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Executives External Pay Gap and Enterprises Open Innovation

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Abstract. This study uses a panel regression model to empirically examine the influence of the executive pay gap on open innovation and its moderating effect. It picks the annual data of listed high-tech businesses in China from 2010 to 2022. The study demonstrates that a rise in the external executive pay gap will result in a rise in the degree of open innovation within businesses. The size of the board acts as a moderator. This research will offer crucial theoretical direction and decision-making resources for enhancing the corporate incentive structure for remuneration and developing innovative ideas of the highest caliber.

Keywords: Executives Pay Gap, Executives External Pay Gap, Innovation, Open Innovation.

1. Introduction

Amid global economic integration and intense competition, innovation is crucial for competitiveness and sustainability. However, independent R&D faces long cycles, high uncertainty, and relies on management's drive. Motivating executives to collaborate with research partners is vital. Compensation incentives are effective tools to spur executives and maximize enterprise value. Thus, an incentive-driven executive pay system is crucial for fostering open innovation.

Taking A-share listed companies in high-tech industry as a sample from 2010 to 2022, this essay examines how the executive external pay gap (EGAP) influences corporate open innovation, and further investigates the intrinsic operation mechanism of this impact. The contribution of this paper lies in its enhancement of the existing body of research on EGAP and corporate open innovation;second, it investigates the moderating effect of board size, and analyzes in depth the intrinsic connection between EGAP and corporate open innovation, so as to provide guidance for corporate decision makers to construct pay incentive mechanism and then stimulate the innovation vitality of enterprises.

2. Literature review

2.1. Executives external pay gap

As a key EGAP theory, social comparison theory suggests executives' work effort is driven by perceived compensation fairness [1]. EGAP factors include CEO compensation relative to market levels affecting turnover & performance [2]. Pan et al., through an empirical study that grouped executives by gender, demonstrated that gender influences the executive compensation gap [3]. Another body of research on EGAP centers on its economic consequences, such as its effects on corporate environmental performance [4], risk tolerance [5], and bond yields [6]. Currently, most economic consequences have been focused on corporate performance, and the relationship between the external executive

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compensation gap and open innovation remains an area of ongoing debate, with a notable absence of consensus and comprehensive research.

2.2. Influencing factors of open innovation

Chesbrough introduced "open innovation," integrating internal and external R&D resources for commercialization [7]. Factors influencing it involve both enterprise's internal and external aspects. Nambisan et al. identified through theoretical research that technological enablement is a key factor in making open innovation feasible [8]. Giagnocavo et al., through an analysis from the knowledge creation perspective, identified that absorptive capacity plays a critical role in shaping the practice of open innovation within agricultural enterprises [9]. Jennifer pointed out that companies subject to a certain degree of external regulation tend to exhibit higher quality governance and greater capacity for open innovation [10]. Existing research has predominantly concentrated on the influence of external environmental factors and internal management systems on corporate open innovation, with relatively little exploration into the role of executive compensation incentive mechanisms.

2.3. The relationship between executives external pay gap and innovation

Kini showed EGAP raise corporate risk tolerance, promoting high-risk innovation [11,12]. Cowherd, through an analysis of data from numerous publicly listed pharmaceutical companies, indicated that an EGAP can enhance product quality and, to some extent, drive corporate innovation. Jia et al. argued that the emergence of pay gaps is inevitable and can motivate executives to work harder, leading to more frequent innovation activities and more prominent innovation outcomes [13]. Zhu and Hua conducted an empirical study showing a positive relationship between corporate green innovation EGAP [14]. However, Fredrickson found that an excessively large external pay gap can disrupt the overall pay structure balance within a company, harm employee morale, and have a negative impact on corporate innovation activities [15]. Existing literature has primarily explored the effects of EGAP on corporate innovation performance, risk tolerance, and various factors influencing open innovation. However, the impact of EGAP on corporate open innovation has received limited attention. Consequently, this paper aims to analyze the influence of EGAP on corporate open innovation, further examining the conditions under which this relationship manifests.

3. Methodology

3.1. Research hypotheses

When executive salaries exceed industry averages, social comparison theory suggests their self-worth is affirmed, boosting satisfaction and work ethic. In high-tech firms, this drives R&D investment and innovation decisions, fostering open innovation. Conversely, a salary gap below industry norms motivates executives to boost performance for personal gain. However, since the external salary gap reflects the status and scale of the enterprise to some extent, the enterprises with low salary are usually small in scale and the R&D funds are not sufficient. Pisano argues collaboration can share risks, costs, and resources, enhancing innovation [16]. Hence, the executive salary gap encourages external cooperation to elevate enterprise innovation and promote open innovation., so as to promote the firms' open innovation. Based on this, the following hypothesis is put out in this paper:

H1: Executive external pay gap promotes enterprises open innovation

When firm's board size is larger, the number of interlocking directors may be larger, and the degree of linkage between directors of different firms is higher. This linkage provides a shortcut for executives to understand the salary information which is more real and accurate. For example, if the comparison

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found that their own pay is higher, according to Thong [17], it helps to considerably increase executives' job satisfaction, which strengthens the executive pay gap's incentive effect on open innovation. In addition, relying on interlocking directors, firms at the focal point can access more innovation knowledge and technological information by utilizing their positional advantage in the chain director network [18]. While gaining access to more external resources, it also increases its likelihood of reorganizing these resources and thus applying them to open innovation [19]. Based on this, the following hypothesis is put out in this paper:

H2: The board size moderates the influence of executive external pay gap on enterprises open innovation, such that the relationship is stronger in firms with larger board sizes and weaker in firms with smaller board sizes.

3.2. Data resources

Referring to the methodology of Peng and Mao and the Guidelines for Industry Classification of Listed Companies issued by the China Securities Regulatory Commission (CSRC) [20], this paper selects listed companies in the high-tech industry of the A-share market as the research sample from 2010 to 2022, mainly based on the following considerations: (1) before 2010, the concept of open innovation had not been proposed, and joint patent data were seriously missing. (2) high-tech industry is characterized by fast product renewal and high demand for core innovation ability, so it is more representative for analyzing open innovation. The data are analyzed in the following ways: (1) samples of businesses that had ST or * ST throughout the sample period is not included; (2) samples of businesses that have important characteristics missing are not included; (3) To account for the effect of heterogeneity, a Winsorize tailing treatment is applied at the 1% level to all continuous variables. The CSMAR database is the source of all data.

3.2.1. Explained variable

Open Innovation (OI). Referring to Brockman's measure, this paper uses the number of joint patent applications plus one and taking the logarithm as the metric [21]. This is because collaborative innovation, as characterized by joint patent applications, is the most critical part and driving force of firms' open innovation.

3.2.2. Core explanatory variable

Executive external pay gap (EGAP). Referring to the measurement method of Gu and Zhu [22], it is measured by the absolute number of core executives' average salary minus the average salary of executives in the industry (EGAP_abs), where the core executives define the top three most highly compensated executives [23]. In this paper, EGAP_abs is normalized to obtain EGAP, the larger its value, the larger the executive external pay gap.

3.2.3. Control variables

Drawing on the studies of Li et al. [24] and Niu et al. [23], we control for micro-level variables: firm size (Size), firm age (Age), leverage (Lev), return on assets (Roa), fixed asset ratio (Fixed), dual (Dual) and nature of the firm (Soe).

Table 1. Variable definition

Variables	Definition

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OI	Add 1 to the number of joint patent applications per company per year, and take the logarithm
EGAP	The absolute value of differences between the average salary of core executives and the average salary of industry executives after standardized processing
Size	The natural logarithm of total assets
Age	Year - Year of listing + 1, taking the natural logarithm
Lev	Total liabilities/ Total assets
Roa	Total liabilities/ Total assets
Fixed	Net fixed assets/total assets
Dual	The chairman and general manager take 1 for the same person, and 0 for different people
Soe	The value is 1 for state-owned enterprises and 0 for non-state-owned enterprises

3.3. Regression equation

To evaluate this paper's hypothesis, the executive external pay gap will promote enterprise open innovation, this paper constructs the following model:

$$OI_{i,t} = \alpha_0 + \alpha_1 EGAP_{i,t} + \alpha_j \sum Controls_{i,t} + \mu_i + \theta_t + \varepsilon_{i,t} \quad (1)$$

where, $OI_{i,t}$ is enterprise open innovation, $EGAP_{i,t}$ is the executive external pay gap, $Controls_{i,t}$ is control variable set, μ_i is the industry fixed effect of firm i, θ_t denotes the yearly effect in year t, and $\varepsilon_{i,t}$ is a random disturbance term.

4. Results and discussion

4.1. Descriptive statistics and correlations

Table 2 displays the findings of the descriptive statistics for the primary variables used in this study. Open innovation (OI) has a mean value of 0.984 and a standard deviation of 1.286, which indicates that there is no over-dispersion of OI, and the distribution pattern is close to normal distribution. The data distribution of the other variables, such as Size, Age, Lev, Roa, etc., is reasonable in general.

Table 2. Descriptive statistics

Variable	N	mean	sd	min	p50	max
OI	17175	0.894	1.286	0.000	0.000	5.220
EGAP	17175	0.000	1.000	-1.192	-0.277	4.764
Size	17175	21.990	1.151	20.030	21.810	25.690
Age	17175	2.866	0.329	1.792	2.890	3.497
Lev	17175	0.369	0.183	0.054	0.359	0.782
Roa	17175	0.050	0.061	-0.179	0.047	0.219
Fixed	17175	0.193	0.126	0.007	0.171	0.567
Dual	17175	0.341	0.474	0.000	0.000	1.000
SOE	17175	0.246	0.431	0.000	0.000	1.000

The Pearson correlation coefficient is shown in the bottom triangle and the Spearman correlation coefficient is shown in the top triangle in Table 3, which displays the correlation coefficient analysis of

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the major variables. At the 1% level, both are statistically significant positive, which first validates the research hypothesis H1. This work also makes use of the variance inflation factor (VIF) for the detection of multicollinearity in order to eliminate the influence of multicollinearity. The average VIF value for all variables is 1.31, and the maximum value is 1.86. These values are significantly less than the multiple regression model's thumb rule of 10.00, indicating that there may not be a significant covariance issue among the variables [25].

Table 3. Correlations

	OI	EGAP	Size	Age	Lev	Roa	Fixed	Dual	SOE
OI	1.000	0.224***	0.410***	0.141***	0.204***	-0.009	-0.014*	-0.087***	0.207***
EGAP	0.246***	1.000	0.392***	0.021***	0.113***	0.209***	-0.035***	-0.052***	0.126***
Size	0.476***	0.422***	1.000	0.237***	0.509***	-0.057***	0.091***	-0.172***	0.322***
Age	0.138***	0.046***	0.227***	1.000	0.138***	-0.091***	0.043***	-0.080***	0.147***
Lev	0.223***	0.128***	0.521***	0.153***	1.000	-0.367***	0.186***	-0.121***	0.273***
Roa	0.007	0.191***	-0.010	-0.082***	-0.338***	1.000	-0.131***	0.058***	-0.147***
Fixed	-0.013	-0.031***	0.131***	0.037***	0.203***	-0.105***	1.000	-0.084***	0.101***
Dual	-0.089***	-0.041***	-0.168***	-0.078***	-0.124***	0.038***	-0.092***	1.000	-0.287***
SOE	0.211***	0.098***	0.350***	0.147***	0.285***	-0.091***	0.137***	-0.287***	1.000

4.2. Baseline regression results

The baseline regression results are shown in Table 4. Each column of the regression uses robust standard errors to reduce heteroskedasticity while accounting for the fixed effects of year and industry. The results are shown in Column (1) without any additional control variables. Additional controls are provided for the fundamental attributes of the company in column (2). According to both findings, the EGAP coefficient is substantial and positive at the 1% level. According to the regression results in both columns, company open innovation increases with the size of the executive external salary difference, supporting hypothesis H1. In terms of economic relevance, OI rises by 7.05% (0.063 × 1/0.894) standard deviations for every standard deviation increase in EGAP. This demonstrates how the EGAP adds to the OI in terms of statistical and economic importance.

Table 4. Baseline regression

	(1)	(2)
	OI	OI
EGAP	0.3276***	0.0630***
	(28.3762)	(5.6470)
Size		0.5282***
		(46.1266)
Age		0.0839***
		(2.7620)
Lev		-0.3638***
		(-6.1955)
Roa		-0.2617*
		(-1.7416)

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Fixed		-0.5040***
		(-6.3932)
Dual		-0.0050
		(-0.2799)
SOE		0.2480***
		(10.1978)
_cons	0.2278*	-11.3112***
	(1.9569)	(-42.8365)
Industry	Yes	Yes
Year	Yes	Yes
N	17175	17175
r2_a	0.1029	0.2650

t statistics in parentheses

* p < 0.1, ** p < 0.05, *** p < 0.01

4.3. Robustness check

4.3.1. Alternative control variables and sample

This paper modifies the samples and control variables, respectively, to test the robustness. First, by including businesses' independent innovation in the control variables, this analysis re-regresses Model 3-1. The independent innovation level is determined in this research by taking the logarithm of the number of independent innovation patent applications. Table 5's Column 1 demonstrates that EGAP's influence on OI is still highly favorable, suggesting that EGAP encourages OI regardless of how much independent innovation a firm produces. In addition, this study has a new treatment of the sample by replacing the samples with zeroes where OI is missing, and the total number of samples is increased to 17,432, and the result is still significantly positive, which ensures the robustness of this study.

Table 5. Robustness check

	(1)	(2)
	OI	OI
EGAP	0.0562***	0.0653***
	(5.0404)	(5.9112)
Size	0.4813***	0.5227***
	(38.2534)	(45.8763)
Age	0.0927***	0.0853***
	(3.0567)	(2.8290)
Lev	-0.3835***	-0.3496***
	(-6.5708)	(-5.9962)
Roa	-0.3148**	-0.2358
	(-2.0971)	(-1.5747)
Fixed	-0.4661***	-0.4905***
	(-5.9506)	(-6.2792)
Dual	-0.0080	-0.0040

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	(-0.4457)	(-0.2215)
SOE	0.2377***	0.2484***
	(9.8168)	(10.2723)
lnII1	0.0709***	
	(8.6704)	
_cons	-10.3947***	-11.2081***
	(-36.5085)	(-42.6957)
Industry	Yes	Yes
Year	Yes	Yes
N	17175	17432
r2_a	0.2691	0.2631

t statistics in parentheses

* p < 0.1, ** p < 0.05, *** p < 0.01

4.3.2. Instrument variable estimation

This article employs the instrumental variable strategy to address the endogeneity problem and uses the one-period lagged EGAP as an instrumental variable for the explanatory variables in a two-stage regression, drawing on Sheng et al. [26]. Tables 6 present the results derived from the instrumental variable. First-stage EGAP for L.EGAP is significantly positive at the 1% level. For the weak instrumental variable test, the Cragg-Donald f-statistic is 35646.89, which is significantly higher than the threshold value of 16.38. Consequently, the weak instrumental variable theory is disproved. At a significance level of 1%, the coefficient of EGAP and OI in the second stage is 0. 0831, suggesting that EGAP will encourage open innovation within enterprises.

Table 6. Instrument variable

	(1)	(2)
	First	Second
Variables	EGAP	OI
L.EGAP	0.8417***	
	(188.8038)	
EGAP		0.0831***
		(6.4696)
Size	0.0738***	0.5451***
	(14.9157)	(43.8465)
Age	0.0392***	0.0450
	(2.5969)	(1.2284)
Lev	0.0789***	-0.4436***
	(2.7742)	(-6.4387)
Roa	1.1178***	-0.4564***
	(15.6065)	(-2.5978)
Fixed	-0.0604	-0.5064***
	(-1.6184)	(-5.5913)

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Dual	-0.0007	-0.0010
	(-0.0745)	(-0.0455)
SOE	-0.0442***	0.2431***
	(-4.2472)	(9.6220)
_cons	-1.8147***	-11.6598***
	(-14.3154)	(-36.7791)
Industry	Yes	Yes
Year	Yes	Yes
N	14,296	14,296
r2_a	0.789	0.269

t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

4.4. Channel analysis

Board size reflects corporate co-directorship to some extent and may have an impact on executive incentives. In order to verify the moderating effect of board size, this study uses the logarithm of the number of board members to measure board size and adds the cross-multiplier term (EGAP x Board) of the executive external pay gap (EGAP) and board size (Board) to Model (1) to establish the following model:

$$OI_{i,t} = \alpha_0 + \alpha_1 EGAP_{i,t} + \alpha_2 Board_{i,t} + \alpha_3 EGAP_{i,t} \times Board_{i,t} + \alpha_j \sum Controls_{i,t} + \mu_i + \theta_t + \varepsilon_{i,t} \quad (2)$$

The findings in Tables 7 demonstrate that, at the 1% level, the coefficient of EGAP x Board is significantly positive, suggesting that the effect of EGAP on the enhancement of OI is more prominent the bigger the board size.

Table 7. Channel analysis

	(1)
	OI
EGAP	0.0481***
	(4.2146)
Board	0.1007**
	(2.1424)
EGAP x Board	0.1654***
	(3.5366)
Size	0.4800***
	(37.9494)
Age	0.0914***
	(3.0142)
Lev	-0.3798***
	(-6.5182)
Roa	-0.3042**

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	(-2.0263)
Fixed	-0.4742***
	(-6.0341)
lnII1	0.0703***
	(8.5983)
Dual	-0.0063
	(-0.3505)
SOE	0.2300***
	(9.4065)
_cons	-10.5832***
	(-35.9211)
Industry	Yes
Year	Yes
N	17174
r2_a	0.2699

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5. Conclusion

This essay utilizes a sample of A-share high-tech listed companies from 2010 to 2022, concluding that there is a significant positive correlation between EGAP and open innovation. Board size plays a moderating role in this relationship. The findings suggest that when executive compensation is below industry standards, the external compensation gap will stimulate the desire of executives to prove their capabilities, thereby encouraging them to expand externally and exerting a positive incentive effect on open innovation within the enterprise. Conversely, when executive compensation surpasses the industry average, the resulting external compensation gap may incentivize executives to influence the industry ecosystem, thereby facilitating the unlocking of internal innovation resources. This paper expands on social comparison theory, with implications for corporate compensation systems: first, to harness the external pay gap's drive for open innovation, enterprises should adjust executive incentives to mitigate negative impacts from gaps too small or large; second, adjust pay gaps timely based on external manager market conditions to boost future open innovation. As external market pays rises, widen internal-external gaps to enhance executive team remuneration and spur innovation. This paper offers a comprehensive study of the relationship between executive external pay gaps (EGAP) and open innovation. However, the findings of this study are specific to China and may not be fully applicable to firms in other countries. There is still a lack of research on how EGAP affects the breadth and depth of open innovation under different conditions, which warrants further investigation in the future.

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