation of internal control, which differs between state-owned firms and privately-owned firms. Compared with privately-owned firms, state-owned firms are more deeply influenced by labour protection, employee welfare, and other related regulations. Existing studies find that state-owned firms show lower flexibility in employment decisions and stronger labour cost stickiness (Lu and Chen, 2015; Pan and Chen, 2017).

Table 11 The Effect of Adequacy of Internal Control Implementation

Variable	(1) *Rd*		(2) *Invr*	
	Coefficient	t statistic	Coefficient	t statistic
Tight×Nonsoe	**-0.144****	**(-2.145)**	**-1.213****	**(-2.448)**
Nonsoe	-0.000	(-0.217)	-0.035***	(-3.380)
Tight	-0.020	(-0.424)	0.201	(0.539)
ICQ	0.005*	(1.756)	0.038*	(1.802)
Ln(1+Rd)			0.013***	(3.850)
Rdmiss	-0.023***	(-23.799)	0.201***	(3.321)
Roa	-0.056***	(-6.245)	-0.025	(-0.339)
Lev	-0.024***	(-8.008)	-0.025	(-0.866)
Size	-0.002***	(-2.892)	0.005	(0.919)
Btm	-0.003	(-1.643)	-0.059***	(-3.477)
Tang	0.003	(0.912)	-0.006	(-0.205)
Inddiv	-0.003***	(-4.148)	-0.007	(-1.258)
Subnum	0.000	(0.428)	-0.009**	(-2.111)
Ceochng	-0.002**	(-2.517)	-0.002	(-0.375)
Dual	0.002*	(1.713)	0.005	(0.658)
Indratio	0.020**	(2.304)	-0.069	(-1.155)
Inst	0.018***	(3.022)	0.051	(1.027)
Age	-0.005***	(-7.323)	-0.010**	(-2.124)
Constant	0.066***	(5.080)	0.159	(1.564)
Industry fixed effects	Yes		Yes	
Year fixed effects	Yes		Yes	
Observations	11,669		8,693	
Pseudo R-squared	-0.183		1.029	

*, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Tobit regression is adopted, and standard errors are clustered at firm level.

[16] We also consider how the relation varies with firms' agency problems. We expect the role of tight internal control in promoting innovation by reducing agency costs is more evident when the firms have more severe agency problems. Because agency problems are more pronounced in firms with impending CEO turnover and firms with small profits or consecutive losses, the negative relation between strictness of internal control and firm innovation is expected to be weakened in these firms. However, we find no empirical evidence in support of this view. This suggests that that the negative-incentive impact of tight internal control on employees dominates.

Although we observe that state-owned firms have implemented stricter standards in internal control, they have difficulty setting penalties for employees or firing employees. Compared with state-owned firms, non-state-owned firms are profit-oriented and their activities are more influenced by internal governance and institutions. Hence, we expect that the negative effect of internal control strictness on firm innovation strengthens in non-state-owned firms.

Table 11 provides evidence for the above analysis. The main effect of *Tight* is not significant. In columns (1) and (2), the coefficients on the interaction term *Tight×Nonsoe* are -0.144 and -1.213, respectively, both significant at the 5% level. This suggests that the negative effect of tight internal control on firm innovation is more pronounced in non-state-owned firms.

5.1.2 Staff composition

R&D staff contribute to forming innovative ideas and implementing innovation decisions. Because there is higher uncertainty and failure risk in their work, they are affected by tight internal control to a greater extent. We expect that in firms with more R&D staff, the negative relation between tight internal control and firm innovation is stronger.

Table 12 The Effect of Staff Composition

Variable	(1) *Rd*		(2) *Invr*	
	Coefficient	t statistic	Coefficient	t statistic
Tight×Rdstaff	**-0.837****	**(-2.453)**	**-5.236*****	**(-3.006)**
Rdstaff	0.035***	(5.947)	0.129***	(2.900)
Tight	-0.026	(-0.373)	0.241	(0.459)
ICQ	-0.001	(-0.187)	0.078**	(2.061)
Ln(1+Rd)			0.030***	(5.633)
Rdmiss	-0.265***	(-34.100)	0.467***	(4.795)
Roa	-0.078***	(-6.903)	-0.072	(-0.649)
Lev	-0.032***	(-8.016)	-0.047	(-1.075)
Size	-0.002***	(-3.052)	0.017**	(2.193)
Btm	-0.005**	(-2.135)	-0.086***	(-3.275)
Tang	0.008*	(1.855)	0.018	(0.451)
Inddiv	-0.003***	(-3.861)	-0.009	(-1.147)
Subnum	0.001	(1.295)	-0.003	(-0.475)
Ceochng	-0.002**	(-2.258)	-0.003	(-0.339)
Dual	0.002*	(1.821)	0.007	(0.578)
Indratio	0.029***	(2.792)	-0.115	(-1.279)
Inst	0.021***	(2.967)	0.048	(0.697)
Age	-0.004***	(-5.110)	-0.012*	(-1.658)
Nonsoe	0.003**	(2.000)	-0.032**	(-2.380)
Constant	0.070***	(4.289)	-0.471***	(-3.072)
Industry fixed effects	Yes		Yes	
Year fixed effects	Yes		Yes	
Observations	11,669		8,693	
Pseudo R-squared	-0.506		0.381	

*, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Tobit regression is adopted, and standard errors are clustered at firm level.

In columns (1) and (2) of Table 12, the regression coefficients on *Rdstaff* are 0.035 and 0.129, respectively, and the significance level is 1%. This verifies the role of R&D staff as the main undertakers of innovation activities. The coefficients on *Tight×Rdstaff* are significantly negative, indicating that in firms with more R&D staff, the negative effect of tight internal control on firm innovation is more pronounced. The main effect of *Tight* is not significant, implying that tight internal control does not affect innovation when the percentage of R&D staff in the firm is low. These results further support the argument that tight internal control stifles innovation activities mainly through creating negative incentives for R&D staff.

5.1.3 Positive incentives

As mentioned earlier, due to the important role of employees in firm operations, how to effectively motivate employees has become an issue faced by Chinese enterprises. In order to encourage employees to create value, firms provide monetary and equity incentives. Whether positive incentives for employees offset the negative impact of tight internal control on employees is an empirical question.

Table 13 The Effect of Positive Incentives

Variable	(1) *Rd*		(2) *Invr*	
	Coefficient	t statistic	Coefficient	t statistic
Tight×Salary	**-0.075**	**(-1.368)**	**-0.337**	**(-0.622)**
Salary	0.007***	(6.421)	0.018*	(1.748)
Tight	-0.090**	(-2.347)	-0.461	(-1.447)
ICQ	0.005*	(1.873)	0.043**	(2.048)
Ln(1+Rd)			0.013***	(3.771)
Rdmiss	-0.023***	(-23.748)	0.193***	(3.223)
Roa	-0.058***	(-6.581)	-0.041	(-0.550)
Lev	-0.024***	(-7.968)	-0.024	(-0.817)
Size	-0.002***	(-3.890)	0.003	(0.547)
Btm	-0.003*	(-1.684)	-0.057***	(-3.387)
Tang	0.005	(1.600)	0.002	(0.058)
Inddiv	-0.003***	(-3.798)	-0.006	(-1.055)
Subnum	0.001	(1.092)	-0.008*	(-1.818)
Ceochng	-0.002**	(-2.448)	-0.002	(-0.293)
Dual	0.002*	(1.878)	0.006	(0.738)
Indratio	0.019**	(2.252)	-0.069	(-1.157)
Inst	0.018***	(3.126)	0.051	(1.029)
Age	-0.005***	(-7.383)	-0.010**	(-2.142)
Nonsoe	0.003**	(2.362)	-0.019**	(-2.087)
Constant	0.075***	(5.702)	0.183*	(1.783)
Industry fixed effects	Yes		Yes	
Year fixed effects	Yes		Yes	
Observations	11,669		8,693	
Pseudo R-squared	-0.187		1.030	

*, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Tobit regression is adopted, and standard errors are clustered at firm level.

Table 13 reports the results on the relation between positive incentives and the effect of internal control strictness. Since Chinese firms restarted employee stock ownership plans (ESOPs) in 2014, a limited number of firms have completed their ESOP. We measure positive incentives for employees using their salaries (*Salary*). *Salary* is the firm's per capita salary adjusted for regional per capita salary. In columns (1) and (2), the main effect of *Salary* is significantly positive, while the coefficients on *Tight×Salary* are not significant, suggesting that although providing employees with positive incentives effectively fosters firm innovation, it does not offset the negative impact of tight internal control on firm innovation.

5.1.4 Specialised R&D centres

An increasing number of firms have established specialised R&D centres. Special internal control systems may exist for these R&D centres to avoid negative incentives for employees, reducing the negative impact of tight internal control on innovation activities. Thus, in firms with specialised R&D centres, we expect the negative impact of tight internal control on innovation to be weaker.

Table 14 The Effect of Specialised R&D Centres

Variable	(1) *Rd*		(2) *Invr*	
	Coefficient	t statistic	Coefficient	t statistic
Tight×Rdcenter	**0.040**	**(0.371)**	**0.974***	**(1.909)**
Rdcenter	0.003*	(1.823)	0.015	(1.308)
Tight	-0.116***	(-3.214)	-0.780***	(-2.736)
ICQ	0.005*	(1.818)	0.041**	(1.976)
Ln(1+Rd)			0.013***	(4.010)
Rdmiss	-0.023***	(-23.593)	0.209***	(3.465)
Roa	-0.056***	(-6.332)	-0.036	(-0.486)
Lev	-0.024***	(-8.065)	-0.027	(-0.919)
Size	-0.002***	(-3.057)	0.004	(0.803)
Btm	-0.003	(-1.479)	-0.059***	(-3.466)
Tang	0.003	(0.951)	-0.005	(-0.174)
Inddiv	-0.003***	(-4.049)	-0.006	(-1.199)
Subnum	-0.000	(-0.011)	-0.009**	(-2.084)
Ceochng	-0.002**	(-2.446)	-0.002	(-0.367)
Dual	0.002*	(1.732)	0.006	(0.713)
Indratio	0.019**	(2.230)	-0.069	(-1.163)
Inst	0.018***	(3.095)	0.048	(0.982)
Age	-0.005***	(-7.288)	-0.010**	(-2.031)
Nonsoe	0.001	(1.192)	-0.023**	(-2.488)
Constant	0.067***	(5.188)	0.153	(1.503)
Industry fixed effects	Yes		Yes	
Year fixed effects	Yes		Yes	
Observations	11,669		8,693	
Pseudo R-squared	-0.183		1.028	

*, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. Tobit regression is adopted, and standard errors are clustered at firm level.

The results in Table 14 provide evidence for the above analysis. *RDCenter* is an indicator variable that takes the value of one if the group has at least one specialised R&D centre and zero otherwise. A subsidiary is identified as a specialised R&D centre if its main business includes key words related to research or technology but not key words related to other business areas, such as real estate, consultation, exportation, and management.[17]

In column (1), the main effect of *Rdcenter* is significantly positive while the coefficient on *Tight×Rdcenter* is 0.040 but not significant. This shows that specialised R&D centres lead to an increase in innovation investment but cannot alleviate the negative impact of tight internal control. In column (2), the coefficient on *Tight×Rdcenter* is 0.974, significant at the 10% level, indicating that in firms with specialised R&D centres, the negative impact of internal control strictness on innovation quality is significantly diminished.

It is worth mentioning that the main effect of *Tight* is negative and significant. The negative effect of tight internal control on innovation is mainly found in firms without specialised R&D centres. Establishing specialised R&D centres is indeed a measure to encourage innovation and avoid the negative impact of tight internal control.

5.2 Endogeneity Issues

This paper finds a negative relation between strictness of internal control and firm innovation. However, there can be alternative explanations for the results. First, our findings are subject to reverse causality issues, but to a lesser degree. Strictness of internal control is measured using the identification criteria for internal control weaknesses first disclosed or changed by the firm. For each firm, there is little change in *Tight* relative to other firm characteristics, while innovation activities vary greatly from year to year. There is a low possibility that a firm will change its internal control standards due to innovation activities.

Second, both the strictness of internal control and firm innovation may be affected by some firm characteristics, such as firm's life cycle, strategy, and managers' background. To mitigate the influence of omitted variables on our results, in the baseline regressions, we control for firms' listing period and managers' willingness to innovate, measured using the innovation index of MD&A text obtained from the WinGo Textual Analysis Database. Since managers' background as well as firms' risk-taking affect both the strictness of internal control and firm innovation, we also control for whether managers have an R&D background and firms' operating risk. The conclusions remain unchanged. Wu and Wang (2018) point out that fraudulent firms tend to set relaxed internal control standards. Whether the firm is fraudulent

[17] The key words related to research and technology that we use are 研 (research), 技术 (technology), and 试验 (experiment), and the key words related to other business areas are 房地产 (real estate), 土地 (land), 制 (manufacture), 生产 (produce), 销 (sell), 咨询 (consult), 推广 (promote), 服务 (service), 施工 (construct), 管理 (manage), 营 (trade), 出口 (export), 加工 (machining), 检测 (detect), 教育 (educate), and 发行 (publish). We make a primitive list of key words after reading some subsidiaries' business descriptions and keep polishing the list until the subsidiaries are satisfactorily classified.

is also an omitted variable. If we control for an indicator for fraudulent firms and firms' likelihood of committing fraud, the conclusions remain unchanged.

To further address endogeneity issues and establish causality, we utilise *Atight*, the minimum value of internal control strictness among firm-year observations in the same industry audited by the same audit firm, as an instrumental variable.[18]

The results from the two-stage regression are shown in Table 15. The *Basic Standard* requires listed firms to engage qualified accounting firms to certify their self-assessment report on their internal control system. Previous literature finds that auditors have a significant impact on their clients' internal control (De Simone *et al.*, 2015; Fitzgerald *et al.*, 2018). Although there may be a two-way choice between the auditor and the firm, the auditor's requirement for internal control standards may not be the primary consideration in a firm's selection of the auditor. The auditor's lower limit of tolerance for firms' internal control strictness is unlikely to be affected by firm characteristics. Thus, *Atight* meets the exclusion restriction requirement for instrumental variables.

Table 15 Two-Stage Regression with the Instrumental Variable

Variable	1st stage (1) *Tight*	2nd stage (2) *Rd*	1st stage (3) *Tight*	2nd stage (4) *Invr*
Atight	**0.154*** **		**0.116*** **	
	(30.500)		**(21.209)**	
Tight		**-0.115***		**-2.842*** **
		(-1.705)		**(-3.301)**
ICQ	0.007***	0.008***	0.005***	0.056***
	(6.559)	(3.907)	(3.964)	(2.627)
Constant	-0.038***	0.042***	-0.028***	0.086
	(-9.690)	(4.755)	(-6.590)	(1.024)
Other controls	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	11,669	11,669	8,693	8,693
Adjusted R-squared	0.144	0.449	0.114	0.287
F statistic of the IV	930.22***		449.83***	

Two-stage least-squares regression is adopted. Standard errors are clustered at firm level, and t-statistics are reported in parentheses. All control variables are included but not reported. *, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively.

Columns (1) and (3) in Table 15 present the results from the first stage with *Atight* as the instrumental variable. The coefficients on *Atight* are positive and significant at the 1% level, suggesting that *Atight* is highly correlated with *Tight*. Columns (2) and (4) show the results

[18] We exclude observations with no other observations in the same industry audited by the same audit firm, and the results of the two-stage regression with the instrumental variable remain unchanged.

from the second stage, and the coefficients on *Tight* are significantly negative, indicating a negative causal relationship between decision rights allocation and innovation investments. Our hypotheses 1b and 2b are further supported.

We do not alleviate endogeneity concerns in this paper by controlling for firm fixed effects because there is little within-firm variation in *Tight* and the cross-firm variation in *Tight* is relatively significant. Few firms change their internal control standards since they first established the standards. Only 399 firms in our sample changed their internal control standards. By relying on within-firm variation, fixed effects estimators may not detect an effect of internal control strictness on firm innovation even if one exists. But according to Zhou (2001), this does not mean that explanatory variables do not have a significant effect on explained variables. Since for each firm there is little change in the strictness of internal control, the relation between strictness of internal control and firm innovation is likely to be a cross-sectional phenomenon.

5.3 Strictness of Internal Control and the Relation between Innovation Output and Operating Performance

We further examine whether the innovative activities of firms with tight internal control improve their operating performance. Innovation in firms is expected to help firms form competitive advantages and improve operating performance. Equation (4) is used to examine the effect of strictness of internal control on the relation between innovation output and operating performance, with *⊿margin* as the dependent variable. If the regression coefficient on *Tight×Ln(1+Patent)*, β_3, is negative, firms with tighter internal control are less able to convert their innovation output into improvements of operating performance.

$$\begin{aligned}\Delta margin_{i,t+1} = {} & \beta_0 + \beta_1 \times Ln(1+Patent)_{i,t} + \beta_2 \times Tight_{i,t} \\ & + \beta_3 \times Tight_{i,t} \times Ln(1+Patent)_{i,t} + \beta_4 \times ICQ_{i,t} \\ & + \beta_5 \times ICQ_{i,t} \times Ln(1+Patent)_{i,t} \\ & + \beta_5 \times Other\ \ Controls_{i,t} + \sum Industry + \sum Year + \varepsilon \end{aligned} \quad (4)$$

The results are reported in Table 16. In column (1), the main effect of *Ln(1+Patent)* is significantly positive, suggesting that innovation contributes to improved operating performance. The coefficient on *Tight×Ln(1+Patent)* is -0.192, and the significance level is 10%. This indicates that under tight internal control, employees tend to choose innovation projects with short-term visible output and the positive impact of patent output on firm performance is weakened.

Table 16 Strictness of Internal Control and the Correlation between Innovation Output and Operating Performance

Variable	(1) $\Delta margin_{t+1}$		(2) $\Delta margin_{t+1}$	
	Coefficient	t statistic	Coefficient	t statistic

Ln(1+Patent)	0.006***	(3.507)	0.011	(0.947)
Tight			0.862***	(2.727)
Tight×Ln(1+Patent)			**-0.192***	**(-1.720)**
ICQ			0.086*	(1.720)
ICQ×Ln(1+Patent)			-0.013	(-0.753)
Lev	-0.009	(-0.530)	-0.001	(-0.074)
Size	0.000	(0.019)	-0.002	(-0.635)
Btm	-0.007	(-0.666)	-0.008	(-0.757)
Tang	0.067***	(3.855)	0.065***	(3.825)
Inddiv	0.000	(0.114)	-0.000	(-0.114)
Subnum	0.002	(0.684)	0.001	(0.451)
Ceochng	-0.009	(-1.447)	-0.008	(-1.223)
Dual	-0.006	(-1.218)	-0.006	(-1.179)
Indratio	-0.035	(-0.911)	-0.031	(-0.822)
Inst	0.071**	(2.391)	0.061**	(2.004)
Age	-0.011***	(-3.996)	-0.008***	(-3.159)
Nonsoe	-0.025***	(-5.260)	-0.023***	(-5.095)
Constant	0.008	(0.139)	0.005	(0.069)
Industry fixed effects	Yes		Yes	
Year fixed effects	Yes		Yes	
Observations	11,569		11,569	
Adjusted R-squared	0.021		0.024	

*, **, and *** represent significance levels of 0.10, 0.05, and 0.01, respectively. OLS regression is adopted, and standard errors are clustered at firm level.

VI. Conclusion

This paper investigates the impact of strictness of internal control on firm innovation. Tight internal control fosters firm innovation through reducing agency behaviours within a firm. Meanwhile, it creates negative incentives for employees, who are more likely to be punished for not meeting the defined standards under tighter internal control. Because the innovation process is characterised by the unpredictability of outcomes and the high probability of failure, tight internal control discourages employees from participating in innovation activities. Employees tend to choose innovation projects with short-term visible output to reduce the risk of failure and the propensity for penalties.

Using identification criteria for internal control weaknesses publicly disclosed by Chinese listed firms, we construct a proxy for strictness ofinternal control. The empirical results show that tighter internal control leads to less innovation input and lower innovation quality. In a further analysis, we find that the negative relation between tight internal control and innovation strengthens in firms with more R&D staff and is weaker for firms with specialised R&D centres and for state-owned firms. Incentivising employees with high compensation cannot alleviate the negative effects of tight internal control on innovation activities. Thus, relaxing internal control is essential for promoting innovation. Moreover, the

results show that firms with tighter internal control are less able to convert their innovation output into improvements of operating performance.

Our findings prove that relaxing internal control facilitates firms to enhance their innovation performance. The theoretical contribution of this paper is to identify strictness as a feature of internal control systems. Controlling for internal control quality, the strictness of internal control still has a significant effect on firm innovation. This suggests that strictness of internal control is an important omitted variable from the previous literature on internal control. Additionally, the existing literature mostly focuses on the impact of positive incentives on employees' innovation. This paper reveals the effect of negative incentives on firm activities and provides insights for firms on how to promote high-quality innovation. Firms should consider the balance between incentives and controls when designing their internal control systems. Although tight internal control leads to an improvement in operational efficiency, it is not beneficial for maximising firm value in the long run. Likewise, relaxing the control over firms is of great relevance to enhance social innovation as well as industrial transformation and upgrading in the form of creative destruction.

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Appendix: Variable Definitions

Variable	Definition	Calculation
A. Main variables		
Rd	Innovation investment	R&D input divided by sales revenue
Ln(1+Patent)	Patent output	Natural logarithm of 1 plus the number of patent grants
Ln(1+Invent)	Invention patent output	Natural logarithm of 1 plus the number of invention patent grants
Invr	Innovation quality	The number of invention patent grants divided by the number of patent grants
Tight	Strictness of Internal control	We select the lower limit of quantitative criteria for major weaknesses in the firm's financial reporting, convert each ratio criterion into an absolute value using annual report data, remove the negative value, and take the minimum value among all criteria (including absolute value criteria, if any). We divide this minimum value by current operating income and take the opposite as *Tight*.
B. Control variables		
ICQ	Internal control quality	DIB internal control index divided by 1,000
Tightnum	Number of identification criteria for internal control weaknesses	Number of quantitative criteria used for identifying internal control weaknesses in financial reporting
Rdmiss	Missing R&D	An indicator variable for firms which do not report R&D input
Roa	Profitability	Earnings before interest and tax divided by total assets
Lev	Financial leverage	Interest-bearing liabilities divided by total assets
Size	Firm size	Natural logarithm of total assets
Btm	Growth opportunities	Book value of equity divided by book value of equity
Tang	Fixed assets intensity	Fixed assets divided by total assets
Inddiv	Industry diversification	Natural logarithm of the number of industries reported in the footnote of income statement
Subnum	Number of subsidiaries	Natural logarithm of the number of subsidiaries
Ceochng	CEO change	An indicator variable for the change in CEO
Dual	CEO duality	An indicator variable for CEO chairing the board
Indratio	Board independence	Proportion of directors that are independent.
Inst	Institutional ownership	Institutional shareholding divided by total share capital
Age	Firm age	Natural logarithm of the number of years since listing
Nonsoe	State ownership	An indicator variable for firms controlled by departments below the county level or by natural persons

C. Other variables		
Rdcenter	Specialised R&D centre	An indicator variable for firms with specialised R&D centres
Rdstaff	Proportion of R&D staff	Number of R&D staff divided by total number of employees
Salary	Per capita salary	Natural logarithm of per capita salary after excluding executives, adjusted by per capita salary in the region
Atight	Auditors' lower limit of tolerance for strictness of internal control	Minimum value of internal control strictness among firm-year observations in the same industry audited by the same audit firm
⊿margin	Growth in net profit margin	Change in net profit as a percentage of operating income compared to the previous period