Effects of External Competitive Compensation Disparities on Corporate Innovation: A Signaling Game Analysis of Manufacturing Enterprises

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Abstract

The manufacturing industry is the lifeblood of China's economy. Manufacturing enterprises are faced with the dilemma of core technology being controlled by others and a lack of talent in innovation. Manufacturing enterprises raise their salaries to attract talent. However, enterprises may face the problem of untruthful employees. Therefore, how to set an external competitive salary gap that can not only distinguish innovative employees from non-innovative employees, but also maximize innovation profits, has become a valuable question. In this paper, employees are divided into innovative and non-innovative groups. Based on signaling theory, we establish a theoretical model about the impact of external competitive salary gap on the innovation of manufacturing enterprises, and introduce the lying utility function and Cobb Douglas production function to analyze two effects under different equilibrium conditions—the talent screening effect and the output incentive effects. Then, combined with the data of manufacturing competitive enterprises, we further analyze how these effects will change when the characteristics of regional labor market changes. The findings show that, when the competitive salary gap is wider, enterprises are more likely to screen innovative employees from non-innovative ones. Besides, the output incentive effect exists in both pooling and separating equilibria, and intensifies as the proportion of innovative employees increases, and the competitive salary gap widens.

Keywords: *external competitive compensation disparities, corporate innovation, signaling games, manufacturing sector*

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1 INTRODUCTION

Enterprises play a crucial role in driving innovation, as they are well-positioned to respond promptly to market demands and possess abundant innovative elements and resources. Enterprises are a vital force in overcoming bottleneck technologies and enhancing supply chain security. The CPC Central Committee's proposals for formulating the 14th five-year plan (2021-2025) for national economic and social development and the long-range objectives through 2035 emphasize the need to strengthen the central position of enterprises in innovation, promote the concentration of innovative elements within enterprises, and enhance their technological innovation capabilities. President Xi Jinping, in the 20th National Congress of the Communist Party of China, stressed that driving enterprise innovation and raising the levels of supply and industrial chains are essential prerequisites for achieving high-quality economic development. Driving enterprise innovation is a requirement for establishing the "dual circulation" development pattern. In December 2021, the State Council executive meeting emphasized the importance of tax reduction and fee reductions, particularly favoring

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manufacturing enterprises, and increasing the weighted deduction ratio for research and development expenses to 100%. In November 2022, the document "Measures to Support Innovation and Development of Small and Medium-sized Specialized and Sophisticated Enterprises in Intellectual Property" was introduced, presenting 16 measures, including prioritized examination of intellectual property, to promote innovation and development within these businesses. The 2022 Government Work Report highlighted the need to "enhance incentives for enterprise innovation" and provide strong support for enterprise innovation.

A report from the Chinese entrepreneur system reveals that the primary obstacle to enterprise innovation is the lack of innovative talent, with approximately 80% of entrepreneurs believing that the impact of talent shortages on innovation is significant. The 2021 China CEO survey report by IBM's Institute for Business Value highlighted talent shortages as one of the most significant internal organizational challenges for enterprise innovation, as reported by CEOs. The "2021 Annual Report on the Employment Quality of Graduates," published by Tsinghua University and Peking University, reveals that only 26.8% of students choose to work in private enterprises. Enterprises find themselves in a talent predicament marked by the challenges of "finding," "hiring," and "retaining" talent. This predicament is not only characterized by an increasingly significant shortage of innovative talent but also a scarcity of foundational technical personnel resources. The issue of a lack of innovative talent is particularly pronounced in manufacturing enterprises. In recent years, China's manufacturing sector has been transitioning towards intelligence and digitalization, leading to an increased demand for highly skilled and innovative talent. However, due to factors such as salary and working conditions, the competitiveness of the manufacturing sector in the labor market has diminished. Data from Career International indicates that China's traditional manufacturing sector currently has fewer than 120 million workers, which stands in stark contrast to China's vast labor force. Data released by the National Bureau of Statistics reveals a noticeable decline in the number of manufacturing sector employees over the past decade, with an average annual reduction of approximately 1.2 million[1]. This severe talent supply-demand imbalance is poised to hinder innovation and development within the manufacturing sector. Therefore, the issue of how manufacturing enterprises can attract, retain, and motivate innovative talent is an urgent challenge that needs to be addressed.

Competitive compensation serves to attract, retain, and motivate talent. According to the "2022 College Graduates' Employment Strength Research Report," approximately 70% of college students consider salary and benefits as their primary job-seeking considerations, marking an increase of 7.7 percentage points from the previous year[2]. According to the "China Statistical Yearbook 2022," the average salary in Beijing and Shanghai exceeds 190,000 CNY, making them the highest in the nation. Moreover, both cities have witnessed a significant increase in talent inflow compared to population growth, indicating a potential correlation between salary levels and talent attraction. According to the 2022 "China Enterprise Recruitment Compensation Report" published by Zhaopin.com, there is a robust demand for talent in China's manufacturing industry, resulting in significant increases in compensation. The average monthly salary growth rate in the manufacturing sector is 9.8% per year. Notably, in the second and third quarters, the equipment manufacturing and heavy industry sectors saw quarter-on-quarter salary growth rates of 5.7% and 1.7%, respectively, whereas the biopharmaceutical

[1] http://www.stats.gov.cn/

[2] https://www.dsb.cn/184224.html

sector reported quarter-on-quarter salary growth rates of 2.1% and 1.2%, significantly outperforming other verticals or subsectors within the manufacturing industry[3].

A high level of competitive compensation increases the likelihood of enterprises attracting innovative talent in the labor market, as employees are more likely to be motivated to work diligently. However, because employees' innovation capabilities and willingness are private information, ordinary employees may potentially pretend to be innovative employees under the influence of incentives. Therefore, in the face of information asymmetry between employees and enterprises in the labor market, it becomes a subject worth exploring whether manufacturing enterprises can effectively identify the types of employee innovation by adjusting the range of external competitive compensation disparities. Attracting innovative talent is not the ultimate goal for enterprises; rather, the ultimate goal is to enhance innovation output and maximize innovation profits. Thus, this study delves further into the incentive effect of external competitive compensation disparities on innovation output for manufacturing enterprises based on different employee behavioral choices. It also examines how the effects of external compensation disparities on innovation in the manufacturing sector change when labor market characteristics undergo transformations.

2 THEORETICAL BACKGROUND

External competitive compensation disparities typically refer to variations in compensation for employees holding similar or identical positions across different companies within an industry. Scholars worldwide have explored various methods to measure external competitive compensation disparities, with much of the emphasis placed on evaluating the fairness of these wage differentials. Kong et al. (2020) defined external competitive compensation disparities as the ratio of employee salaries to the average salaries of all companies within the same industry. Regarding whether external compensation disparities can motivate employee output, Biajak et al. (2008) found that using the industry's average salary level as a benchmark is a common practice in the business world and is a method for determining competitive compensation. Building upon the aforementioned research, this study defines external competitive compensation disparities as the portion of salaries paid by companies that exceed the market's average salary level. There additional payments are offered to innovative, high-output employees. Enterprises implement external competitive wage gaps to attract innovative talent, stimulate innovation output, and ultimately increase innovation profits (Elena et al.,2016, Goldstein & Sapra, 2014, Faria-e-Castro et al., 2017, Goldstein & Leitner, 2018, Goldstein & Huang, 2016, and Xi et al., 2022).

Scholars have primarily focused their research on the impact of external competitive compensation disparities on enterprise performance. Hart et al. (2015) found that firms with lower pay inequality had higher corporate social performance than firms with higher pay inequality by examining the relationship between top management pay inequality and corporate social performance. However, due to differences in sample selection and variable measurement, ongoing debates persist regarding the conclusions drawn about the impact of external compensation disparities on corporate performance. Cowherd (2001), analyzing data from pharmaceutical companies, found a positive correlation between external compensation disparities and product quality, suggesting that increasing external wage gaps can enhance corporate performance. In contrast, Hambrick (2005), using data from technology-intensive enterprises, observed a negative impact of external compensation disparities on corporate performance. In recent years, some studies have delved into the impact of external competitive

[3] https://img.shangyexinzhi.com/xztest-file/article/1b6a4fd7760107e6d48e2f0169de15ff.pdf

compensation disparities on enterprises' operational and managerial activities. Zhong et al. (2022) investigate the impact of vertical pay differentials among executives on firms' choice of corporate social responsibility (CSR) activities. The study finds that such differentials incentivize executives to increase CSR activities that benefit shareholders' long-term interests (Forker, 1992, Ferreira & Rezende, 2007, Hermalin & Weisbach, 2012, Bova & Yang, 2018, Doshi et al., 2013, and Badia et al., 2021).

In the field of corporate innovation, scholars have conducted in-depth research. The concept of innovation was initially introduced by Schumpeter (1912), who defined corporate innovation as the introduction of a new good or a new method of production, the opening of a new market, the conquest of a new source of supply of raw materials or semi-manufactured goods, and the establishment of new organizational structures within an industry. Building on this foundation, Freeman (1982) further defined innovation as the management system that involves the development of new engineering, new technologies, and new products, making them commercially valuable. Crossan and Apaydin (2010) defined corporate innovation as the "production or adoption, assimilation, and exploitation of a value-added novelty in economic and social spheres; renewal and enlargement of products, services, and markets; development of new methods of production; and establishment of new management systems." This definition not only highlights the outcome-oriented nature of business innovation but also underscores the dynamic process of innovation within enterprises. Strategic innovation is an innovative activity undertaken by enterprises to seek economic benefits such as policy subsidies, tax incentives, and patent litigation compensation. Substantive innovation, on the other hand, involves significant technological breakthroughs by enterprises and is typically presented in the form of invention patents. This study, based on the theoretical framework of Crossan and Apaydin (2010), defines innovation as the renewal of production methods and the enhancement of production efficiency.

Regarding research on factors that influence firm innovation, some literature suggests that the market is a significant factor. Wachsen and Blind (2016) found a negative correlation between labor market flexibility and the likelihood of firms engaging in technological innovation activities, based on data from a study of Dutch firms in the manufacturing and service sectors from 1998 to 2008. The literature includes an examination of the impact of CSR on firms' innovation. Chkir et al. (2021) validate the idea that CSR drives firms' innovation using a new comprehensive innovation database for 20 countries. Yang et al. (2021) come to a similar conclusion. However, Ullah and Sun (2021) concluded that there is no significant relationship between CSR and firm innovation in developing countries. Furthermore, government actions can significantly influence corporate innovation. Li et al. (2021) discovered that government subsidies can promote corporate innovation, partially offsetting the inhibitory effects of financial constraints on innovation, based on data from listed companies in China between 2007 and 2017. The correlation between tax enforcement and firms' investment in innovation is stronger in cities with high government integrity, efficiency, and sound legal frameworks. Additionally, some scholars have found that firm size also affects firm innovation (Cohen & Klepper, 1996). He and Tian (2013) discovered that analyst coverage has a negative impact on firms' R&D innovativeness. Although there is a wealth of literature exploring factors influencing corporate innovation (Li et al., 2019, Zhang et al., 2022, Lin, 2022, Hermanson, 2000, Parwitt et al., 2009, Xuan and Thi, 2022, and Panditharathna & Kawshala, 2017), research specifically on the impact of external compensation disparities on corporate innovation is relatively limited.

While some of the literature has empirically explored the facilitating effect of the external competitive pay gap of executives on firms' innovation commitment and investment in innovation (Zhao & Wang, 2019, Nguyen & Zhao, 2021, and Zhong et al., 2023), there is relatively limited theoretical literature addressing the perspective of ordinary technical staff. Specifically, research on how competitive compensation incentives influence corporate innovation remains scarce (Xuan et al., 2022), Panditharathna & Kawshala, 2017, Akram & Haq, 2022, Luong et al., 2017, Nofsinger et al., 2019, Shleifer & Wolfenzon, 2002, and Hassel et al., 2005). To address this, we construct a signaling game between firms and employees, incorporating incomplete information, production functions and talent screening mechanisms to assess whether competitive compensation disparities help identify high-productive innovative talents. We also explore how these competitive compensation disparities influence corporate innovation and enterprise performance, by clarifying the underlying mechanism through a theoretical framework and conducting simulation analysis of Chinese manufacturing enterprises.

3 THEORETICAL MODEL

3.1 Model Setup

This section presents a signaling game model between employees and manufacturing enterprises based on the model by Bagwell and Riordan (1991), incorporating the Cobb Douglas production function and the employee deception utility function introduced by Abeler et al. (2019). The study examined the talent screening effects and incentive effects on innovation output of external compensation disparities under both separating and pooling equilibria.

In this signaling game model involving employees and manufacturing enterprises, employees act as signal senders, and enterprises function as signal receivers. Within the market, there is a single type of commodity that requires a certain amount of labor and capital for production. It is assumed that the total number of employees hired by the enterprise, denoted as L, remains constant, and two types of employees exist in the market: high-output innovative employees, denoted as I, and low-output ordinary employees, denoted as N. The proportion of innovative employees is represented as μ, and that of ordinary employees is $1-\mu$. Therefore, in the labor market, the number of innovative employees can be expressed as $L_I = \mu L$, and that of ordinary employees can be represented as $L_N = (1-\mu)L$. The type space of employee t is defined as $t \in T = \{I, N\}$.

Employees gain an understanding of the enterprise's wage payment strategy, potential job pressures, and performance evaluation system. Based on their individual types, they send signals to the enterprise, $S = \{s_I, s_N\}$, where s_I represents an employee signaling to the enterprise that they are a high-output innovative employee, and s_N represents an employee signaling that they are a low-output ordinary employee. After observing the signals sent by employees, the enterprise makes determinations about their types and pays them wage $W = \{w_I, w_N\}$, with w_I representing the wage for innovative employees and w_N representing the wage for ordinary employees. Assume that $w_I > w_N = \gamma w_I$, and $\gamma \in [0,1]$. Hence, external competitive compensation disparities can be expressed as $w_I - w_N = (1-\gamma)w_I > 0$. The labor market for ordinary employees operates under perfect competition, meaning that wage level w_N are determined by the entire external market. Therefore, under a given w_N, the greater w_I is, the larger the external wage gap. The specific game between employees and manufacturing enterprises is as follows:

First, there is a "natural" random selection of employee types $t \in \{I, N\}$, with the probability of selecting innovative employees being $\mu \in (0,1)$ and the probability of selecting non-innovative employees being $1-\mu \in (0,1)$.

Second, after employees are informed of their innovation type t, they send signals to the enterprise as either innovative or non-innovative employees, represented as $s \in \{s_I, s_N\}$.

Finally, the manufacturing enterprise, based on the signals sent by the employees, applies Bayes' rule to modify its assessment of the employee's innovation type and selects the wage level $w \in \{w_I, w_N\}$.

Employee behavior s depends on the type naturally assigned to them, which is denoted as t, while enterprise behavior w depends on the enterprise's judgment of the employee's type and the signals sent by the employee s. Their respective payoffs are represented as $U(t, s, w)$ and $\pi(t, s, w)$. Fig. 1 illustrates the dynamic process of the signaling game between employees and the manufacturing enterprise:

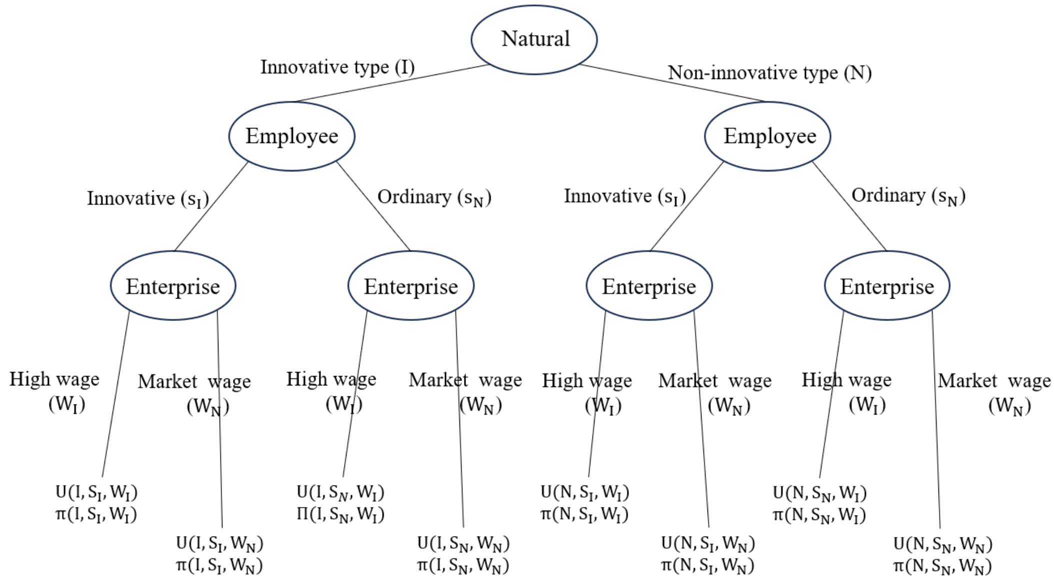

Fig. 1: Schematic Representation of the Dynamic Signaling Game Between Employees and the Manufacturing Enterprise

Fig. 1 reveals that employees have four pure strategies: ①Regardless of "nature's" choice, they always send an innovative signal, denoted as (s_I, s_I). ②They honestly send a signal based on their "natural" type. If their "natural" type is innovative, they send an innovative signal. If their "natural" type is ordinary, they send an ordinary signal, denoted as (s_I, s_N). ③Regardless of "nature's" selection, they always send a signal that they are ordinary, denoted as (s_N, s_N). ④ They send a signal that is exactly the opposite of the type received from "nature," denoted as (s_N, s_I). Among them, (s_I, s_I) and (s_N, s_N) represent mixed strategies, while (s_I, s_N) and (s_N, s_I) represent separating strategies. Under mixed strategies, enterprises cannot accurately determine the innovation type of employees based on their behavior, while under separating strategies, enterprises can accurately determine the innovation type of employees based on their behavior.

Likewise, manufacturing enterprises also have four pure strategies. ①If the employee chooses to send an innovative signal, the enterprise pays a wage higher than the market average. If the employee chooses to send a non-innovative or ordinary signal, the enterprise pays the market-average wage. This strategy is denoted as (w_I, w_N). ②Regardless of the signal sent by the employee, the enterprise always pays a wage higher than the market average. This strategy is denoted as (w_I, w_I). ③If the employee chooses to send an innovative signal, the enterprise pays the market-average wage. If the employee chooses to send an ordinary signal, the enterprise pays a wage higher than the market average. This strategy is denoted as (w_N, w_I). ④Regardless of the signal sent by the employee, the enterprise always pays the market-average wage. This strategy is denoted as (w_N, w_N).

3.2 Employee Payoff

Let the comprehensive cost for innovative employees be denoted as C_I, and that for ordinary employees be denoted as C_N. Generally, becoming an innovative employee requires more effort, so the comprehensive cost of innovative employees is higher than that of ordinary employees, i.e., $C_I > C_N$. Suppose that the cost for each type of employee is a multiple of the minimum salary level, where $c_I$and c_N represent these multiples, i. e., $C_I = c_I w_N, C_N = c_N w_N$. Specifically, $c_I$represents the coefficient of the comprehensive cost of innovative employees, while c_N denotes the coefficient of the comprehensive cost of ordinary employees. To incentivize employees to join the enterprise, their comprehensive costs must be smaller than a relatively low wage level. Therefore, we assume that: $0 < c_N < c_I < 1$.

Whether employees' resort to deception depends on the trade-off between the payoff deception brings and the psychological costs it incurs. Deception might lead to higher financial payoffs, but it also generates a certain degree of guilt or moral discomfort. The psychological cost of deception is determined by the employee's inherent aversion to dishonesty and the differences in the payoffs between engaging in deception and being honest. In this context, the present study introduced the concept of an "employee deception utility function," inspired by Abeler et al. (2019). The assumption is that the costs of engaging in deception for innovative and ordinary employees are given by the following:

$$\varepsilon_I = \theta_I (w_I - w_N)^2 \tag{1.}$$

$$\varepsilon_N = \theta_N (w_I - w_N)^2 \tag{2.}$$

where ε_I and ε_N represent the respective deception utilities for innovative and ordinary employees, $w_I - w_N$ denotes the external compensation disparities, signifying the differences between the wage of innovative employees and the market average wage, $\theta_I > 0$ represents the aversion level of innovative employees toward deception, and $\theta_I (w_I - w_N)^2$ represents the psychological cost for innovative employees to engage in deception. Similarly, $\theta_N > 0$ represents the aversion level of ordinary employees toward deception, and $\theta_N (w_I - w_N)^2$ represents the psychological cost for ordinary employees to engage in deception. The external compensation disparities and the employee's aversion to deception affect their deception utility. Moreover, the deception cost increases as the deviation between payoffs associated with deception and honesty grows, as well as with the employee's increased aversion to deception.

If the signal type an employee sends matches their actual innovation type, the employee's payoffs depend solely on their wage level and comprehensive costs. However, if the signal type an employee sends does not align with their actual innovation type, the employee's payoffs are influenced by their wage level, comprehensive costs, and their deception utility. That is:

$$U(t, s, w) = \begin{cases} w - C_t, & \text{when} t = I, \ s = s_I, \text{or} t = N, \ s = s_N \\ w - C_t - \varepsilon_t, & \text{when} t = I, \ s = s_N, \text{or} t = N, \ s = s_I \end{cases} \tag{3.}$$

This equation reveals that when an employee chooses to be honest and sends an accurate signal, their payoffs are calculated as the salary paid by the enterprise w minus the cost associated with their respective type C_t. In the case where an employee chooses to engage in deception by sending an incorrect signal, they incur a cost related to deception ε_t.

3.3 Innovation Profit

The manufacturing enterprise's innovation output is represented by a Cobb-Douglas production function, which depends on the number of employees L_t, the amount of capital input K, and the production efficiency A. When the enterprise employs innovative employees instead of ordinary ones, the difference is reflected in the overall technological level of the enterprise. Typically, innovative employees possess higher innovation capabilities and greater labor productivity, leading to increased innovation output. Thus, A>1. However, when the enterprise hires ordinary employees, there is no significant improvement in the overall technological level, so A=1. Furthermore, to investigate the impact of external compensation disparities on stimulating the production efficiency of innovative employees, this study extends the traditional Cobb-Douglas production function by assuming that the external compensation disparities of employees positively influence the enterprise's production efficiency, thereby amplifying A by a factor of $(w_I^2 - w_N^2 + 1)$. Therefore, the innovation output of the manufacturing enterprise can be expressed as:

$$Q(L_t, K, w) = \begin{cases} (w_I^2 - w_N^2 + 1)AL_I^{\alpha}K^{\beta}, & \text{when } t = I \\ L_N^{\alpha}K^{\beta}, & \text{when } t = N \end{cases} \tag{4.}$$

where $L_I$and L_N represent the number of innovative non-innovative employees, respectively, K is the amount of capital input, and α and β denote the output elasticity of labor and capital, respectively. Assume that $\alpha, \beta \in (0,1)$, with $\alpha + \beta = 1$. The term $w_I^2 - w_N^2 + 1$ captures the impact of wages paid by the enterprise on innovation output. From the equation above, it can be observed that when $w_I > w_N$, $w_I^2 - w_N^2 + 1 >1$, indicating an incentive effect of external competitive compensation disparities on innovation output. In contrast, when $w_I = w_N$, $w_I^2 - w_N^2 + 1 =1$, meaning the enterprise pays employees the market average wage, and the incentive effect on innovation output is absent.

The innovation revenue for manufacturing enterprises can be expressed as:

$$R(L_t, t, w) = Q(L_t, K, w) \times P.$$

Without loss of generality, we standardize commodity prices to 1, i.e., $P = 1$. Therefore, the equation can be further expressed as $R(L_t, t, w) = Q(L_t, K, w)$. The innovation profits of manufacturing enterprises are the differences between innovation revenue and innovation costs:

$$\pi(t, w) = \begin{cases} (w_I^2 - w_N^2 + 1)AL_I^{\alpha}K^{\beta} - wL_I, & \text{when } t = I \\ L_N^{\alpha}K^{\beta} - wL_N, & \text{when } t = N. \end{cases} \tag{5.}$$

As demonstrated in this equation, both the types of employees and wage levels collectively influence the manufacturing enterprise's innovation profits, whereas the type of signal sent by employees is not directly related to the manufacturing enterprise's innovation profits.

Since the capital input for an enterprise's innovation investment typically remains constant in the short term, it is assumed that the capital input K remains unchanged. In the labor market for ordinary employees, the average wage w_N is determined by the external labor market. Therefore, the enterprise optimizes the number of ordinary employees L_N to maximize the profit generated by these employees while also ensuring that employees have an incentive to work for the enterprise, i.e.,

$$\max_{L_N} \pi = {L_N}^{\alpha}K^{\beta} - w_N \times L_N$$

subject to

$$w_N > C_I\,.$$

Taking the first derivative of the equation with respect to L_N yields:

$$\frac{\partial\left({L_N}^{\alpha}K^{\beta}\right)}{\partial L_N} - \frac{\partial(w_N L_N)}{\partial L_N} = \alpha {L_N}^{\alpha-1}K^{\beta} - w_N$$

Hence, the optimal number of non-innovative or ordinary workers employed by the enterprise should satisfy:

$${L_N}^{*} = \left(\frac{w_N}{\alpha K^{\beta}}\right)^{\frac{1}{\alpha-1}} \tag{6.}$$

Substituting $\frac{{L_N}^{*}}{{L_I}^{*}} = \frac{\mu}{1-\mu}$ into the previous equation, we can determine the optimal number of innovative workers employed by the enterprise to be:

$${L_I}^{*} = \mu\left(\frac{w_N}{\alpha K^{\beta}}\right)^{\frac{1}{\alpha-1}} \Big/ (1-\mu) \tag{7.}$$

In the market for innovative workers, the enterprise maximizes its innovation profits by adjusting the wage level w_I, i.e.,

$$\max_{w_I} \pi = ({w_I}^2 - {w_N}^2 + 1)A{L_I}^{\alpha}K^{\beta} - w_I \times L_I$$

subject to

$$w_I > w_N$$

Taking the first derivative with respect to w_I yields:

$$\frac{\partial\left(({w_I}^2 - {w_N}^2 + 1)A{L_I}^{\alpha}K^{\beta}\right)}{\partial w_I} - \frac{\partial(w_I L_I)}{\partial w_I} = 2A{L_I}^{\alpha}K^{\beta}w_I - L_I$$

Thus, the optimal wage level for innovative workers is:

$${w_I}^{*} = \frac{\alpha\mu^{1-\alpha}}{2Aw_N(1-\mu)^{1-\alpha}} \tag{8.}$$

At the optimal salary level ${w_I}^{*}$, the external competitive compensation disparities ${w_I}^{*} - w_N$ are given by:

$$w_I{}^* - w_N = \frac{\alpha\mu^\alpha}{2Aw_N(1-\mu)^\alpha} - w_N = \frac{\alpha\mu^{1-\alpha} - 2Aw_N{}^2(1-\mu)^{1-\alpha}}{2Aw_N(1-\mu)^{1-\alpha}}$$

3.4 Posterior Probability

In the signaling game between employees and manufacturing enterprises, employees possess complete information about their innovation type, while enterprises, upon observing employee behavior, adjust their inferences regarding the employees' innovation type based on the Bayes' rule, resulting in posterior probabilities:

$$P(I|s_I) = \frac{P(I)P(s_I|I)}{P(s_I)} = \frac{P(I)P(s_I|I)}{P(I)P(s_I|I) + P(N)P(s_I|N)}; \quad (9.)$$

$$P(N|s_I) = \frac{P(N)P(s_I|N)}{P(s_I)} = \frac{P(N)P(s_I|N)}{P(I)P(s_I|I) + P(N)P(s_I|N)};$$

$$P(I|s_N) = \frac{P(I)P(s_N|I)}{P(s_N)} = \frac{P(I)P(s_N|I)}{P(I)P(s_N|I) + P(N)P(s_N|N)}; \quad (10.)$$

$$P(N|s_N) = \frac{P(N)P(s_N|N)}{P(s_N)} = \frac{P(N)P(s_N|N)}{P(I)P(s_N|I) + P(N)P(s_N|N)},$$

where P(I) and P(N) are the respective probabilities of innovative and ordinary employees in the labor market, $P(s_I)$ is the probability of employees choosing to send an innovation signal while $P(s_N)$ is the probability of employees choosing to send an ordinary signal, and $P(I|s_I)$ represents the conditional probability that the enterprise observes an innovation signal and believes the employee is innovative. The conditional probabilities, $P(s_I|I)$, $P(s_I|N)$, $P(s_N|I)$, $P(s_N|N)$, $P(N|s_I)$, $P(I|s_N)$ and $P(N|s_N)$, are defined similarly.

Therefore, the payoff matrix for the signaling game between employees and manufacturing enterprises is as shown in Fig. 2:

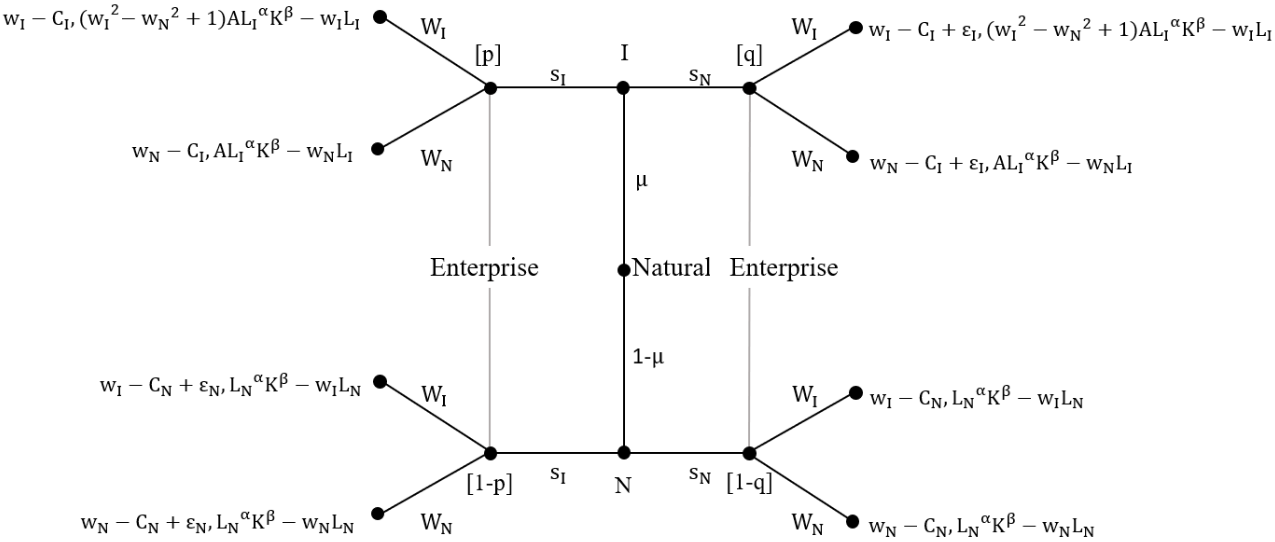

Fig. 2: Payoff Matrix Model for the Signaling Game

4 EFFECTS OF EXTERNAL COMPETITIVE COMPENSATION DISPARITIES ON TALENT SCREENING AND OUTPUT INCENTIVE IN MANUFACTURING ENTERPRISES

To further investigate the impact of external competitive compensation disparities on innovative and ordinary employees, as well as manufacturing enterprises, this study separately discusses the talent screening effect and output incentive effect of the external compensation disparities under both separating equilibrium and pooling equilibrium scenarios.

4.1 Separating Equilibrium

In this section, I analyze the effects of compensation disparities on corporate innovation in separating equilibria: $[(s_I, s_N), (w_I, w_N)], [(s_N, s_I), (w_I, w_N)]$, $[(s_I, s_N), (w_N, w_I)]$, $[(s_I, s_N), (w_I, w_N)]$.

IWe first focus on the separating equilibrium $[(s_I, s_N), (w_I, w_N)]$. When innovative employees send innovative signals and ordinary employees send ordinary signals, i.e., $P(s_I|I) = 1$, $P(s_N|N) = 1$. The enterprise's inference about the type of employees can be obtained from Equations (9) and (11):

$$p = 1,\ \ q = 0$$

The equation above illustrates that Bayesian inference for the information set corresponding to s_I (the left information set) on the equilibrium path is $(1,0)$, and for the information set corresponding to s_N (the right information set) on the equilibrium path is $(0,1)$. This means that when the enterprise observes an innovative signal, it can infer that the employee is of the innovative type, and when the enterprise observes a non-innovative signal, it can infer that the employee is of the ordinary type.

Next, when the enterprise observes an innovative signal and infers that the employee is of the innovative type, the innovation profit from paying the wage w_I is $\pi(I, s_I, w_I) = ({w_I}^2 - {w_N}^2 + 1)A{L_I}^{\alpha}K^{\beta} - w_I L_I$, and the innovation profit from paying the wage w_N is $\pi(I, s_I, w_N) = A{L_I}^{\alpha}K^{\beta} - w_N L_I$. When the enterprise observes an ordinary signal and infers that the employee is of the ordinary type, the innovation profit from paying the wage w_I is $\pi(N, s_N, w_I) = {L_N}^{\alpha}K^{\beta} - w_I L_N$, and the innovation profit from paying the wage w_N is $\pi(N, s_N, w_N) = {L_N}^{\alpha}K^{\beta} - w_N L_N$. Since $w_I > w_N, \pi(N, s_N, w_N) > \pi(N, s_N, w_I)$ always holds, therefore, when the enterprise receives an ordinary signal and infers that the employee is ordinary, paying the market average wage is its optimal response. The wage payment decision made by the enterprise after observing an innovative signal depends on the size or scale of the innovative profit. If the enterprise chooses to pay a salary higher than the market average, it must satisfy $\pi(I, s_I, w_I) > \pi(I, s_I, w_N)$.

Furthermore, it is essential to examine whether the employee's strategy is optimal when the enterprise's strategy is given. When the enterprise receives an innovative signal and pays the employee's wage w_I or receives an ordinary signal and pays the employee's salary w_N, the payoffs for the innovative type employee is $U(I, s_I, w_I) = w_I - C_I$, and for the ordinary type employee, it is $U(N, s_N, w_N) = w_N - C_N$. If the innovative-type employee sends an ordinary signal, the enterprise's response remains to pay a salary higher than the market average. In this case, the payoff for the innovative employee is $U(I, s_N, w_I) = w_I - C_I - \varepsilon_I$, and it can be observed that:

$$U(I, s_I, w_I) = w_I - C_I > U(I, s_N, w_N) = w_N - C_I - \varepsilon_I.$$

Hence, ordinary employees have no incentive to send an innovative signal, meaning that ordinary type employees will not engage in deception. If an ordinary employee sends an innovative signal, the enterprise pays an innovative salary. In this case, the payoff for the ordinary employees is:

$$U(N, s_I, w_I) = w_N - C_N - \varepsilon_N.$$

Therefore, to ensure that ordinary-type employees have no incentive to send innovative signals, i.e., ordinary-type employees will not engage in deception, it is necessary to satisfy the following condition:

$$U(N, s_N, w_N) = w_N - C_N > U(N, s_I, w_N) = w_I - C_N - \varepsilon_N.$$

To ensure the existence of a separating equilibrium path (s_I, s_N) and with the enterprise's strategy being (w_I, w_N), the following conditions need to be satisfied:

$$\begin{cases} \pi(I, s_I, w_I) > \pi(I, s_I, w_N) \\ U(N, s_N, w_N) > U(N, s_I, w_I) \end{cases}$$

By substituting the manufacturing enterprise's innovation profit function and the employee's payoff function into the above equation and further rearranging, we can obtain:

$$\begin{cases} ({w_I}^2 - {w_N}^2) A {L_I}^{\alpha} K^{\beta} > (w_I - w_N) L_I \\ w_N > w_I - \varepsilon_N \end{cases}$$

By substituting Equations (1) and (2) and $w_N = \gamma w_I$ into the equation above and simplifying it, we get:

$$\begin{cases} (1+\gamma) A {L_I}^{\alpha-1} K^{\beta} w_I > 1 \\ \theta_N w_I (1-\gamma) > 1 \end{cases}$$

Since $\frac{1}{(1-\gamma)\theta_N} > \frac{1}{(1+\gamma) A {L_I}^{\alpha-1} K^{\beta}}$, if a separating equilibrium $[(s_I, s_N), (w_I, w_N)]$ exists, it must satisfy:

$$w_I > \frac{1}{(1+\gamma) A {L_I}^{\alpha-1} K^{\beta}}$$

Further substituting Equations (7) and (8) into the above equation and simplifying, we get:

$$\frac{(1+\gamma)\mu^{1-\alpha} - 2(1-\mu)^{2-\alpha}}{(1+\gamma)\mu^{1-\alpha}} > 0. \quad (11.)$$

Therefore, we can conclude:

Proposition 1: When $\frac{(1+\gamma)\mu^{1-\alpha} - 2(1-\mu)^{2-\alpha}}{(1+\gamma)\mu^{1-\alpha}} > 0$, there exists a separating equilibrium where innovative employees signal innovative and receive external compensation disparities, while ordinary employees signal ordinary and earn the market average salary., i.e., $[(s_I, s_N), (w_I, w_N)]$.

From Equation (11), we observe that:

$$\frac{(1+\gamma)\mu^{1-\alpha} - 2(1-\mu)^{2-\alpha}}{(1+\gamma)\mu^{1-\alpha}} = 1 - \frac{2(1-\mu)^{2-\alpha}}{(1+\gamma)\mu^{1-\alpha}}.$$

As $\frac{2(1-\mu)^{2-\alpha}}{\mu^{1-\alpha}} > 0$, we can deduce the following:

Corollary 1: When the external compensation disparities between innovative and ordinary employees are wider, meaning γ is smaller, the enterprise is more likely to distinguish between high-output innovative employees and ordinary ones.

This corollary takes the idea that when the salary gap is wider, then it is more likely for the ordinary workers to tell the truth as the costs for lying is more likely to be larger than the benefits they can get. Since enterprises in a separating equilibrium $[(s_I, s_N), (w_I, w_N)]$ trust the employees, and will follow their signal to pay the wages, the innovative workers will always tell the truth. Hence, a larger competitive wage gap guarantees the ordinary workers will not mimic at the cost that the high-skilled workers will receive a relatively low innovative wage.

Next, this study discusses the output incentive effect of external compensation disparities on manufacturing enterprises in the case of a separating equilibrium $[(s_I, s_N), (w_I, w_N)]$.

In a separating equilibrium $[(s_I, s_N), (w_I, w_N)]$, the effect of external compensation disparities on innovation output of manufacturing enterprises is as follows:

$$w_I^2 - w_N^2 + 1 = (1-\gamma^2)w_I^2 + 1,$$

Given $0 < \gamma < 1$, it follows that $w_I^2 - w_N^2 + 1 > 1$. Therefore, the incentive effect of external compensation disparities on innovation output in manufacturing enterprises exists. The first-order derivative with respect to w_I for the above equation is:

$$\frac{\partial w_I^2 - w_N^2 + 1}{\partial w_I} = 2(1-\gamma^2)w_I > 0.$$

Substituting Equation (8) into the above equation, we get:

$$\frac{\partial w_I^2 - w_N^2 + 1}{\partial w_I} = \frac{\alpha(1-\gamma^2)\mu^{1-\alpha}}{A w_N (1-\mu)^{1-\alpha}} > 0. \quad (12.)$$

Therefore, in the separating equilibrium $[(s_I, s_N), (w_I, w_N)]$, the output incentive effect exists. Hence, we have the following:

Proposition 2: In the separating equilibrium $[(s_I, s_N), (w_I, w_N)]$, when $\frac{(1+\gamma)\mu^{1-\alpha} - 2(1-\mu)^{2-\alpha}}{(1+\gamma)\mu^{1-\alpha}} > 0$, external compensation disparities have talent screening effects and output incentive effects on innovation in manufacturing enterprises.

By following similar steps, it is easy to verify the following:

Proposition 3: When the manufacturing enterprise's production function satisfies Equation (4), the innovation profit function satisfies Equation (5), the employee utility function satisfies Equation (3), and the employee deception utility satisfies Equations (1) and (2), then separating equilibria $[(s_N, s_I), (w_I, w_N)]$, $[(s_I, s_N), (w_N, w_I)]$, $[(s_I, s_N), (w_I, w_N)]$ do not exist.

4.2 Pooling Equilibrium

We next analyze the effects of compensation disparities on corporate innovation in pooling equilibriums. In the context of the models in this study, employees have two forms of mixed strategies: one where both innovative and non-innovative employees send innovation signals, i.e., (s_I, s_I); and another where both innovative and non-innovative employees send non-innovation signals, i.e., (s_N, s_N). In these cases, the enterprise cannot determine the actual innovation type of employees based on their behavior, and the posterior probabilities based on Bayes' rule are equal to the prior probabilities. Therefore, after observing the behavior of employees, the enterprise may choose to pay either the market-average salary or a salary above the market average. This study goes on to analyze the pooling equilibrium: $[(s_I, s_I), (w_I, w_I)][(s_N, s_N), (w_I, w_N)][(s_I, s_I), (w_I, w_I)], [(s_I, s_I), (w_N, w_N)], (s_I, s_I), (w_N, w_I)]$, $[(s_N, s_N), (w_I, w_I)], [(s_N, s_N), (w_N, w_N)], [(s_N, s_N), (w_N, w_I)]$.

Assuming both types of employees send innovative signals, i.e., employees choose mixed strategies (s_I, s_I), conditional probabilities can be obtained: $P(s_I|I) = 1$ and $P(s_I|N) = 1$. Manufacturing enterprises, upon observing the innovation signal, update their beliefs about the employee's innovation type according to Bayes' rule. Posterior probabilities $P(I|s_I) = \mu$ and $P(N|s_I) = 1 - \mu$ are derived from equation (8), i.e., $p = \mu$, signifying that the enterprise believes there is a probability of μ that the employee emitting the innovative signal is of the innovative type, and a probability of $1 - \mu$ that the employee is of ordinary type.

Manufacturing enterprises, upon observing the innovative signal, pay a salary w_I and w_N, with the expected profits for the two salary levels given by:

$$E[\pi(t, s_I, w_I)] = \mu[(w_I{}^2 - w_N{}^2 + 1)AL_I{}^\alpha K^\beta - w_I L_I] + (1 - \mu)(L_N{}^\alpha K^\beta - w_I L_N);$$

$$E[\pi(t, s_I, w_N)] = \mu(AL_I{}^\alpha K^\beta - w_N L_I) + (1 - \mu)(L_N{}^\alpha K^\beta - w_N L_N).$$

From these equations, the expected profit $E[\pi(t, s_I, w_I)]$ from paying a salary w_I, $\mu[(w_I{}^2 - w_N{}^2 + 1)AL_I{}^\alpha K^\beta - w_I L_I]$represents the manufacturing enterprise's innovation output brought by innovative employees when paying a salary w_I, and $(1 - \mu)(L_N{}^\alpha K^\beta - w_I L_N)$ represents the manufacturing enterprise's innovation output brought by ordinary employees when paying a salary w_I. Similarly, the expected profit$E[\pi(t, s_I, w_N)]$ from paying a salary w_N, $\mu(AL_I{}^\alpha K^\beta - w_N L_I)$ represents the manufacturing enterprise's innovation profit brought by innovative employees when paying a salary w_N, and $(1 - \mu)(L_N{}^\alpha K^\beta - w_N L_N)$ represents the manufacturing enterprise's innovation profit brought by ordinary employees when paying a salary w_N.

If a pooling equilibrium path (s_I, s_I) exists, and the enterprise's strategy is (w_I, w_N), the following conditions must be satisfied:

$$\begin{cases} E[\pi(t, s_I, w_I)] > E[\pi(t, s_I, w_N)] \\ U(I, s_I, w_I) > U(I, s_N, w_N) \\ U(N, s_I, w_I) > U(N, s_N, w_N) \end{cases}$$

In this equation, when $E[\pi(t, s_I, w_I)] > E[\pi(t, s_I, w_N)]$, manufacturing firms can expect greater profit from paying higher-than-market-average salary w_I when they receive ordinary signals compared to paying the market-average salary w_N. Therefore, when the enterprise receives innovative signals, it will pay higher-than-market-average salaries. When the enterprise observes an innovation signal and pays a salary higher than the market average, the payoffs for innovative employees are $U(I, s_I, w_I) = w_I - C_I$, and the payoffs for non-innovative or ordinary employees are $U(N, s_I, w_I) = w_I - C_N - \varepsilon_N$. If the enterprise observes an ordinary or non-innovative signal and chooses to pay employees the market-average salary, then the payoffs for innovative employees sending ordinary signals are $U(I, s_N, w_N) = w_N - C_I - \varepsilon_I$and for non-innovative or ordinary employees sending ordinary signals, it is $U(N, s_N, w_N) = w_N - C_N$. If both innovative and ordinary employees send innovative signals, then the following conditions must be satisfied: $U(I, s_I, w_I) > U(I, s_N, w_N), U(N, s_I, w_I) > U(N, s_N, w_N)$.

Substituting the manufacturing enterprise's innovation profit function and the employee payoff function into the equation, we obtain:

$$\begin{cases} \mu[({w_I}^2 - {w_N}^2)A{L_I}^{\alpha}K^{\beta} - (w_I - w_N)L_I] - (1-\mu)[(w_I - w_N)L_N] > 0 \\ w_I - C_I > w_N - C_I - \varepsilon_I \\ w_I - C_N - \varepsilon_N > w_N - C_N \end{cases}$$

Substituting the expressions for deception utility from Equations (1) and (2) into the equation above and simplifying it, the following can be obtained:

$$\begin{cases} \mu\left[(w_I + w_N)A{L_I}^{\alpha}K^{\beta} - L_I\right] - (1-\mu)L_N > 0 \\ \varepsilon_I = \theta_I(w_I - w_N)^2 > w_N - w_I \\ \varepsilon_N = \theta_N(w_I - w_N)^2 < w_I - w_N \end{cases}$$

As $\varepsilon_I > 0$, and the external compensation disparities $w_I - w_N = (1-\gamma)w_I > 0$, we have $\varepsilon_I > w_N - w_I$. Hence, the above equation holds as long as

$$\begin{cases} \mu\left[(w_I + w_N)A{L_I}^{\alpha}K^{\beta} - L_I\right] - (1-\mu)L_N > 0 \\ \varepsilon_N = \theta_N(w_I - w_N)^2 < w_I - w_N \end{cases}$$

Substituting $w_N = \gamma w_I$ into the above equation and simplifying it allows the following to be obtained:

$$\begin{cases} w_I > \dfrac{(1-\mu)L_N + \mu L_I}{(1+\gamma)\mu A{L_I}^{\alpha}K^{\beta}} \\ w_I < \dfrac{1}{\theta_N(1-\gamma)} \end{cases}$$

When $\frac{1}{\theta_N(1-\gamma)} > \frac{(1-\mu)L_N + \mu L_I}{(1+\gamma)\mu A{L_I}^{\alpha}K^{\beta}}$, it leads to

$$\frac{(1-\mu)L_N + \mu L_I}{(1+\gamma)\mu A{L_I}^{\alpha}K^{\beta}} < w_I < \frac{1}{\theta_N(1-\gamma)}.$$

Substituting Equations (6) to (8) into the previous equation and simplifying it gives us the following:

$$-\frac{1}{\gamma} - \frac{\alpha\left(\frac{\mu}{1-\mu}\right)^{-\alpha}(1-2\mu+2\mu^2)}{A(1+\gamma)(-1+\mu)\mu w_N} < 0 < \frac{1}{\theta_N(1-\gamma)} - \frac{\alpha(1-\mu)^{-1+\alpha}\mu^{1-\alpha}}{2Aw_N}.$$

Therefore, when ordinary employees have a lower aversion to deception, and when $-\frac{1}{\gamma} -$

$\frac{\alpha\left(\frac{\mu}{1-\mu}\right)^{-\alpha}(1-2\mu+2\mu^2)}{A(1+\gamma)(-1+\mu)\mu w_N} < 0 < \frac{1}{\theta_N(1-\gamma)} - \frac{\alpha(1-\mu)^{-1+\alpha}\mu^{1-\alpha}}{2Aw_N}$, both innovative and non-innovative employees emit innovative signals, and external compensation disparities have no talent screening effect on innovation in manufacturing enterprises. This leads to the following result:

Proposition 4: When $-\frac{1}{\gamma} - \frac{\alpha\left(\frac{\mu}{1-\mu}\right)^{-\alpha}(1-2\mu+2\mu^2)}{A(1+\gamma)(-1+\mu)\mu w_N} < 0 < \frac{1}{\theta_N(1-\gamma)} - \frac{\alpha(1-\mu)^{-1+\alpha}\mu^{1-\alpha}}{2Aw_N}$, there exists a pooling equilibrium $[(s_I, s_I), (w_I, w_N)]$ where both innovative and non-innovative employees emit innovative signals, and the enterprise offers innovative salaries for such signals but provides market salaries for non-innovative signals.

In the pooling equilibrium $[(s_I, s_I), (w_I, w_N)]$, the coefficient representing the impact of external compensation disparities on innovation output in manufacturing enterprises is given by the following:

$$w_I^2 - w_N^2 + 1 = (1-\gamma^2)w_N^2 + 1 > 1,$$

Therefore, external compensation disparities have an incentive effect on innovation output in manufacturing enterprises. Taking the first derivative of the equation with respect to w_I yields

$$\frac{\partial w_I^2 - w_N^2 + 1}{\partial w_I} = \frac{\alpha(1-\gamma^2)\mu^{1-\alpha}}{Aw_N(1-\mu)^{1-\alpha}} > 0.$$

Hence:

Proposition 5: In a pooling equilibrium $[(s_I, s_I), (w_I, w_N)]$, external compensation disparities have no talent screening effect on manufacturing talents.

This result is straightforward, since all employees emit the same signal in a pooling equilibrium, compensation disparities fail to differentiate between innovative and ordinary talents, rendering screening ineffective. The next result establishes the existence condition for the output incentive effect in a pooling equilibrium:

Proposition 6: When $-\frac{1}{\gamma} - \frac{\alpha\left(\frac{\mu}{1-\mu}\right)^{-\alpha}(1-2\mu+2\mu^2)}{A(1+\gamma)(-1+\mu)\mu w_N} < 0 < \frac{1}{\theta_N(1-\gamma)} - \frac{\alpha(1-\mu)^{-1+\alpha}\mu^{1-\alpha}}{2Aw_N}$, there exists an output incentive effect.

This result suggests that the output incentive effect arises because higher compensation disparities motivate employees to increase effort, enhancing overall productivity and differentiating high performers from ordinary workers. By following similar steps, the following can be derived:

Proposition 7: When the manufacturing enterprise's production function follows equation (4), the innovation profit function complies with equation (5), employee utility functions adhere to equation (3), and employee deception utility aligns with equations (1) and (2), then pooling equilibriums:

$[(s_N, s_N), (w_I, w_N)]$, $[(s_I, s_I), (w_I, w_I)]$, $[(s_I, s_I), (w_N, w_N)]$, $[(s_I, s_I), (w_N, w_I)]$, $[(s_N, s_N), (w_I, w_I)]$, $[(s_N, s_N), (w_N, w_N)]$, and $[(s_N, s_N), (w_N, w_I)]$do not exist.

5 SIMULATION ANALYSIS

To gain a deeper understanding of the impact of external competitive compensation disparities on innovation in China's manufacturing enterprises, this study conducted a simulation analysis using the CSMAR database. The analysis focused on the talent screening effect and output incentive effect of external compensation disparities on innovation in manufacturing enterprises.

5.1 Regression Analysis

Estimating the overall technological level A directly is challenging due to differences in sample selection, variable choice, and other factors. Therefore, this study calculates labor output elasticity through empirical regression methods. For the development of China's manufacturing industry, 2015 marked a crucial turning point. During that year, the State Council issued the strategic document "Made in China 2025," which outlined the comprehensive promotion and implementation of the strategy to build a strong manufacturing country. Considering the lagged impact of policies, this study selects data samples of 25,482 A-share listed companies in China from 2016 to 2021 from the China stock market and accounting research database (CSMAR). The regression equation is as follows:

$$\ln Y_{i,t} = \alpha \ln L_{i,t} + (1-\alpha) \ln K_{i,t} + \varepsilon_{i,t},$$

where $Y_{i,t}$ represents the revenue (unit: CNY) of main businesses of the manufacturing enterprise i in year t. $L_{i,t}$ represents the number of employees (unit: persons(s)) of manufacturing enterprise i in year t. $K_{i,t}$ denotes the net fixed assets (unit: CNY) of the manufacturing enterprise i in year t, and $\varepsilon_{i,t}$ indicates the random disturbance term. The regression results are presented in Tab.1:

Tab. 1: Regression Analysis of Listed Manufacturing Companies from 2016 to 2021

Variable	$\ln Y_{i,t}$
$\ln L$	0.7043^{***} （91.44）
$\ln k$	0.3100^{***} （53.12）
Cons	9.7491^{***} （123.46）
Adj-R2	0.7844

Note: *** represents a 1% significance level, and the values within the parentheses are the corresponding t-values.

The regression result shows that the labor output elasticity α is approximately 0.70, and the capital output elasticity β is around 0.31, both of which are statistically significant at the 1% level. Furthermore, the sum of these elasticities is approximately equal to 1, which aligns with the assumption of constant returns to scale as proposed in Section 4. Based on the regression analysis results, the initial value for the labor output elasticity α is set to 0.7 in the simulation analysis.

Additionally, this study is based on "Enterprise Accounting Standard No. 9 - Employee Compensation" to set the employee comprehensive cost coefficient. It takes 0.08 as the initial value for the comprehensive cost coefficient of innovative employees, i.e., $c_I = 0.08$, and 0.025, as the initial value for the comprehensive cost coefficient of non-innovative employees, i.e., $c_N = 0.025$. Subsequent changes in the cost coefficients are determined relative to these initial values. Furthermore, based on the experimental results of the "lying dice" reported by Fischbacher and Föllmi-Heusi (2013), the initial value for the employee's aversion to deception was set at 2. Therefore, the initial parameter values are as shown in Tab. 2:

Tab. 2: Initial Parameter Values for Simulation Analysis

Symbol	Definition	Initial Value
α	Labor Output Elasticity	0.7
A	Overall Technological Level	1.2
c_I	Comprehensive Cost Coefficient for Innovative Employees	0.08
c_N	Comprehensive Cost Coefficient for Non-Innovative Employees	0.025
θ_I	Degree of Aversion to Deception in Innovative Employees	2
θ_N	Degree of Aversion to Deception in Non-Innovative Employees	0.5
L	Total Workforce	1
w_N	Salary for Non-Innovative Employees	1
k	Fixed Capital	1

5.2 Simulation Analysis in Separation Equilibrium

From the previous section, we know that the separating equilibrium $[(s_N, s_I), (w_I, w_N)]$, $[(s_N, s_I), (w_N, w_I)]$, $[(s_I, s_N), (w_N, w_I)]$ do not exist. According to proposition 2, when

$$\emptyset = \frac{(1+\gamma)\mu^{1-\alpha} - 2(1-\mu)^{2-\alpha}}{(1+\gamma)\mu^{1-\alpha}} > 0,$$

the separating equilibrium$[(s_I, s_N), (w_I, w_N)]$exists. This section analyzes the talent screening effects and the output incentive effect of compensation disparities on innovation in manufacturing enterprises under the separating equilibrium$[(s_I, s_N), (w_I, w_N)]$.

By substituting the parameters from Tab. 2 into the inequalities, and when $0 < \gamma < 1,\ 0 < \mu < 1$, the conditions for the existence of the separating equilibrium $[(s_I, s_N), (w_I, w_N)]$ can be obtained, as shown in the yellow area in Fig. 3:

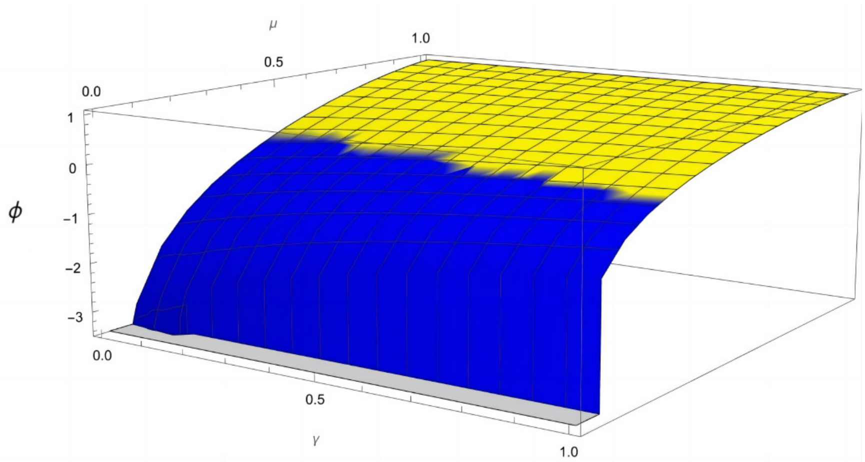

Fig. 3: Talent Screening Effect of Separation Equilibrium $[(s_I, s_N), (w_I, w_N)]$

In Fig. 3, the x-axis represents the ratio of wages between non-innovative employees and innovative employees $0 < \gamma < 1$. By definition, when this ratio γ is greater and approaches 1, the compensation disparities between the two types of employees become smaller. The y-axis represents the proportion of innovative employees $0 < \mu < 1$, and the z-axis represents the expression $\emptyset = \frac{(1+\gamma)\mu^{1-\alpha} - 2(1-\mu)^{2-\alpha}}{(1+\gamma)\mu^{1-\alpha}}$. Therefore, the yellow portion of the graph indicates the existence of the separating equilibrium, i.e., the talent screening effect exists. From the figure, the following can be observed:

Proposition 8: In the separating equilibrium $[(s_I, s_N), (w_I, w_N)]$, the greater the competitive compensation disparity, the higher the proportion of innovative employees, resulting in a more effective talent screening effect on manufacturing enterprises.

Next, we will analyze the output incentive effect in the context of the separating equilibrium $[(s_I, s_N), (w_I, w_N)]$. According to equation (12), the output incentive effect in the separating equilibrium $[(s_I, s_N), (w_I, w_N)]$ is determined as follows:

$$\kappa = \frac{\alpha(1-\gamma^2)\mu^{1-\alpha}}{Aw_N(1-\mu)^{1-\alpha}}.$$

By substituting the parameters from Tab. 2 into the above equation, we can obtain the simulation for the output incentive effect concerning the wage differential (compensation disparities) γ and the proportion of innovative employees μ when $0 < \gamma < 1,\ 0 < \mu < 1$. The simulation is as follows:

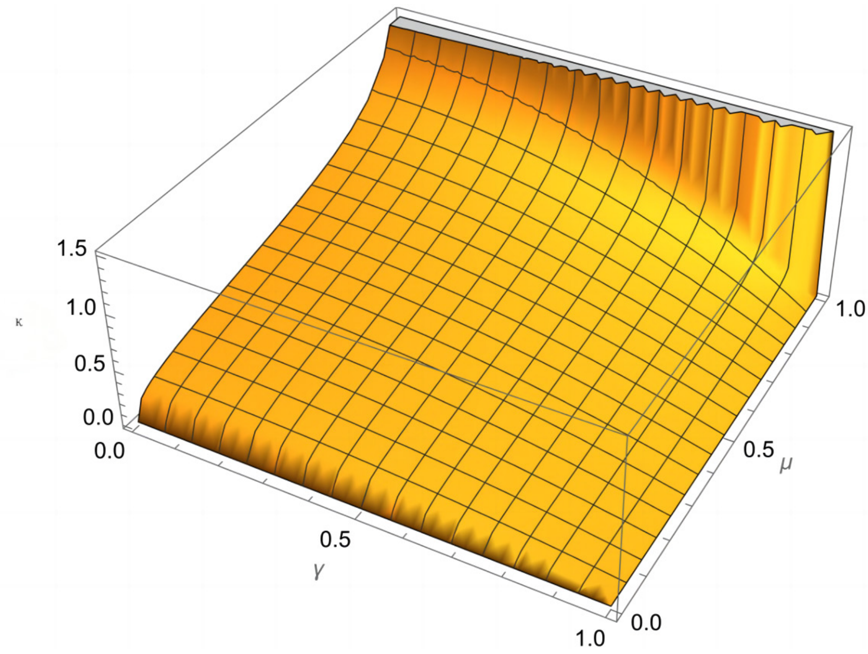

Fig. 4: Output Incentive Effect in the Separating Equilibrium $[(s_I, s_N), (w_I, w_N)]$

In Fig. 4, the x-axis represents the ratio of non-innovative employees' wages to innovative employees' wages, with $0 < \gamma < 1$，. When this ratio γ is greater, it means that the wage gap between the two types of employees is smaller. The y-axis represents the proportion of innovative employees, with $0 < \mu < 1$. The z-axis represents the expression $\kappa = \frac{\alpha(1-\gamma^2)\mu^{1-\alpha}}{Aw_N(1-\mu)^{1-\alpha}}$. The simulation results show that:

Proposition 9: In the separating equilibrium $[(s_I, s_N), (w_I, w_N)]$, when the parameters satisfy the conditions in Tab. 2, and when $0 < \gamma < 1$, $0 < \mu < 1$, the external compensation disparities $1 - \gamma$ consistently have a positive incentive effect on output. Moreover, as the salary gap increases, i.e., when γ is smaller, and the proportion of innovative employees μ is higher, the incentive effect of the external compensation disparities on output is larger.

This result implies that if the compensation disparities between innovative employees and ordinary employees are larger, innovative employees, motivated by higher salaries, are more likely to increase their productivity, leading to higher output. Similarly, if the proportion of innovative employees in the overall labor market is larger, enterprises are more likely to hire innovative employees, consequently further increasing output.

5.3 Simulation Analysis in Pooling Equilibrium

Next, this study discusses the impact of external compensation disparities on enterprises in a pooling equilibrium. As mentioned in the previous section, compensation disparities do not affect talent screening in enterprises in a pooling equilibrium. By substituting the parameters from Tab. 2 into the inequalities, we have

$$\varphi = -\frac{1}{\gamma} - \frac{\alpha\left(\frac{\mu}{1-\mu}\right)^{-\alpha}(1-2\mu+2\mu^2)}{A(1+\gamma)(-1+\mu)\mu w_N} < 0 < \chi = \frac{1}{\theta_N(1-\gamma)} - \frac{\alpha(1-\mu)^{-1+\alpha}\mu^{1-\alpha}}{2Aw_N}.$$

When $0 < \gamma < 1$, $0 < \mu < 1$, we can obtain the conditions for the existence of the pooling equilibrium $[(s_I, s_I), (w_I, w_N)]$ as shown in the red and yellow areas in Fig. 5.

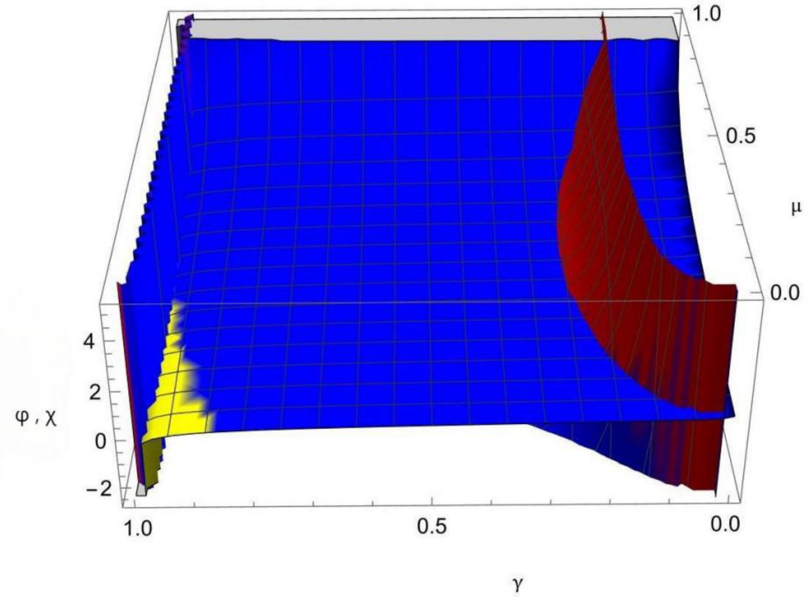

Fig. 5: Conditions for the Existence of Pooling Equilibrium $[(s_I, s_I), (w_I, w_N)]$.

In Fig. 5, the x-axis represents the ratio of non-innovative employees' salaries to innovative employees' salaries $0 < \gamma < 1$. The y-axis represents the proportion of innovative employees $0 < \mu < 1$, and the z-axis respectively represents the expressions $-\frac{1}{\gamma} - \frac{\alpha\left(\frac{\mu}{1-\mu}\right)^{-\alpha}(1-2\mu+2\mu^2)}{A(1+\gamma)(-1+\mu)\mu w_N}$ and $\frac{1}{\theta_N(1-\gamma)} - \frac{\alpha(1-\mu)^{-1+\alpha}\mu^{1-\alpha}}{2Aw_N}$ The yellow region is $-\frac{1}{\gamma} - \frac{\alpha\left(\frac{\mu}{1-\mu}\right)^{-\alpha}(1-2\mu+2\mu^2)}{A(1+\gamma)(-1+\mu)\mu w_N} < 0$, and the red region is $\frac{1}{\theta_N(1-\gamma)} - \frac{\alpha(1-\mu)^{-1+\alpha}\mu^{1-\alpha}}{2Aw_N} > 0$. Therefore, in this figure, when γ is equal to μ, the yellow and red regions represent the scenario where the pooling equilibrium $[(s_I, s_I), (w_I, w_N)]$ exists. From the figure, we can observe the following:

Proposition 10: When the parameters satisfy the conditions in Tab. 2, and $0 < \gamma < 1,\ 0 < \mu < 1$, the smaller the compensation disparities $(1 - \gamma)$, and the lower the proportion of innovative employees (μ), the more likely the pooling equilibrium $[(s_I, s_I), (w_I, w_N)]$ is to exist.

This result reveals that when the differences between innovative and ordinary employees are smaller, and the proportion of innovative employees is lower, it is more likely to achieve pooling equilibriums. In such cases, distinguishing between innovative and ordinary employees becomes even more challenging for enterprises.

In a pooling equilibrium, the talent screening effect of compensation disparities in the enterprise does not exist. Therefore, this study separately analyzed the output incentive effect and talent screening effect of compensation disparities in the pooling equilibrium.

This study first analyzed the output incentive effect in the pooling equilibrium $[(s_I, s_I), (w_I, w_N)]$. As mentioned in the previous section, in the pooling equilibrium $[(s_I, s_I), (w_I, w_N)]$, the output incentive effect is given by

$$\Lambda = \frac{\alpha(1-\gamma^2)\mu^{1-\alpha}}{Aw_N(1-\mu)^{1-\alpha}}.$$

When the parameters from Tab. 2 are plugged into the above equation, we can find that in the pooling equilibrium $[(s_I, s_I), (w_I, w_N)]$, when $0 < \gamma < 1,\ 0 < \mu < 1$, the simulation results for the output incentive effect with the proportion of innovative employees μ are as follows:

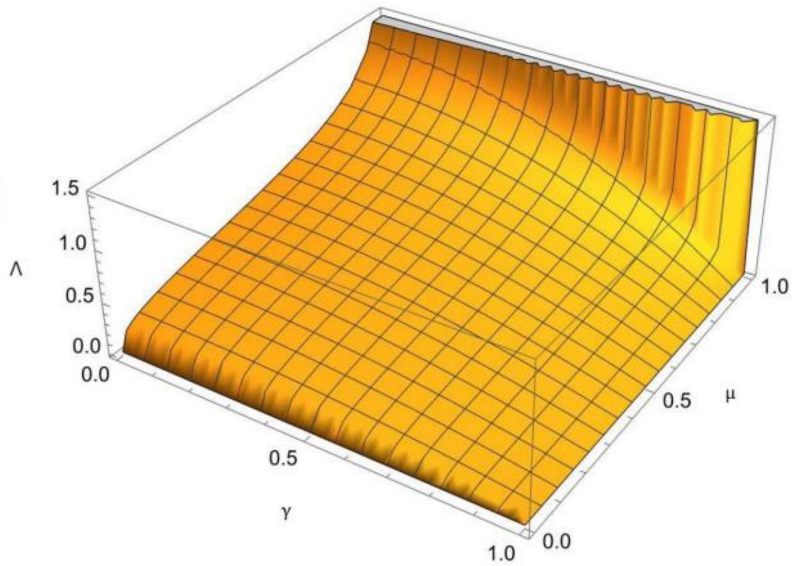

Fig. 6: Output incentive effect in the pooling equilibrium $[(s_I, s_I), (w_I, w_N)]$.

In Fig. 6, the x-axis and y-axis represent the ratio of non-innovative employee salaries to innovative employee salaries $0 < \gamma < 1$ and the proportion of innovative employees $0 < \mu < 1$, respetively. The z-axis corresponds to the expression $\Lambda = \frac{\alpha(1-\gamma^2)\mu^{1-\alpha}}{A w_N (1-\mu)^{1-\alpha}}$. The simulation results show the following:

Proposition 11: In the pooling equilibrium $[(s_I, s_I), (w_I, w_N)]$, when the parameters meet the conditions specified in Tab. 2 and $0 < \gamma < 1,\ 0 < \mu < 1$, the external compensation disparities μ have a consistently positive impact on output incentive effects. Furthermore, as the compensation disparities become larger, that is, $1 - \gamma$ is smaller, and the proportion of innovative employees γ becomes higher, the external compensation disparities' impact on output incentive effects becomes more significant.

Similar to the results drawn in the case of the separating equilibrium, in the pooling equilibrium, offering higher competitive salaries to innovative employees and increasing the proportion of innovative employees can stimulate greater output.

6 CONCLUSION

This study highlights the pronounced issue of the lack of innovative talent and insufficient innovation profits within the manufacturing industry. Competitive compensation serves as a critical link between enterprises and employees. Therefore, this study provides theoretical insights into setting competitive wage levels and stimulating innovation by examining the effects of external competitive compensation disparities on talent screening and innovation output incentives in manufacturing enterprises. Considering that employees' innovative types are private information, resulting in information asymmetry between employees and enterprises in the labor market, this study is grounded in signaling theory and builds a theoretical model to analyze the effects of external competitive compensation disparities on manufacturing industry innovation. The model incorporates employee deception utility functions and Cobb-Douglas production functions, allowing us to analyze talent screening and output incentive effects under separating and pooling equilibriums. Finally, through MATLAB simulation, the study examines how changes in labor market characteristics impact the effects of external compensation disparities on manufacturing industry innovation. The main conclusions of this study can be summarized as follows:

First, external competitive compensation disparities have a talent screening effect on manufacturing enterprise innovation, which only exists in the separating equilibrium where employees truthfully signal their innovation type. When compensation disparities within manufacturing enterprises are larger, enterprises find it easier to screen high-output innovative talents.

Second, external competitive compensation disparities have an incentive effect on innovation output in manufacturing enterprises, and this effect exists in both separating and pooling equilibriums. Under similar conditions, as the proportion of innovative employees in the labor market and compensation disparities increase, the incentive effect of external compensation disparities on innovation output in manufacturing enterprises strengthens.

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