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Assessing the Role of Risk in Corporate Entrepreneurship: The Mediating Roles of Innovation and Research and Development

ABSTRACT

Corporate entrepreneurship is an important managerial approach that has attracted considerable attention from researchers and managers over the past several decades. Corporate entrepreneurship concerns the development of ideas and opportunities within existing organizations. This concept reflects organizations' ability to transform threats into opportunities, improve processes, and create new value within existing organizational structures. Risk, innovation, and research and development are among the factors that may influence corporate entrepreneurship. This study aimed to assess the role of risk in corporate entrepreneurship, with innovation and research and development serving as mediating variables. Accordingly, a research framework was initially developed through a review of the theoretical literature. Based on this framework, the conceptual model was formulated, and the research hypotheses were developed. To test the hypotheses, the statistical population consisted of 60 managers and experts employed by a knowledge-based company operating in the oil and gas industry. Because the entire population was included through a census approach, the questionnaire was distributed among all personnel. The questionnaire items were adopted from valid and relevant sources, and their validity and reliability were confirmed. Convergent and discriminant validity were used to assess validity, while composite reliability was employed to evaluate reliability. Because the data were not normally distributed, partial least squares structural equation modeling was performed using SmartPLS 2. Based on the significance values obtained for the hypothesized relationships, all hypotheses were supported. The effect of risk on research and development was 0.851, the effect of risk on corporate entrepreneurship was 0.583, the effect of risk on innovation was 0.764, the effect of research and development on corporate entrepreneurship was 0.877, and the effect of innovation on corporate entrepreneurship was 0.845. Finally, recommendations were proposed for improving corporate entrepreneurship.

Keywords: corporate entrepreneurship, innovation, research and development, risk

Introduction

Contemporary organizations operate in business environments characterized by accelerating technological change, shortened product life cycles, increasing competitive pressure, market uncertainty, and the continuous emergence of new customer expectations. Under these conditions, the sustainability of organizational performance depends not only on the efficient exploitation of existing resources but also on the capacity to identify, develop, and commercialize new opportunities. Corporate entrepreneurship has therefore emerged as a central managerial approach through which established organizations seek to renew their strategies, introduce new products and services, redesign internal processes, and create new ventures without abandoning their existing organizational identities. Unlike independent entrepreneurship, which generally involves the establishment of a new business, corporate entrepreneurship occurs within the boundaries of an existing organization and draws on its financial, technological, human, and relational resources. It enables established firms

to behave entrepreneurially while maintaining the structural advantages associated with organizational experience, accumulated knowledge, and market legitimacy [1, 2].

Corporate entrepreneurship is commonly understood as a multidimensional phenomenon involving innovation, strategic renewal, organizational venturing, opportunity recognition, proactiveness, and calculated risk-taking. These dimensions allow an organization to move beyond routine administrative behavior and respond creatively to internal and external changes. From a strategic and structural perspective, corporate entrepreneurship requires organizational arrangements that support experimentation, decentralized decision-making, opportunity-seeking behavior, and the allocation of resources to uncertain initiatives [2]. In industrial organizations, corporate entrepreneurship may be manifested through the introduction of new production methods, development of new technologies, creation of new business units, entry into emerging markets, or substantial modification of existing business models. Process-oriented approaches further suggest that corporate entrepreneurship develops through interconnected stages, including opportunity identification, idea generation, resource mobilization, experimentation, implementation, and institutionalization [3]. Consequently, corporate entrepreneurship should be regarded not as an isolated managerial action but as an organizational process through which entrepreneurial initiatives are generated, evaluated, supported, and transformed into measurable outcomes.

The growing importance of corporate entrepreneurship is also associated with its potential contribution to organizational competitiveness and performance. Entrepreneurial organizations are generally more capable of responding to environmental discontinuities, introducing differentiated offerings, exploiting technological opportunities, and adapting their structures to changing market requirements. Evidence indicates that corporate entrepreneurship can enhance the financial performance of organizational units and subsidiaries, although the strength of this relationship may depend on the degree of environmental dynamism in which the organization operates [4]. In highly dynamic environments, organizations must continuously revise their assumptions, scan for emerging opportunities, and respond to threats before competitors do. Corporate entrepreneurship can therefore provide a mechanism through which environmental turbulence is converted into strategic action. Similarly, corporate entrepreneurship has been associated with organizational performance excellence, particularly when entrepreneurial activities are aligned with an appropriate approach to risk recognition and management [5]. This relationship suggests that entrepreneurial behavior does not produce desirable performance automatically; rather, its effectiveness depends on how the organization evaluates uncertainty, supports innovation, and manages the resources committed to entrepreneurial initiatives.

Although corporate entrepreneurship may contribute to growth and renewal, its development depends heavily on organizational and cultural conditions. An entrepreneurial culture supports autonomy, creativity, open communication, experimentation, learning from failure, and the active participation of employees in organizational decision-making. Organizational culture determines whether new ideas are encouraged or suppressed, whether calculated mistakes are tolerated, and whether managers are willing to allocate resources to projects whose outcomes cannot be predicted with certainty. Research on organizational culture has therefore emphasized its role in facilitating or constraining corporate entrepreneurship [6]. Participatory management may similarly strengthen corporate entrepreneurship by involving employees in problem-solving, improving the circulation of information, and increasing their psychological ownership of organizational initiatives [7]. When employees perceive that their expertise is valued and that they are permitted to

contribute to strategic and operational decisions, they are more likely to identify opportunities and propose innovative solutions.

Human resource conditions also influence the organization's entrepreneurial capacity. Employees represent an important source of tacit knowledge, technical expertise, creativity, and opportunity recognition, while managerial systems determine whether these capacities are mobilized effectively. Factors affecting human resources, such as motivation, competence, leadership support, reward systems, professional development, and organizational justice, can influence the willingness of personnel to participate in entrepreneurial activities [8]. Work ethics and professional responsibility may also shape the quality of entrepreneurial behavior by ensuring that opportunity-seeking and innovation remain compatible with organizational values and social expectations [9]. Professional ethics is especially important in knowledge-intensive and technologically sensitive organizations because entrepreneurial decisions may have consequences for employee safety, information security, customers, the environment, and other stakeholders. Findings concerning professional ethics further indicate that organizational members evaluate not only performance outcomes but also the values and behavioral standards governing professional conduct [10]. Thus, corporate entrepreneurship requires both freedom to experiment and institutional mechanisms that ensure accountability.

Risk is an inseparable component of corporate entrepreneurship because entrepreneurial initiatives involve commitments to actions whose outcomes are uncertain. New technologies may fail to produce expected results, new products may not be accepted by the market, research projects may exceed their budgets, and organizational ventures may encounter technical, regulatory, operational, or financial obstacles. Corporate entrepreneurship therefore requires neither the complete avoidance of risk nor the uncontrolled acceptance of uncertainty. Instead, it depends on calculated risk-taking, meaning that managers identify potential threats, estimate their probability and consequences, evaluate alternative courses of action, and allocate resources in accordance with organizational risk tolerance. From an organizational perspective, corporate risk management provides a systematic framework for identifying, evaluating, treating, and monitoring risks across different functions and levels of the organization [11]. When integrated with strategic decision-making, risk management can improve the quality of entrepreneurial choices by distinguishing manageable uncertainty from unacceptable exposure.

The concept of risk in contemporary organizations extends beyond conventional financial and operational concerns. Information security risks, for example, can affect the confidentiality, integrity, and availability of organizational information and may undermine technology-based innovation when they are not appropriately managed [12]. Knowledge-based organizations depend heavily on proprietary data, intellectual property, digital infrastructures, and specialized technical knowledge; consequently, entrepreneurial projects may expose them to cyber threats, data loss, knowledge leakage, or unauthorized access. Human capital risk is also relevant because organizations may lose critical expertise, experience shortages of specialized personnel, or become excessively dependent on a limited number of key employees [13]. These risks are particularly significant in research-intensive industries, where the success of entrepreneurial initiatives often depends on multidisciplinary teams, highly specialized competencies, and the continuity of organizational knowledge. Effective risk management can therefore support corporate entrepreneurship by protecting the informational and human foundations on which innovation and research activities depend.

Nevertheless, risk may also stimulate entrepreneurial behavior. Perceived threats can encourage organizations to search for alternative technologies, redesign inefficient processes, diversify their activities, and identify new markets. The critical

issue is whether the organization possesses the capabilities required to convert risk exposure into constructive strategic responses. When risk is recognized but not supported by adequate learning, innovation, and research capacities, it may produce defensive behavior and organizational inertia. In contrast, when risk is accompanied by managerial support, flexible resource allocation, technical expertise, and effective knowledge-sharing systems, it may motivate opportunity-seeking and organizational renewal. Corporate entrepreneurship therefore reflects the organizational ability to transform uncertainty into innovation rather than merely tolerate exposure to uncertain outcomes. This perspective is consistent with models that regard corporate entrepreneurship as a structured organizational process rather than an impulsive or purely individual activity [3].

Innovation represents one of the principal mechanisms through which risk may influence corporate entrepreneurship. Innovation involves the development and implementation of new or significantly improved products, services, processes, technologies, administrative practices, or business models. Risk can stimulate innovation by revealing weaknesses in existing organizational arrangements and increasing the perceived necessity of alternative solutions. At the same time, innovation can translate entrepreneurial intentions into concrete organizational outcomes. Without innovation, organizational risk-taking may remain speculative and fail to generate new value. Knowledge management is particularly important in this process because innovation depends on the acquisition, integration, sharing, and application of knowledge across organizational units. Knowledge management strategies can complement other organizational capabilities and contribute to improved performance by ensuring that relevant knowledge is available for decision-making and problem-solving [14]. Empirical research has also highlighted relationships among knowledge management, entrepreneurship, and organizational performance, suggesting that effective knowledge processes can strengthen the conversion of entrepreneurial activities into performance outcomes [15].

Innovation in corporate entrepreneurship is not limited to products and technologies. Business model innovation may allow organizations to redefine how value is created, delivered, and captured. Corporate accelerators and similar organizational mechanisms can provide established firms with structures through which entrepreneurial projects are developed, tested, and connected to external innovation ecosystems [16]. Such mechanisms may reduce the distance between entrepreneurial ideas and organizational implementation by providing access to mentors, technological resources, networks, and investment. Innovation ambidexterity is also important because organizations must simultaneously exploit existing competencies and explore new technological or market opportunities. Technological capabilities and marketing capabilities can jointly support innovation ambidexterity by enabling firms to develop new solutions while aligning them with customer needs and market conditions [17]. Accordingly, innovation may mediate the relationship between risk and corporate entrepreneurship by transforming perceived uncertainty into new organizational offerings and practices.

Research and development constitutes another major mechanism through which risk can be converted into corporate entrepreneurial outcomes. Research and development activities create scientific and technical knowledge, improve the organization's absorptive capacity, and provide the experimentation necessary for the development of new technologies and processes. Investment in research and development can increase the probability of technological innovation by expanding the range of alternatives available to decision-makers and improving the organization's ability to solve complex problems [18]. In knowledge-based companies, research and development units often serve as central institutional platforms for opportunity recognition, technological experimentation, prototyping, testing, and commercialization. These activities can

reduce some forms of uncertainty by generating information about technical feasibility, cost, performance, and market applicability. At the same time, research and development itself is risky because its outcomes are uncertain, its expenditures may be substantial, and the commercial value of its results may not become evident for a considerable period.

The intensity and direction of research and development investment may be influenced by managerial and institutional characteristics. Research has shown that managerial overconfidence and political connections can affect research and development intensity, indicating that investment decisions are not based solely on objective technological opportunities [19]. Managers' perceptions of risk, access to external resources, expectations concerning future returns, and organizational power structures may all influence the allocation of resources to research and development. Moreover, innovation sustainability does not depend exclusively on formal research and development activities. Non-R&D innovation activities, including technology acquisition, employee training, design, market research, collaboration, and process improvement, can also contribute to sustained innovation, particularly in high-technology industries [20]. The distinction between R&D and non-R&D innovation activities is therefore important because corporate entrepreneurship may require a portfolio of complementary investments rather than reliance on a single technological function.

At the macroeconomic level, entrepreneurship and technological innovation are closely related to economic growth, productivity, and the development of knowledge-based industries [21]. At the organizational level, the same relationship implies that entrepreneurial outcomes are likely to be stronger when firms possess the ability to generate, acquire, and apply technological knowledge. Research and development can provide the technical content of entrepreneurial initiatives, while innovation can facilitate their organizational and commercial realization. These variables may therefore operate as complementary mediators between risk and corporate entrepreneurship. Risk creates pressure or motivation for change; research and development generates new knowledge and technical alternatives; innovation transforms those alternatives into usable products, services, processes, or business models; and corporate entrepreneurship institutionalizes these outcomes within the broader strategic direction of the organization.

The development of entrepreneurial capabilities also depends on education, learning, and the reduction of organizational barriers. Entrepreneurship education has evolved substantially and now encompasses opportunity recognition, innovation management, strategic thinking, resource mobilization, and the management of uncertainty [22]. Within organizations, similar learning processes are required to equip managers and employees with the competencies needed to evaluate opportunities and participate in entrepreneurial projects. However, organizational entrepreneurship may be constrained by bureaucracy, inadequate incentives, centralized decision-making, limited financial support, weak collaboration, fear of failure, and insufficient infrastructure. Studies examining barriers to entrepreneurship have demonstrated that structural, cultural, managerial, and resource-related obstacles can restrict entrepreneurial behavior even in knowledge-oriented environments such as universities [23]. The presence of resources alone is therefore insufficient; organizations must establish processes and policies that allow those resources to be used entrepreneurially.

The need to examine these relationships is particularly pronounced in knowledge-based companies operating in the oil and gas industry. Such companies work in an environment characterized by complex technologies, high capital requirements, demanding safety standards, environmental concerns, fluctuating markets, sanctions or supply limitations, regulatory requirements, and long development cycles. Their survival and competitiveness depend on the ability to localize technologies, improve operational processes, develop specialized products, and respond rapidly to emerging technical problems. However,

each of these activities involves considerable technical, financial, operational, human capital, and information-related risk. In this context, corporate entrepreneurship cannot be adequately explained by risk-taking alone. The organization must possess innovation and research and development capabilities that enable it to interpret risk, generate viable solutions, test alternatives, and institutionalize successful initiatives.

Despite the theoretical relevance of these variables, prior studies have frequently examined corporate entrepreneurship in relation to organizational culture, participatory management, knowledge management, performance, human resources, or environmental dynamism as separate relationships [4, 6, 7, 15]. Other studies have focused on risk management, information security risk, human capital risk, research and development intensity, technological innovation, or business model innovation without integrating these concepts into a unified explanatory framework [12, 13, 16, 19]. Public-sector models have likewise emphasized that corporate entrepreneurship may differ across institutional contexts and must be examined in relation to the specific structures, constraints, and objectives of the organization [24]. These fragmented approaches indicate the need for an integrated model explaining both the direct relationship between risk and corporate entrepreneurship and the indirect mechanisms through which this relationship may operate.

Methodologically, examining such a model requires a quantitative approach capable of estimating multiple interdependent relationships among latent organizational constructs. Quantitative research designs in the social sciences provide systematic procedures for operationalizing theoretical concepts, collecting standardized data, and testing hypothesized relationships [25]. Appropriate measurement assessment is particularly important because variables such as risk, innovation, research and development, and corporate entrepreneurship cannot be observed directly and must be represented through multiple indicators. Analytical methods should therefore provide evidence regarding construct validity, reliability, and the magnitude and significance of structural relationships. Although methodological techniques such as data envelopment analysis can improve discrimination and weighting in organizational assessment contexts [26], structural equation modeling is more directly suited to testing the simultaneous direct and mediating relationships proposed in the present conceptual model.

Accordingly, an integrated examination of risk, innovation, research and development, and corporate entrepreneurship can contribute to both theory and managerial practice. Theoretically, it can clarify whether risk functions only as a direct antecedent of corporate entrepreneurship or whether its influence is substantially transmitted through organizational innovation and research and development. Practically, it can help managers determine whether encouraging risk-taking is sufficient or whether entrepreneurial outcomes require parallel investments in technological knowledge, innovation systems, human resources, and organizational learning. Such evidence is particularly valuable for knowledge-based firms in strategically important industries, where the consequences of entrepreneurial success or failure may extend beyond the organization to national technological capability, industrial self-sufficiency, employment, and economic development.

Therefore, the aim of this study was to assess the role of risk in corporate entrepreneurship by examining the mediating roles of innovation and research and development in a knowledge-based company operating in the oil and gas industry.

Methodology

In terms of its objective, this study was applied research. Regarding the method of data collection, it employed a descriptive-survey and correlational research design. The statistical population consisted of 60 managers and experts

employed by a knowledge-based company operating in the oil and gas industry. Given the limited population size, a census approach was adopted, and the questionnaire was distributed among all managers and employees. The demographic characteristics of the study sample are presented in Table 1.

Table 1

Demographic Characteristics of the Study Sample

Characteristic	Category	Percentage	Characteristic	Category	Percentage	Characteristic	Category	Percentage
Gender	Female	30%	Marital status	Single	29%	Organizational position	Manager	21%
	Male	70%		Married	71%		Employee	79%
Characteristic	Category	Percentage	Characteristic	Category	Percentage	Characteristic	Category	Percentage
Work experience (years)	Less than 3	9%	Education	Below bachelor's degree	10%	Age (years)	Below 30	15%
	3–5	21%		Bachelor's degree	30%		30–40	27%
	6–10	50%		Master's degree	40%		41–50	33%
	More than 11	20%		Doctoral degree	20%		More than 51	25%

Considering the data collection technique, the measurement instrument was adopted from existing research and the original studies. A five-point Likert scale was used to assess the questionnaire items, with a score of 5 representing “strongly agree” and a score of 1 representing “strongly disagree.” The questionnaires were extracted from relevant articles and subsequently revised based on expert evaluations. The number, sequence, and sources of the questionnaire items are presented in Table 2.

Table 2

Structure of the Research Questionnaire

Variable	Number of Items	Item Sequence	Source
Risk	6	1–6	James et al. (2015)
Research and development	5	7–11	Jean and Chen (2005)
Innovation	5	12–16	Lee and Kang (2014)
Corporate entrepreneurship	6	17–22	Ryan and Chi (2010)

Convergent validity was subsequently evaluated using the average variance extracted (AVE), while discriminant validity was also assessed. Composite reliability (CR) was used to evaluate the reliability of the constructs. These indices are discussed in the following sections.

To establish construct validity, the t-statistic values should exceed 1.96. As shown in Table 3, all values fell within the acceptable range; therefore, construct validity was confirmed. Furthermore, according to Table 3, all factor loadings exceeded 0.40 and were therefore within the acceptable range. A summary of these values is presented in Table 3.

Table 3

Factor Loadings and Significance of the Questionnaire Items: Construct Validity

Item	Factor Loading	t-Statistic	Item	Factor Loading	t-Statistic
Q1	0.854	3.214	Q12	0.587	6.584
Q2	0.658	4.152	Q13	0.519	3.667
Q3	0.663	3.336	Q14	0.597	4.931
Q4	0.645	6.773	Q15	0.558	6.823
Q5	0.637	7.209	Q16	0.561	4.054
Q6	0.705	4.660	Q17	0.669	3.215
Q7	0.603	3.001	Q18	0.654	4.527
Q8	0.669	5.099	Q19	0.608	6.228
Q9	0.753	4.147	Q20	0.611	6.151

Q10	0.841	5.369	Q21	0.632	4.687
Q11	0.695	4.427	Q22	0.671	3.668

Findings and Results

Before analyzing the data and testing the research hypotheses, it was necessary to determine whether the data followed a normal distribution. For this purpose, the Kolmogorov–Smirnov test was conducted. Because the significance levels obtained for all variables were below .05, the data were not normally distributed. Therefore, PLS structural equation modeling was used to test the hypotheses. The analyses were conducted using SmartPLS 2, as presented in Table 4.

Table 4

Test of Data Distribution Normality

Variable	Significance Level	Distribution
Risk	< .001	Non-normal
Research and development	< .001	Non-normal
Innovation	< .001	Non-normal
Corporate entrepreneurship	< .001	Non-normal

The t-statistics model presented in Figure 1 and the standardized coefficient model presented in Figure 2 are reported below. The acceptable threshold is greater than 1.96 for t-statistics and greater than 0.40 for standardized estimates and factor loadings.

Figure 1

t-Statistics Model

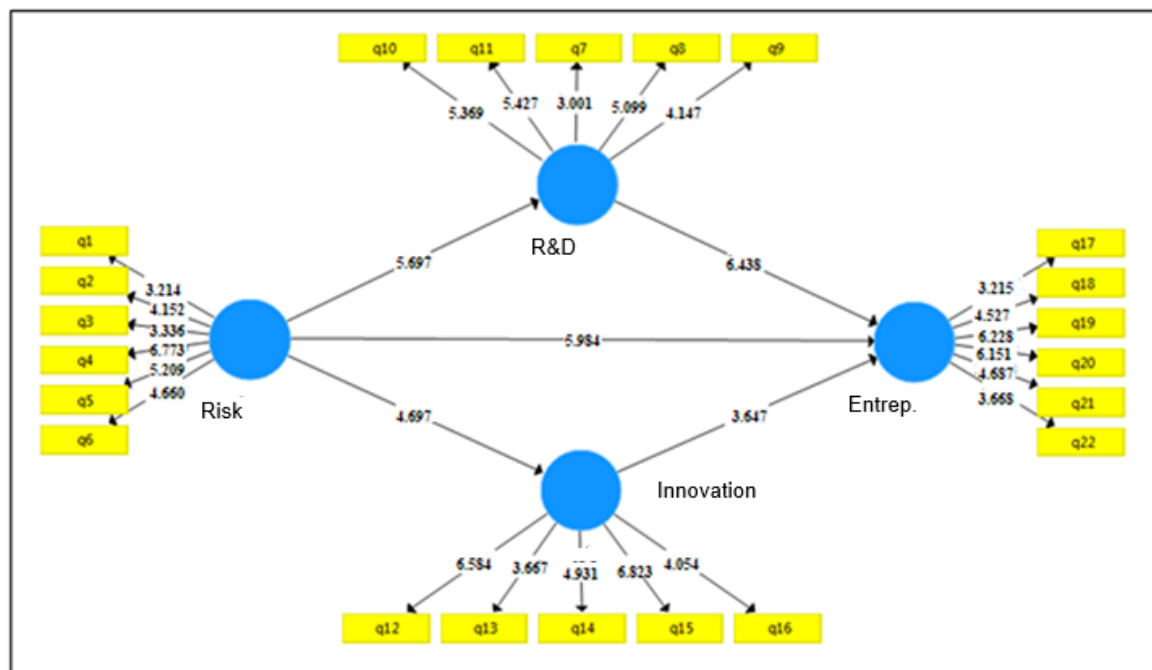
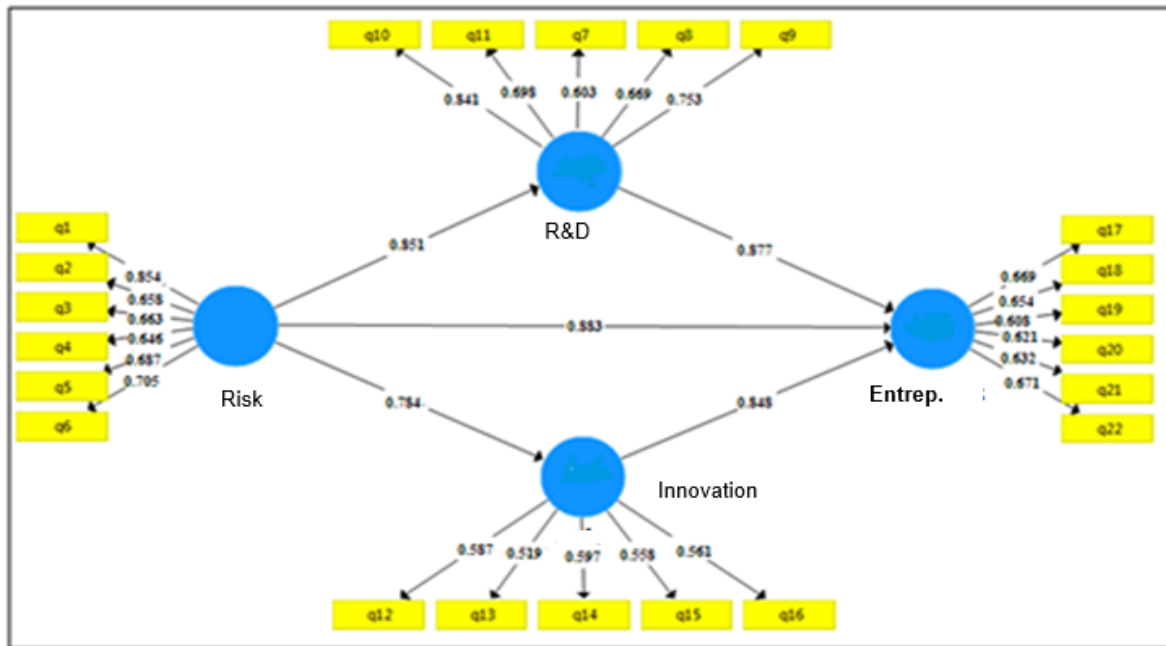


Figure 2*Standardized Coefficient Model*

The discriminant validity values for the study variables are presented in Table 5. Because each value on the main diagonal is greater than the corresponding off-diagonal values below and to its right, discriminant validity was confirmed.

Table 5*Discriminant Validity*

Variable	Risk	Research and Development	Innovation	Corporate Entrepreneurship
Risk	0.851			
Research and development	0.159	0.741		
Innovation	0.325	0.205	0.806	
Corporate entrepreneurship	0.229	0.133	0.229	0.741

The model fit indices, average variance extracted values exceeding 0.50, and composite reliability values exceeding 0.70 are presented in Table 6. The AVE values were greater than 0.50, and the composite reliability values were greater than 0.70, indicating acceptable convergent validity and construct reliability. Table 6 also shows that the model demonstrated a very good fit. The model fit was considered satisfactory because the fit indices were close to 1 and the RMSEA values were within the recommended range.

Table 6*Model Fit Indices, Average Variance Extracted, and Composite Reliability*

Variable	NFI	RFI	IFI	TLI	CFI	RMSEA	AVE	CR
Risk	0.893	0.869	0.950	0.951	0.987	0.000	0.547	0.741
Research and development	0.859	0.887	0.879	0.957	0.887	0.000	0.552	0.847
Innovation	0.867	0.863	0.882	0.862	0.849	0.000	0.562	0.708
Corporate entrepreneurship	0.955	0.971	0.932	0.911	0.962	0.000	0.508	0.815

A summary of the results of the research hypothesis tests is presented in Table 7.

Table 7*Summary of the Research Hypothesis Tests*

No.	Hypothesis	Path Coefficient	t-Statistic	Result
1	Risk has a significant effect on research and development.	0.851	5.697	Supported
2	Risk has a significant effect on corporate entrepreneurship.	0.583	5.984	Supported
3	Risk has a significant effect on innovation.	0.764	4.697	Supported
4	Research and development have a significant effect on corporate entrepreneurship.	0.877	6.438	Supported
5	Innovation has a significant effect on corporate entrepreneurship.	0.845	3.647	Supported

Discussion and Conclusion

The present study examined the role of risk in corporate entrepreneurship and investigated the mediating roles of innovation and research and development in a knowledge-based company operating in the oil and gas industry. The results supported all five research hypotheses. Risk had a positive and significant effect on research and development, with a path coefficient of 0.851 and a t-statistic of 5.697. Risk also had a positive and significant direct effect on corporate entrepreneurship, with a path coefficient of 0.583 and a t-statistic of 5.984. Moreover, risk significantly affected innovation, with a path coefficient of 0.764 and a t-statistic of 4.697. Research and development exerted a strong positive effect on corporate entrepreneurship, with a path coefficient of 0.877 and a t-statistic of 6.438. Finally, innovation had a positive and significant effect on corporate entrepreneurship, with a path coefficient of 0.845 and a t-statistic of 3.647. Collectively, these findings indicate that risk is not merely an unavoidable feature of entrepreneurial activity but also a potentially productive organizational force whose effects on corporate entrepreneurship are strengthened through innovation and research and development.

The first finding showed that risk had a strong positive effect on research and development. This result suggests that increased exposure to technological, market, operational, financial, and competitive uncertainty may encourage knowledge-based companies to invest more actively in research, experimentation, technological learning, and product development. In knowledge-intensive industries, risk often reveals gaps in existing technologies, processes, or capabilities and creates pressure to generate new technical solutions. Therefore, organizations that face greater uncertainty may strengthen their research and development activities to reduce technological ambiguity, improve the feasibility of strategic decisions, and create alternatives for responding to environmental threats. This interpretation is consistent with the organizational perspective on corporate risk management, according to which risk identification and assessment should be integrated with strategic resource allocation and organizational planning [11]. Rather than producing only defensive responses, systematic risk recognition may direct organizational attention toward research projects capable of reducing vulnerability and generating new opportunities.

The positive relationship between risk and research and development also aligns with the argument that research and development investment is influenced by managerial perceptions, strategic expectations, and organizational exposure to uncertainty. Research on R&D intensity has shown that managerial characteristics and institutional conditions can shape decisions concerning the allocation of resources to technological development [19]. In this respect, managers who perceive substantial technological or competitive risk may regard research and development as a strategic response to uncertainty. Similarly, R&D input has been identified as an important antecedent of technological innovation because it expands the organization's technical knowledge base and improves its capacity to generate new solutions [18]. The present finding

extends this argument by indicating that risk may serve as an antecedent of such investment. In other words, risk can motivate the organization to develop the knowledge and technical competencies required to manage uncertainty more effectively.

This finding is particularly meaningful in the oil and gas industry, where organizations face complex technical requirements, long project cycles, costly equipment, safety concerns, environmental pressures, and rapid changes in technological standards. In such settings, research and development may function as both a risk-reduction mechanism and an opportunity-creation mechanism. It can reduce uncertainty by testing technologies, validating technical assumptions, improving operational processes, and identifying potential failures before implementation. At the same time, it can create new products, services, and technological capabilities that form the basis of corporate entrepreneurial initiatives. This interpretation is consistent with the broader association among entrepreneurship, technological innovation, and economic growth, according to which technological development enhances the capacity of organizations and industries to generate productive entrepreneurial outcomes [21].

The second finding indicated that risk had a positive and significant direct effect on corporate entrepreneurship. This result supports the view that calculated risk-taking is a fundamental component of entrepreneurial behavior within established organizations. Corporate entrepreneurship involves the pursuit of new opportunities under conditions in which outcomes cannot be predicted with certainty. Organizations must commit financial, human, and technological resources before the success of new products, markets, processes, or ventures becomes fully known. Therefore, an organization's willingness and ability to accept manageable risk can facilitate entrepreneurial action. The present result is consistent with the view that corporate entrepreneurship is strengthened when organizations integrate risk considerations into their pursuit of performance excellence [5]. It also supports strategic and structural perspectives that regard risk-taking as one of the essential organizational conditions for corporate entrepreneurial activity [2].

However, the positive effect observed in this study should not be interpreted as support for uncontrolled or excessive risk-taking. The relationship reflects the organizational capacity to identify, evaluate, and accept calculated risks in pursuit of new opportunities. Effective corporate entrepreneurship requires managers to distinguish between productive uncertainty and avoidable exposure. Information security risks, for example, can threaten technological projects, intellectual property, and organizational knowledge if they are not managed appropriately [12]. Human capital risks may similarly weaken entrepreneurial initiatives when key technical expertise is lost or when the organization lacks employees capable of implementing innovative projects [13]. Thus, the positive relationship between risk and corporate entrepreneurship is most likely to emerge when risk is supported by adequate governance, information, expertise, and organizational learning.

The finding also accords with process models of corporate entrepreneurship, which emphasize that entrepreneurial outcomes emerge through opportunity recognition, evaluation, resource mobilization, implementation, and institutionalization [3]. Risk influences each of these stages. Managers must assess the uncertainty associated with an opportunity, determine whether the potential value justifies the required commitment, and establish mechanisms for monitoring implementation. In dynamic environments, firms that avoid all risk may lose opportunities, while firms that accept risk without systematic evaluation may experience resource waste or strategic failure. The present finding therefore highlights the importance of balanced entrepreneurial judgment.

The third result showed that risk positively and significantly affected innovation. This finding indicates that uncertainty and perceived threats can stimulate organizations to search for new methods, technologies, products, services, and business

models. When existing approaches appear insufficient or vulnerable, organizations may be compelled to generate alternative solutions. Risk can therefore operate as a source of innovation pressure by challenging established routines and revealing the limitations of current capabilities. This result aligns with studies emphasizing the importance of technological and marketing capabilities in supporting innovation ambidexterity [17]. Organizations facing risk must often exploit their existing competencies while simultaneously exploring new technical and commercial possibilities.

The result is also consistent with evidence that innovation can be sustained through both formal research and development and non-R&D activities such as training, collaboration, design, technology acquisition, and process improvement [20]. Risk may influence all of these activities by encouraging organizations to diversify their innovation mechanisms. For example, a company exposed to supply-chain risk may seek alternative technologies or local suppliers, whereas a company facing market risk may redesign products or explore new customer segments. Business model innovation may likewise enable organizations to respond to uncertainty by changing how they create and capture value [16]. Thus, risk may stimulate innovation not only at the technological level but also at the organizational, administrative, and commercial levels.

The fourth and strongest relationship in the model was the positive effect of research and development on corporate entrepreneurship. The path coefficient of 0.877 indicates that research and development is a particularly important driver of entrepreneurial activity in the studied organization. This result suggests that corporate entrepreneurship in knowledge-based companies depends substantially on the organization's capacity to generate scientific and technical knowledge, conduct experimentation, test new ideas, and transform research outcomes into viable organizational initiatives. Research and development provides the technical foundation for new products, process improvements, technological ventures, and entry into emerging markets. Without such a foundation, entrepreneurial intentions may remain abstract and may not be converted into implementable projects.

This finding is consistent with the argument that R&D input promotes technological innovation by strengthening knowledge creation and problem-solving capacity [18]. It also aligns with studies indicating that sustained innovation depends on a combination of research-related and complementary innovation activities [20]. Corporate entrepreneurship requires more than the generation of ideas; it requires evidence concerning technical feasibility, scalability, cost, safety, and market applicability. Research and development activities provide this evidence and reduce uncertainty during the entrepreneurial process. Accordingly, R&D may enable organizations to move from opportunity recognition to commercialization more effectively.

The strong effect of research and development on corporate entrepreneurship can also be explained through knowledge management. Research and development generates valuable knowledge, but this knowledge must be transferred, integrated, and applied across organizational units. Knowledge management strategies have been associated with improved organizational performance because they facilitate the complementary use of information, expertise, and organizational capabilities [14]. The relationship among knowledge management, entrepreneurship, and performance likewise suggests that entrepreneurial outcomes depend on the organization's ability to circulate and apply knowledge [15]. In the studied company, research and development may have enhanced corporate entrepreneurship by providing managers and employees with the technical knowledge required to identify opportunities and implement innovative initiatives.

The fifth finding demonstrated that innovation had a strong positive effect on corporate entrepreneurship. This result confirms that innovation is a central mechanism through which entrepreneurial orientation is converted into organizational outcomes. Corporate entrepreneurship is not limited to an organization's intention to pursue opportunities; it requires the implementation of new products, services, technologies, processes, or business models. Innovation translates entrepreneurial aspirations into tangible changes and creates the value expected from corporate entrepreneurial activity. The finding is consistent with strategic perspectives that place innovation at the core of corporate entrepreneurship [1, 2].

The positive relationship between innovation and corporate entrepreneurship also aligns with the role of corporate accelerators and other organizational mechanisms that support the development of innovative business models [16]. Such arrangements provide structures for experimentation, mentoring, networking, and resource access, thereby improving the likelihood that innovative ideas will develop into entrepreneurial ventures. The finding is also compatible with evidence that technological and marketing capabilities jointly contribute to exploratory and exploitative innovation [17]. An organization may possess strong technical ideas, but corporate entrepreneurial success also depends on its ability to align those ideas with market requirements and organizational strategy.

At the organizational level, the effect of innovation on corporate entrepreneurship may also depend on culture, participation, and human resources. An organizational culture that encourages autonomy, experimentation, and learning can improve the implementation of innovative ideas [6]. Participatory management can strengthen this process by involving employees in decision-making and allowing knowledge from different organizational levels to contribute to entrepreneurial projects [7]. Human resource factors such as competence, motivation, leadership support, and reward systems may further determine whether employees are willing to propose and implement innovative solutions [8]. Therefore, innovation should be understood not only as a technological outcome but also as an organizational process shaped by cultural and managerial conditions.

Taken together, the findings indicate that innovation and research and development constitute key explanatory mechanisms connecting risk to corporate entrepreneurship. Risk appears to create pressure and motivation for organizational change, while research and development generates technical knowledge and innovation converts that knowledge into new organizational practices and market offerings. The comparatively stronger effects of research and development and innovation on corporate entrepreneurship suggest that risk alone is insufficient to produce entrepreneurial outcomes. Organizations must possess institutional capacities that transform uncertainty into knowledge, experimentation, and implementation. This conclusion supports the process-oriented understanding of corporate entrepreneurship and explains why some organizations respond to uncertainty through renewal while others respond through avoidance or inertia [3, 24].

The findings also have implications for the relationship between corporate entrepreneurship and performance. Previous evidence has shown that corporate entrepreneurship can contribute to financial performance, particularly under dynamic environmental conditions [4]. The present study suggests that this contribution may depend on whether risk is supported by adequate innovation and research and development capabilities. Entrepreneurship education and organizational learning can help managers develop the competencies required to recognize opportunities and manage uncertainty [22]. Conversely, structural, cultural, and resource barriers may prevent organizations from translating risk and innovative ideas into entrepreneurial action [23]. Professional and work ethics are also relevant because entrepreneurial initiatives must be pursued responsibly and in accordance with organizational and societal expectations [9, 10]. Therefore, the development of

corporate entrepreneurship requires an integrated system combining calculated risk-taking, technological investment, innovation support, ethical governance, and organizational learning.

This study had several limitations. First, the statistical population was limited to 60 managers and experts in a single knowledge-based company operating in the oil and gas industry, which restricts the generalizability of the findings to other companies, industries, and institutional environments. Second, the study used a cross-sectional design, and the variables were measured at one point in time; therefore, causal relationships and changes in risk, innovation, research and development, and corporate entrepreneurship over time could not be examined directly. Third, the data were collected through self-report questionnaires, which may have been influenced by social desirability, common method bias, respondents' subjective interpretations, and concerns about reporting organizational weaknesses. Fourth, risk was treated as an overall construct, although financial, technological, operational, market, information security, and human capital risks may have different relationships with innovation and corporate entrepreneurship. Finally, the study did not examine organizational culture, leadership style, firm size, environmental dynamism, access to financial resources, or knowledge management as potential contextual or moderating variables.

Future studies should examine the proposed model in larger samples drawn from multiple knowledge-based companies and different industries to improve the external validity of the findings. Longitudinal research could be conducted to determine how changes in risk exposure influence research and development investment, innovation, and corporate entrepreneurship over time. Researchers may also distinguish among different types of risk and compare their direct and indirect effects on entrepreneurial outcomes. Future studies could test organizational culture, entrepreneurial leadership, environmental dynamism, knowledge management, employee empowerment, and access to financial resources as moderating variables. Comparative studies between private and public organizations, large and small firms, and high-technology and traditional industries may provide a more detailed understanding of contextual differences. Mixed-method studies combining surveys with interviews, organizational documents, and objective performance indicators could also clarify the mechanisms through which risk is translated into innovation and entrepreneurial action.

Managers of knowledge-based companies should establish an integrated system for identifying and evaluating risks and linking them to research, innovation, and strategic decision-making. Risk registers should be used not only to record threats but also to identify opportunities for technological improvement, new products, process redesign, and market development. Organizations should allocate stable financial resources to research and development, create multidisciplinary project teams, and establish clear procedures for evaluating and commercializing research outcomes. Employees should be encouraged to propose innovative ideas without fear of punishment for well-managed experimentation, while reward systems should recognize both successful innovations and valuable learning from unsuccessful projects. Managers should strengthen collaboration among research and development, marketing, operations, finance, and senior management so that technical ideas are aligned with market needs and organizational priorities. Training programs should also develop employees' capabilities in risk analysis, creativity, project management, commercialization, and entrepreneurial decision-making.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants. Written consent was obtained from all participants in the study.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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