

ORIGINAL RESEARCH ARTICLE

Does gender, health enterprise, and safety performance induce research and development expenditure in firms in Hong Kong, China?

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Abstract

This paper explores the relationship between expenditure on research and development, gender and health and safety performances in enterprises in Hong Kong, China. Using nationally representative survey datasets from the Hong-Kong-SAR-China-2023-survey data, responses of 598 workers were considered. Descriptive statistics and probit regression were used to identify the associating impacts of adherence to health, safety and environmental performance on research and development expenditure in enterprises. The findings revealed that investment on research and development have positive association with manufacturing and retail business and among enterprises with compliance with energy use and occupational safety measures. Although gender have insignificant negative effect, yet female-led enterprises have lower performance than their male counterparts on the association of employers-gender role effect on expenditure on research and expenditure while enterprises that undergo training and adequately audit their account have positive and significant association with expenditure on research and development. This study suggests the need to consider safety and health measures in research and development expenditure for fostering innovation and enhancing adequate introduction of new markets and the enhancement of business enterprises. It also calls for female led enterprises to consider innovative and occupational safety programmes for workers health and increased productivity. (*Afr J Reprod Health 2025; 29 [8]:101-111*)

Keywords: R&D expenditure; health and safety performance; gender, business sector; China

Résumé

Cet article explore la relation entre les dépenses de recherche et développement, le genre et les performances en matière de santé et de sécurité au travail dans les entreprises de Hong Kong, en Chine. À partir de données d'enquête représentatives au niveau national issues de l'enquête de 2023 menée dans la RAS de Hong Kong, en Chine, les réponses de 598 travailleurs ont été prises en compte. Des statistiques descriptives et une régression probit ont été utilisées pour identifier les impacts du respect des normes de santé, de sécurité et d'environnement sur les dépenses de recherche et développement des entreprises. Les résultats ont révélé que les investissements en recherche et développement sont positivement associés aux activités manufacturières et de vente au détail, ainsi qu'aux entreprises respectant les mesures de consommation d'énergie et de sécurité au travail. Bien que le genre n'ait qu'un effet négatif négligeable, les entreprises dirigées par des femmes affichent des performances inférieures à celles de leurs homologues masculins concernant l'association entre l'influence du rôle des employeurs et celle du genre sur les dépenses de recherche et développement, tandis que les entreprises qui suivent des formations et auditent correctement leurs comptes présentent une corrélation positive et significative avec les dépenses de recherche et développement. Cette étude souligne la nécessité de prendre en compte les mesures de sécurité et de santé dans les dépenses de recherche et développement afin de favoriser l'innovation, de favoriser l'introduction de nouveaux marchés et de renforcer les entreprises. Elle appelle également les entreprises dirigées par des femmes à envisager des programmes innovants de sécurité au travail pour la santé des travailleurs et une productivité accrue. (*Afr J Reprod Health 2025; 29 [8]: 101-111*).

Mots-clés: dépenses de R&D; performance en matière de santé et de sécurité, genre; secteur d'activité; Chine

Introduction

Research and development (R&D) are crucial for the expansion of enterprise in the production of new products, services, and technologies^{1,2}. Expenditure on research and development can result in

innovations and improvements that can boost customer health and revenue^{3,4}. Rapid transformation of the industrial sectors in China have been associated with investments in research and development^{5,6}. As the world's second-

largest expenditure on R&D after the United States, China is undoubtedly a major player in the global development scene⁷. In the past few years, China's research and development expenditure has been continuously increasing, with overall R&D spending in China approximately to around 3.34 trillion yuan in 2023 while the World Bank (2024) reported that Research and development expenditure (% of GDP) in China was 2.4326 % in 2021. Effective management techniques have been demonstrated to be a crucial component of businesses' efficiency which is reflected in the quest for a safe and healthy working environment for adequate overall performance and overall sustainability⁸.

The enterprises management practices to promote health and safety performances and actions to boost productivity are intertwined⁹⁻¹¹. Safety is a crucial aspect of any research and development laboratory, as it affects the well-being of the staff, the quality of the results, and the reputation of the organization^{12,13}. However, maintaining a culture of security requires adherence to the relevant guidelines and rules, such as those set forth by the Occupational Safety and Health Administration (OSHA) or the National Fire Protection Association (NFPA)^{4,14-17}. These standards provide guidelines and best practices for various aspects of R&D lab design, operation, and maintenance, such as ventilation, fire protection, electrical safety, waste disposal, or emergency response.

An enterprise security amenity, precautions, security control and safety environmental compliance. The productivity factors specify the real behaviors of employees at work, particularly adherence to health and safety regulations¹⁸.

The promotion of research and development has helped the growth of China's industries in recent years with occupational hazards becoming more common^{19,20}. Although China has made great progress in reducing industrial deaths and illnesses, yet workplace exposures continue to produce major occupational health concerns even with this development^{21,22}. The scope of work-related injuries varies across enterprises and stem from inadequate legislative frameworks, and a lack of a safety and health culture at the national and workplace levels^{23,24}.

The role of workers training and development have been identified as crucial for advancement of new innovation and the introduction of new product and market expansion²⁵. Despite laws on occupational safety and the need to promote workers safety, little is known on the influence of enterprise adherence to safety and health culture on enterprise expenditure on research and development^{26,29}. The viability of enterprise with environmental and health awareness and adequate control of pollution and use of safety measures to boost workers productivity and morale to work have been earlier established^{8,30}.

Rising advancement in expenditure on research and development requires evidence on the linkage between work-related safety and health measures and the expenditure on research innovation^{31,32}. Enhancing existing goods or bringing new products and services to consumers in an ordered way are the strategic objectives of all businesses, whether they are industrial or service-oriented. Reaching this objective may cause workers' working conditions and corporate entities to change more quickly, which could affect their health and need workplace safety and compliance. The ability of management to obtain, carry out, update, and utilize the resources required for efficient development of new items that would attract customers' attention is one of the fundamental prerequisites for accomplishing this aim.

Over the past decade, research on workplace safety has accelerated worldwide, particularly in China, where organizational management practices are seen as critical to health and safety inspections^{26,33}. Staff turnover, or the deliberate termination of labor relationships, is a serious problem for all firms³⁴. Previous studies on the significance of wellness and security in maintaining workers have shown that increasing safety norms at work and regulations has been demonstrated to assist retain healthcare workers^{35,36}. Similarly, job crafting and innovation promote occupational satisfaction amid the COVID-19 pandemic³⁷⁻³⁹.

In China, the National Occupational Safety and Health Law and Regulations on Workplace Safety and Health provide the framework for ensuring a safe working environment. Despite these

efforts, workplace accidents and injuries remain a significant concern. In addition to having a substantial effect on the victims directly, work-related diseases and injuries also have a major effect on the macro and local economies. Annually, less occupational injuries occur in Hong Kong, and industry initiative and research and development investment are being prioritized more and more.⁴⁰ However, the effectiveness of R&D in improving occupational safety is influenced by various factors, including limited resources and funding, insufficient training and expertise, inadequate safety infrastructure and regulatory complexities.

This research aims to examine the nexus between R&D and occupational safety in China enterprises in order to assist the workplace create short and long-term goals for occupational safety and health. In the highly competitive global market, the ability to innovate promotes enterprises' success, which anchors on the enterprise's human and economic resources and also on the establishment strategic actions on workers. This study thus extends previous studies on expenditure on research and development by examining the impact of enterprise safety performance in Chinese organizations. In addition, it examines the differences that exist across female and male led Chinese enterprise in Hong Kong, China and the role organizational quality control and safety performance plays in research and development.

Conceptual framework: Gender, safety, and R&D expenditure

This study is guided by a conceptual framework that integrates organizational, environmental, and gender-related factors to explain variations in enterprises' expenditure on research and development (R&D). The framework is built upon several theoretical foundations that collectively explain how internal and external factors drive firms' strategic innovation decisions.

Firstly, the Resource-Based View (RBV) posits that firms develop unique internal resources and capabilities—such as effective health and safety practices, environmental sustainability measures, and employee training—that can serve as sources of

competitive advantage and foster innovation⁴¹. Firms that prioritize occupational safety and health may create stable, motivated workforces capable of contributing to innovative processes, thus increasing the likelihood of R&D investment.

Secondly, Institutional Theory emphasizes that organizations operate within broader institutional environments that impose norms, rules, and expectations. Regulatory frameworks on occupational safety and environmental compliance compel firms to adopt responsible practices, which can simultaneously create pathways for innovation and improve organizational legitimacy⁴². The framework also incorporates Gender and Innovation Theory, which suggests that gender diversity in leadership can influence decision-making dynamics, risk perception, and access to networks and resources. Female-led enterprises may differ in their approach to R&D expenditure due to societal stereotypes, leadership styles, and potential structural barriers, although evidence is mixed on whether gender differences significantly affect innovation outcomes⁴³.

Furthermore, prior research on workplace safety and innovation indicates that adherence to safety protocols and proactive environmental management positively correlate with innovative performance and R&D engagement. Safe and well-managed workplaces reduce employee turnover and absenteeism, enhance morale, and enable organizations to allocate resources toward innovative activities rather than mitigating workplace risks¹².

Based on these theoretical perspectives, the study hypothesizes that firms with stronger safety and health practices, robust environmental measures, comprehensive training programs, and higher managerial accountability are more likely to invest in R&D. It also examines how the gender of top management moderates this relationship. These relationships are empirically tested using probit regression models on data collected from enterprises in Hong Kong, China. This conceptual framework provides a holistic lens for understanding how organizational and contextual variables collectively shape firms' strategic decisions concerning R&D expenditure.

Methods

This study utilized the Hong-Kong-SAR-China-2023 Enterprise Survey Dataset, collected under the World Bank Enterprise Surveys initiative⁴⁵. The survey provides firm-level data across multiple administrative regions in Hong Kong, targeting private-sector businesses. Data were collected between April and October 2023, involving 598 formal non-agricultural firms selected through stratified random sampling based on size, sector, and location. The data cover areas such as innovation activity, managerial practices, gender leadership, environmental compliance, and R&D behaviour. These variables provided a robust foundation for empirical analysis on the intersection between organizational practices and innovation outcomes.

The dataset can be accessed via the World Bank's Enterprise Surveys portal: <https://www.enterprisesurveys.org>. The survey instruments are standardized across participating countries, thereby enhancing cross-regional comparability. Each survey module was designed to capture enterprise-level decisions, constraints, and practices in detail.

In the context of this research, the dataset's relevance lies in its extensive coverage of variables relating to environmental performance, organizational structure, leadership demographics (including gender), and innovation activities such as R&D. The use of this secondary dataset allowed for a cost-effective but data-rich exploration of how internal enterprise characteristics relate to strategic expenditure on R&D.

Variable definition

The dependent variable for this study is Research and Development (R&D) expenditure. This is captured as a binary outcome based on the question: "During the last fiscal year, did the institution spend on R&D (excluding market research)? Responses were coded as 1 for "Yes" and 0 for "No." Key independent variables include: Gender of top management (female or male); Safety and health performance metrics (e.g., monitoring CO₂ emissions, adopting energy management systems); Quality control and administrative accountability

(e.g., whether the firm's financial statements were externally audited)

Employee development initiatives (e.g., presence of formal training programs for permanent workers); Control variables comprise the sector of operation (manufacturing, retail, or other), and firm size categorized as small, medium, or large. The dependent variable is expenditure on research and development (RD) measured by the question "During last fiscal year, institution spent on R&D (with the exemption market research)?" with responses coded "Yes or No". Explanatory variables of interest are embedded in: The management practices on workers development measured by official training initiatives for long-term and regular workers, etc.

Environmental preservation. Adherence to safety and health performance measured by occupational adherence to business regulations on licensing and permits, the adoption of energy management measures by establishment; Management practices on accountability and administrative openness determined by establishment accounting records, which have been verified and approved by the auditing firm. Control variables: gender role in Management measured by the number of firms with a female and male executive, Type of business (manufacturing, retail and others), size of business classified into three groups: small, medium and large.

Data analysis and model

To empirically examine the proposed relationships, the study employed a two-step analytical strategy. First, descriptive statistics were conducted to present a comprehensive picture of the characteristics of surveyed firms. These descriptive insights included proportions of firms by sector, size, gender leadership, safety practices, and engagement in R&D. These statistics highlighted the general landscape and informed preliminary observations about possible associations.

Second, a Probit regression model was utilized to identify the likelihood of firms engaging in R&D as a function of explanatory variables. The Probit model is appropriate for binary outcomes and estimates the probability of an event occurring—in

this case, R&D expenditure—based on the normal cumulative distribution function.

$$P(Y = 1) = \Phi(\alpha + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_N X_N) \quad (1)$$

Where $P(Y = 1)$ represents the probability that a firm invests in R&D; Φ is the cumulative distribution function of a standard normal distribution; α is the constant term; β_1 through β_N are coefficients estimated through maximum likelihood; X_1 through X_N are explanatory variables such as gender of manager, energy management, training, etc.

Results

Descriptive analysis

Descriptive analysis in Table 1 presents the statistics of the surveyed 598 respondents. Only 50(8.36%) out of the 598-establishment surveyed spent on research and development. About 45% establishment were managed by women, 53% managed by men; an indication that male managers are more than the female top managers in the surveyed business establishments in Hong Kong, China. Only about 8% business monitor their carbon dioxide emission, 20% have internationally recognized quality certification while only 14% adopt energy management measures and about 47% enterprises provide formal training for their employees. Manufacturing and retail business enterprises captured 15% and 12% only while others such as hotel, transport system, automotive repair, restaurants, communications, construction, and IT comprise of 72% of the surveyed enterprises. Only 3% of the enterprises are classified as large-scale business with 54% being small and 42% medium business enterprises.

Relationship of variables with R&D expenditure

Table 2 present the result of the relationship among the variables and expenditure on research and development among the business enterprises surveyed. Enterprises that monitor their carbon dioxide have a beneficial relationship but not adverse impact on expenditure on research and development while firms with internationally

recognized quality certification, those that adopt energy management measures, firms with formal training programs for their employees and those that have their financial statement checked by external auditors have positive association with expenditure on research and development.

Although both female and male led managers exhibit a negative relationship with investment on research and development, the result is not significant and thus signifies that gender differences does not have significant effect on research and development in enterprises in Hong Kong, China. It is noteworthy to state that variation still persist as the female managers has about 42% less likelihood of spending on research when compared with 29% chance of male le managers. This shows that female managers have higher tendency of not spending on research and development and need to consider the role of advancement in business enterprises.

Enterprises that adopt energy management measures have about 66% chance of spending on research and development, enterprises that have internationally recognized quality certification has about 37 % chance, business that have adequate accountability and audit their financial records by external auditor's exhibit 63% chance of spending on research and innovations while those that train their permanent employees exhibit about 58% likelihood of spending on research and development. Also, small and medium enterprises exhibit negative relationship when compared with large enterprise but manufacturing and retail enterprises have positive significant relationship with research and development expenditure. This result shows that the size of the enterprise matters as large manufacturing and retail enterprises have the tendency to spend on research and development than other forms of business. A further test of the average marginal effect presented in Table 3 revealed that occupational safety and health measures induce expenditure on research and development. These findings corroborate the result of the probit regression and shows that female led enterprise exhibit slightly higher negative relationship with expenditure on research and development.

In Table 3, a unit increase in energy management measures and having internationally

Table 1: Descriptive statistics of respondents

Variable	Total (of 598)	%
No of establishment that spend on Research & Development	50	8.36
Establishment monitor its CO2 emissions	45	7.53
Percent of firms with a female top manager	268	44.8
Percent of firms with a male top manager	320	53.2
Estab. with Internationally Quality Certification	122	20.42
Establishment adopt energy management measures?	87	14.54
Manufacturing	92	15.38
Retail	74	12.37
Others	432	72.2
Small business enterprise	323	54
Medium business enterprise	254	42.47
Large business enterprise	21	3.5
Formal Training Programs For Permanent Employees	282	47.1
Financial Statements Checked & Certified By External Auditor	415	69.4

Table 2: Probit regression result

Variable	Coeffi	Std.err	P> z	[95%	Coeff]
Establishment monitor its CO2 emissions	0.247	0.331	0.454	-0.401	0.896
Firms with a female top manager	-0.429	0.686	0.532	-1.774	0.916
Firms with a male top manager	-0.293	0.682	0.668	-1.630	1.045
Firms with International Quality Certification	0.371	0.201	0.065	-0.023	0.764
Firm that adopt energy management measures	0.655	0.266	0.014	0.133	1.177
Manufacturing	0.684	0.221	0.002	0.249	1.118
Retail	0.703	0.268	0.009	0.179	1.228
Others	0.000	(omitted)			
Small	-0.700	0.382	0.067	-1.449	0.049
Medium	-0.038	0.354	0.915	-0.731	0.656
Large	0.000	(omitted)			
Firms with Formal training program for employees	0.585	0.206	0.004	0.182	0.989
Financial statements checked by auditor	0.633	0.243	0.009	0.156	1.110
_cons	-2.159	0.798	0.007	-3.723	-0.595

Table 3: Average marginal effect result

Variable	dy/dxi	Std.err	P> z	[95%	conf.
Establishment monitor its CO2 emissions	0.028	0.037	0.453	-0.045	0.101
Firms with a female top manager	-0.048	0.077	0.533	-0.200	0.104
Firms with a male top manager	-0.033	0.077	0.668	-0.184	0.118
Firms with International Quality Certification	0.042	0.023	0.065	-0.003	0.086
Firm that adopt energy management measures	0.074	0.030	0.014	0.015	0.133
Manufacturing	0.077	0.025	0.002	0.029	0.126
Retail	0.079	0.030	0.008	0.020	0.138
Others	0.000				
Small	-0.079	0.043	0.067	-0.163	0.005
Medium	-0.004	0.040	0.915	-0.082	0.074
Large	0.000				
Firms with Formal training program for employees	0.066	0.023	0.004	0.021	0.112
Financial statements checked by auditor	0.071	0.027	0.009	0.018	0.125

Table 4: Goodness of fit test (Hosmer-Lemeshow goodness-of-fit test (gof))

Variable:	
no of observations	598
No of groups	10
Hosmer–Lemeshow chi2(8)	4.49
prob>chi2	0.81

recognized certification has the tendency of increasing the probability of rising investment on research and development in enterprises in Hong Kong, China by 7.4% and 4.2% respectively. A unit increase in the manufacturing and retail enterprise has 7% chance of increasing the rate of expenditure on R&D than other business firms.

Both female and male led enterprises have negative relationship with expenditure on research and development but female has higher negative association.

The goodness of fit test

The Hosmer-Lemeshow goodness of fit evaluation, as presented in Table 4 confirms the stability of the model. The Hosmer-Lemeshow goodness of evaluation test is a method for determining whether the number of expected events in a stochastic or probit regression framework matches the number of observed occurrences in the data. The null hypothesis is that the actual and anticipated proportions are the same. Having chi 2 probability values greater than 0.05 indicates that the method is a good fit, and the variables of the models are a good match in establishing the link between the two set of variables

Discussion

This study provides nuanced insights into how organizational practices, gender dynamics, and governance influence enterprises' decisions to engage in research and development (R&D) in Hong Kong, China. The findings reaffirm that innovation is not a stand-alone process but is shaped by the interplay of organizational culture, environmental stewardship, governance structures, and socio-cultural factors^{41,12}.

A significant implication arising from the research is that sustainability-oriented practices have

shifted from being mere compliance activities to strategic imperatives that enhance competitive advantage. Enterprises that integrate environmental measures, such as energy management systems, into their operational and strategic processes appear better positioned to innovate. This supports Tao *et al.*⁴⁵, who argue that environmental responsibility has become a vital driver of long-term business sustainability. In a regulatory environment as stringent as Hong Kong's, promoting sustainability as a pathway to innovation rather than simply as a compliance requirement could help foster greater R&D engagement among enterprises.

Similarly, the observed relationship between quality certifications and innovation suggests that institutionalized quality standards foster a culture of continuous improvement and operational excellence. Such standards appear to create an enabling environment for innovation by promoting disciplined processes, accountability, and organizational learning⁸. This has practical implications for policymakers and industry bodies, who could facilitate SMEs' access to certification programs through financial incentives or technical support, thus democratizing innovation potential across firms of different sizes.

Another key insight pertains to human capital development. Enterprises investing in workforce training appear better equipped to engage in innovative activities, underscoring the critical role of employee expertise and adaptability in sustaining competitive advantage⁴⁶. The study by Li *et al.*⁴⁷ reinforces this perspective, showing that educational diversity significantly influences how individuals absorb and apply new knowledge. Tailoring training programs to accommodate varying educational backgrounds could therefore help firms maximize their innovation outcomes. For policymakers, initiatives that subsidize sector-specific training could be vital for bridging skills gaps, particularly in industries experiencing rapid technological change. Governance also emerges as a pivotal factor influencing innovation. Firms maintaining strong financial accountability and undergoing regular external audits are better positioned to manage risk and allocate resources toward forward-looking initiatives like R&D¹². Transparent governance fosters trust among stakeholders and may facilitate

better access to funding, a critical enabler of sustained R&D engagement. Thus, regulatory frameworks emphasizing financial transparency and accountability may indirectly stimulate enterprise-level innovation.

An especially compelling dimension of this study is the exploration of gender dynamics in R&D engagement. Although statistical significance was not established for gender differences in R&D spending, the consistent directional trend indicating lower R&D engagement among female-led enterprises raises important questions about subtle barriers faced by women in leadership. Dong *et al.*⁴⁸ highlight how stereotype awareness and prejudicial attitudes can constrain women's career progression and strategic decision-making, potentially translating into more cautious approaches toward high-risk investments such as R&D. Hong *et al.*⁴⁹ and Gao *et al.*⁵⁰ further illuminate how societal expectations and family responsibilities disproportionately affect women's professional choices, influencing their capacity to engage fully in entrepreneurial and innovative endeavors.

This interplay between personal, social, and professional spheres suggests that gender-related disparities in innovation may not simply reflect firm-level dynamics but are deeply rooted in broader socio-cultural norms. Educational attainment, as shown by Chang *et al.*⁵¹ and Fei and Li⁵², also shapes individuals' confidence and decision-making styles, pointing to a potential avenue for mitigating gender gaps through education and leadership development.

The findings collectively underscore the importance of adopting a multidimensional policy approach to fostering enterprise innovation. Policymakers should consider integrated strategies that simultaneously address environmental sustainability, quality standards, workforce development, and governance, while also incorporating targeted interventions to mitigate gender disparities. For instance, mentorship programs, networking opportunities, and family support services tailored to women entrepreneurs and managers could help unlock untapped innovation potential within female-led enterprises.

In practice, enterprises seeking to boost R&D engagement should view environmental practices,

governance quality, and human capital investments as interconnected levers of competitive advantage rather than isolated operational concerns. The holistic integration of these factors into organizational strategy can enhance innovation readiness and resilience, particularly in a competitive and evolving market like Hong Kong's. Ultimately, this study reinforces that innovation is a complex phenomenon driven by organizational resources, institutional pressures, and socio-cultural contexts. By illuminating how diverse factors—from environmental compliance to gender roles—influence R&D decisions, the research offers practical insights for firms aiming to embed innovation into their strategic agendas and for policymakers striving to create an ecosystem conducive to sustainable, inclusive innovation-driven growth.

Conclusion

Research and development in the business sector plays a crucial part of the innovation system. The expenditure made on research and development can be seen as the main precondition of successful innovation. In the current competitive environment, one of the key significant aspects that may impact a company's earnings and long-term viability is its efforts to investigate and develop as well as its insight and creativity initiatives. In recent years, China has considered innovation as a key strategy in the last few years. Since R&D is the foundation of science and technical advancement, businesses should invest more in it to boost their primary strength.

This study investigates the connection between R&D spending and workplace safety and organizational health using a regression approach and a descriptive evaluation. The findings indicate that companies will invest more in R&D if they have accountable investment. It reveals that all businesses should prioritize industrial well-being and security across every sector. Usually, unsafe behavior, unsafe conditions at work, or broken technological infrastructure have been blamed for catastrophes. A subfield of safety science called "industrial safety" works to give companies a clean, harmless working environment.

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