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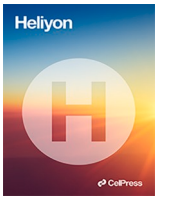

Research article

The impact of corporate digital strategic orientation on innovation output

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ABSTRACT

Given the development of the digital economy, the shift to digitalization is an inevitable direction for corporate strategic planning. This empirical study investigates the impact of corporate digital strategic orientation on innovation output. It also examines the moderating effects of executive equity and compensation incentives on the relationship between corporate digital strategic orientation and innovation output. We selected a sample of Chinese listed companies and adopted the Heckman two-stage and two-stage least square (2 S LS) methods to control for potential endogenous problems. Our findings indicate that corporate digital strategic orientation significantly enhances innovation output. Additionally, we found that executive compensation and equity incentives positively moderate the impact of corporate digital strategic orientation on innovation output, with equity incentives having a greater moderating effect than compensation incentives. Further analysis shows that the impact of corporate digital strategic orientation on innovation output is greater in non-manufacturing industries and non-state-owned enterprises. Our study provides policy insights on how companies can enhance their innovation capability in the digital economy.

1. Introduction

Innovation has long been considered a key factor in determining corporate competitiveness and achieving sustainable growth [1]. With the acceleration of the global integration process, corporate external environment is more complex and dynamic. Firms need to survive and develop in the fierce market competition through innovation [2,3]. However, corporate innovation is a high-risk activity due to its high failure rate and unpredictability [4]. Given the importance and risks of innovation, scholars carried out extensive research on how to effectively promote firms' innovation activities and thus increase their innovation output [5,6].

Among them, scholars in innovation and strategic research domain have focused on the role of corporate strategic orientation. Strategic orientation refers to a company's chosen future direction and posture. Adams and Freitas [7] thought that strategic orientation could guide a firm's innovation activities and determine its innovation performance. Nowadays, digital strategic orientation is a strategic decision for companies to respond to the development of the digital economy and the increasingly widespread use of technologies such as artificial intelligence, big data, and blockchain [8]. Despite a growing interest in digital strategic orientation as an emerging construct of strategic orientation, the understanding of its impact on innovation is not enough. In light of this, we discuss how digital strategic orientation affects a firm's innovation output, this being an important area to address for companies to meet the

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demands of the present and future.

Additionally, we examine the contingent role of corporate governance on the relationship between corporate digital strategic orientation and innovation output because corporate governance mechanisms can impact the success of implementing digital strategy orientation. Executives are responsible for a company's strategic planning and implementation, and a company's strategic orientation and decision-making involve trade-offs between executive behavior and a particular corporate governance mechanism. However, executives may have self-interest motives which can lead to an agency problem where they prioritize their interests over those of the company. Monitoring and incentives can effectively alleviate agency problems. For instance, Arzubiaga and Kotlar [9] revealed the contingent role of the board of directors in the relationship between strategic orientation and innovation capability. Incentives for executives are also considered an effective way to alleviate this problem. Digital orientation and innovation are significant strategic decisions that contribute to long-term growth, but they require significant capital investments and increase business risks, which can suffer from agency issues. Therefore, we investigate whether executive incentives moderate the effect of corporate digital strategy orientation on innovation output. As typical executive incentives include short-term compensation and long-term equity incentives, we introduce these two incentives as moderating variables in our study.

Based on the above analysis, this study investigates the impact of corporate digital strategic orientation on innovation output performance. Besides, we incorporate executive incentives into the research framework to explore the moderating role of executive equity and compensation incentives in the relationship between corporate digital strategic orientation and innovation output performance. The study is conducted in the Chinese context for the following reasons. Firstly, China is one of the developing and emerging economies [10]. This growth comes from the fact that Chinese firms rely mainly on technology importation and replicative imitation to achieve growth but have low independent innovation capacity [11]. They currently face the joint challenge of a crisis of traditional strengths and a lack of breakthroughs in key technologies. Reducing the technology gap with developed economies through innovation to achieve innovative development is a crucial issue needing to be addressed by Chinese firms. Secondly, China has the world's second-largest digital economy, making digitalization a core strategy for business development [12]. Therefore, exploring the relationship between digital strategic orientation and corporate innovation based on the Chinese experience can not only benefit Chinese economic development but can be used as a reference point for similar economies.

The empirical study has been conducted using panel data of Chinese listed companies, applying the Heckman two-stage and two-stage least square method (2 S LS) to control for potential endogeneity issues. This study has the following marginal contributions. Firstly, this study follows the willingness-outcome research logic to explore the impact of corporate digital strategic orientation on innovation output performance in the context of China, a developing and emerging economy, unlike previous studies that are based on the context of developed economies [13], thus making an addition to the digital strategic orientation literature. Secondly, this study investigates the moderating role of executive incentives in the relationship between corporate digital strategic orientation and innovation output performance, providing a new perspective to explain the value-creation mechanism of digital strategic orientation. This study compares the moderating effects of equity and compensation incentives to identify more effective corporate governance factor. Lastly, this study provides an in-depth analysis based on the heterogeneity of industry and enterprise characteristics, which helps to clarify the effectiveness of corporate digital strategy practice.

The remainder of this paper is organized as follows. In Section 2, we theoretically propose the research hypotheses of this study. Section 3 describes the data sources, measurement methods, and regression models used. Section 4 presents descriptive statistics, multicollinearity tests, empirical results, and robustness tests. Section 5 discusses the outcomes and generalizability of the study findings. Finally, in Section 6, we summarize this study and present its practical implications, limitations, and future research directions.

2. Theoretical analysis and research hypotheses

2.1. Corporate digital transformation and innovation output

According to the resource-based view (RBV), companies are integrated organizational forms of various types of resources, which differ in their resources as well as in the ways and means of controlling or utilizing them [14]. Valuable, scarce, inimitable, and irreplaceable resources are considered heterogeneous resources [15]. A general heterogeneity of resources exists among companies and the possession of such heterogeneous resources directly affects corporate competitive advantage [14]. Strategic orientation is an important part of a company's resources because the right business strategy can influence its behavior and play a key role in determining its competitive advantage [14]. For instance, Muangmee et al. [16] believed that green entrepreneurial orientation improved green innovation performance. Digital strategic orientation refers to a company's propensity to undertake digital transformation, which reflects its willingness to use digital resources to create value. Several studies have demonstrated that digitalization is critical to innovation and growth in uncertain environments [17]. Therefore, we believe that digital strategic orientation helps improve innovation output performance as a principle that guides corporate behavior.

On the one hand, digital strategic orientation guides companies in introducing advanced digital technologies in their daily production activities, thereby enhancing their ability to collect, analyze, and process data. This helps to significantly improve operational efficiency and flexibility, leading to more innovative outputs within the original research and development (R&D) resource boundaries [18]. Companies use this available data to inform their innovation decisions and activities, reduce information asymmetries, increase access to external financing, and improve risk-taking, thus stimulating innovation of companies [19]. On the other hand, digital strategic orientation encourages companies to change traditional business models and enrich the way in which they interact with the outside world, communicate patterns, and link channels [20,21]. This enables the firm's suppliers and customers to participate in all

aspects of product design and production, provide timely feedback, and achieve digital synergy. This change strengthens corporate understanding of market changes and demands, helping enterprises anticipate market trends, identify innovation opportunities, and generate ideas for developing new products, thus increasing innovation output capabilities [22]. Based on the above analysis, this study proposes the following hypothesis.

H1. Digital strategic orientation contributes to enhancing the innovation output.

2.2. Moderating role of executive incentives in the relationship between corporate digital transformation and innovation output

A digital strategic orientation creates opportunities for innovation. However, internal and external corporate governance factors may affect its impact [9,23]. Due to a company's executives being the primary developers and implementers of important corporate strategies and their attitudes having a significant role in strategy formulation and implementation, executives in a company are an important factor in internal corporate management. According to the principal-agent theory, executives tend to act selfishly based on their self-interest, focusing on short-term economic benefits, rather than implementing measures that are risky and uncertain, but will help improve a company's competitive advantage in the long-term. However, the principal–agent theory also points out that executive incentives are effective ways to promote the convergence of the goals of both the principal and agent and thus, reduce agency problems [24]. Therefore, we argue that executive incentives can influence the impact of corporate digital strategic orientation on innovation output. There are two main types of executive incentives, executive equity and executive compensation incentives [25]. As a long-term incentive mechanism, executive equity incentives refer to the granting of stocks or stock options to executives, meaning that executives participate in the profit distribution and risk-taking process of the company as shareholders [26]. Executive equity incentives have a convergence of interest effect, meaning that executive and corporate interests converge as executive shareholding rises [27]. As a short-term incentive mechanism, executive compensation incentives refer to monetary compensation such as salaries and bonuses [28]. Executive compensation incentives are measured by focusing on executives' short-term ability to deliver corporate or innovation performance. On the one hand, executive incentives enable executives to focus on enhancing corporate sustainable competitiveness. This helps them to better implement digital strategies throughout the company's operations and work to overcome barriers to digitalization, thus maximizing the value benefits of digital strategic orientation. On the other hand, executive incentives create innovation-oriented incentives for executives to increase their level of innovation input while driving digital transformation to drive sustainable innovation output. Based on the above analysis, we propose the following hypotheses.

H2. Executive equity incentives positively moderate the impact of corporate digital strategic orientation on innovation output.

H3. Executive compensation incentives positively moderate the impact of corporate digital strategic orientation on innovation output.

3. Data and research methodology

3.1. Sample selection and sources of data

The study's preliminary sample comprised all Chinese A-share companies in Shanghai and Shenzhen from 2007 to 2020. The data used in the study was obtained from the China Stock Market and Accounting Research (CSMAR) and Wind databases. Following previous research, we excluded companies marked with ST or *ST and those without variable data, as well as firms in the financial and insurance industries. The resulting dataset comprised 15,769 observations were obtained from 3453 companies. To eliminate the influence of extreme values, all continuous variables were winsorized at the upper and lower 1% of the dataset.

3.2. Variables and measurements

3.2.1. Dependent variable

According to the availability of data, we used patent grants, including invention, utility model, and design patents, to measure innovation output with reference to existing innovation research methods [29]. Specifically, we used the natural logarithm of the total number of patent grants plus one to measure innovation output.

3.2.2. Independent variable

Drawing on Cooper and Ewing [30], we used a text mining approach to measure our independent variable, digital strategic orientation. The content of an annual report reflects a company's strategic planning; therefore, text analysis of a company's annual report can reflect its strategic positioning. Specifically, the frequency of content analysis words and phrases related to digitalization reflects a company's digital strategic orientation [31]. Referring to Tian and Li [8], we calculated the total frequency of content analysis words and phrases related to digitalization and used the natural logarithm of one plus the total number to measure digital strategic orientation.

3.2.3. Moderating variables

Referring to Chinese Company Law, we defined the company's executives as its directors, president, vice president, general manager, deputy general manager, secretary of the board of directors, supervisors, and other senior management. Based on existing

research [32], we used the executive holdings ratio to measure executive equity incentives (Share). We measured executive compensation incentives (Pay) using the natural logarithm of the company's mean disclosed compensation for the top three management personnel following the approach by Cai and Liu [33].

3.2.4. Control variables

Consistent with previous studies [34–36], we controlled for other variables. First, in terms of the basic characteristics of companies, we controlled for firm age (Age) and ownership structure (SOE). Second, in terms of corporate governance structure, we controlled for the shareholding ratio of the largest shareholder (Top1) and independent director ratio (Indep). Finally, regarding the financial characteristics of companies, we controlled for cash flow ratio (Cashflow) and asset-liability ratio (Lev). Additionally, we controlled for year (Year) and industry (Industry) to remove factors that did not change over time and the effects of common time trends. Table 1 listed all variables' definitions.

3.3. Regression model

Our dependent variable was continuous; thus, we constructed the following multiple linear regression model:

$$Patent_{i,t} = \alpha_0 + \alpha_1 \times DSO_{i,t} + \alpha_2 \times ControlVariables_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t} \quad (1)$$

$$Patent_{i,t} = \alpha_0 + \alpha_1 \times DSO_{i,t} + \alpha_2 \times Share_{i,t} + \alpha_3 \times DSO_{i,t} \times Share_{i,t} + \alpha_4 \times ControlVariables_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t} \quad (2)$$

$$Patent_{i,t} = \alpha_0 + \alpha_1 \times DSO_{i,t} + \alpha_2 \times Pay_{i,t} + \alpha_3 \times DSO_{i,t} \times Pay_{i,t} + \alpha_4 \times ControlVariables_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t} \quad (3)$$

In the above formulas, *i* represents a company, *t* represents the year, *Patent* is the dependent variable, *DSO* is the independent variable, *Control Variables* represents all control variables, *Year* is the period of sample, *Industry* is the industry of the company, *Share* and *Pay* represent executive equity incentives and executive compensation incentives, respectively, *DSO* × *Share* represents the interaction between digital strategic orientation and executive equity incentives, *DSO* × *Pay* represents the interaction between digital strategic orientation and executive compensation incentives, ε is random residual deviation, and α represents a constant term or the degree to which a one-unit change in the independent and control variables explain the dependent variable. Equation (1) was used to test Hypothesis 1. If the regression coefficient of *DSO* (α_1) in equation (1) is significant and positive, Hypothesis 1 is supported. We set up moderating effects model according to Balli and Sorensen [37] to test Hypotheses 2 and 3. Specifically, based on equation (1), we added *Share* and *DSO* × *Share* in equation (2) to test Hypothesis 2. If the regression coefficient of *DSO* × *Share* (α_3) in equation (2) is significant and has the same sign equation as the coefficient of *DSO* (α_1) in equation (1), executive equity incentives amplify the relationship between digital strategic orientation and corporate innovation output, indicating that Hypothesis 2 is supported. Similarly, if the regression coefficient of *DSO* × *Pay* (α_3) in equation (3) is significant and has the same sign equation as the coefficient of *DSO* (α_1) in equation (1), executive compensation incentives amplify the relationship between digital strategic orientation and corporate innovation output, indicating that Hypothesis 3 is supported. Referring to previous studies, the t+1 period of the explained variables was added to the regression model because of the lag between strategic decisions and innovation output [38].

4. Results

4.1. Descriptive statistics

The descriptive statistics for all variables are provided in Table 2. Patents had a mean and standard deviation of 2.508 and 1.679, respectively, with a minimum and maximum of 0 and 6.635. This indicates a significant gap in the innovation capabilities of Chinese listed companies. DSO had a mean and standard deviation of 2.050 and 1.132, respectively, with a minimum and maximum of 0.693

Table 1
Variable definition.

Variable	Symbol	Description
Digital strategic orientation	DSO	The natural logarithm of the total word frequency of content analysis words and phrases related to digital orientation plus one
Innovation Output	Patent	The natural logarithm of the total number of patents granted plus one
Executive Compensation Incentives	Pay	The natural logarithm of the average compensation of the top three senior executives
Executive Equity Incentives	Share	The number of shares held by executives as a percentage of the total number of shares
Asset-liability Ratio	Lev	The ratio of total liabilities to total assets at the end of the year
Cash Flow Ratio	Cashflow	The ratio of net cash flow from operating activities to total assets
Age of the firm	FirmAge	The natural logarithm of the age of the enterprise plus one
Largest Shareholder' Shareholding Ratio	Top 1	The proportion of shares held by the largest shareholder in the total number of shares held by all shareholders
Independent Director Ratio	Indep	The ratio of the number of independent directors to the total number of directors
Enterprise Ownership	SOE	If the enterprise is a state-owned enterprise, the value is 1, otherwise 0

and 5.011, indicating that the sample companies' willingness to transform digitally varies widely. The average shareholding ratio of executives was 0.156. However, there were extremes of executives not holding shares (the minimum value is 0) and of those holding a high shareholding ratio (the maximum value is 0.690). Moreover, only a few companies had a higher average degree of equity incentives, indicating that listed companies have different attitudes toward equity incentives. The minimum and maximum of Pay are 11.830 and 15.501, indicating that the degree of pay incentives varies among the sample companies. The SOE had an average value of 0.281, indicating that more than half of the companies in the sample were non-state-owned enterprises (non-SOEs).

4.2. Correlation analysis and VIF test

Table 3 displays the Pearson correlation of all variables. The correlation coefficient between DSO and Patent is 0.051, and it is significant at the 1% level, preliminarily indicating that corporate DSO can improve innovation performance. The absolute values of nearly all correlation coefficients are less than 0.8 and all variance inflation factor (VIF) values are much less than 10, indicating that there is no serious multicollinearity problem.

4.3. Multivariate analysis

Before conducting the regression, the F-test and Hausman test were performed on all models to determine the most appropriate regression method. Based on the results, the fixed-effects regression model was chosen over the random-effects regression model for the baseline regression analysis. Table 4 reports the regression results.

We first add independent and all control variables. Model 1 verifies the significant positive impact of corporate digital strategic orientation on innovation output ($\beta = 0.082$, $p < 0.01$). This result suggests that corporate digital strategic orientation promotes innovation output, thus supporting H1. The coefficient of DSO indicates that ceteris paribus, digital strategic orientation is associated, on average, with an increase of 0.082 in innovation output. Second, to test the moderating effects of executive incentives on the relationship between digital strategic orientation and innovation output, we construct interaction terms with independent and moderating variables centralized to reduce the problem of multicollinearity among variables in the regression equation [39]. In Model 2, the coefficient of *DSO* × *Share* is significant ($\beta = 0.124$, $p < 0.1$), indicating that executive equity incentives positively moderate the relationship between corporate digital strategic orientation and innovation output. Thus, H2 is supported. In Model 3, the coefficient of *DSO* × *Pay* is positive and significant ($\beta = 0.048$, $p < 0.05$), indicating that executive compensation incentives positively moderate the relationship between corporate digital strategic orientation and innovation output. Thus, H3 is supported as well.

This study also includes moderating effect figures to illustrate the moderating effects of executive incentives on the relationship between corporate digital strategic orientation and innovation output. Fig. 1 shows that the positive impact of corporate digital strategic orientation on innovation output is stronger for higher executive equity incentives. Similarly, Fig. 2 indicates that the positive impact of corporate digital strategic orientation on innovation output is stronger for higher executive compensation incentives. Furthermore, the moderating effect figures demonstrate that equity incentives have a greater moderating effect than compensation incentives.

4.4. Robustness tests

4.4.1. Heckman two-stage

Although we forwarded the dependent variable for one period, which can solve the endogeneity problem to some extent, this approach is not rigorous. Whether to disclose innovation output is a firm's choice. Thus, our study faces sample self-selection bias. To address the problem, we utilized the Heckman two-stage method. In the first stage, we used whether companies disclose patent grants as the dependent variable and applied a Probit model to obtain the inverse Mills ratio (IMR). Then IMR was added to the regression model as a control variable in the second stage. Table 5 reports the regression results of the Heckman two-stage regression. While the coefficients of IMR in Models 4 to 6 were positive, they were not statistically significant, indicating that there is no significant sample self-selection bias. These results further supported the main findings of this study.

Table 2
Descriptive statistics.

Variables	Obs	Mean	SD	Min	Max
Patent	15,769	2.508	1.679	0	6.635
DSO	15,769	2.050	1.132	0.693	5.011
Share	15,769	0.156	0.205	0	0.690
Pay	15,769	13.469	0.697	11.830	15.501
Lev	15,769	0.406	0.201	0.051	0.886
Cashflow	15,769	0.047	0.068	−0.151	0.243
Age	15,769	2.846	0.355	1.792	3.526
Top1	15,769	0.335	0.147	0.084	0.743
Indep	15,769	0.378	0.054	0.333	0.571
SOE	15,769	0.281	0.450	0	1

Table 3
Correlation of all variables and VIF.

	Patent	DSO	Pay	Share	Lev	Cash flow	Age	Top1	Indep	SOE	VIF
Patent	1										
DSO	0.051 ***	1									1.54
Pay	0.235 ***	0.122 ***	1								1.31
Share	0.003	0.087 ***	−0.128 ***	1							1.45
Lev	0.115 ***	−0.076 ***	0.150 ***	−0.329 ***	1						1.41
Cash flow	0.051 ***	−0.035 ***	0.184 ***	0.009	−0.142 ***	1					1.17
Age	0.023 ***	0.008	0.196 ***	−0.255 ***	0.211 ***	0.020 **	1				1.49
Top1	0.008	−0.140 ***	−0.012	−0.077 ***	0.030 ***	0.100 ***	−0.079 ***	1			1.19
Indep	0.020 **	0.046 ***	−0.023 ***	0.075 ***	−0.016 **	−0.003	−0.002	0.042 ***	1		1.04
SOE	0.003	−0.135 ***	0.030 ***	−0.447 ***	0.263 ***	0.006	0.191 ***	0.229 ***	−0.060 ***	1	1.58

Notes: ***, **, and * denote statistically significant levels at 1%, 5%, and 10%, respectively.

Table 4
Empirical test results.

	Model 1	Model 2	Model 3
DSO	0.082*** (4.27)	0.081*** (4.18)	0.082*** (4.24)
DSO × Share		0.124* (1.68)	
Share		0.084 (0.38)	
DSO × Pay			0.048** (2.09)
Pay			0.191*** (4.84)
Lev	0.492*** (3.56)	0.485*** (3.56)	0.436*** (3.22)
Cashflow	−0.403* (−1.92)	−0.408* (−1.95)	−0.413** (−1.98)
Age	0.043 (0.14)	0.022 (0.07)	0.053 (0.17)
Top1	0.110 (0.35)	0.095 (0.30)	0.138 (0.46)
Indep	0.050 (0.14)	0.054 (0.16)	0.152 (0.45)
SOE	0.003 (0.02)	0.007 (0.05)	0.006 (0.04)
Industry	YES	YES	YES
Year	YES	YES	YES
_cons	1.348 (1.53)	1.385 (1.56)	−1.139 (−1.09)
N	10,478	10,478	10,478
R^2	0.197	0.197	0.203

Notes. t-statistics are shown in parentheses.
***, **, and * denote statistically significant levels at 1%, 5%, and 10%, respectively.

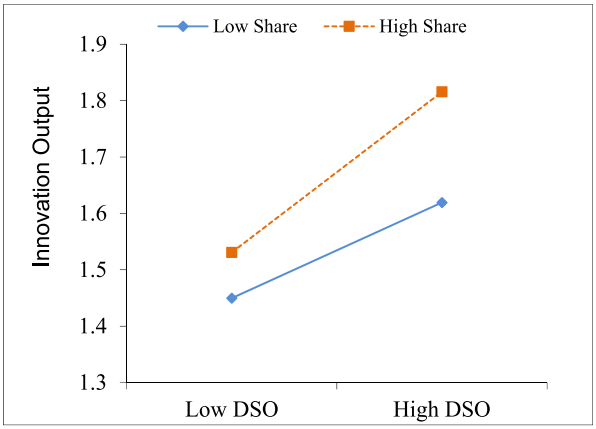

Fig. 1. The moderating effect of executive equity incentives.

4.4.2. Two-stage least square method

To mitigate other potential endogeneity problems, we used the two-stage least square (2 S LS) method. Referring to Chen and Hao [40], we used the industry-year level corporate digital strategic orientation average as an instrumental variable. Companies in the same industry face the same industry and market environment, so individual company decisions may be influenced by the decisions of peer companies. As shown in Table 6, these results were consistent with our initial results.

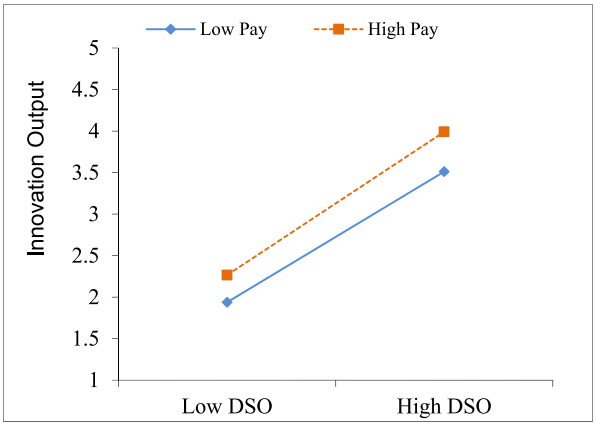

Fig. 2. The moderating effect of executive compensation incentives.

Table 5
Robustness analysis 1: Heckman Two-stage results.

	Model 4	Model 5	Model 6
DSO	0.085*** (4.32)	0.083*** (4.23)	0.084*** (4.30)
DSO × Share		0.124* (1.66)	
Share		0.073 (0.33)	
DSO × Pay			0.048** (2.07)
Pay			0.195*** (4.85)
IMR	0.280 (0.87)	0.253 (0.79)	0.284 (0.89)
Lev	0.531*** (3.66)	0.519*** (3.65)	0.473*** (3.33)
Cashflow	−0.398* (−1.84)	−0.405* (−1.88)	−0.404* (−1.88)
Age	0.036 (0.12)	0.014 (0.04)	0.047 (0.15)
Top1	0.119 (0.37)	0.106 (0.33)	0.151 (0.49)
Indep	0.013 (0.04)	0.02 (0.06)	0.112 (0.33)
SOE	0.055 (0.40)	0.058 (0.41)	0.053 (0.39)
Industry	YES	YES	YES
Year	YES	YES	YES
_cons	1.155 (1.27)	1.215 (1.34)	−1.384 (−1.30)
N	10,263	10,263	10,263
R^2	0.194	0.194	0.200

Notes. t-statistics are shown in parentheses.
***, **, and * denote statistically significant levels at 1%, 5%, and 10%, respectively.

Table 6
Robustness analysis 2: 2SLS.

	Model 7	Model 8	Model 9
DSO	0.213*** (2.68)	0.222*** (2.79)	0.168** (2.26)
DSO × Share		0.301* (1.67)	
Share		0.135 (0.60)	
DSO × Pay			0.140*** (3.35)
Pay			0.171*** (4.32)
Lev	0.450*** (3.16)	0.423*** (3.00)	0.392*** (2.83)
Cashflow	−0.371* (−1.75)	−0.381* (−1.80)	−0.360* (−1.70)
Age	0.055 (0.18)	−0.016 (−0.05)	0.062 (0.20)
Top1	0.301 (0.92)	0.288 (0.88)	0.236 (0.76)
Indep	0.180 (0.52)	0.199 (0.58)	0.241 (0.71)
SOE	0.001 (0.01)	0.007 (0.05)	−0.016 (−0.12)
Industry	YES	YES	YES
Year	YES	YES	YES
_cons	2.287** (2.26)	2.462** (2.43)	−0.003 (−0.00)
N	10,478	10,478	10,478
R^2	0.179	0.176	0.187

Notes. t-statistics are shown in parentheses.
***, **, and * denote statistically significant levels at 1%, 5%, and 10%, respectively.

4.4.3. Change the measurement method of patent

To further demonstrate the robustness of this study, we replace the dependent variable measure and rerun the regression. Referring to He and Ding [41], we used the number of patent applications to measure companies' innovation output. The regression results obtained after changing the Patent measure method are presented in Table 7. The results further demonstrated the robustness of the main findings.

4.5. Further analysis

4.5.1. Industry nature

The impact of corporate digital strategic orientation may vary due to industry specificity. Therefore, this study divided the entire sample into manufacturing and non-manufacturing companies and performed regression analyses. The results are reported in Table 8. Corporate digital strategic orientation positively impacts innovation output of both manufacturing and non-manufacturing firms. However, the contribution of DSO to innovation output of non-manufacturing companies ($\beta = 0.117$, $p < 0.01$) is significantly higher than that of manufacturing firms ($\beta = 0.055$, $p < 0.05$). A possible reason is that non-manufacturing companies have more flexibility than manufacturing companies, allowing them access to a richer pool of complementary resources that can better facilitate the implementation of digital strategic orientation through a combination of resources.

4.5.2. Ownership nature

Ownership is an essential aspect of the corporate governance structure, where state-owned enterprises (SOEs) and non-SOEs represent two primary ownership types in the Chinese economic transition [42]. SOEs are more affected by national macro policies than non-SOEs. It is important to investigate whether there are significant differences in the impact of corporate digital strategic orientation on innovation output between companies with different ownership types in the Chinese context. This study divided the entire sample into two groups, SOEs and non-SOEs, and performed regression analyses. Table 9 reports the results. Corporate digital strategic orientation improves innovation output of both SOEs and non-SOEs, but the contribution of corporate digital strategic orientation to innovation output of non-SOEs ($\beta = 0.072$, $p < 0.01$) is significantly greater than that of SOEs ($\beta = 0.064$, $p < 0.1$). A possible reason is that non-SOEs are more motivated to transform their corporate sustainable innovation with corporate digital strategic orientation than SOEs.

5. Discussion

The digital strategic orientation is a strategic decision orientation for companies to develop digital technologies in the digital economy [43]. While scholars have conducted extensive research on the outcomes of digital strategic orientation, research on the relationship between digital strategic orientation and innovation remains limited and is mainly based on developed economies [44]. This research gap provides an opportunity and further reflection for our study. We find that digital strategic orientation increases firms' innovation output in the context of an emerging economy, China. Digital strategic orientation drives companies to increase digital input, enabling them to rely on digitalization for efficient innovation activities and business model innovation, thereby increasing innovation output. Our findings echo the view of Ardito and Raby [13] that digital strategic orientation of companies can help boost innovation. Following Wang and Nie [45], we extend the boundary conditions between the impact of corporate digital strategic orientation on innovation output from the corporate governance perspective because firms' good functioning requires a matching of effective governance mechanisms and strategic orientation. From the incentive mechanism of corporate governance,

Table 7
Robustness analysis 3: Change the Measurement Method of Patent.

	Model 10	Model 11	Model 12
DSO	0.100*** (4.81)	0.098*** (4.71)	0.100*** (4.81)
DSO × Share		0.160* (1.91)	
Share		0.026 (0.12)	
DSO × Pay			0.049** (2.06)
Pay			0.164*** (4.09)
Lev	0.204 (1.39)	0.189 (1.29)	0.153 (1.05)
Cashflow	−0.614*** (−2.86)	−0.622*** (−2.90)	−0.620*** (−2.90)
Age	−0.030 (−0.09)	−0.077 (−0.23)	−0.021 (−0.07)
Top1	0.415 (1.32)	0.406 (1.28)	0.435 (1.42)
Indep	−0.305 (−0.79)	−0.309 (−0.80)	−0.216 (−0.56)
SOE	0.185 (1.29)	0.186 (1.29)	0.186 (1.33)
Industry	YES	YES	YES
Year	YES	YES	YES
_cons	1.902** (2.26)	2.013** (2.38)	−0.244 (−0.25)
	10,478	10,478	10,478
R^2	0.175	0.175	0.179

Notes. t-statistics are shown in parentheses.
***, **, and * denote statistically significant levels at 1%, 5%, and 10%, respectively.

Table 8
Further analysis 1: industry nature heterogeneity.

	Model 13	Model 14
DSO	0.055** (2.43)	0.117*** (3.52)
Lev	0.603*** (3.53)	0.240 (1.15)
Cashflow	−0.222 (−0.78)	−0.504* (−1.66)
Age	0.283 (0.70)	−0.243 (−0.53)
Top1	0.399 (1.04)	−0.971** (−2.02)
Indep	−0.374 (−0.97)	0.761 (1.16)
SOE	0.142 (1.01)	−0.129 (−0.53)
Industry	YES	YES
Year	YES	YES
_cons	0.195 (0.20)	1.004 (0.80)
N	6569	3909
R^2	0.181	0.226

Notes. t-statistics are shown in parentheses.
***, **, and * denote statistically significant levels at 1%, 5%, and 10%, respectively.

Table 9
Further analysis 2: ownership nature heterogeneity.

	Model 15	Model 16
DSO	0.064* (1.76)	0.072*** (3.14)
Lev	0.132 (0.45)	0.526*** (3.39)
Cashflow	0.341 (0.94)	−0.735*** (−2.91)
Age	0.597 (1.12)	−0.205 (−0.54)
Top1	−0.399 (−0.68)	0.379 (0.99)
Indep	0.888 (1.36)	−0.419 (−1.02)
Industry	YES	YES
Year	YES	YES
_cons	−0.371 (−0.28)	2.980*** (3.00)
N	2753	7725
R^2	0.234	0.197

Notes. t-statistics are shown in parentheses.
***, **, and * denote statistically significant levels at 1%, 5%, and 10%, respectively.

executive compensation and equity incentives are introduced into our research framework. The moderation analysis suggests that both executive equity and compensation incentives enhance the impact of corporate digital strategy orientation on innovation output. Equity and compensation incentives for executives can motivate them to overcome barriers in digital strategies and avoid a short-term orientation towards achieving digitally empowered innovation. In particular, equity incentives play a greater moderating role than compensation incentives. One reason for this is that executive equity incentives, as a long-term incentive mechanism that binds executives to their firm in the long run, reinforce the integration of digital strategic orientation and innovative behavior that contributes to corporate sustainable growth. Our findings echo the idea that equity incentives play a more significant role than compensation incentives [46]. In addition, heterogeneity analyses reveal that the impact of corporate digital strategic orientation on innovation output is more significant in non-manufacturing and non-SOEs. The manufacturing industry's complexities make it difficult to fully realize the value of digital strategy in a short time. While SOEs are more likely to prioritize digital strategic orientation in response to policy requirements, non-SOEs are more proactive in integrating digital strategic orientation to address dynamic competitive environments. These findings are consistent with Chen and Kim [47]. Overall, this study expands the scope of research on corporate digital strategic orientation. Regarding the study sample, this study makes up for previous literature that focuses on developed countries by taking China as the context. In addition, this study enriches the digital strategic orientation research by exploring its boundary conditions and heterogeneity. In terms of research methodology, this study uses panel data and considers time lags to better address real-world issues. Combining previous studies based on different contexts [13,48], digital strategic orientation is an effective approach to promoting innovation output and enhancing innovation capabilities for firms in developed and developing economies, which means that our findings are applicable. However, our moderating and heterogeneity analyses may be more relevant for firms in developing economies due to them being in the same stage of development and having a more similar background than those in developed countries, including an imperfect institutional environment and lack of governance capacity [49,50].

6. Conclusions

Organizational strategic orientation is one of the driving factors for improving innovation performance in companies. However, research on the relationship between corporate digital strategic orientation and innovation output is limited. Selecting a sample of Chinese listed companies, this study conducted an empirical analysis based on willingness-outcome research logic. We found that corporate digital strategic orientation significantly enhances innovation output. We further investigated the moderating effects of

executive equity and compensation incentives on the relationship between digital strategic orientation and innovation output. We found that both executive equity and compensation incentives enhance the positive impact of digital strategic orientation on innovation output. Moreover, the moderating effect of equity incentives was stronger than that of compensation incentives. We also examined how the impact of digital strategic orientation on innovation output varies across industries and ownerships. We found that the impact of corporate digital strategic orientation on innovation output is greater in non-manufacturing industries and non-SOEs.

6.1. Theoretical contributions

This study makes several theoretical contributions to research on firm digitization and innovation. First, it examines the relationship between corporate digital strategic orientation and innovation output by focusing on companies' attention to digital technologies. Strategic orientation is an important resource for companies. Therefore, the impact of digital strategic orientation as a key strategic orientation towards the current developments in digital technologies deserves attention. This study complements the emerging literature on corporate digitalization by examining the relationship between digital strategic orientation and innovation output. Second, this study extends the literature on the antecedents of firm innovation. Enhancing innovation capability in current uncertain environments is crucial. This study reveals the positive role of digital strategic orientation in increasing innovation output based on the RBV theory, which complements the literature on factors influencing firm innovation in the current digital economy context. Finally, this study provides unique insights into how digital strategic orientation and corporate governance can be integrated to create value. This study explores the interactive effects of digital strategic orientation and executive incentives, thus complementing research on corporate governance incentives. In addition, we explore the differences in the impact of digital strategic orientation on innovation output based on industry and firm heterogeneity, providing empirical evidence to better understand innovation in emerging economies.

6.2. Practical implications

This study has important practical implications for both companies and government departments. First, companies should emphasize the value of digitalization in promoting innovation capability. Companies should raise their awareness of digital strategy and promote the integration of digital orientation with existing strategies to improve their innovation capability. To achieve this, companies need to improve their corporate governance mechanisms and establish reasonable executive incentives that discourage managers' management defense motives and maximize their sustainable competitive advantage. Second, the government should improve policy support for corporate digitalization. On the one hand, the government should vigorously develop the digital economy, increase investment in new-generation information infrastructure, and create a good digital development platform. On the other hand, the government should implement targeted and differentiated support policies based on technical characteristics, ownership nature, and other heterogeneous conditions to address the difficulties faced by companies during the implementation of digital strategy.

6.3. Limitations and future research

The limitations and prospects of this study are as follows. First, while this study examined heterogeneity in terms of industry characteristics and ownership nature, it remains to be tested whether it has implications for companies of all sizes and regions. Future studies can be conducted to enhance the generalizability of these findings. Second, this study focuses only on the linear relationship between corporate digital strategic orientation and innovation output, while innovation output of companies may result from multiple factors acting together. Future research could include factors and use the fuzzy-set qualitative comparative analysis (fsQCA) method to investigate how digital strategic orientation affects firm innovation based on the technology-organization-environment (TOE) framework. Finally, due to limitations in data availability, it is not cautious to extend our findings to other economies without empirical testing. Therefore, future studies should analyze and explain the similarities and differences in the impact of corporate digital strategy orientation on innovation output between China and other economies.

Author contribution statement

Xueyuan Fan: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Shukuan Zhao; Shuang Wang: Performed the experiments; Wrote the paper.

Bochen Zhang: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Dong Shao: Analyzed and interpreted the data; Wrote the paper.

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Data availability statement

This study data mainly from CSMAR database (www.gtarsc.com.cn) and Wind database (www.wind.com.cn).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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