

Article

The Roles of Directors from Related Industries on Enterprise Innovation

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Abstract: To remain agile in response to market dynamics, foster innovation, and effectively manage potential risks, companies draw upon information from both their upstream and downstream supply chain collaborators to enhance their core competitiveness. This research, conducted on A-share listed companies in Shanghai and Shenzhen from 2010 to 2021, empirically investigates the influence of directors from upstream or downstream supply chain collaborators, referred to as Directors from Related Industries (DRIs), on corporate innovation activities. This study reveals that DRIs significantly boost the innovation activities of enterprises, irrespective of their position within the operational structure. When there is considerable information asymmetry in the related industries of the industry chain, the impact of DRIs on enterprise innovation is evident in both input and output aspects. Conversely, when management has serious concerns about their career, the impact is primarily on the input side. This underscores the role of DRIs in providing relevant information about upstream and downstream industries and alleviating management's career anxieties, enhancing their effectiveness in consulting and supervising innovation. By examining the economic consequence, corporate innovation emerges as a potential mechanism through which industry chain directors can enhance corporate value. This research delves into the effects of DRIs on enterprise innovation, offering valuable theoretical and practical insights for advancing innovation within the context of value chain integration.



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1. Introduction

Innovation plays a pivotal role in sustaining a company's long-term competitiveness [1] and is a driving force behind a nation's economic growth. Enterprises represent the key actors in national innovation efforts. According to the 2021 Statistical Bulletin of National Science and Technology Expenditure, Chinese enterprises invested CNY 2.8 trillion in R&D in 2021, marking a 14.6% increase from the previous year. The R&D investment intensity reached 2.44%, a slight uptick of 0.03 percentage points. However, the R&D investments by enterprises still exhibit a "quantity-over-quality" trend [2]. Enhancing enterprise innovation behavior and boosting their innovation capabilities holds significant theoretical importance and practical relevance. It not only contributes to the transformation of the economic growth model but also accelerates the journey toward becoming an innovative nation and a global leader in science and technology. However, during the innovation process, enterprises encounter not only the risk of R&D failures, but also face the risk that the market may not accept the new product after R&D success [3,4]. Access to information regarding terminal demand and factor supply empowers enterprises to stay at the forefront of technological innovation. It helps them refine the direction and feasibility of their innovation efforts, thereby reducing market uncertainty. This, in turn, provides a solid foundation

for enhancing the success rate of technological innovation. While existing research with this perspective predominantly focuses on customers and suppliers within the upstream and downstream segments of the industrial chain [2,3,5–10], there is limited literature exploring the inter-firm connections established by directors within the industrial chain.

According to Dass et al. [11], Nanda and Onal [12], Burns et al. [13] and Ke et al. [14], directors or executives from upstream or downstream supply chain collaborators of a firm of interest, referred to as “directors from related industries” and referred to as DRIs hereafter, play important roles in various aspects of enterprises, including earnings forecasts, salary contract design, profitability, M&A, voluntary disclosure and enterprise value. These individuals serve as crucial conduits for information transmission, offering valuable insights into both the factor and product markets, which can impact innovation behavior. While information related to factor and product markets can be acquired through interactions with major customers and suppliers, communication channels with other potential customers and suppliers often go overlooked, making them susceptible to exploitation by larger counterparts [2,5,8]. Consequently, information gleaned through DRIs tends to be more comprehensive and reliable. Given the pivotal role of market demand and factor supply information in driving innovation within enterprises, this article seeks to explore whether DRIs, functioning as informal information channels, influence enterprise innovation, and if so, whether their impact is predominantly on the input or output side. Additionally, the article aims to elucidate the specific mechanisms through which DRIs exert their influence.

Utilizing A-share listed companies in Shanghai and Shenzhen as its research sample over the period spanning from 2010 to 2021, this paper empirically assesses the impact of DRIs on enterprise innovation behavior, with a specific focus on the roles taken by these directors. This study reveals that, irrespective of whether it pertains to the input or output side of innovation, DRIs significantly bolster the innovation activities of enterprises. This conclusion remains robust even after a series of robustness tests, including instrumental variables, propensity score matching (PSM), and the Heckman two-stage test. Further investigation into the mechanisms at play indicates that in situations characterized by a high level of information asymmetry within related industries, DRIs exert their influence across both the input and output facets of innovation. Conversely, in cases marked by serious management career anxiety, the influence stemming from DRIs’ connections primarily stays on the input side. This finding underscores that DRIs could effectively serve as sources of consultation and oversight in innovation by providing insights into both upstream and downstream industries, while simultaneously alleviating management’s concerns. Delving into the economic consequence, this study discerns that enterprise innovation serves as a potential conduit through which DRIs can enhance enterprise value. By conducting a comprehensive examination of the mechanisms underlying DRIs’ influence on enterprise innovation, this paper contributes valuable theoretical and practical insights, offering support for the enhancement of enterprise innovation levels within the context of embedded value chains [15,16].

This article has the potential to contribute to several key areas. Firstly, it broadens the scope of research concerning the economic implications of Directors from Related Industries (DRIs). The existing literature primarily concentrates on these distinctive directors with respect to earnings forecasts, salary contract design, profitability, mergers and acquisitions (M&A), total factor productivity, and enterprise value [11,13,14,17], but relatively little attention is paid to the relationship between DRIs and enterprise innovation. From the perspective of the directors’ functions, this paper scientifically reveals the influence and mechanism between directors’ linkage and enterprise innovation, which provides a new idea and perspective for studying the economic consequences of DRIs and enriches the research on the directors’ functions. Secondly, it expands the exploration of the company’s innovation motivation from the perspective of DRIs. The existing research on the influencing factors of enterprise innovation mainly focus on national, industry and enterprise levels, such as industrial policy [18], comparability of accounting information [19], pro-

professional experience of executives [20], accounting information quality [21], research and development subsidies [22]. However, there are few studies about the impact of the unique social relationship of DRIs on enterprise innovation. Based on the study of this relationship, this paper further confirms the role of DRIs as a consultant and supervisor, realizes the seamless connection between the macro- and micro- behavioral economics perspective, and supplements and expands the existing related studies on the influencing factors of enterprise innovation. Thirdly, it enriches the literature on the potential mechanisms regarding the impact of DRIs on enterprise value. The previous literature found that DRIs can increase enterprise value by strengthening liquidity management and easing financing constraints [11], but this paper found that DRIs can increase enterprise value by promoting enterprise innovation activities.

The remainder of the paper is organized as follows. Section 2 demonstrates the literature review and develops research hypotheses. Section 3 describes the research design. Section 4 presents the empirical results, then further tests the influence mechanism and economic consequences of the DRIs on enterprise innovation activities. Section 5 reports the robustness tests of the main hypothesis. Section 6 indicates the research conclusions.

2. Literature Review and Hypothesis Development

Innovation refers to the extent to which corporations internally generate, develop, and implement an idea, practice, product, process, or administrative systems, perceived to be new by the relevant unit of adoption [23]. Innovation contributes to the formation of the core competitiveness of enterprises [1], and is an important guarantee for promoting national economic growth and enhancing comprehensive national strength [24]. However, enterprise innovation usually has the characteristics of high cost, long investment time and uncertain results, which makes it difficult for outsiders who lack the necessary information to understand its real value. Existing studies hold that agency problems existing in enterprises are the key to innovation success, and that information is an important way to solve the information asymmetry between the inside and outside of a company [25,26]. However, there is a general information gap between enterprises. When enterprises do business with other members in the industrial chain, they usually tend to retain internal information or private information in order to gain advantages in market competition and maximize their own interests. Generally, this private information cannot be verified or the verification cost is high, and other enterprises cannot sign an effective contract to check and balance it, which increases the operational risks and transaction costs between enterprises. Therefore, there will inevitably be an information gap between independent enterprises, and opportunistic behaviors are more likely to occur in the industrial chain, which leads to the failure to meet the personalized and differentiated market requirements and the lack of motivation for enterprise innovation.

According to the social embeddedness theory, social relations directly affect various strategic decision-making behaviors of enterprises [27]. Since enterprises cannot master all the resources needed for their own innovation, they need to seek the assistance of upstream and downstream industries in the industrial chain; adopt various forms of resource trading, integration and sharing [28]; maximize the exploitation of knowledge resources and technical resources in the industrial chain; promote the flow of innovation factors in the industrial chain; ensure the smooth implementation of their innovation activities; and realize the optimal allocation of resources, then improve the level of innovation [29–31].

How do companies within the industrial chain acquire the vital resources from upstream and downstream supply chain collaborators to optimize their innovation behavior? Directors from Related Industries (DRIs) play a pivotal role in offering guidance and oversight. With the existence of DRIs, the upstream and downstream collaborators of a company become embedded in the industrial chain network, engaging in frequent business interactions with the company, thereby fostering a shared interest community. DRIs have more valuable information than other directors, which helps the company conduct an objective and comprehensive evaluation. Specifically, on the one hand, DRIs enables enterprises

to obtain important information such as relevant industry resources and knowledge [11], which has positive knowledge spillover and learning effects, and acts as an information transmitter in social networks [32]. DRIs can also introduce management to key contacts from related industries that also hold valuable industry information [14]. On the other hand, compared with other companies that do not contain DRIs, companies with DRIs are more likely to obtain relevant information about the product market needed for innovation, such as market terminal demand and factor supply, which can help companies overcome information challenges and formulate future strategies according to industry trends, making the innovation direction more targeted and feasible. Finally, it can gain the first-mover advantage in market competition [33,34]. In particular, related industries are most closely related to target industries in terms of input/output and process technology, which affect the business decisions of listed companies [17]. In short, important resources needed for enterprise innovation, such as the update of cutting-edge technology in the industrial chain and changes in supply and demand and development trends, can be obtained through DRIs, which can effectively drive enterprise innovation. Accordingly, the hypothesis is proposed.

H1. *DRIs realizes the effective connection between upstream and downstream industries, which is the important way for enterprises to obtain the resources needed for innovation and effectively promotes enterprise innovation.*

The theoretical framework of this research is shown in Figure 1. According to the framework, DRIs can alleviate the problem of information asymmetry and effectively exert its consulting function. For enterprises in the industrial chain, innovation is faced with a highly unpredictable demand and supply of upstream and downstream industries [11,14,35]. It is easy to have an information gap between enterprises and related industries in the industrial chain, which affects the development of enterprises' innovation activities and the utilization of innovation capabilities. Directors who work in related industries go directly into the upstream and downstream industries to obtain professional knowledge rooted in different fields and information advantages of the industrial chain [36]. Using this information advantage, enterprises can further realize the information penetration between the upstream and downstream industries in the industrial chain and drive innovation and upgrading. This effect may be more significant in environments with high information asymmetry [21]. DRIs directly participate in the formal production and operation of related industries and have early access to the information of technological changes within the industry. Using the information brought by DRIs, enterprises can directly use the innovation results of upstream enterprises to achieve their own technological upgrades. On the other hand, since enterprises' willingness to innovate is often proportional to customer demand [37], the greater the proportion of customer demand in the total sales of the enterprise, the stronger the positive effect of innovation of the target enterprise [5]. DRIs go deep into related industries to better understand the demand information of downstream customers for products and services in the industrial chain, reduces the information transportation cost of such key information [12,38], realizes the dynamic tracking and demand locking of customer demand, and enables enterprises to be more targeted when developing new technologies and new products. Enterprises continuously accumulate industrial chain information sourced by DRIs from related industries. Through the process of organizing, expanding, sorting, and analyzing this information, enterprises enhance their absorptive capacity and break through technological innovation barriers [26,39]. Conversely, the soft innovation-related information collected in this manner, driven by the demand for diversified customer needs and intense market competition, compels enterprises to innovate.

Moreover, the proximity between customers and suppliers plays a significant role in facilitating the production and transmission of innovative soft information [40]. This proximity allows for the swift capture of customer feedback, as DRIs reduce the distance between enterprises and customers, enabling timely adjustments during the research and development process. This, in turn, significantly enhances the likelihood of successful

innovation for enterprises. In line with this finding, Prahalad [41] revealed an increasing emphasis among companies on leveraging customer feedback and involving customers in their innovation processes. In summary, DRIs play a role in bridging the information gap between enterprises, customers, and suppliers by providing insights from upstream and downstream industries. This fosters increased interactions and communication between enterprises, expands the channels for information sourcing, and enables enterprises to fully utilize their internal resources within the industrial chain. Consequently, it facilitates the free flow of informational elements within the industrial chain [17], thereby boosting the willingness and capacity of enterprises to innovate. Based on this analysis, we propose the following hypothesis.

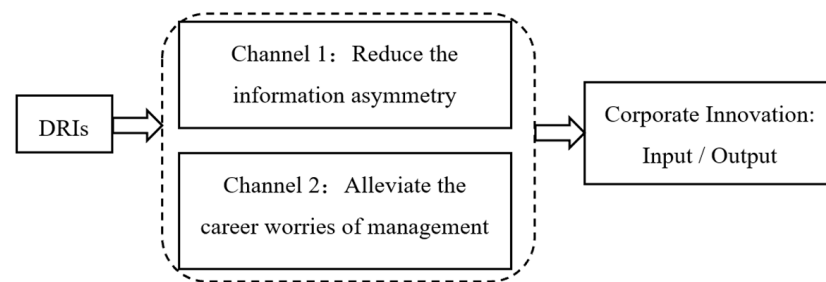


Figure 1. Theoretical framework.

H2. *When the degree of information asymmetry in the industrial chain is high, the role of DRIs in enhancing the innovation ability of enterprises is stronger.*

As presented in the research framework in Figure 1, DRIs can effectively carry out the supervision function, enhance the risk preference of management, alleviate their professional worries, and thus enhance the innovation probability. Graham et al. [42] survey found that most CFOs are committed to improving the short-term performance of enterprises in order to improve their positions and reputation, at the expense of the long-term value of enterprises. Although innovation is the key factor for an enterprise to maintain its long-term core competitiveness, the management may not have enough will to innovate. Innovation often costs a lot of money, requires a lot of manpower and material resources, and takes a long time. Management also needs to deal with potential conflicts of interest among stakeholders. Corresponding to the huge investment is the uncertainty of output, low success probability of innovation, unstable income, and high risk [43], which cannot greatly improve short-term performance, and sometimes even have adverse effects. Then, for managers who are deeply worried about their careers, they tend to be short-sighted in risk avoidance, and their innovative activities are not sufficiently motivated [26]. At this time, if the information between enterprises is transparent, the cost of supervising the innovation process will be reduced, and shareholders can distinguish whether the reason for the decline of short-term performance in the current period is due to the implementation of innovation activities or the management ability of the management. As a result, shareholders have higher tolerance for the short-term performance decline caused by innovation, which alleviates the professional worries of management. By improving the information environment, DRIs can help to alleviate the occupational anxiety of management, reduce the probability of opportunistic behavior, and enhance enterprise innovation. According to this logic, with the aggravation of information asymmetry, the positive relationship between DRIs and enterprise innovation will be strengthened.

That is to say, if an enterprise exists in a completely efficient market and can obtain all the information, then it does not need DRIs to obtain the upstream and downstream industry information by taking part-time jobs, which is conducive to the rational layout and fund allocation of innovative projects beforehand. In the process, it can supervise the management's efforts according to the progress of innovative projects and reward

or punish the management afterwards according to the output, quality, and effect of innovation, so that the enterprise has the full will and ability to innovate [19]. Currently, the impact of DRIs on enterprise innovation is not significant. However, there is no completely efficient market in real life, especially when enterprises face serious information asymmetry. Shareholders often attribute the decline of short-term performance to the incompetence of the management, which leads to the professional anxiety of the management. Existing studies have found that the higher the level of professional anxiety of the managers, the more daring they are to enter new business fields, and the more inclined they are to adopt radical and high-risk exploratory strategies [44,45], such as increasing R&D investment, opening up new markets, etc. [46], and preferring innovation projects with high returns [47]. Shareholders cannot supervise the management's willingness and ability to innovate, nor can they reasonably predict the risks and benefits of innovative projects, thus reducing the probability of enterprise innovation. At this time, the industry information possessed by DRIs will play an important role; it has mastered abundant information in the factor market and product market, and information is the basis of supervision. DRIs can effectively play the role of supervision, reduce the sensitivity of changes in factor market and product market, and alleviate the adverse effects of information asymmetry, thus alleviating the occupational anxiety of management, improving its risk-taking level, reducing management inaction and opportunistic behavior, increasing innovation risk and return, reducing the probability of innovation failure, and promoting enterprise innovation. Accordingly, the hypothesis is proposed in this study.

H3. *When the career anxiety of management in the industrial chain is stronger, the DRIs on enterprise innovation activities are stronger.*

3. Research Design

3.1. Sample Selection and Data Sources

Taking China's A-share listed companies in Shanghai and Shenzhen from 2010 to 2021 as the research object, this paper studies the impact of DRIs on the innovation activities of listed companies. The sample observations of financial industry, ST companies and related data are excluded, and finally 3199 listed companies and 22,456 sample observations are included. In order to eliminate the influence of extreme values on the empirical results, the main continuous variables are narrowed by 1% up and down (Winsorize). Property right nature (SOE) data comes from CCER database (China Center for Economic Research database); innovation input (RD) and innovation output (Patent) data comes from CNRDS database (China research data services database); and other financial data and market transaction data come from CSMAR database (China Stock Market & Accounting Research database). Stata 15.0 was used to perform statistical analysis.

3.2. Variable Definition

Explained variable: enterprise innovation. The innovation of enterprises is measured from the perspectives of innovation input (RD) and innovation output (Patent). The innovation input (RD) is measured by adding 1 to the R&D input of the current year and taking the natural logarithm [48]. At the same time, the sum of the Patent applications for inventions, utility models, and designs of listed companies in that year plus 1 is used as the proxy variable of innovation output [20].

Explanatory variable: DRIs. Firstly, according to the input–output table published by the National Accounting Department of the National Bureau of Statistics, the industrial chain relationship among various industries is determined [11,14,49]. Suppose that for two different industries X and Y, the percentage of industry Y's output into industry X is a%, and the percentage of industry Y's input from industry X is b%. If the sum of a% and b% (called vertical correlation coefficient or VRC) exceeds 1%, the Y industry is regarded as forming a correlation relationship with the X industry through the industrial chain. Next, according to the information of directors' concurrent positions in CSMAR database, for

each director of the company's board of directors in a certain year, it is judged whether other companies in which the director works are related to the formation of the industrial chain of the company, and if so, the director is determined as the DRI of the company. If the part-time director is an executive or a non-independent director in a related industry chain, the weight is set to 1, and the weight is set to 0.5 if the part-time director is an independent director. Finally, all directors are weighted and divided by the board size of the company to obtain the DRI_Val variable. In addition, the virtual variable (DRI_Dum) is also set to determine whether there is a director connection in the industrial chain. If the enterprise has at least one director in the industrial chain, the value of the DRI_Dum variable is 1, otherwise it is 0.

In order to further clarify the causal relationship between DRIs and enterprise innovation, this paper examines the impacts of DRIs on enterprise innovation. Additionally, the influence of directors' concurrent job in related industries on the performance of consulting and supervision functions is different. This article also wants to know whether there are differences between these two channels, whether the differences are at the input end or the output end of the innovation process.

As for the information supply channels, this paper mainly tests from two aspects: (1) It examines the influence of DRIs on inventory management efficiency. Enhanced efficiency in inventory management indicates a better alignment of supply and demand within enterprises. When directors gain access to more insights from upstream and downstream industries through their roles in these sectors, they can make more accurate predictions regarding factor market and product market supply and demand. Consequently, this can lead to improved inventory management efficiency within enterprises. (2) This paper conducts a scenario analysis based on the information asymmetry within related industries along the industrial chain. If part-time DRIs can provide enterprises with additional information related to innovation, then in situations where there is a high level of information asymmetry within related industries along the industrial chain, the impact of DRIs on enterprise innovation activities should be more pronounced.

Patatoukas [50] measures the efficiency of enterprise inventory management by considering enterprise inventory holding level (InvHold) and inventory turnover period (ICP). The inventory holding level is the ratio of the ending inventory balance to the ending total assets, and the inventory turnover period is 365 times the average inventory occupancy divided by the operating cost. This paper measures the information environment of industry chain related industries from two angles: earnings management degree and analyst attention degree. As for the measurement of the earnings management degree (EM) of related industries in the industrial chain, the revised Jones (1991) model of performance matching is used to estimate the earnings management level of enterprises [51], and the absolute value is used to measure the information environment of enterprises. The greater the earnings management degree, the worse the information environment of enterprises. Then, based on the earnings management degree of enterprises, calculate the average earnings management degree of enterprises in the industry, and obtain the earnings management degree of the industry. Finally, the average earnings management degree of upstream and downstream industries in the industrial chain is calculated, and the earnings management degree (EM) of related industries in the industrial chain is obtained. In order to eliminate the estimation error of the model, this paper sorts the EM from small to large by year, and divides the samples less than the smaller third into the lower EM group and the samples larger than the larger third into the higher EM group.

As for the measurement of the analyst's attention degree in the industry chain, first calculate the analyst's industry attention, using the ratio of the number tracked by analysts in the industry to the number of companies in the industry. The higher the value, the better the information environment is. Then, according to the degree of concern of analysts in the industry, the average degree of concern of analysts in upstream and downstream industries in the industrial chain is calculated, and the degree of concern of analysts in related industries in the industrial chain (analyst) is obtained. Sort analysts from small to

large by year, and divide the samples higher than the median of the year into the higher analyst group, and vice versa.

Regarding the channels to relieve executives' career worries, this paper examines them from two aspects: (1) It investigates the impact of DRIs on enterprise risk-taking. If the concurrent directors in the upstream and downstream industries of the industrial chain can make full use of their own information advantages, supervise the managers, and alleviate the agency problems caused by the management's occupational worries, then the management's behavior will no longer be conservative, which will lead to an increase in the overall risk-taking level of the enterprise. (2) This paper investigates the perspective of management's occupational anxiety and conducts scenario test. If part-time directors from related industries can reduce agency costs caused by management's occupational anxiety, then the impact of DRIs on enterprise innovation should be stronger when management's occupational anxiety is high.

Learning from the research of He et al. [20], Return on Assets (ROA) volatility is used to measure the risk-taking level of enterprises. The greater the volatility, the higher the risk-taking level of enterprises. Specifically, the standard deviation (Sd_ROA) and Range (Range_ROA) of ROA adjusted by the industry average in the years t , $t + 1$, and $t + 2$ are used to measure the risk-taking level of enterprises. We use the Tenure (Tenure) and Turnover Rate (Turn) to measure management's occupational anxiety [19,52]. Specifically, the stock turnover rate (Turn) is measured by the average annual turnover rate of individual stocks adjusted by the industry average. The higher the turn, the more short-term traders, and the higher the professional anxiety of executives; Tenure is measured by the average Tenure of company executives. The shorter the tenure, the lower the trench defense ability of executives, and the higher the degree of career anxiety.

Control variables: Referring to previous studies [11,14,18], control variables are defined in CONTROLS, as shown in Table 1, including enterprise size (size), leverage ratio (Lev), profitability (ROA), growth opportunity (TobinQ), speed of development (growth rate), CashFlow (cash flow), duration (CorpAge), capital intensity (CapInt), management's shareholding ratio (Mhold), the largest shareholder's shareholding ratio (Top1), duality (Dual), property right nature (SOE), the proportion of independent directors (Indep), the BoardSize (Board size), the institutional shareholding ratio (InstOwn), and the degree of industry competition (HHI). YEAR is the annual fixed effect, IND is the fixed effect of the company, and $\varepsilon_{i,t}$ is the random disturbance term. The standard errors of regression coefficients are all cluster at the company level. The specific variable names and definitions are shown in Table 1.

Table 1. Definitions of variables.

Variable Name	Variable Code	Variable Declaration
Explained variables (Dependent variables)		
Innovation investment	RD	Natural logarithm of R&D input plus 1
Innovation output	Patent	The natural logarithm of the total number of patent applications plus 1.
Explanatory variables (Independent variables)		
Directors from related industries	DRI_Val	If the part-time director is an executive or a non-independent director in a related industry chain, the weight is set to 1, and the weight is set to 0.5 if the part-time director is an independent director. Finally, all directors are weighted and divided by the board size of the company.
	DRI_Dum	If DRI_Val is greater than 0, the value is 1, otherwise it is 0.
Mechanism test variables (Information supply channels)		
Inventory management efficiency	InvHold	The ratio of the ending inventory balance to the ending total assets
	ICP	Calculated by 365 times the average inventory occupancy divided by the operating cost.

Table 1. Cont.

Variable Name	Variable Code	Variable Declaration
Information environment of industry chain related industries	EM	The revised Jones (1991) model of performance matching was used to estimate the earnings management level of the firm. For details, see Section 3.2.
	analyst	Calculate the degree of concern of analysts in related industries in the industrial chain and sort. For details, see Section 3.2.
Mechanism test variables (Channel for relieving executives' career worries)		
Enterprise risk-taking	ROA volatility	The standard deviation (Sd_ROA) and Range (Range_ROA) of ROA adjusted by the industry average in the years t , $t + 1$, and $t + 2$ are used to measure the risk-taking level of enterprises
Management's occupational anxiety	Tenure	Tenure is measured by the average Tenure of company executives
	Turn	the stock turnover rate (Turn) is measured by the average annual turnover rate of individual stocks adjusted by the industry average.
Control variables		
Size	Size	Take the natural logarithm of total assets
Leverage ratio	Lev	Asset-liability ratio, total liabilities/total assets
Profitability	ROA	(total profit + financial expenses)/total assets
Growth opportunity	TobinQ	Company market value/total assets
Speed of development	Growth	The growth rate of the company's operating income
Cash flow	CashFlow	Net increase in cash and cash equivalents/total assets
Duration	CorpAge	The natural logarithm is obtained by adding 1 to the establishment time of the company.
Capital density	CapInt	Natural logarithm of net fixed assets per capita
Management shareholding ratio	MHold	Number of shares held by management/total share capital
The largest shareholder's shareholding ratio	Top1	Number of shares held by the largest shareholder/total share capital
Duality	Dual	Chairman concurrently serves as general manager, the variable value is equal to 1, otherwise it is 0.
Property right nature	SOE	The actual controller of the company is state-owned, and the variable value is equal to 1, otherwise it is equal to 0.
Proportion of independent directors	Indep	Number of independent directors/total number of company directors
Board size	BoardSize	The number of directors of the company plus 1, takes the natural logarithm.
Institutional shareholding ratio	InstOwn	Number of shares held by institutional investors/total share capital
Industry competition	HHI	Herfindal industry index

3.3. Model Design

To test the research hypotheses of this study, the following model is constructed by referring to the research of [52].

$$RD_{i,t+1} \text{ or } Patent_{i,t+1} = \alpha_0 + \alpha_1 DRI_{i,t} + \sum \text{CONTROLS}_{i,t} + \text{YEAR} + \text{IND} + \varepsilon_{i,t} \quad (1)$$

RD is innovation input and Patent is innovation output. DRIs is measured by the ratio of DRIs (DRI_Val) and whether there is DRI (DRI_Dum). CONTROLS is the control variable. In the model (1), we mainly focus on the regression coefficient before DRIs, and the regression coefficient α_1 indicates the influence of DRIs on enterprise innovation. If

α_1 is significantly positive, it supports hypothesis, which indicates that DRIs can promote enterprise innovation.

4. Analysis of Empirical Results

4.1. Descriptive Statistics

Table 2 shows the results of the descriptive statistics for the main variables. The mean innovation input (RD) of listed companies is 13.460, and the standard deviation is 7.693; The mean value of innovation output is 2.344, and the standard deviation is 1.781. Whether there is DRI (DRI_Dum), the mean value is 0.655, and the standard deviation is 0.475, indicating that 65.5% of the samples observed the existence of DRIs. The average value of DRIs (DRI_Val) is 0.272, and the standard deviation is 0.226. The distribution of other variables is basically consistent with the previous literature.

Table 2. Descriptive statistics of main variables.

Variables	Num	Mean	SD	Min	Med	Max
RD	22,456	13.460	7.693	0	17.240	21.490
Patent	22,441	2.344	1.781	0	2.398	6.809
DRI_Val	22,456	0.272	0.226	0	0.222	1.056
DRI_Dum	22,456	0.655	0.475	0	1	1
Size	22,456	22.080	1.264	19.770	21.900	25.990
Lev	22,456	0.433	0.205	0.052	0.431	0.869
ROA	22,456	0.059	0.053	−0.129	0.054	0.238
TobinQ	22,456	2.546	1.750	0.861	1.987	10.470
Growth	22,456	0.214	0.481	−0.521	0.128	3.273
CashFlow	22,456	0.005	0.086	−0.254	0.003	0.310
CorpAge	22,456	2.760	0.364	1.609	2.833	3.434
CapInt	22,456	12.520	1.134	9.482	12.490	15.710
Mhold	22,456	0.120	0.194	0	0.001	0.681
Top1	22,456	0.353	0.149	0.087	0.334	0.750
Dual	22,456	0.241	0.428	0	0	1
SOE	22,456	0.424	0.494	0	0	1
Indep	22,456	0.372	0.053	0.333	0.333	0.571
BoardSize	22,456	1.867	0.239	1.099	1.946	2.398
InstOwn	22,456	0.783	0.759	0.006	0.582	4.533
HHI	22,456	0.145	0.167	0.014	0.089	1

All variables as previously defined.

4.2. Baseline Regression

Table 3 reports the empirical regression results of the main assumptions in this paper. Columns (1) and (2) are the regression results from the perspective of innovation input (RD) to examine the impact of DRIs on enterprise innovation. The main explanatory variable of column (1) is the ratio of DRIs (DRI_Val). The empirical results show that the regression coefficient before DRI_Val is 1.346, which is significantly positive at 1%. The main explanatory variable of column (2) is whether there is DRI (DRI_Dum) in the enterprise. The results show that the regression coefficient before DRI_Dum is 0.630, which is significantly positive at the level of 1%. Columns (3) and (4) are the regression results of investigating the influence of DRIs on enterprise innovation from the perspective of innovation output. The main explanatory variable of column (3) is the ratio of DRIs (DRI_Val), and the regression coefficient before DRI_Val is 0.368, which is significantly positive at 1%. The main ex-

planatory variable of column (4) is whether there is DRI (DRI_Dum) in the enterprise. The results show that the regression coefficient before DRI_Dum is 0.166, which is significantly positive at the level of 1%. The above results show that the DRIs can significantly increase the innovation input and output of enterprises, and promote the innovation activities of enterprises, thus supporting the research hypothesis H1.

Table 3. DRIs and enterprise innovation.

Variables	(1)	(2)	(3)	(4)
	RD	RD	Patent	Patent
DRI_Val	1.346 ***		0.368 ***	
	(4.426)		(4.577)	
DRI_Dum		0.630 ***		0.166 ***
		(5.158)		(5.305)
Size	1.142 ***	1.157 ***	0.649 ***	0.654 ***
	(11.813)	(12.070)	(25.332)	(25.655)
Lev	−1.652 ***	−1.675 ***	−0.319 ***	−0.325 ***
	(−3.277)	(−3.324)	(−2.753)	(−2.807)
ROA	2.213 *	2.235 *	1.632 ***	1.639 ***
	(1.788)	(1.804)	(5.049)	(5.070)
TobinQ	0.050	0.052	0.025 **	0.025 **
	(1.102)	(1.147)	(2.102)	(2.148)
Growth	−0.067	−0.067	−0.021	−0.022
	(−0.742)	(−0.742)	(−0.998)	(−1.002)
CashFlow	−0.362	−0.386	0.084	0.077
	(−1.058)	(−1.131)	(0.972)	(0.898)
CorpAge	−2.221 ***	−2.209 ***	−0.271 ***	−0.268 ***
	(−9.074)	(−9.035)	(−3.988)	(−3.953)
CapInt	−0.505 ***	−0.511 ***	−0.182 ***	−0.184 ***
	(−5.990)	(−6.088)	(−9.008)	(−9.128)
Mhold	2.473 ***	2.420 ***	0.259 **	0.244 **
	(6.748)	(6.621)	(2.338)	(2.207)
Top1	0.088	0.099	−0.168	−0.166
	(0.164)	(0.183)	(−1.096)	(−1.079)
Dual	0.208	0.211	0.093 **	0.093 **
	(1.482)	(1.502)	(2.369)	(2.390)
SOE	−0.255	−0.260	0.015	0.015
	(−1.191)	(−1.210)	(0.292)	(0.275)
Indep	−2.367	−2.202	−0.206	−0.159
	(−1.550)	(−1.446)	(−0.489)	(−0.379)
Boardsize	0.482	0.328	0.005	−0.036
	(1.375)	(0.938)	(0.052)	(−0.391)
InstOwn	−0.066	−0.069	−0.063 ***	−0.063 ***
	(−0.743)	(−0.773)	(−2.739)	(−2.767)

Table 3. Cont.

Variables	(1)	(2)	(3)	(4)
	RD	RD	Patent	Patent
HHI	−0.160 (−0.263)	−0.191 (−0.315)	−0.069 (−0.486)	−0.078 (−0.550)
IND	control	control	control	control
YEAR	control	control	control	control
_cons	−8.326 *** (−3.296)	−8.420 *** (−3.357)	−10.145 *** (−15.689)	−10.178 *** (−15.766)
N	22,456	22,456	22,441	22,441
r2_a	0.526	0.526	0.466	0.466

Values in parentheses are t-statistics; ***, **, * denote 1%, 5%, and 10% significance levels, respectively. All variables as previously defined.

4.3. Mechanism Test

4.3.1. Information Supply Channels

Firstly, this paper examines the impact of the DRIs on the efficiency of enterprise inventory management. The empirical results are shown in Table 4. DRIs reduces the inventory holding level of enterprises and shortens the inventory turnover period of enterprises. Furthermore, the information environment of related industries is measured according to the earnings management degree and analyst attention degree of related industries, and the main assumptions of this paper are tested in groups. The empirical results are shown in Table 5. Panel A found that when the earnings management degree of related industries in the industrial chain is high, the influence of DRIs on enterprise innovation activities is stronger. This result exists in both the input and output of the innovation process, and both have passed the Chi2 Test. Panel B found that the impact of DRIs on the innovation input and output of enterprises was stronger when the attention of industry chain analysts was low, and all of them passed the inter-group coefficient difference test. The above results support the consultation channel, thus supporting the research hypothesis H2. That is, the concurrent employment of directors in the upstream and downstream industries of the industrial chain can provide relevant information for enterprises' innovation activities, increase enterprises' innovation investment, and promote the effective output of enterprises' innovation investment.

Table 4. DRIs and inventory management efficiency.

	(1)	(2)	(3)	(4)
Explained variable	InvHold	InvHold	ICP	ICP
DRI_Val	−0.019 *** (−2.802)		−54.445 *** (−3.451)	
DRI_Dum		−0.006 ** (−2.208)		−20.531 *** (−2.692)
CONTROLS	control	control	control	control
YEAR&IND	control	control	control	control
N	22,456	22,456	22,454	22,454
r2_a	0.487	0.487	0.478	0.478

Values in parentheses are t-statistics; ***, ** denote 1% and 5%, significance levels, respectively. All variables as previously defined.

Table 5. DRIs, Information asymmetry and enterprise innovation.

Panel A: Measure information asymmetry by the earnings management degree (EM) of related industries								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EM	low	tall	low	tall	low	tall	low	tall
Explained variable	RD	RD	RD	RD	Patent	Patent	Patent	Patent
DRI_Val	0.896 ***	1.849 ***			0.240 ***	0.432 ***		
	(3.295)	(5.909)			(3.433)	(6.109)		
DRI_Dum			0.486 ***	0.895 ***			0.125 ***	0.227 ***
			(4.025)	(5.924)			(4.011)	(6.654)
CONTROLS	control	control	control	control	control	control	control	control
YEAR&IND	control	control	control	control	control	control	control	control
N	7482	7485	7482	7485	7480	7480	7480	7480
r2_a	0.575	0.511	0.575	0.511	0.417	0.477	0.417	0.478
Chi2 Test (p-Value)	5.27 **		4.37 **		3.55 *		4.95 **	
	(0.022)		(0.037)		(0.059)		(0.026)	
Panel B: Measure information asymmetry by the degree of concern of industry analyst								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Analyst	tall	low	tall	low	tall	low	tall	low
Explained variable	RD	RD	RD	RD	Patent	Patent	Patent	Patent
DRI_Val	0.966 ***	1.596 ***			0.270 ***	0.463 ***		
	(4.282)	(6.567)			(4.715)	(7.970)		
DRI_Dum			0.471 ***	0.737 ***			0.131 ***	0.200 ***
			(4.384)	(6.607)			(4.779)	(7.498)
CONTROLS	control	control	control	control	control	control	control	control
YEAR&IND	control	control	control	control	control	control	control	control
N	11,231	11,225	11,231	11,225	11,225	11,216	11,225	11,216
r2_a	0.564	0.495	0.564	0.495	0.501	0.424	0.501	0.423
Chi2 Test (p-Value)	3.57 *		2.94 *		5.38 **		3.36 *	
	(0.059)		(0.087)		(0.020)		(0.067)	

Values in parentheses are t-statistics; ***, **, * denote 1%, 5%, and 10% significance levels, respectively. All variables as previously defined.

4.3.2. Channel for Relieving Executives' Career Worries

First, we assessed the influence of DRIs on enterprise risk tolerance. The empirical findings are presented in Table 6, where DRIs contribute to an increase in the standard deviation and range of ROA. Additionally, group tests were conducted based on the annual median values of stock turnover rate (Turn) and senior management tenure (Tenure), and the empirical results are detailed in Table 7. Panel A found that when the stock turnover rate is high, the influence of DRIs on enterprise innovation is stronger. However, this conclusion only exists at the input end of innovation activities, and its influence is not obvious at the output end. Specifically, the regression results with innovation input (RD), as the explained variable passed the inter-group coefficient difference test, while the regression results with innovation output (Patent), as the explained variable failed the inter-group coefficient difference test. The above results support the supervision channel, that is, the director's concurrent job in the upstream and downstream industries of the industrial chain can make better use of the information advantage to supervise the management, alleviate the professional anxiety of the executives, and promote the innovation investment of enterprises, but it has no influence on the transformation effect of innovation investment.

Table 6. DRIs and risk-taking.

	(1)	(2)	(3)	(4)
	Sd_ROA	Sd_ROA	Range_ROA	Range_ROA
DRI_Val	0.035 **		0.063 **	
	(2.126)		(2.122)	
DRI_Dum		0.020 *		0.036 *
		(1.682)		(1.683)
CONTROLS	control	control	control	control
YEAR&IND	control	control	control	control
N	16,740	16,740	16,740	16,740
r2_a	0.065	0.065	0.064	0.065

Values in parentheses are t-statistics; **, * denote 5%, and 10% significance levels, respectively. All variables as previously defined.

Table 7. DRIs, executives' career worries, and enterprise innovation.

Panel A: Measuring executives' career worries by turnover rate								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Turn	low	tall	low	tall	low	tall	low	tall
Explained variable	RD	RD	RD	RD	Patent	Patent	Patent	Patent
DRI_Val	1.028 ***	1.718 ***			0.356 ***	0.386 ***		
	(4.495)	(7.098)			(6.186)	(6.680)		
DRI_Dum			0.442 ***	0.781 ***			0.165 ***	0.167 ***
			(3.939)	(7.254)			(6.451)	(5.877)
CONTROLS	control	control	control	control	control	control	control	control
YEAR&IND	control	control	control	control	control	control	control	control
N	11,224	11,229	11,224	11,229	11,226	11,212	11,226	11,212
r2_a	0.539	0.514	0.539	0.514	0.423	0.497	0.423	0.496
Chi2 Test	4.22 **		4.74 **		0.12		0.00	
(p-Value)	(0.040)		(0.029)		(0.724)		(0.976)	
Panel B: Measuring executives' career worries by their tenure.								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Tenure	short	long	short	long	short	long	short	long
Explained variable	RD	RD	RD	RD	Patent	Patent	Patent	Patent
DRI_Val	1.867 ***	0.807 ***			0.396 ***	0.336 ***		
	(7.873)	(3.490)			(6.909)	(5.774)		
DRI_Dum			0.781 ***	0.479 ***			0.171 ***	0.157 ***
			(6.856)	(4.552)			(6.215)	(5.937)
CONTROLS	control	control	control	control	control	control	control	control
YEAR&IND	control	control	control	control	control	control	control	control
N	11,224	11,231	11,224	11,231	11,216	11,224	11,216	11,224
r2_a	0.520	0.536	0.520	0.537	0.469	0.464	0.468	0.464
Chi2 Test	10.12 ***		3.75 *		0.53		0.14	
(p-Value)	(0.002)		(0.053)		(0.465)		(0.712)	

Values in parentheses are t-statistics; ***, **, * denote 1%, 5%, and 10% significance levels, respectively. All variables as previously defined.

4.4. Economic Consequences

Existing studies have found that the directors' concurrent jobs in upstream and downstream industries of the industrial chain can enhance corporate value and financial performance [11,53], but few studies focus on how it works. Innovation helps enterprises to form core competitiveness and is the core driving force for the long-term value enhancement of enterprises. Based on the previous findings, this paper expects that an important factor for the promotion of enterprise value and financial performance by the DRIs may be that DRIs promotes the innovation activities of enterprises. Therefore, using the intermediary effect model of [54] for reference, this paper examines whether enterprise innovation plays an intermediary role between DRIs and enterprise value and uses the empirical model of [55] for reference to control the related variables.

Table 8 reports the regression results of the enterprise value measured by TobinQ, and Table 9 reports the regression results of financial performance measured by ROA. Columns (1) and (4) of Tables 8 and 9 found that directors' concurrent jobs in the upstream and downstream industries of the industrial chain can enhance corporate value and financial performance, which is consistent with the results of [11,53]. Columns (2) and (5) are consistent with the previous regression results, and the DRIs can promote innovation input and innovation output. Further considering the intermediary effect, column (3) and column (6) found that after controlling the innovation activities of enterprises, the positive correlation between directors' concurrent jobs in the upstream and downstream industries of the industrial chain and enterprise value decreased, and Sobel Z statistics were significant, which indicated that the innovation activities of enterprises played an intermediary effect. The above results show that the innovation activities of enterprises are an important channel to realize the promotion of enterprise value and financial performance by the DRIs in the industrial chain.

Table 8. DRIs, Enterprise innovation and enterprise value.

Panel A: The empirical results with innovation input (RD) as intermediary variable.						
	(1)	(2)	(3)	(4)	(5)	(6)
	DRI_Val	DRI_Val	DRI_Val	DRI_Dum	DRI_Dum	DRI_Dum
Explained variable	TobinQ	RD	TobinQ	TobinQ	RD	TobinQ
DRI	0.099 *** (2.599)	1.472 *** (8.762)	0.093 ** (2.439)	0.032 * (1.767)	0.622 *** (7.837)	0.029 (1.629)
RD			0.004 *** (2.644)			0.004 ** (2.561)
CONTROLS	control	control	control	control	control	control
YEAR& IND	control	control	control	control	control	control
N	21,855	21,855	21,855	21,855	21,855	21,855
Adj-R2	0.439	0.525	0.439	0.438	0.520	0.439
Sobel Z (p-Value)		2.551 (0.011)			2.434 (0.015)	
Panel B: The empirical results with innovation output(patent) as intermediary variable.						
	(1)	(2)	(3)	(4)	(5)	(6)
	DRI_Val	DRI_Val	DRI_Val	DRI_Dum	DRI_Dum	DRI_Dum
Explained variable	TobinQ	Patent	TobinQ	TobinQ	Patent	TobinQ
DRI	0.104 *** (2.732)	0.394 *** (9.471)	0.091 ** (2.369)	0.033 * (1.817)	0.174 *** (8.887)	0.027 (1.475)
Patent			0.035 *** (5.599)			0.035 *** (5.663)

Table 8. *Cont.*

Panel B: The empirical results with innovation output(patent) as intermediary variable.						
	(1)	(2)	(3)	(4)	(5)	(6)
DRI	DRI_Val	DRI_Val	DRI_Val	DRI_Dum	DRI_Dum	DRI_Dum
CONTROLS	control	control	control	control	control	control
YEAR& IND	control	control	control	control	control	control
N	21,840	21,840	21,840	21,840	21,840	21,840
Adj-R2	0.438	0.456	0.439	0.438	0.456	0.439
Sobel Z (p-Value)		4.820 (0.000)			4.776 (0.000)	

Values in parentheses are t-statistics; ***, **, * denote 1%, 5%, and 10% significance levels, respectively. All variables as previously defined.

Table 9. DRIs, enterprise innovation, and financial performance in industry chain.

Panel A: The empirical results with innovation input (RD) as intermediary variable.						
	(1)	(2)	(3)	(4)	(5)	(6)
DRI	DRI_Val	DRI_Val	DRI_Val	DRI_Dum	DRI_Dum	DRI_Dum
Explained variable	ROA	RD	ROA	ROA	RD	ROA
DRI	0.009 *** (4.868)	1.323 *** (7.836)	0.008 *** (4.514)	0.003 *** (4.120)	0.622 *** (7.837)	0.003 *** (3.763)
RD			0.001 *** (6.681)			0.001 *** (6.710)
CONTROLS	control	control	control	control	control	control
YEAR& IND	control	control	control	control	control	control
N	21,855	21,855	21,855	21,855	21,855	21,855
Adj-R2	0.126	0.520	0.128	0.126	0.520	0.128
Sobel Z (p-Value)		7.836 (0.000)			7.837 (0.000)	

Panel B: The empirical results with innovation output(patent) as intermediary variable.						
	(1)	(2)	(3)	(4)	(5)	(6)
DRI	DRI_Val	DRI_Val	DRI_Val	DRI_Dum	DRI_Dum	DRI_Dum
Explained variable	ROA	Patent	ROA	ROA	Patent	ROA
DRI	0.008 *** (4.836)	0.394 *** (9.471)	0.007 *** (4.035)	0.003 *** (4.076)	0.174 *** (8.887)	0.003 *** (3.321)
Patent			0.004 *** (12.645)			0.004 *** (12.704)
CONTROLS	control	control	control	control	control	control
YEAR& IND	control	control	control	control	control	control
N	21,840	21,840	21,840	21,840	21,840	21,840
Adj-R2	0.126	0.456	0.132	0.126	0.456	0.132
Sobel Z (p-Value)		7.580 (0.000)			7.282 (0.000)	

Values in parentheses are t-statistics; *** denote 1% significance levels, respectively. All variables as previously defined.

5. Robustness Test

5.1. Discussion on Endogenous Issues

In order to eliminate “there may be systematic differences between enterprises with and without DRIs”, this paper uses the propensity score matching method (PSM) to alleviate such problems and carries out the 1:1 nearest neighbor matching with a radius constraint (0.001) for the samples with DRIs. Before PSM, the balance test is required. As shown in Table 10, the standard deviation of all covariates after matching is less than 5%, and the T value of the difference between groups after matching is not significantly different from 0, which indicates that the matching effect is good. Table 11 reports the regression results using matched samples and finds that the positive correlation between the DRIs and enterprise innovation has not changed, which further supports the main conclusions of this paper.

Table 10. Balance test of table matching variables.

Variables	Matching	Average/Mean Value		Standard Deviation (%)	Reduction in Standard Deviation (%)	T Test	
		Processing Group	Processing Group			T Value	p Value
Size	Front matching	22.24	21.76	39.90		27.820	0.000
	After matching	21.81	21.82	−0.50	98.70	−0.350	0.727
Lev	Front matching	0.443	0.415	13.60		9.740	0.000
	After matching	0.418	0.418	0.00	99.80	0.020	0.984
ROA	Front matching	0.060	0.058	4.10		2.910	0.004
	After matching	0.059	0.059	0.60	84.50	0.380	0.707
TobinQ	Front matching	2.456	2.716	−14.70		−10.59	0.000
	After matching	2.684	2.672	0.60	95.60	0.370	0.708
Growth	Front matching	0.211	0.219	−1.70		−1.190	0.235
	After matching	0.210	0.214	−0.80	52.10	−0.480	0.633
CashFlow	Front matching	0.006	0.001	5.90		4.230	0.000
	After matching	0.003	0.002	0.90	84.50	0.530	0.596
CorpAge	Front matching	2.775	2.731	12.00		8.630	0.000
	After matching	2.739	2.737	0.40	96.40	0.260	0.793
CapInt	Front matching	12.57	12.43	12.80		9.040	0.000
	After matching	12.43	12.44	0.00	99.80	−0.010	0.991
Mhold	Front matching	0.109	0.140	−15.80		−11.49	0.000
	After matching	0.138	0.137	0.50	96.50	0.310	0.755
Top1	Front matching	0.354	0.352	1.10		0.810	0.420
	After matching	0.350	0.351	−1.00	10	−0.620	0.537
Dual	Front matching	0.233	0.255	−5.10		−3.680	0.000
	After matching	0.256	0.254	0.30	94.30	0.170	0.863
SOE	Front matching	0.453	0.368	17.20		12.22	0.000
	After matching	0.370	0.376	−1.30	92.70	−0.760	0.447
Indep	Front matching	0.371	0.374	−4.80		−3.380	0.001
	After matching	0.374	0.373	1.10	76.20	0.670	0.504
BoardSize	Front matching	1.884	1.835	20.90		14.86	0.000
	After matching	1.839	1.843	−1.80	91.40	−1.080	0.282
InstOwn	Front matching	0.794	0.763	4.10		2.930	0.003
	After matching	0.752	0.763	−1.40	65	−0.870	0.384
HHI	Front matching	0.138	0.158	−11.70		−8.590	0.000
	After matching	0.147	0.149	−1.20	89.40	−0.740	0.460

Table 11. Propensity score-matched post-sample test.

Variables	(1)	(2)	(3)	(4)
	RD	RD	Patent	Patent
DRI_Val	1.737 *** (4.912)		0.391 *** (4.537)	
DRI_Dum		0.653 *** (4.919)		0.161 *** (4.886)
Size	1.042 *** (9.274)	1.067 *** (9.541)	0.595 *** (20.096)	0.600 *** (20.408)
Lev	−1.767 *** (−3.077)	−1.784 *** (−3.107)	−0.298 ** (−2.356)	−0.302 ** (−2.385)
ROA	4.052 *** (2.919)	4.068 *** (2.924)	1.900 *** (5.493)	1.903 *** (5.499)
TobinQ	0.016 (0.306)	0.019 (0.368)	0.012 (0.937)	0.013 (0.991)
Growth	−0.183 (−1.580)	−0.180 (−1.553)	−0.049 * (−1.885)	−0.049 * (−1.858)
CashFlow	−0.881 ** (−2.030)	−0.904 ** (−2.084)	−0.062 (−0.583)	−0.068 (−0.638)
CorpAge	−2.651 *** (−10.092)	−2.654 *** (−10.096)	−0.281 *** (−3.979)	−0.281 *** (−3.986)
CapInt	−0.502 *** (−5.501)	−0.509 *** (−5.594)	−0.177 *** (−8.417)	−0.178 *** (−8.498)
Mhold	2.222 *** (5.757)	2.139 *** (5.546)	0.300 *** (2.610)	0.281 ** (2.451)
Top1	−0.468 (−0.764)	−0.473 (−0.773)	−0.297 * (−1.818)	−0.298 * (−1.825)
Dual	0.315 ** (1.972)	0.322 ** (2.014)	0.105 ** (2.505)	0.106 ** (2.544)
SOE	−0.362 (−1.446)	−0.357 (−1.423)	0.014 (0.250)	0.016 (0.274)
Indep	−0.502 (−0.292)	−0.230 (−0.134)	−0.117 (−0.258)	−0.056 (−0.123)
BoardSize	0.721 * (1.831)	0.580 (1.475)	−0.051 (−0.504)	−0.082 (−0.826)
InstOwn	−0.081 (−0.766)	−0.080 (−0.757)	−0.049 ** (−1.967)	−0.049 * (−1.956)
HHI	−0.625 (−0.910)	−0.663 (−0.969)	−0.096 (−0.651)	−0.104 (−0.708)
IND	control	control	control	control
YEAR	control	control	control	control

Table 11. *Cont.*

Variables	(1)	(2)	(3)	(4)
	RD	RD	Patent	Patent
_cons	−5.593 *	−5.924 **	−8.967 ***	−9.049 ***
	(−1.919)	(−2.033)	(−12.468)	(−12.599)
N	14,300	14,300	14,291	14,291
r2_a	0.518	0.518	0.413	0.413

Values in parentheses are t-statistics; ***, **, * denote 1%, 5%, and 10% significance levels, respectively. All variables as previously defined.

Because the systematic difference between enterprises with and without DRIs may be influenced by unobservable factors, this paper further uses the Heckman two-stage test to alleviate the possible problem of sample self-selection. In the first stage of Probit regression, the explained variables are set according to whether there is DRI in the industrial chain of the enterprise, and the inverse Mills ratio (IMR) is calculated by using the regression results of this stage. Then, it is added into the model (1), and the main assumptions are regressed again. The empirical results are shown in Table 12. The relationship between the DRIs and enterprise innovation is still significantly positive, indicating that the main regression results of this paper have not changed after considering the sample self-selection, which further supports the hypothesis of this paper.

Table 12. Heckman's two-stage test.

Variables	(1)	(2)	(3)	(4)
	RD Stage I	RD Stage II	Patent Stage I	Patent Stage II
DRI_Val	1.207 ***		0.366 ***	
	(3.876)		(4.479)	
DRI_Dum		0.570 ***		0.165 ***
		(4.625)		(5.196)
Size	1.042 ***	1.051 ***	0.648 ***	0.651 ***
	(9.521)	(9.614)	(23.314)	(23.442)
Lev	−1.668 ***	−1.690 ***	−0.319 ***	−0.326 ***
	(−3.312)	(−3.355)	(−2.756)	(−2.812)
ROA	1.805	1.807	1.627 ***	1.628 ***
	(1.446)	(1.447)	(4.983)	(4.984)
TobinQ	0.047	0.048	0.025 **	0.025 **
	(1.025)	(1.061)	(2.098)	(2.139)
Growth	−0.043	−0.042	−0.021	−0.021
	(−0.471)	(−0.461)	(−0.977)	(−0.965)
CashFlow	−0.478	−0.504	0.082	0.074
	(−1.385)	(−1.465)	(0.944)	(0.852)
CorpAge	−2.138 ***	−2.124 ***	−0.270 ***	−0.266 ***
	(−8.610)	(−8.567)	(−3.932)	(−3.880)
CapInt	−0.4900 ***	−0.495 ***	−0.182 ***	−0.184 ***
	(−5.809)	(−5.889)	(−8.993)	(−9.095)

Table 12. Cont.

Variables	(1)	(2)	(3)	(4)
	RD Stage I	RD Stage II	Patent Stage I	Patent Stage II
Mhold	2.681 *** (7.052)	2.642 *** (6.955)	0.262 ** (2.322)	0.250 ** (2.219)
Top1	0.244 (0.447)	0.260 (0.476)	−0.166 (−1.064)	−0.162 (−1.033)
Dual	0.194 (1.380)	0.195 (1.393)	0.092 ** (2.359)	0.093 ** (2.375)
SOE	−0.342 (−1.581)	−0.349 (−1.617)	0.014 (0.266)	0.012 (0.226)
Indep	−2.956 * (−1.903)	−2.832 * (−1.824)	−0.214 (−0.500)	−0.176 (−0.413)
BoardSize	0.106 (0.281)	−0.046 (−0.123)	0.0001 (0.001)	−0.046 (−0.460)
InstOwn	−0.073 (−0.818)	−0.075 (−0.849)	−0.063 *** (−2.739)	−0.063 *** (−2.772)
HHI	−0.013 (−0.021)	−0.034 (−0.056)	−0.067 (−0.468)	−0.073 (−0.515)
IMR	−1.245 ** (−2.267)	−1.290 ** (−2.377)	−0.016 (−0.125)	−0.035 (−0.276)
_cons	−4.147 (−1.284)	−4.070 (−1.260)	−10.093 *** (−12.964)	−10.061 *** (−12.897)
N	22,456	22,456	22,441	22,441
r2_a	0.5259	0.5259	0.4658	0.4657

Values in parentheses are t-statistics; ***, **, * denote 1%, 5%, and 10% significance levels, respectively. All variables as previously defined.

In addition, in order to further ensure the robustness of the results of this paper, we use “the average value of DRIs (Ind_DRI) of other companies in Chinese industry” and “the average value of DRIs (Prvn_DRI) of other companies in Chinese province” as the instrumental variable of DRIs to test the relationship between DRIs and enterprise innovation. Table 13 reports the regression results using instrumental variables. Columns (1), (3), (5), and (7) found that whether the ratio (DRI_Val) or the dummy variable (DRI_Dum) were used to measure the DRIs. In the first stage of regression results, the regression coefficients of instrumental variables Ind_DRI and Prvn_DRI were all significantly positive at the level of 1%. The F statistics are all greater than 10, and the *p* value of Anderson–Rubin statistics is also significantly different from 0, which indicates that there is no weak instrumental variable problem. Columns (2), (4), (6), and (8) reported the regression results of the second stage. It was found that the relationship between the DRIs, innovation input, and innovation output was significantly positive at least at the level of 5%, and the previous regression results were still valid. In addition, the Hansen–J statistic is not significant at the level of 10%, which indicates that it has passed the test of over-recognition, thus further illustrating the credibility of the regression results of instrumental variables.

Table 13. Instrumental variable method test.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Stage I	stage II	Stage I	stage II	Stage I	stage II	Stage I	stage II
	DRI_Val	RD	DRI_Dum	RD	DRI_Val	Patent	DRI_Dum	Patent
Ind_DRI	0.921 ***		1.678 ***		0.920 ***		1.678 ***	
	(13.983)		(11.464)		(14.957)		(11.459)	
Prvn_DRI	0.965 ***		1.470 ***		0.966 ***		1.472 ***	
	(15.505)		(12.546)		(15.509)		(12.560)	
DRIs_Val		4.700 ***				0.798 **		
		(3.255)				(2.327)		
DRIs_Dum				2.921 ***				0.500 **
				(3.316)				(2.423)
Size	0.034 ***	1.018 ***	0.051 ***	1.033 ***	0.035 ***	0.633 ***	0.051 ***	0.636 ***
	(9.409)	(9.095)	(8.607)	(9.463)	(9.423)	(22.131)	(8.618)	(22.710)
Lev	−0.001	−1.605 ***	0.028	−1.692 ***	−0.001	−0.313 ***	0.027	−0.328 ***
	(−0.047)	(−3.183)	(0.813)	(−3.355)	(−0.044)	(−2.703)	(0.809)	(−2.837)
ROA	0.101 **	1.810	0.191 **	1.725	0.099 **	1.581 ***	0.187 **	1.567 ***
	(2.043)	(1.434)	(2.044)	(1.353)	(2.000)	(4.828)	(1.992)	(4.762)
TobinQ	0.002	0.042	0.002	0.047	0.002	0.024 **	0.002	0.025 **
	(1.177)	(0.915)	(0.424)	(1.030)	(1.193)	(2.014)	(0.445)	(2.088)
Growth	−0.003	−0.049	−0.008	−0.040	−0.003	−0.019	−0.008	−0.018
	(−0.948)	(−0.533)	(−1.124)	(−0.434)	(−0.917)	(−0.883)	(−1.099)	(−0.811)
CashFlow	0.014	−0.395	0.067 **	−0.523	0.014	0.079	0.069 **	0.057
	(1.026)	(−1.135)	(2.131)	(−1.480)	(1.039)	(0.915)	(2.183)	(0.645)
CorpAge	−0.014	−2.184 ***	−0.467 **	−2.111 ***	−0.014	−0.266 ***	−0.047 **	−0.254 ***
	(−1.428)	(−8.778)	(−2.547)	(−8.366)	(−1.444)	(−3.893)	(−2.572)	(−3.689)
CapInt	−0.008 **	−0.476 ***	−0.007	−0.494 ***	−0.008 **	−0.179 ***	−0.007	−0.182 ***
	(−2.559)	(−5.552)	(−1.228)	(−5.836)	(−2.576)	(−8.713)	(−1.240)	(−8.950)
Mhold	−0.099 ***	2.789 ***	−0.124 ***	2.689 ***	−0.099 ***	0.300 ***	−0.125 ***	0.284 **
	(−5.924)	(7.054)	(−3.616)	(6.919)	(−5.924)	(2.598)	(−3.628)	(2.497)
Top1	−0.040 *	0.192	−0.096 **	0.288	−0.040 *	−0.155	−0.096 **	−0.139
	(−1.841)	(0.353)	(−2.366)	(0.526)	(−1.859)	(−1.002)	(−2.364)	(−0.886)
Dual	0.005	0.190	0.007	0.193	0.005	0.090 **	0.007	0.091 **
	(0.819)	(1.347)	(0.575)	(1.370)	(0.835)	(2.302)	(0.575)	(2.321)
SOE	0.021 ***	−0.316	0.049 ***	−0.364 *	0.021 ***	0.008	0.049 ***	−0.001
	(2.594)	(−1.466)	(3.419)	(−1.683)	(2.589)	(0.143)	(3.413)	(−0.011)
Indep	0.277 ***	−3.265 **	0.326 ***	−2.914 *	0.279 ***	−0.322	0.328 ***	−0.264
	(4.293)	(−2.053)	(2.813)	(−1.861)	(4.312)	(−0.743)	(2.833)	(−0.616)
BoardSize	−0.027 *	0.571	0.187 ***	−0.100	−0.026 *	0.016	0.188 ***	−0.099
	(−1.931)	(1.607)	(7.298)	(−0.263)	(−1.910)	(0.175)	(7.320)	(−0.990)
InstOwn	−0.001	−0.064	0.002	−0.076	−0.001	−0.062 ***	0.002	−0.064 ***
	(−0.277)	(−0.722)	(0.359)	(−0.849)	(−0.307)	(−2.732)	(0.324)	(−2.806)
HHI	−0.051 ***	0.025	−0.060	−0.034	−0.052 ***	−0.045	−0.060	−0.055
	(−2.903)	(0.040)	(−1.569)	(−0.056)	(−2.916)	(−0.314)	(−1.565)	(−0.386)

Table 13. Cont.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Stage I	stage II	Stage I	stage II	Stage I	stage II	Stage I	stage II
	DRI_Val	RD	DRI_Dum	RD	DRI_Val	Patent	DRI_Dum	Patent
IND	control	control	control	control	control	control	control	control
YEAR	control	control	control	control	control	control	control	control
_cons	−0.803 *** (−8.808)	−6.272 ** (−2.313)	−1.465 *** (−9.431)	−5.763 ** (−2.096)	−0.804 *** (−8.514)	−9.882 *** (−14.634)	−1.467 *** (−9.441)	−9.790 *** (−14.297)
N	22,456	22,456	22,456	22,456	22,441	22,441	22,441	22,441
r2_a	0.152	0.517	0.107	0.507	0.152	0.463	0.107	0.458
F-Statistics	39.44	152.24	32.45	147.46	39.40	124.78	32.43	123.64
Hansen-J (p value)	0.023 (0.879)		0.211 (0.665)		0.064 (0.800)		0.000 (0.990)	
Anderson-Rubin (p value)	5.90 (0.003)		5.90 (0.003)		5.02 (0.007)		5.02 (0.007)	

Values in parentheses are t-statistics; ***, **, * denote 1%, 5%, and 10% significance levels, respectively. All variables as previously defined.

5.2. Other Robustness Tests

In order to further ensure the reliability of the research conclusion, the following robustness tests were carried out: (1) The measurement method of innovation investment was changed, and the enterprise innovation investment was measured by dividing R&D expenditure by the total assets at the end of the period and R&D expenditure by the current operating income [56], but the empirical regression results remained unchanged. (2) This paper changed the measurement method of innovation output. Firstly, the number of patent applications is used to measure innovation output [57]. Since the number of patent applications is a non-negative integer, negative binomial regression is used to re-estimate the model (1); secondly, the innovation output of enterprises is measured by the total number of invention patents and utility model patent applications with stronger technological innovation [58]; finally, the number of patents granted is used to measure the innovation output of enterprises [59], and the above empirical results are all valid. (3) Considering the lag effect of innovation output, extend the measurement period of enterprise innovation output, and use $t + 2$ and $t + 3$ Patent to measure enterprise innovation output. The research conclusion remains unchanged. (4) Consider the situation that innovation input and innovation output have a large number of zero values. In order to eliminate the influence of the distribution of the explained variables on the regression results of this paper, firstly, according to whether the innovation input and innovation output are greater than 0, set whether the explained variables have innovation input (RD_Dum) and innovation output (Patent_Dum), and use Logit or Probit to re-estimate hypothesis 1. The empirical results have not changed; secondly, the Tobit model is used to regress the model (1), and the research conclusion remains unchanged. Finally, delete the sample observation whose explanatory variable is 0, and re-estimate hypothesis 1; the empirical results are all valid. (5) As some enterprises can still maintain sustainable operation without innovative activities, refer to the practice of [20], and keep high-tech industries as research samples (i.e., eliminate the sample observation with industry codes A, D, F, H, J, K, and M). All the above tests have not changed the empirical regression results of this paper, which are not listed in detail due to the space.

6. Conclusions and Discussion

Overall, this study examines the implementation effect of corporate governance structure arrangement from the perspective of industrial chain, and explores how enterprises play the role of DRIs, thus having an important impact on innovation.

The results show that the DRIs significantly promotes the innovation activities of enterprises, and the innovation input and innovation output have been significantly increased. Further research shows that DRIs can reduce the inventory holding level and shorten the inventory turnover period of enterprises, thus improving the inventory management efficiency of enterprises. DRIs have a more significant positive impact on innovation input and innovation output when the earnings management degree of related industries in the industrial chain is high and analysts' attention is low. These results show that DRIs can provide enterprises with the upstream and downstream information of the industrial chain and promote the innovation activities of enterprises. DRIs improves the risk-taking level of enterprises, and when the stock turnover rate is high and the tenure of executives is short, DRIs has a more significant positive impact on innovation investment, but has no impact on innovation output. These results show that DRIs can supervise executives and relieve their career worries. The above results confirm that the DRIs can play a better role of supervision and consultation in the innovation activities of enterprises. Finally, the study of economic consequences shows that enterprise innovation activities are an important channel to realize the promotion of enterprise value and financial performance by DRIs in industrial chain.

The research provides some valuable revelations for directors, enterprises, associated upstream and downstream supply chains, and government regulatory authorities. First, for enterprises and the associated upstream and downstream supply chains, it is imperative to establish a systematic and standardized mechanism for selecting directors. This approach can fully leverage the unique roles these directors play in supervising and advising on the innovation endeavors of enterprises to meet the evolving demands for innovation in their ongoing development. Second, enhancing the corporate governance system and refining the institutional structure of companies is essential. These measures will help the market gain clearer insights into the prospects of a company's innovative activities and enhance the oversight and evaluation of the implementation of these initiatives. Third, the government should provide appropriate guidance to enterprises, encouraging them to consider the advantages of DRIs in job placement. This encouragement can stimulate increased attention to the positive governance effects these directors bring to the innovation process. Regulatory authorities should also prompt upstream and downstream industries to strengthen information exchange, enabling them to fully leverage their constructive role in driving innovation. Ultimately, these actions can promote the optimization and advancement of the industrial structure.

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