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The Impact of CEO-Employee Pay Gap on Firm Innovativeness

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Abstract

This study investigates the impact of the CEO-employee pay gap on firm innovativeness, defined as a company's ability to generate economic value from its R&D activities. While prior research has focused on financial performance, the effect of vertical pay dispersion on innovation outcomes remains underexplored, particularly in developed European and Asian markets. Using a sample of public 362 companies from technology-intensive and non-technology-intensive industries over the 2012–2022 periods, we employ the Research Quotient (RQ) as output-elasticity-based measure of innovativeness. Our panel data analysis reveals three main findings. First, the CEO-employee pay gap has a significant negative net effect on firm innovativeness, supporting social comparison and pay equity theories over tournament theory. Second, this relationship is moderated by industry and regional contexts: the negative impact is less pronounced in technology-intensive industries and among firms located in developed Asian countries, where collectivist cultural norms may foster long-term orientation and tolerance for hierarchical differences. Third, we document an indirect moderating effect whereby the pay gap dampens the positive relationship between employee pay growth and firm innovativeness. Our results are robust to fixed-effects specifications and various sensitivity checks. These findings have important implications for corporate governance, compensation design, and investment analysis, suggesting that optimal incentive structures must balance CEO incentives with rank-and-file motivation to foster sustainable innovation.

Keywords: pay gap, firm innovativeness, CEO, employee, research quotient, pay equity theory, tournament theory
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Introduction

Commercialising a firm's innovative research and development (R&D) activities is a vital objective for most companies, as it promotes long-term sustainable growth and competitiveness in a rapidly changing environment [1]. These advantages can be achieved through the development and sale of new products, or by improving cost efficiency through the implementation of cost-reducing technologies. Therefore, the ability to create economic value from innovation-related activities distinguishes successful leaders from other firms. This highlights the relevance and significance of researching firm innovativeness, which can be defined as a company's ability to generate profit from its R&D activities.

The issue of firm innovativeness is of great interest to scholars due to its practical importance for company survival. A significant body of research has been devoted to analysing the organisational factors that affect firm innovativeness and the invention of new products [2; 3]. Planning frameworks, the accuracy of operational execution, customer relationship management and efficient marketing are all confirmed as contributing to company innovation outcomes. The quality of these organisational elements depends heavily on management coordination and support. This is precisely why increasingly more attention is being paid to the influence of top management characteristics, such as age, gender, and experience, on company performance [4]. Prior scientific literature has also examined the relationship between company efficiency and executive compensation, which affects strategic priorities and decision-making processes [5; 6]. However, the impact of top management incentive structures on a firm's innovative capabilities has not been sufficiently researched. Managerial incentives significantly affect important decisions related to company investments, innovation and funding [7]. These decisions lay the groundwork for the company's future performance, prospects, and development path. Therefore, this study focuses on one of the main questions related to this influential factor: the pay gap between the chief executive officer (CEO) and ordinary employees, which represents the firm's incentive structure.

A clear understanding of the relationship between the CEO–employee pay gap (hereafter referred to as the 'pay gap') and firm innovativeness requires detailed academic research to be carried out. The results of this research will be useful in setting up an effective incentive system, which will improve a company's innovativeness and, consequently, its successful development.

The attitudes towards the pay gap between managers, scientists and employees vary depending on the industry and the level of a country's development, among other factors. In this study, we apply knowledge from social equality and tournament theories to increase the company's innovativeness. In accordance with the principles of the wage equality theory, individuals are wont to compare the efforts, experience and talents they invest in their professional activities with the remuneration they receive in return. Consequently, the exacerbation of the wage disparity between CEOs and employees is unlikely to motivate employees to allocate greater effort towards R&D endeavours. In contrast, the principles of the tournament theory have been demonstrated to motivate employees at all levels of an organisation to enhance their performance, thereby inspiring them to generate and execute novel concepts to achieve a superior objective. The persistent incongruities between these two theories highlight the necessity for further research in this domain.

This study aims to determine the presence and strength of the influence of the pay gap between CEOs and non-executive employees on firm innovativeness.

The research focuses on public companies in technology-intensive and non-technology-intensive industries operating in developed European and Asian countries. These two regions are examined because they have unique features, such as cultural and institutional environments, which could affect the relationship between the pay gap and innovative company outcomes.

The vertical pay gap between CEOs and ordinary employees is a poorly understood factor that influences motivation towards the successful commercialisation of innovation activities within an organisation. The scope of the research also includes investigating the industrial specifics of the impact of the pay gap, as well as its indirect effects.

This paper is novel due to the following distinctive features. First, few research papers use the Research Quotient (RQ), a universal and effective measure of firm innovativeness that is superior to conditional indicators such as patents, R&D intensity and expenditure. This study uses RQ (the percentage increase in revenues from a one percent increase in R&D expenditure) to evaluate a company's innovativeness in relation to the pay gap. Second, this research provides an analysis of the industrial specifics of the impact of the pay gap on innovative activities. Third, cultural differences between countries are used as a moderating effect to reflect the relationship between the wage gap and the innovation of companies in developed countries in Europe and Asia. The cultural characteristics of nations, such as individualism, power distance and time orientation, are more closely associated with companies' investment in innovation. According to theory of social equality and the tournament theory, these factors influence workers' attitudes towards such processes. Fourth, this study explores not only the direct effect of the pay gap, but also its indirect effect through its influence on the relationship between employee pay growth and firm innovativeness.

The practical significance of the study lies in the policy implications of its results for company management and investors. First of all, an understanding of the impact of the pay gap on innovative efficiency will help to design an optimal incentive system that improves firm innovativeness. Such a system should balance the innovation motives of personnel and the motivation of top management to promote corporate innovative activities. Furthermore, inclusion of the pay gap as a factor in company analysis, along-

side other drivers of innovativeness, will help investors correctly assess firms' long-term sustainability and growth opportunities.

Using information about the size and dynamics of the pay gap, it will be possible to make more accurate forecasts about fundamental aspects of a company's future development, which largely determine its valuation. Therefore, the results of this study will contribute to the implementation of a reliable investment strategy.

Theoretical framework

Pay gap

The pay gap is a topic that has recently become the subject of active discussion, attracting researchers from many academic fields [8; 9]. The main problems associated with this issue are dispersion and disparity. Some research papers focus on the vertical pay gap, exploring compensation differences between employees at different levels within an organisation [10; 11]. Other studies have examined the horizontal pay gap, describing pay variations among workers at the same level with similar jobs [12]. The present study focuses on the former issue and, more specifically, on the pay gap between rank-and-file employees and CEOs.

The first scientific papers related to this matter appeared in the 1950s, providing the theoretical basis for subsequent research. In 1954, Festinger [13] introduced the social comparison theory, whereby individuals compare themselves to others in order to evaluate their social status. To make such comparisons, individuals choose "referents", or people who seem similar to them. The outcome of this choice and subsequent comparisons is an essential determinant of future behaviour and attitudes towards various aspects of life. Unexplained differences force individuals to act in order to eliminate or at least reduce such anomalies. This tendency has been confirmed by researchers studying different groups, such as CEOs of large, successful firms [14] and students [15].

The next logical step was the pay equity theory proposed by Adams [16]. This theory suggested that workers not only compare themselves to others, but also match the inputs, such as effort, work experience and talents that they put into their work to the outputs they receive in the form of compensation working conditions and social package. This ratio, calculated mentally by taking into account the individual utility of each element, should then be compared to that of other employees. Individuals perceive differences in these ratios as inequalities that must be addressed. This creates pressure, driving individuals to take action to reduce inequity.

Several studies confirm the practical implications of the pay equity theory. According to Fredrickson et al. [17], the growth of the pay gap between CEOs and top management team members negatively affects company performance, resulting from social comparisons among them. Bloom [18] discovered that rising pay variation within a firm worsens results both individually and collectively. Pay dispersion has been found to have a short-term positive effect on company profit [5]. However, this effect becomes negative in the long term. This is due to employees being motivated by immediate benefits rather than acting in the firm's strategic interest.

Another theory that competes with the social comparison theory was developed by Lazear and Rosen [19] and is called the tournament theory. It was further improved and expanded by Rosen [20]. The core idea of the tournament theory is that employee motivation is based on a pay hierarchy. Payment disparity at different levels of the hierarchy motivates employees at both lower and higher levels. Several empirical studies have confirmed the positive association between a vertical pay gap and a company's overall performance, thus verifying the concepts of the tournament theory.

However, an analysis of related research papers revealed several conflicting theories that explain the effect of the pay gap on different dimensions of company performance.

Firm innovativeness

An organisation's innovation capabilities form the basis of its competitiveness and promote sustainable growth in a rapidly changing environment [1]. At the same time, however, R&D investment projects tend to have a long-term outlook and are often characterised by a high degree of uncertainty and a high probability of failure [21]. The practical significance of firm innovativeness, as well as these qualities, have prompted many researchers to study the factors that influence it.

A company's research and development activities are susceptible to external influences such as government policy and the institutional and cultural environment. Gortzen [22] stated that government support significantly promotes the dissemination of technological knowledge by providing funding and tax benefits for joint research projects between private companies. Regulatory policy, the development of advanced institutions and access to human capital and technological solutions have important implications for company innovativeness. Culture is another factor whose impact on corporate performance and innovativeness has been gradually recognised by different scholars. It influences how individuals gain knowledge, prioritise values, and select appropriate behaviours, such as imitation or education. These aspects define an individual's behaviour and shape their personality [23]. The same applies to the decision-making process related to economic activities, where the values, motivations and expectations grounded in culture determine corporate behaviour. Florida [24] argued that the inclusiveness and openness of the people living in a certain region are positively associated with the ability to innovate.

The impact of individualism on firm innovativeness, as it relates to the population of certain regions, was investigated in research conducted by Hofstede [25]. The Hofstede typology consists of six indicators: power distance, individualism, masculinity, avoidance of uncertainty, time orientation and indulgence. These characteristics can only

undergo significant long-term alterations following major global changes. The study of individualism showed that collectivist societies are less creative than individualist ones. This is because individualism promotes individual efforts and freedom, which are beneficial for creative activities, efficient communication and the availability of information, as its main values. Together, these factors contribute to innovative efficiency. Societies with a high degree of individualism, such as those in Western Europe and North America, are characterised by employees who make decisions independently and pursue their own interests rather than those of the firm. This could negatively affect the innovation process due to ambiguous results.

However, collectivism also has advantages in terms of innovation. Collectivist culture, which is prevalent in Asian countries, is characterised by greater interdependence among team members, including the sharing of risks and benefits in long-term cooperation. Collectivism prioritises compliance with rules and tolerance of failure. Due to the long-term nature of R&D projects, which are associated with a high level of uncertainty and a high probability of failure, the characteristics of collectivist societies play an important role in the successful development of innovations.

Firms located in countries with high long-term orientation indicators, such as South Korea and Japan, will have business structures that focus on long-term results. This has a positive influence on the innovative process. The results of this process are only delivered in the long term: thus, the longer the planning horizon, the more likely the company is to engage in this activity. The new product manufacturing process of Japanese companies is the perfect illustration of this theory. Collective cooperation among Japanese employees significantly facilitates the development of innovative manufacturing methods [26].

In the corporate world, the power distance index shows the degree to which management is accessible to employees. In countries with high power distance indices, such as those in Southeast Asia and the Arab world, strategic planning is the responsibility of senior management, with employees simply following orders. This can have a negative impact on the innovative process, affecting the agility of internal dynamics and overall team creativity.

The necessity of innovative product development is determined by industry characteristics, including the level of competition and specifics of dominant strategy. Each year, pharmaceutical, information technology and automobile companies register a significantly higher number of innovative products and patents than companies in other sectors [27]. Therefore, the distribution of innovation is subject to industry specifics. Using data on Korean manufacturing companies, Lee [28] demonstrated that R&D intensity – a measure of a firm's innovativeness – depends on factors such as firm density, the cost structure of R&D projects, the ability to commercialise results and consumer preferences regarding quality and price.

Another study on organisational innovation found that various factors significantly impact a company's new product development at different levels. These factors include an in-depth understanding of customer needs and market conditions, strong strategic planning, and effective coordination between production volumes and cost optimisation [3]. The top management team is responsible for providing oversight and support for all these elements, as well as for determining investment policy and the R&D agenda. Furthermore, the performance of innovative product development depends heavily on corporate culture, collaboration, and communication within the company [29]. Santos and Spann [30] demonstrated the substantial importance of ordinary employees' motivation and willingness to participate in new product development. Therefore, engagement of both rank-and-file employees and top management is essential for a company to commercialise its innovative R&D activities. The behaviour of both groups has a significant impact on the company's overall working climate and culture. The incentive structure at the top and bottom of an organisational hierarchy affects a firm's innovativeness. The configuration of compensation schemes defines individual workers' efforts towards innovative activities [31]. The pay gap between rank-and-file employees and top management reflects the overall shape of a company's incentive structure, making it a highly suitable and reliable indicator. Consequently, it can be assumed that the pay gap is significantly associated with an organisation's ability to benefit from innovative activities.

Although innovative activities are generally considered beneficial, expanding R&D programmes does not necessarily create economic value. The ability to commercialise innovations is vital for any company. This study therefore focuses on this ability by exploring firm innovativeness. The Research Quotient (RQ), also known as Organisational IQ (IQ), which was designed by Knott [32], is a reliable metric for this purpose. RQ represents the output elasticity of R&D spending for each firm and therefore measures its ability to generate revenue from R&D investments.

Relationship between CEO-employee pay gap and firm innovativeness

Prior academic papers on the topic of the pay gap have mainly focused on its influence on a company's financial performance [33]. For example, Yanadori and Cui [12] examined the relationship between a firm's ability to innovate and the level of pay dispersion within the research and development team. They discovered that an increase in the horizontal pay gap among R&D workers reduces the number of patent applications in high-tech companies. However, the authors' results are limited by the business model of high-tech companies and consider only the horizontal pay gap. Wang et al. [11] studied the influence of workers' motivation and voluntary turnover on the relationship between a company's innovative capabilities and the pay gap. Using surveys based on respondents' self-assessment of this relationship, they found that the factors under consideration had a moderating effect.

One of the most relevant studies on this topic was published by Zhao and Wang [34]. They examined how the

pay gap between executives and ordinary employees affects a firm's ability to innovate from the perspective of promoting inventors. The average pay of ordinary employees was used as a proxy for the average pay of R&D department staff. The authors concluded that a wider vertical pay gap could enhance a company's innovativeness, as measured by the number of patents. This improvement could be attributed to the effects of two main mechanisms. First, a larger pay gap creates additional incentives for inventors, who are responsible for innovative outcomes. Since inventors are selected for management positions based on their innovative performance, increased motivation leads to more inventors being promoted. Second, inventors who are promoted to management roles tend to increase investment in R&D projects and involve more R&D staff in management processes due to their professional preferences. Together, these two mechanisms ensure that the pay gap positively influences corporate innovativeness [35].

A review of the extant literature on the pay gap issue suggests that the social comparison theory, the pay equity theory and the tournament theory predict multidirectional effects of the pay gap within an organisation. Therefore, Mingli et al. [27] proposed testing not only the net effect of the pay gap, but also the nonlinearity of the pay gap–firm innovativeness relationship, for which they constructed a quadratic regression model. The authors found that the relationship between an organisation's ability to innovate, as measured by the number of patent applications, and the pay gap follows an inverted-U pattern. The social comparison theory dominates where there is a significant pay gap, while the tournament theory explains the effect where the gap is small. However, subgroup analysis of companies with a small pay gap produced more reliable results. The authors verified whether the above results were robust for companies in technology-intensive industries. The results were consistent.

Apart from its direct influence, the pay gap can have an additional indirect effect on a company's innovative efficiency. According to previously analysed scientific literature, workers are motivated by immediate benefits. A significant part of these benefits is comprised by employee pay. Based on this reasoning, we can conclude that average employee pay growth is associated with an individual's future behaviour and attitude towards the work process. This is particularly relevant for employees and managers in research departments. Numerous studies have confirmed that an increase in the compensation amount has a positive effect on labour productivity, job satisfaction, and overall performance [36]. This is because people tend to compare themselves with others and with their past selves. Furthermore, pay increases may positively affect the motivation of employees to engage in creative and innovative behaviour related to R&D activities. Different research papers claim that the extent of pay inequality among employees affects total satisfaction with working conditions [37]. Therefore, when the rate of CEO compensation growth exceeds the growth rate of ordinary employees' pay (i.e., when the pay gap widens), it creates a sense of inequality that may reduce the positive impact of employee pay growth on firm innovativeness. Thus, the CEO–employee pay gap mitigates the positive impact of employee pay growth on company innovativeness.

Hypotheses development

As posited by Fredrickson et al. [17], the social comparison and pay equity theories, which are predicated on social status comparison within an organisation, suggest that pay inequity has a deleterious effect on the efficiency of a company's innovative activities. Public companies are obliged to disclose a substantial amount of information in order to increase investor confidence. The information provided is increasingly replete with details pertaining to CEO remuneration. These details are disseminated to the general public by the media, due to the high ratings of such publications. Consequently, it is highly probable that rank-and-file employees possess a considerable degree of awareness with regard to the remuneration packages enjoyed by Chief Executive Officers. The existence of a significant vertical pay gap has the potential to engender a perception of inequality among employees, which can adversely impact their motivation and behaviour towards collaboration and innovation. This, in turn, can have detrimental consequences on a company's capacity to commercialise its R&D activities. Concurrently, the principles of the tournament theory posit that a vertical pay gap exerts a positive influence on the innovativeness of firms. This is attributable to the differential remuneration for distinct levels within the organisational hierarchy, which serves as a stimulant for employees across both the lower and higher echelons [19]. It is imperative to undertake a comprehensive investigation into the net effect of the CEO-employee pay gap for companies. This investigation should employ the RQ methodology to ascertain the degree of consistency with the social comparison and pay equity theories, as well as the tournament theory [16; 17; 19]:

H1.1: *According to the theory of social comparison and the pay equity theory, the size of the CEO-employee pay gap negatively affects firm innovativeness as measured by Research Quotient (RQ).*

H1.2: *According to the tournament theory the size of the CEO-employee pay gap positively affects firm innovativeness as measured by Research Quotient (RQ).*

Despite the fact that the default linear model displays a strict dependence on one sign, it merely reflects the net effect. However, the effect of the pay gap within an organisation, as proposed by the social comparison and pay equity theories, is contrary to predictions made by the tournament theory. The multidirectional effects described by these theories have the capacity to engender nonlinearity in the relationships under consideration. Nonlinearity implies that the theories of social comparison and pay equity, or the tournament theory, dominate up to a certain level of pay gap, after which the relationship becomes the opposite [27]. In accordance with this logic, it is recommended that the nonlinearity of the pay gap-firm innovativeness relation-

ship be verified for the sample under consideration by constructing a quadratic regression model.

H2: *The relationship between the CEO-employee pay gap and firm innovativeness is non-linear (quadratic).*

The third hypothesis pertains to a distinctive feature of this study – an investigation of the industrial specifics of the pay gap-firm innovativeness relationship. The necessity of innovative product creation is contingent upon the industry in which the company operates. Enterprises operating within technology-intensive industries demonstrate a markedly elevated annual rate of innovation, as evidenced by the registration of a substantially higher number of innovative products and patents when compared with companies in other sectors. The success of competition and the long-term development of companies in technology-intensive industries is contingent upon the constant implementation of innovations, a feat that cannot be achieved without the involvement of numerous inventors [34]. The authors of the study identified two channels through which the CEO-employee pay gap can influence firm innovativeness: career promotion and pay raises, and promotion of investments in innovations. The primary channel's mechanism is predicated on the significance of fostering innovation as a selection criterion for promoting inventors. This suggests that the widening pay gap engenders further incentives for investors to enhance their innovative output. This phenomenon can be attributed to the second channel's mechanism, which involves an increase in the proportion of inventors within the management team. These individuals tend to allocate a greater amount of resources to R&D activities and to engage more inventors in management roles, often in alignment with their preferences. The overall effect of this dynamic is a positive feedback mechanism between innovative activities, inventor promotion and R&D investments. Consequently, the technology-intensive industry's specifics imply that inventors' promotion incentives related to widening the vertical pay gap become dominant and positively affect firm innovativeness. It is proposed that the relationship between company innovativeness and the CEO-employee pay gap be examined in technology-intensive and non-technology-intensive industries.

H3: *The size of CEO-employee pay gap has a positive effect on firm innovativeness for companies in technology-intensive industries (compared to non-technology-intensive industries).*

As Gortzen [22] concluded in their analysis of the preceding scientific literature, the institutional and cultural environment is found to play an important role in the development of human capital and the ability to access technological innovations. The values, motivations and expectations that are ingrained in a given culture have been shown to have a significant impact on an individual's corporate behaviour [23]. This includes the question of the attitude towards pay inequality represented by the CEO-employee pay gap. As Florida (2004) asserts, qualities such as transparency and inclusivity are conducive to the effective dissemination of information regarding working conditions, employee efforts in the realm of innovative activities, and compensation plans. Furthermore, Hofstede [25] asserts that individualism and collectivism, which are prevalent in societies across diverse regions, exert a substantial influence on labour relations within organisational frameworks. Individualistic societies are oriented towards freedom and creativity and encourage individual efforts, whereas collectivistic ones are characterised by a focus on risk and benefit-sharing in long-term cooperation and higher tolerance for failure. In light of the collectivistic nature of Asian societies and their focus on the long term, it is reasonable to hypothesise that employees of Asian companies are more motivated to contribute to their organisation's long-term development and less discouraged when the pay gap increases. Conversely, employees of European companies that are regarded as individualistic perceive an increasing pay gap as an escalating form of inequality that has a demotivating effect on them. The present study puts forward a hypothesis that reflects the idea of cultural and institutional specifics of European and Asian regions.

H4: *The size of the CEO-employee pay gap has a positive impact on firm innovativeness for companies in developed Asian countries (compared to companies in developed European countries).*

The final hypothesis pertains to the investigation of the indirect impact of the pay gap between a key management team member (CEO) and non-executive employees. As Rambo and Pinto [36] demonstrated, immediate benefits, a substantial portion of which is derived from employee remuneration, play a significant role in the motivation of workers. It is the conclusion of this study that average employee remuneration is associated with future behaviour and attitude to the work process. This, in turn, has a positive impact on the innovativeness of the firm. Conversely, the magnitude of employees' pay inequality has been demonstrated to exert an adverse influence on the aggregate satisfaction with working conditions [37]. Consequently, if the CEO compensation growth rate exceeds the growth rate of ordinary employees' pay, this will engender an increase in the sense of inequality due to a widening pay gap. It is hypothesised that an increase in the CEO-employee pay gap may serve to negate the positive impact of employee pay growth on firm innovativeness.

H5: *Increase in the CEO-employee pay gap reduces positive influence of employee pay growth on firm innovativeness.*

Methodology of research

Step 1. Measuring CEO-employee pay gap

The pay gap is the primary independent variable. As is commonly understood in the scientific literature, the approach to calculating the CEO-employee pay gap is defined as the ratio of the total annual compensation awarded to the CEO to the average compensation of the firm's ordinary employees [33]. It is noteworthy that the mean remuneration of employees is commensurate with that of employees engaged in innovative activities. Furthermore, the average pay is used instead of the median pay, indicating the incen-

tive structure more precisely. This is attributable to the unavailability of disaggregated data. However, the theoretical framework underpinning the study is such that it allows for the use of employees' average compensation for the purpose of this study. As indicated in the preceding literature review, the majority of ratio variations are comparable, exhibiting only minor discrepancies in the composition of elements incorporated into the compensation of CEOs. The elements of this ratio are determined as follows:

- The mean remuneration of the typical rank-and-file employee (denominator). In the absence of data pertaining to individual employees, aggregates such as labour costs (wages, bonuses) will be utilised, with the exclusion of top management compensation. In order to ascertain the mean remuneration of employees, it is necessary to divide the total costs by the number of non-executive personnel in the company.
- The mean aggregate remuneration for a Chief Executive Officer in a specified year, encompassing wages, bonuses, long-term incentive payments and all other forms of compensation (nominator).

In order to exert greater control over the influence of outliers, the logarithm of the pay gap is utilised. In addition, given the construction properties of RQ, which is calculated based on 7-year windows data, the geometric mean of the CEO-employee pay gap is calculated in order to ensure that the main dependent and independent variables are consistent. The subsequent CEO-employee pay gap calculation approach was thus developed:

$$CEO-employee\ gap_t = Geometric\ mean\left(\frac{CEO_{compensation}}{\frac{Labor\ costs - top\ managment\ compensation}{Number\ of\ employees}}\right)_{t:t-6}. \quad (1)$$

Step 2. Assessing firm innovativeness

In the academic literature, a number of scholars have drawn attention to several common approaches to measuring firm innovativeness [27; 38]. These approaches include the size of R&D expenditures, the number of R&D staff, asset intangibility, R&D intensity, and patent-based metrics. However, it should be noted that all of these conventional indicators are subject to certain disadvantages when compared to the Research Quotient, otherwise known as organisational IQ, as developed by Knott [32]. First, it is important to note that R&D expenditures, R&D intensity, and other input metrics are less precise and reliable measures of a company's innovative development. This is because they could potentially reflect low yield or useless R&D costs. It has been demonstrated that patents do not invariably engender economic value. This assertion is substantiated by the example of IT companies, such as Apple and Samsung, which patent numerous inventions that are commercially unviable. Second, patent applications and granted patents, which are the output measures that more accurately reflect the result of the effective use of available resources and cooperation within the company, continue to ignore industry heterogeneity and do not account for the varying profitability of innovations. Finally, existing databases have been found to provide insufficient information on patent applications, especially in developing countries. Formal theoretical arguments were further concretised by Obrimah [39], who stated that both R&D spending and patents are not robust measures of innovativeness and therefore can result in false inferences regarding innovativeness. Conversely, RQ, calculated as the percentage increase in revenues from a one percent increase in R&D expenditures, reflects a firm's ability to generate profit from its R&D investments. Given that the objective of our study is to assess a company's capacity to commercialise its innovative activities, the RQ model is an optimal fit for this purpose.

It is evident that there are several other significant advantages associated with this indicator. First, it is important to note that RQ is unitless in nature, given that it represents the ratio of inputs to outputs. Second, it could be derived for any company engaged in R&D activities and providing financial data. Moreover, RQ is universally applicable due to its uniform interpretation across all companies, irrespective of their industry, thereby rendering it suitable for large-scale research involving firms from diverse sectors. Another crucial feature of RQ is related to its construction aspects, which allow investigating the direction of causal relationships between R&D investments and company performance. In conclusion, it can be demonstrated that the aforementioned arguments collectively substantiate the assertion that RQ functions as a universal and reliable indicator of a firm's innovative capabilities [27].

The present study employs the idea of Knott [40], who based the concept of an innovative efficiency metric on endogenous growth models. The proxy (RQ) for firm innovativeness is defined as the exponent γ_i in the following firm *i*'s production function:

$$Y_{it} = K_{it}^{\alpha} L_{it}^{\beta} R_{i,t-1}^{\gamma} S_{i,t-1}^{\delta}, \quad (2)$$

where Y_{it} is company's output (revenue), K_{it} is capital (net PPE), L_{it} is labor (number of full-time equivalent employees), $R_{i,t-1}$ is lagged R&D expenditures. $S_{i,t-1}$ is lagged spillovers, which are calculated as the aggregate of R&D expenditure discrepancies between the focal firm and its competitors [40]. The calculation encompasses all firms within the industry, as classified by GICS, that have higher R&D expenditures than the focal firm. The Cobb–Douglas production function is used as it provides a single, directly interpretable elasticity of revenue with respect to R&D, which maps cleanly into the RQ measure. In contrast, a translog specification produces local elasticities that vary

with factor levels, making RQ harder to interpret and less comparable across firms and time. Additionally, a translog requires estimating significantly more parameters, and given data limitations, this would substantially reduce precision and may lead to unstable coefficient estimates. As such, the Cobb–Douglas production function is deemed to be a more reliable and transparent choice for estimating firm-level RQ.

The empirical foundation of RQ is the random coefficient (RC) model, which allows for heterogeneity in the elasticity of R&D and other inputs. This heterogeneity is consistent with endogenous-growth frameworks, which explicitly predict heterogeneous returns to innovation across firms. The RC specification allows to recover these heterogeneous slopes, whereas a pooled model would impose an implausible common elasticity. A general functional form model is defined as an estimated RC model, in which the coefficients are considered to be neither fixed nor constant across members of a cross-section or over time. These coefficients may be associated with the error term, as indicated by Knott [40]. In order to estimate the coefficients, it is necessary to utilise the following RC model:

$$\ln Y_{i,t} = (\beta_0 + \beta_{01}) + (\beta_1 + \beta_{1i}) \ln K_{i,t} + (\beta_2 + \beta_{2i}) \ln L_{i,t} + \\ + (\beta_3 + \beta_{3i}) \ln R_{i,t} + (\beta_4 + \beta_{4i}) \ln S_{i,t-1} + \varepsilon_{i,t}. \quad (3)$$

where the research quotient (RQ) indicator presented by the sum $(\beta_{3+} \beta_{3i})$ for each firm. The random-coefficients linear-regression model for panel data utilised in this research necessitates a minimum of seven years of complete data for estimation. As each estimation yields a single value, the dependent variable is constructed by utilising rolling seven-year windows for each firm-year, commencing from 2010 to 2016. Consequently, the estimation window is updated by incorporating the most recent year and omitting the earliest one, thereby facilitating the calculation of RQ for the 2016–2020 period [41]. The present study diverges from preceding research in that it employs manually calculated indicators, a departure from the automated methods utilised in previous studies.

Step 3. Defining control variables

The size of the firm has been demonstrated to affect the probability of investing in innovative activities and the ability to benefit from these investments [32]. It is evident that the magnitude of the firm is regulated through the utilisation of the logarithm of the entity's market capitalisation.

As demonstrated by Yanadori and Cui [12], there is a positive correlation between the commercialisation of innovative activities and the success of firms, as measured by profitability. Furthermore, this correlation has a beneficial impact on the innovativeness of the firm. Consequently, it is imperative for a company's performance to be governed by the utilisation of a return on assets (ROA) metric.

The firm's future prospects and growth opportunities could also significantly affect its innovative capabilities, so they are controlled by using the price-to-book value ratio [17]. The indebtedness level of a company, measured as the ratio of long-term and current debt sum to total assets, was utilised as a control variable for management risk appetite. This risk appetite has been demonstrated to influence the decision to invest in long-term, risky R&D projects [42].

The objective of the present study is to examine the impact of employee compensation growth over time. To this end, the log-transformed growth in CEO compensation is maintained constant. In order to ensure that all variables within the model are consistent, the geometric mean of the control variables for the 7-year windowed data must be calculated. Table 1 presents the control variables and their calculation methodology.

Table 1. Overview of the control variables

Control variable	Calculation methodology
Firm size (logarithm)	$\ln(market\ capitalization) = (year-end\ stock\ price \times common\ shares\ outstanding)$
Firm performance	$ROA(Return\ on\ assets) = \frac{Net\ income}{Total\ assets}$
Growth opportunities	$Price-to-book\ value\ ratio = \frac{Market\ vaue\ of\ equity}{Book\ value\ of\ equity}$
Management's risk tolerance	$Leverage\ ratio = \frac{Total\ long-term\ debt + Current\ liabilities}{Total\ assets}$ $Leverage\ ratio = \frac{Total\ long-term\ debt + Current\ liabilities}{Total\ assets}$
CEO pay growth	***CEO pay growth = Percentage change in CEO compensation (log transformed) from year t-1 to year t***

Source: Authors' investigation.

Step 4.1

The empirical model is proposed for testing the first hypothesis regarding the net effect of the CEO-employee pay gap on firm innovativeness (H1.1, H1.2):

$$RQ_{i,t} = \beta_0 + \beta_1 \ln(PayGap)_{i,t-6} + \beta_2 \ln(MarketCap)_{i,t-6} + \beta_3 ROA_{i,t-6} + \\ + \beta_4 Price-to-book\ value\ ratio_{i,t-6} + \beta_5 Leverage_{i,t-6} + \beta_6 \ln(CEOPayGrowth)_{i,t-6} + u_{i,t}, \quad (4)$$

where $\beta_{0\ \text{is}}$ constant, $\ln(PayGap)_{i,t-6}$ is the geometric mean of the logarithm of the CEO-employee pay gap, $\mathrm{n}(MarketCap)_{i,t-6}$ is the geometric mean of the logarithm of the company's market capitalization, $ROA_{i,t-6}$ is the geometric mean of a firm's return on assets, $Price-to-book\ value\ ratio_{i,t-6}$ is the geometric mean of a company's price-to-book value ratio, $Leverage_{i,t-6}$ is the geometric mean of a firm's leverage, $\ln(CEOPayGrowth)_{i,t-6}$ is the geometric mean of a company CEO's compensation growth (in logarithm).

Step 4.2

In order to undertake a rigorous investigation into the nonlinear relationship between pay gap and firm innovativeness, it is necessary to construct a quadratic regression model (H2):

$$RQ_{i,t} = \beta_0 + \beta_1 \ln(PayGap)_{i,t-6} + \beta_2 \ln(PayGap)^2_{i,t-6} + \beta_3 \ln(MarketCap)_{i,t-6} + \beta_4 ROA_{i,t-6} + \\ + \beta_5 Price-to-book\ value\ ratio_{i,t-6} + \beta_6 Leverage_{i,t-6} + \beta_7 \ln(CEOPayGrowth)_{i,t-6} + u_{i,t}, \quad (5)$$

where $\ln(PayGap)^2_{i,t-6}$ is squared logarithm of CEO-employee pay gap geometric mean and other variables are the same as for the first hypothesis.

Step 4.3

The relationship between the CEO-employee pay gap and firm innovativeness is hypothesised to be significantly affected by industrial differences. This has important incentive policy implications for companies that operate in various industries. The significance of these differences is examined by incorporating corresponding dummy variables and their intercepts with the pay gap in the model. The classification of industries is typically divided into two categories: technology-intensive and non-technology intensive. The classification of economic activities employed in this division is derived from the OECD taxonomy of economic activities [43]. In order to evaluate the effect of the pay gap on innovative capabilities for companies from technology-intensive and non-technology-intensive industries, the following model is specified (H3):

$$RQ_{i,t} = \beta_0 + \beta_1 \ln(PayGap)_{i,t-6} + \beta_2 Industry_i + \beta_3 Industry \times \ln(PayGap)_{i,t-6} + \beta_4 \ln(MarketCap)_{i,t-6} + \\ + \beta_5 ROA_{i,t-6} + \beta_6 Price-to-book\ value\ ratio_{i,t-6} + \beta_7 Leverage_{i,t-6} + \beta_8 \ln(CEOPayGrowth)_{i,t-6} + u_{i,t}, \quad (6)$$

where $Industry_i$ is the industry dummy that equals 1 for firms in tech-intensive industries and 0 for others; $Industry \times \ln(PayGap)_{i,t-6}$ is the interaction term between the industry dummy and the pay gap variable, and other variables are the same as for the first hypothesis.

In order to evaluate the impact of the pay gap on the innovative capabilities of companies operating in developed European and Asian countries, the following model (H4) is specified:

$$RQ_{i,t} = \beta_0 + \beta_1 \ln(PayGap)_{i,t} + \beta_2 Region_i + \beta_3 Region \times \ln(PayGap)_{i,t} + \beta_4 \ln(MarketCap)_{i,t-1} + \\ + \beta_5 ROA_{i,t-1} + \beta_6 Price-to-book\ value\ ratio_{i,t-1} + \beta_7 Leverage_{i,t-1} + \beta_8 \ln(CEOPayGrowth)_{i,t-1} + u_{i,t}, \quad (7)$$

where $Region_i$ is the region dummy for companies that operate in developed countries of Asia and Europe, $Region \times \ln(PayGap)_{i,t}$ is the interaction term between region dummy and the pay gap variable, and other variables are the same as for the first hypothesis.

Step 4.4

In order to calculate the indirect effect of the pay gap via employee pay growth, it is first necessary to calculate employee pay growth. This indicator is intended to represent a percentage increase in the average employee remuneration for a given year. In order to confirm or refute this hypothesis, it is necessary to incorporate an additional continuous variable and its interaction term with the primary independent variable of interest into the regression model. (H5):

$$RQ_{i,t} = \beta_0 + \beta_1 \ln(PayGap)_{i,t-6} + \beta_2 EmployeePayGrowth_{i,t-6} + \beta_3 EmployeePayGrowth_{i,t-6} \times \ln(PayGap)_{i,t-6} + \\ + \beta_4 \ln(MarketCap)_{i,t-6} + \beta_5 ROA_{i,t-6} + \beta_6 \mathrm{Pr}ice-to-book\ value\ ratio_{i,t-6} + \beta_7 Leverage_{i,t-6} + \beta_8 \ln(CEOPayGrowth)_{i,t-6} + u_{i,t}, \quad (8)$$

where $EmployeePayGrowth_{i,t-6}$ is the growth of employee pay from year t-1 to t (geometric mean), $EmployeePayGrowth_{i,t-6} \times \ln(PayGap)_{i,t-6}$ is the interaction term between the employee pay growth and pay gap variables. Alternative lag structures consistent with R&D and innovation dynamics were explored during the development of the empirical specification. The results across these alternative lag lengths were broadly consistent, and the lag structure reported in the manuscript was selected because it delivered the most stable and economically meaningful estimates. This reinforces the robustness of the reported findings.

Table 2. Distribution of companies by industry and region (%)

	Industrial distribution
Technology-intensive	11.57
Non- technology-intensive	88.43
	Regional distribution
Developed Asian countries	17.8
Developed European countries	82.2

Source: Authors' calculations.

Research sample and data sources

The primary focus of this research is on European and Asian developed markets, as these societies offer a rich and diverse context for the analysis of cultural differences and institutional development. The entire corpus of company data was obtained from the Bloomberg database for the period from 2012 to 2022 inclusive. The construction of the RQ variable, incorporating one-year lagged R&D spending and R&D spillovers, necessitates a minimum of seven years of complete data to estimate coefficients using the RC model. The sample under consideration contains 1,188 firm-year observations for 362 companies. These companies operate in 21 countries, including 16 European and 5 Asian countries. The data also includes information about industries in which companies operate according to GICS.

As illustrated in Table 2, the firm's distribution is demonstrated by industry (technology-intensive and non-technology-intensive) and region (developed Asian and European countries). A mere 11.57% of the firms operate in technology-intensive industries. The majority of the companies in our sample are those with business operations in developed European countries – 82.20%.

Table 3. CEO compensation and pay gap descriptive analysis

	Min	1st quant.	Median	Mean	3rd quant.	Max
CEO compensation:	0.70	1.09	1.61	2.10	2.48	29.25
Technology-intensive industries	0.07	0.95	1.18	1.96	1.63	28.15
Non-technology-intensive industries	0.10	1.15	1.74	2.13	2.65	29.25
Developed Asian countries	0.07	0.96	1.23	1.82	1.80	28.15
Developed European countries	0.10	1.14	1.18	2.20	2.72	29.25
CEO-employee pay gap:	1.82	17.49	27.88	42.82	45.84	1 013.04
Technology-intensive industries	3.21	23.11	41.90	82.66	85.39	1 013.04
Non-technology-intensive industries	1.82	16.56	26.30	35.09	41.73	418.28
Developed Asian countries	3.21	23.67	41.03	72.82	83.80	1 013.04
Developed European countries	1.82	15.93	24.66	32.96	39.24	418.28

Source: Authors' calculations.

The present study considers CEO compensation and the CEO-employee pay gap through the lens of descriptive statistics, with a focus on industrial and regional detail, as illustrated in Table 3. It is evident from the provided statistics that Chief Executive Officer remuneration is, on average, higher in companies that operate in non-technology-intensive industries. However, a notable disparity emerges in the mean CEO-employee pay gap, with non-technology-intensive industries exhibiting a substantially lower mean gap compared to their technology-intensive counterparts. A study of regional distribution reveals that Chief Executive Officers of companies operating in developed Asian countries receive lower levels of compensation. However, the inequality between the top and bottom levels of an organisation's hierarchy is significantly lower for companies from developed European countries, which are considered more individualistic. Furthermore, it has been determined that over 75% of all organisations have CEO compensation that is less than 50 times higher than average employee pay.

Table 4 provides descriptive statistics of variables included in the regression model. On average, a company's R&D investments contribute to around 31% of its revenue increase.

Table 4. Descriptive statistics

	Min	1st quant.	Median	Mean	3rd quant.	Max
RQ	–2.75	0.04	0.27	0.31	0.57	3.91
CEO-employee pay gap	1.82	17.49	27.88	42.82	45.84	1013.04
Market cap	41.16	2050.18	5417.42	12 859.18	13 135.36	201 564.8
ROA, %	0.39	3.61	5.33	6.13	7.43	28.65
Price-to-book	0.54	1.60	2.46	3.23	3.51	197.32
Leverage	0	0.07	0.15	0.16	0.22	0.59
CEO pay growth, %	-87.03	–3.24	3.08	10.67	12.26	444.09
Industry	0	0	0	0.16	0	1
Employees pay growth, %	–20.90	–1.86	–0.12	3.11	1.72	822.87

Source: Authors' calculations.

Empirical results

Given that the sample under consideration consists of repeated firm-year observations, panel data models are employed. Fixed effect (FE) and random effect (RE) models are the most commonly used panel data models. The FE model is compared with the RE model using the Hausman test. The findings of this study indicate that the FE model is to be preferred over the RE model in instances where specifications encompass year dummies. In instances where the random effects model is deemed to be the superior option, as determined by the Hausman test, the Breusch-Pagan Lagrange multiplier (LM) test was also conducted. This test serves to compare the RE model with the ordinary least squares (OLS) model. The outcomes of the LM test demonstrate that the RE model is suitable. Hence, the empirical analysis follows a two-stage structure. First, firm-level RQ values are obtained using a random-coefficients production-function model with firm fixed effects. Second, these RQ estimates are used as dependent variables in fixed-effects or random-effects panel regressions. Such mixed specification allows for capturing firm-specific R&D elasticities prior to the second-stage regressions and incorporates both fixed effects and random coefficients where theoretically appropriate.

The presence of heteroskedasticity is checked by applying a modified Wald test for groupwise heteroskedasticity to the FE model. The findings suggest the presence of heteroskedasticity in the model, as evidenced by the significant value of the Chi-squared statistic (1.1e + 07) and the low p-value (0.000) for H1. The issue of endogeneity was addressed by performing the Durbin-Wu-Hausman test. The findings of this investigation indicate that the predicted residuals of the potentially endogenous variable of main interest are not significant (p-value: 0.555). This outcome suggests the absence of an endogeneity problem.

In order to ascertain whether the results obtained are influenced by multicollinearity, the correlation matrix is estimated, as presented in Table 5. This matrix demonstrates the correlation between the variables that have been utilised. As demonstrated in the matrix, there is an absence of substantial correlation between the variables in the dataset. The variance inflation factor (VIF) is a measure of the degree to which the variances of a set of variables may be biased by common factors. It is evident from the VIFs (less than 2) and correlation matrix values obtained that there is no significant multicollinearity, and the sustainability of the results is substantiated.

Table 5. Correlation matrix

	RQ	CEO-employee pay gap	Market cap	ROA	Price-to-book	Leverage	CEO pay growth	Industry	Employee pay growth
RQ	1								
CEO-employee pay gap	0.0231	1							
Market cap	0.1062	0.1381	1						
ROA	0.0903	–0.0267	0.0457	1					
Price-to-book	0.0125	–0.0309	0.0390	0.2925	1				
Leverage	–0.1115	–0.0771	0.1522	–0.1985	0.1816	1			
CEO pay growth	–0.0389	0.1169	–0.0652	–0.0285	–0.0100	–0.1568	1		
Industry	0.0147	0.3355	–0.1022	–0.0606	–0.0702	–0.2024	–0.0141	1	
Employee pay growth	0.0077	0.0722	–0.0344	–0.0143	–0.0070	0.0053	0.0112	0.1086	1

Source: Authors' calculations.

Table 6. Analysis of the net and nonlinear effect of the pay gap on firm innovativeness

Variable	Model 4 – H1.1 & H1.2 (FE)	Model 5 – H2 (FE)
CEO-employee pay gap	–0.1481* (0.0823)	–0.1846 (0.3409)
CEO-employee pay gap (squared)		0.0045 (0.0376)
Market cap	0.0724 (0.1741)	0.0702 (0.1792)
ROA	0.5757** (0.23667)	0.5752** (0.2357)
Price-to-book	–0.0174 (0.0197)	–0.0174 (0.0197)
Leverage	0.2587** (0.1023)	0.2585** (0.1026)
CEO pay growth	–0.0467 (0.0749)	–0.0465 (0.0747)
Constant	0.7142** (0.3407)	0.7155** (0.3419)
Year dummies	Yes**	Yes**
R^2	0.005	0.005
Number of firm-year observations	1188	1188

Notes: Robust standard errors clustered by the firms are provided in parentheses. : Respective standard errors are presented in the brackets. Table 6 reports the FE specifications corresponding to Equations (4) and (5) .
*** p < 0.01, ** p < 0.05, * p < 0.1.
Source: Authors' calculations.

In accordance with the findings of the Model 4 regression, the results are displayed in Table 6. The β-coefficient for the CEO-employee gap indicates that a 1% increase in the pay gap is concomitant with a 0.1481% decrease in RQ. This finding suggests that the disparity in remuneration between CEOs and employees exerts a substantial deleterious effect on the innovation capacity of firms (*hypothesis H1.1 is accepted and hypothesis H1.2 is rejected*). These outcomes serve to substantiate the predictions of the social comparison and pay equity theories [13; 16; 19] and refute the implications of the tournament theory [19]. The theory postulating the existence of a negative pay gap as a consequence of social status and the ratio of inputs (efforts) to output (compensation) comparison between individuals within the organisation is linked to the social comparison and pay equity theories. The outcome of this comparison plays an essential role in determining employee behaviour, labour efforts and attitude to innovative activities. It is evident that both ordinary employees and well-educated inventors are most likely to be aware of CEO remuneration packages. This is due to an increase in the requirements for companies to disclose information, as well as the media paying greater attention to such publications. The increase in the vertical pay gap engenders a sense of inequality that has the potential to demotivate employees and adversely affect behaviour towards collaboration and innovation. This, in turn, can have a detrimental effect on a company's ability to commercialise its R&D activities.

In addition to the net negative effect, the impact of the CEO-employee pay gap may exhibit a non-linear (squared) nature, resulting in a multidirectional influence on a firm's innovative capabilities, contingent on the size of the pay gap. The results of the study are presented in Table 6 (Model 5). The findings suggest that there is no statistically significant nonlinear (squared) effect of the pay gap on firm innovativeness, thereby *rejecting Hypothesis 2*. The majority of companies in the sample exhibited a pay gap of less than 50 times the difference, which may not be sufficient to provide substantial positive incentives for employees to engage in innovative activities. In consideration of the findings, it can be deduced that the ramifications of the tournament theory [19] with regard to innovation commercialisation remain unvalidated for the sample under scrutiny.

Further significant results pertain to the testing of Hypothesis 3, which explores the industrial disparities in the relationship between the pay gap and firm innovativeness. The distribution of innovation is contingent upon the particularities of each industry; companies operating within sectors such as pharmaceuticals, information technology and automobiles, for instance, are responsible for a substantially higher number of inventions on an annual basis when compared with companies from other industries [28]. The findings of this study demonstrate that the interaction term between the CEO-employee pay gap and industry dummy is positive. This suggests that, in comparison with non-technology industries, the CEO-employee pay gap is more beneficial for companies operating in technology-intensive industries (see Table 7). The pay gap expansion by 1% has been shown to increase the ability to commercialise innovations measured by RQ for companies that operate in technology-intensive industries by 0.0451% compared to non-technology intensive industries (*Hypothesis 3 is accepted*). The results obtained are consistent with the findings of Zhao and Wang [34], who based their research on the concepts of the tournament theory [19]. The rationale underpinning this phenomenon pertains to the substantial involvement of a considerable number of inventors in a perpetual process of innovation implementation. This is a prerequisite for effective competition and the long-term development of companies in technology-intensive industries. The widening pay gap engenders further incentives for investors to enhance their innovative output. This phenomenon results in an augmentation of the proportion of inventors within the management team, who, in turn, allocate greater resources to R&D activities and engage a higher number of inventors in management roles, driven by their personal preferences. The positive feedback mechanism between innovative activities, inventory promotion and R&D investments is well-documented. Consequently, the technology-intensive industry's specifics imply that inventors' promotion incentives related to increasing the CEO-employee pay gap become dominant and positively affect firm innovativeness measured by RQ.

The seventh model (see Table 7) investigates the impact of regional factors on the correlation between the pay gap and firm innovativeness between European and Asian countries. The findings of the study indicate that there is a 1% increase in the CEO-employee pay gap in companies that operate in developed Asian countries, which results in a 0.0200% rise in the firm's RQ (*Hypothesis 4 is accepted*). These results are consistent with Hofstede's theory, which predicts that Asian societies that are considered to be collectivistic have a focus on risk and benefit-sharing in long-term cooperation, and a higher failure tolerance [25]. The long-term nature of R&D projects, which is associated with a high level of uncertainty and the possibility of failure, has been shown to enhance firms' abilities to commercialise their innovations. This phenomenon can be recognized as a characteristic of a collectivistic society and attributed to the tendency of Asian employees to prioritise the long-term strategic interests of the firm over short-term benefits [44].

When assessed in relation to regional and industry-specific factors, control variables such as firm size, profitability and financial leverage were found to be significant. This finding is consistent with the conclusions of previous studies [32,12, 42]. The impetus to commercialise innovation activities is observed to increase among larger, successful companies that adopt a risk-averse approach to implementing long-term innovation projects.

The present study considers the hypothesis (*H5*) regarding the indirect effect of the CEO-employee pay gap via employee pay growth. As illustrated in Model 8 (see Table 7), the findings demonstrate the substantial and negative impact of the pay gap, thereby moderating the positive

relationship between employee pay growth and firm innovativeness, as measured by RQ. This observation lends *support to Hypothesis 5*. The β-coefficient indicates that the widening of the pay gap by 1% results in a 0.0295% decrease in the positive influence of 1% employee pay growth on the ability to commercialise innovations measured by RQ. The motivation of workers is predominantly influenced by short-term benefits, which primarily comprise employee remuneration [36]. The average employee remuneration growth has been shown to be associated with the individual's behaviour and attitude to work processes, and ultimately has a positive impact on firm innovativeness. Nevertheless, the discrepancy in remuneration between CEOs and ordinary employees, characterised by a disproportionate increase in CEO compensation relative to that of ordinary employees, has been demonstrated to have a detrimental effect on the positive impact of employee remuneration and to impede the innovative capabilities of the company as a whole.

Conclusion and discussion

The present study investigates the relationship between the CEO-employee pay gap and company innovative-

Table 7. Analysis of industrial, regional and indirect effect of the pay gap

Variable	Model 6 – H3 (RE)	Model 7 – H4 (RE)	Model 8 – H5 (FE)
CEO-employee pay gap	–0.0265 (0.0370)	–0.0452 (0.0408)	–0.1180 (0.1139)
Industry	0.0869** (0.0414)		
CEO-employee pay gap·Industry	0.0451** (0.0227)		
Region		0.0236** (0.0104)	
CEO-employee pay gap·Region		0.0200** (0.0097)	
Employee pay growth			0.0784** (0.0380)
CEO-employee pay gap·Employee pay growth			–0.0295** (0.0132)
Market cap	0.0373* (0.0192)	0.0426** (0.0196)	0.0776 (0.1782)
ROA	0.4195* (0.2055)	0.4209* (0.2156)	0.4713** (0.2132)
Price-to-book	-0.0001 (0.0025)	-0.0002 (0.0025)	–0.0177 (0.0197)
Leverage	0.4360* (0.2256)	0.3881* (0.2302)	0.2575** (0.1026)
CEO pay growth	–0.0472 (0.0491)	–0.0444 (0.0490)	–0.0478 (0.0750)
Constant	0.5679*** (0.1983)	0.5816*** (0.1985)	0.7107** (0.3438)
Year dummies	Yes**	Yes**	Yes**
R^2	0.028	0.032	0.005
Number of firm-year observations	1188	1188	1188

Notes: Robust standard errors clustered by firm are provided in parentheses. Respective standard errors are presented in the brackets. Table 7 reports the RE specifications corresponding to Equations (6) and (7) and the FE specification for Equation (8).
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: Authors' calculations.

ness, which is determined as the ability to commercialise innovative activities. The RQ is selected as a measure of firm innovativeness due to its universality and capacity to evaluate a company's aptitude for commercialising its innovations [32; 40].

The study offers empirical evidence demonstrating that the disparity between the remuneration of CEO and that of the wider workforce exerts a substantial deleterious effect on the innovative capacity of the firm. The vertical pay gap, which arises due to the higher increase in compensation of CEOs compared to ordinary employees, has been shown to have a detrimental effect on employees' efforts and behaviour towards collaboration and innovation. This, in turn, has a harmful effect on a company's ability to commercialise its R&D activities. This finding aligns with the social comparison and pay equity theories [13; 16].

In contrast to the findings reported by Mingli et al. [27], our research results did not support the U-shaped relationship between firm innovativeness and the pay gap. The results obtained have only confirmed the theory of social equality. However, the paper considers how this relationship differs depending on the technology intensity of the industry in which a firm operates. The findings demonstrate that the promotion incentives available to inventors are more prevalent in technology-intensive firms. Furthermore, the results indicate that the pay gap has a more beneficial effect on the innovativeness of technology-intensive firms than on non-technology-intensive firms. The theory of tournaments is thus applicable to companies characterised by a high degree of technological intensity. The predominance of inventor incentives, namely career promotion and pay raises, as well as the promotion of investment in innovations in technology-intensive industries, which are characterised by a significantly higher ratio of inventors on their staff, is the foundation for this argument.

A comparison of companies in developed European and Asian countries confirmed the findings of the tournament theory for companies operating in developed Asian countries and the pay equity and social comparison theories for companies operating in developed European countries. These results are consistent with the studies by Hofstede [25] and Nakata and Sivakumar [26]. According to Hofstede's theory, societies with a high rate of individualism, such as developed European countries, are characterised by employees who make decisions independently, pursuing personal benefits and self-realisation rather than those of the firm. This ambiguity may impede the innovative process by introducing an element of uncertainty, which can hinder the confidence and motivation of the research team. Concurrently, the protracted nature of R&D initiatives, characterised by a substantial degree of uncertainty and the potential for failure, contributes to the enhancement of firms' capabilities to commercialise their innovations within a collectivist society. This reduction can be attributed to the tendency of Asian employees to prioritise the long-term strategic interests of the firm over short-term benefits.

The study demonstrated that the widening of the pay gap served to moderate the positive relationship between employee pay growth and firm innovativeness. The phenomenon of remuneration inequality, precipitated by the disparity between the growth rate of CEO compensation and that of ordinary employees' remuneration, has been demonstrated to have a deleterious effect on employee motivation and to concomitantly diminish the innovative capacity of the company as a whole. This finding is consistent with the conclusions drawn by Rambo and Pinto [36] in their research.

The findings of this study carry significant policy and managerial implications. A comprehensive understanding of the influence of the CEO-employee pay gap on firm innovative capabilities is imperative for the development of an organisation's optimal incentive system, which is designed to promote innovativeness. It is imperative that such an incentive system be designed to achieve a balance between the motivation of top management to promote corporate innovation and the innovation impetus of the personnel. This balance must be achieved by taking into account the industrial and regional characteristics of a firm's operations.

The cultural dimensions of individualism, power distance and time orientation have been identified as distinctive features that contribute to the disparities in living standards between Asia and Europe. It is imperative that these fundamental factors, which elucidate the divergent attitudes of nations towards innovation, are given full consideration when determining the remuneration of employees and incentivising their innovation activity.

The incorporation of the pay gap factor into company investment analysis has the potential to enhance the efficacy of the analysis as a driver of innovative efficiency. This, in turn, will improve the accuracy and adequacy of investors' assessments of a firm's long-term sustainability and growth opportunities. The incorporation of data pertaining to the size and dynamics of the pay gap, employee pay growth, and industrial identity within the company's forecast framework will facilitate the determination of its valuation. Consequently, the findings of this study provide a valuable contribution to the formulation of a reliable investment strategy.

The present study is subject to certain limitations that could be addressed in future research. First, due to the unavailability of disaggregated data, the average compensation of rank-and-file employees is used as a proxy for the compensation of staff that is related to R&D activities. The same rationale underpinning the use of average compensation over median compensation is applicable in this context, with the latter potentially offering a more accurate reflection of an incentive structure. Secondly, the study's sample encompasses observations over a comparatively brief period and incorporates solely those public firms that voluntarily disclosed information pertaining to their R&D activities and compensation. These issues have the potential to result in bias with regard to sample selection. However, it should be noted that information disclosure requirements are subject to constant evolution, which will engender new opportunities for the enhancement of meth-

odology and sample construction. Additionally, measurement errors may be attributable to the indirect observation of employees' motivation. Finally, RQ is widely regarded as one of the most universally applicable metrics for measuring a company's innovativeness; however, it must be noted that it does not encompass all the dimensions of a company's innovativeness.

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