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Entrepreneurial Business Tie and Product Innovation: A Moderated Mediation Model

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Abstract: Radical innovation has attracted increasing attention in corporate sustainability research. Employing a social capital perspective, we explore how and when entrepreneurial business ties (EBTs) enhance radical innovation by considering risk taking as a critical mediator and environmental turbulence as a conditional factor of the mediation effect. Data is collected from 322 Chinese new ventures. We find empirical support for the moderated mediation model. Specifically, EBT is positively related to risk taking while risk taking is positively related to radical innovation. Risk taking further serves as a mediator in the EBT-radical innovation relationship, and this indirect effect is stronger at a high level of technological turbulence. By revealing how entrepreneurs translate their business ties into positive radical innovation outcomes through risk taking and when this indirect effect is most effective, we enhance understandings of the value of EBT and how to impel radical innovation.

Keywords: entrepreneurial business tie; risk taking; radical innovation; technological turbulence

1. Introduction

Entrepreneurship has been playing a critical role in economic and social sustainability by creating jobs and improving citizens' quality of life [1,2]. Due to the liabilities of smallness and newness, entrepreneurs often pay more attention to external network ties [3]. The importance of entrepreneurial network ties has been widely documented in the entrepreneurial field (i.e., entrepreneurs' relationships with family members, friends, and business partners) since these ties can help new ventures to overcome potential institutional barriers [4], build political legitimacy [5], access channels of information flow [6], capture market opportunities [7], and acquire human resources [8]. Extant emerging economy research has also emphasized how entrepreneurs leverage their business connections to manage resources and deal with opportunities [7,8]. While this line of research provides a fundamental picture of how entrepreneurial business ties (EBTs) promote new ventures' sustainable growth, three questions are still unanswered.

First, despite the increasing importance of radical innovation in corporate sustainability [9], we know very little about how EBT affects new ventures' radical innovation. New ventures have a tendency to develop and commercialize radically innovative products and services [10]. Specifically, radical innovation emphasizes that firms develop new products or services involved with novel technologies [11]. Through novel product designs, firms are more likely to fundamentally solve the social and environmental issues in business activities, such as environmental pollution, resource waste, and product recycling [12]. Recent scholars have treated radical innovation as a new means for

new ventures to improve their sustainable performance [13,14]. Despite the call to focus on radical innovation in corporate sustainability [14], the drivers of radical innovation in new ventures are still understudied. Specifically, when considering the prevalence and importance of EBT [15], radical innovation presents a critical agenda to explore the missing link between EBT and radical innovation.

Second, by viewing entrepreneurial orientation as a unified construct of proactiveness, innovativeness and risk-taking, previous research has preliminarily contributed to our understanding of risk taking on firm performance [16]. Specifically, risk taking refers to a venture's strategic choices related with uncertain outcomes [17]. Nevertheless, some meta-analysis studies suggest that risk taking has a smaller correlation with performance relative to other dimensions of entrepreneurial orientation [18]. Sobrepere and Keil even found that the effect of risk taking on firm performance was negative in some contexts [19]. Thus, entrepreneurial scholars argue that it is better to analysis the role of entrepreneurial orientation at the dimension level [20]. Obviously, existing research has not put enough emphasis on the individual role of risk taking in innovation activities, especially in the context of new ventures [21].

Third, new ventures' innovation activities do not occur in a vacuum, but are deeply context-dependent [22]. Potential contingency factors thus should be taken into account when investigating the relationship among EBT, risk taking and radical innovation. Recent innovation ecosystem perspective emphasizes that various uncertainties pose severe challenges to entrepreneurs in radical innovation activities [10]. Entrepreneurs should utilize business relationships to cope with uncertainty (a synonymous term with turbulence) when developing or commercializing radically innovative products and services [10,23]. However, we have little knowledge about how environmental turbulence affects the above mediating mechanism.

To address the above issues, by employing a social capital perspective [24], we first investigate the effect of EBT on risk taking and the effect of risk taking on radical innovation. We then argue that risk taking serves as a critical mediator in the EBT-radical innovation relationship. We further predict that technological turbulence, characterized by continuous changes in industrial technologies, will enhance the relationship between risk taking and radical innovation. Finally, a moderated mediation model has been proposed to link EBT, risk taking, technological turbulence, and radical innovation together. Using a sample of 322 Chinese new ventures, we obtain empirical support, which indicates an indirect mechanism through which risk taking enhanced by EBT leads to radical innovation and that technological turbulence will strengthen this indirect effect.

By exploring how and when EBT enhances radical innovation through risk taking, the present study could make the following contributions. Firstly, this study helps to explain how EBT functions in radical innovation activities through investigating its effect on risk taking and further radical innovation. Second, this study enhances understanding of how risk taking serves as a mediator by bridging the missing link between EBT and radical innovation. Finally, by considering the moderating effect of technological turbulence, this study adds to our knowledge about how and when EBT functions by applying a moderated mediation model.

2. Literature Review and Hypotheses

2.1. Literature Review

2.1.1. Radical Innovation and Corporate Sustainability

Corporate sustainability reflects a venture's efforts on social and environmental issues, such as saving resources, reducing environmental pollution, recycling products, and improving stakeholder relations [25]. Despite the increasing efforts of companies to emphasize sustainability issues [12], traditional strategic literature often views corporate sustainability as an extra cost of business activities [26]. Through new products and services, firms are more likely to harmonize the benefits of the environment, the society, and the firm per se, thus improving sustainability and market performance simultaneously [13]. Recent innovation studies has emphasized the importance of

taxonomy rather than unitary product innovation [27]. Specifically, product innovation can be divided into incremental and radical innovations according to the degree of novelty. While incremental innovation refers to minor changes to current products, radical innovation indicates that new products involve a set of fundamental changes and are new to markets, significantly differentiating from current products [9]. The dynamics of technology evolution require firms to simultaneously explore radical competences and exploit existing capabilities in order to be sustainable [28]. Radical innovation fundamentally transforms inter-organizational relationships, changes the market structure, replaces existing products and produces entirely new products and services, thus providing a platform for corporate sustainability [14]. Although traditional corporate sustainability research has not intensely discussed radical product innovations, recent studies have begun to focus on sustainable potential of radical technological innovations (e.g., see Ramani and Mukherjee, 2014) [29]. Through two Indian case studies, Ramani and Mukherjee (2014) explore the interrelationships between innovations and corporate social responsibility (CSR), and indicate that technological innovations, especially radical innovations, trigger firms' involuntary CSR efforts [29].

In addition, the Chinese government paid primary attention on economic growth in the past four decades. During this period, few companies were concerned about environmental issues involving their products when developing new products or services. Existing technologies and products made in China were often criticized for environmental problems, such as resource waste and environmental pollution. In recent years, the government has launched a set of policies on environmental management. According to the institution perspective, commercial incentives has an overall tendency to echo policy imperatives [30]. Product innovation in Chinese firms, especially radical innovation, thus may reduce environmental problems and foster corporate sustainability. With the potential to solve the root causes of social and environmental issues (e.g., environmental pollution, resource waste), radical innovation has attracted an increasing interest in corporate sustainability research [14,29]. Thus, in order to foster corporate sustainability, investigating how to impel radical innovation is a critical research agenda.

2.1.2. EBT and Radical Innovation: A Social Capital Perspective

Despite lacking a generally precise definition, social capital is viewed as one type of resource embedded in the social network [31], which will help individuals or groups realize potential benefits [32]. Social capital provides organizations with opportunities to obtain critical resources from outside [33]. A set of studies has confirmed the positive effect of social capital on firm performance [34]. In business fields, social capital exists in various forms, such as trust, network ties, information-flow capacity, repeated transactions, and so on [35]. With the prevalence and importance of networks in the entrepreneurial stage, how entrepreneurial network ties serving as one kind of social capital contribute to new venture growth has attracted increasing attention [36]. Entrepreneurial network ties are a mixture of various relationships that entrepreneurs build with family members, friends, and business partners [37]. Recent emerging economic research has emphasized the role of EBT in the new venture field [38]. In this study, we define EBT as connections that entrepreneurs build with other business actors (i.e., its suppliers, customers, and peer companies). Business relationships improve knowledge exchange among business actors and assist ventures overcome information asymmetries, thus providing them access to valuable technology- and market-related information [39]. Business ties help a venture build trust with other actors, enhance organizational cooperation, capture and exploit potential opportunities, and access valuable resources [40].

Recent innovation studies began to focus on the role of business ties in firm innovation activities [41,42]. For example, Fredberg and Piller argue that strong ties with customers are more likely to facilitate innovation [41]. Gao, Xu, and Yang indicate that managers' business ties are apt to promote knowledge sharing and innovation with the assistance of absorptive capacity [42]. Zhao, Li, and Liu suggest that managers' business ties serve as critical boundaries in the processes where organizational learning influences radical innovation [43]. Shu, Page, Gao, and Jiang find that managers' business relationships impel firm innovation through various knowledge creation (i.e., exchange and combination) [44].

Wang, Jean, and Zhao differentiate direct and indirect ties, and discuss their impact on innovation [24]. Su and Yang explain how managers' business ties impel exploratory innovation by improving a venture's motivation, abilities, and opportunity screening [7].

Despite the prevalence and importance of business ties in the entrepreneurial field, little research has investigated how EBT affects firm radical innovation. Theoretically and empirically investigating the relationship between EBT and radical innovation represents a critical agenda in the entrepreneurial field. Considering the indirect effect of social capital on performance [34], we further propose that risk taking could be one mediator that translates the benefits of EBT into radical innovation.

2.1.3. The Role of Risk Taking

We propose that the potential benefits of EBT are translated into radical innovation through risk taking as a mediator. Risk taking has been implicitly, although not explicitly, treated as a critical role that links firm resources and firm outcomes [17].

In light of the fact that organizations inevitably cope with uncertainties, the importance of risk taking has been greatly addressed in the strategic research. Previous strategic research has paid great attention on the causes and outcomes of risk taking (see Hoskisson et al. for a review) [17]. With respect to its antecedents, agency perspective [45], behavioral approach [46], prospect perspective [47], and upper echelons theory [48] have often been employed to explain what factors trigger a firm's risk-taking behaviors. For instance, agency theory research has emphasized that institutional investors, as well as board members, can foster risk taking through monitoring and providing incentives [49]. Considering that organizational risk-taking preferences are shaped by comparisons between performance and aspiration level, the behavior theory of the firm often find that underperforming leads to high levels of risk taking while overperforming results in low levels of risk taking [50]. Specifically, organizational slack, one core concept of behavior theory has been viewed as a driver of risk taking [51]. Prospective theory proposes that threat rigidity induced by poor performance, and the degree of ambiguity will reduce an organization's risk-taking behaviors [52]. Upper echelons theory often focuses on how characteristics of executives affect risk taking [48]. Recent entrepreneurial research also suggests that Individual entrepreneurial characteristics will affect firm-level innovation in various environments [21].

When considering the significant influence of entrepreneurs on strategic choices in the entrepreneurial field, it is necessary to investigate characteristics of entrepreneurs on risk taking. In the entrepreneurial field, the concept of risk taking origins from one dimension of entrepreneurial orientation, which emphasizes that learning and selection mechanisms in R&D activities will lead to risk-taking behaviors [53]. Previous research has suggested to study the role of risk taking individually rather than taking it as a dimension of unified entrepreneurial orientation [18].

Previous research also investigates the consequences of risk taking, such as firm financial performance [54], corporate diversification [55], firm recovery [51], learning [56], and product introduction [57]. Given that radical innovation often involves high risk [58,59], it is appropriate to link risk taking and radical innovation together. Nevertheless, the role of risk taking in a new venture's innovation strategies has been understudied [21]. Recent studies has also begun to explore the mediating role of risk taking. Liu, Xu, Zhou, and Li, for instance, emphasize risk-taking will link entrepreneurial attributes (e.g., Buddhist belief) and firm performance together [60]. We thus expect that risk taking help to open the black box between EBT and radical innovation.

2.1.4. The Contingency of Technological Turbulence

As contingency theory suggests, the effectiveness of a strategic decision is up to the environmental situation an organization faces [61]. In business activities, firms face various kinds of environments: unfamiliar, heterogeneous, dynamic, munificent, and turbulent [62,63]. The innovation ecosystem literature has emphasized a set of main contingent factors that affect product innovation, such as technological and market turbulence, competitive intensity, and partner relationships (see Lopes and de Carvalho, 2018 for a review) [64]. Specifically, technological turbulence refers to continuous changes

in technologies [43]. Technological turbulence will disrupt the competitive advantage of existing products by make them obsolete quickly [65], and provide a new venture more opportunities into a prominent position. Technological turbulence has been widely acknowledged as a key factor that triggers a firm's innovation activities [22,66]. Thus, we focus on how technological turbulence serves as a boundary condition for the relationships among EBT, risk taking, and radical innovation.

2.2. EBT and Risk Taking

EBT increases a new venture's risk taking for the following reasons. First, with the assistance of EBT, new ventures are able to acquire technology- and market-related knowledge from external environments. Complex information and tacit knowledge from business partners will enhance new ventures' understanding of business environments and mitigate the information asymmetries. When new ventures can cope with information asymmetries effectively, they will increase their risk-taking intents. For instance, technological knowledge learned from business partners enlarge a new venture's technology base and foster its knowledge diversification, which improve their strategic decision making [67]. Market-related knowledge can help new ventures screen market opportunities and identify potential values of technologies, thus increasing their risk-taking intent.

Second, EBT can help new ventures obtain managerial advices from business partners, serving as a critical tool in fostering adequate risk taking [22]. Through EBT, a new venture can learn more management practices from other business partners and improve its management routines or mindset [68]. A new venture is better able to tackle with risk-averse attitudes and legitimize its risk-taking behaviors. Through acquired managerial knowledge, a new venture can also better cope with the institutional barriers in emerging economies, such as weak intellectual property rights [68].

Third, EBT also enhances trust and repeated transactions between new ventures and their business partners, which help them acquire extra resources and increase organizational slack. Serving as a buffer, resource slack is widely acknowledged as a driving factor for risk taking [46,69].

There, we suggest that:

Hypothesis 1. *EBT is positively related to risk taking.*

2.3. Risk Taking and Radical Innovation

Radical innovation reflects that firms develop new products through adopting novel technologies rather than depending on the evolutionary path of existing technologies [22,43]. With the potential to help new ventures destroy dominant advantage of incumbents, radical innovation has attracted numerous research interests [43]. However, radical innovation is also a high-risk activity and only new ventures with high levels of risk taking tend to introduce radical innovation. First, radical innovation means that a new venture has a low level of control on R&D outcomes. The failure rate of radical innovation is often very high [58]. New ventures will also face more unpredictable conditions in radical innovation activities. For example, R&D projects can be terminated wrongly when managers overestimate the difficulties or underestimate the values of these ongoing R&D projects. New ventures are more likely to make such mistakes due to inexperience. Second, radical innovation often requires a long development cycle [70]. The longevity of R&D projects asks new ventures to make more resource commitments. Considering the resource constraints, these resource commitments greatly challenge the survival of new ventures. Third, radical innovation reflects that new products involve more novel designs [66]. It is more likely that customers are unfamiliar with this kind of products. New ventures will counter more resistance and barriers in the commercialization stage.

Now that a firm with high levels of risk-taking will tolerate more failures and make huge resource commitments [53], we would expect that a risk-taking new venture will tend to introduce radical innovation relative to a risk-averse one. Therefore, we suggest:

Hypothesis 2. *Risk taking is positively related to radical innovation.*

2.4. The Mediation of Risk Taking between EBT and Innovation:

Theory of planned behavior indicates that an organization's behavior control will affect its behavior through its intention, which implies a potential mediating mechanism [71]. Behavior control reflects people's perceptions on to what extent they are able to perform the behavior of interest [71]. Recent entrepreneurship literature has begun to apply the theory of planned behavior, which indicates that entrepreneurs' perceived behavior control will affect their final behavior through entrepreneurial intention, thus implying a potential mediating mechanism [2]. In the present study, EBT improves entrepreneurs' behavior control on high-risky radical innovation by enhancing their organizational learning and increasing their resource endowment. Thus, improved behavior control firstly increases a new venture's risk-taking intent and further radical innovation behaviors. Recent studies also emphasize the indirect effect of EBT on venture outcomes through some mediating mechanisms [38]. Taking Hypothesis 1 and Hypothesis 2 into account, we expect an indirect effect via risk taking between EBT and radical innovation. Thus, we propose:

Hypothesis 3. *The relationship between EBT and radical innovation is mediated by risk taking*.

2.5. The Contingency Effect of Technological Turbulence

We describe technological turbulence as a condition that an industry is undergoing rapid technological changes [66]. Fast technological advances will corrupt the competitive advantage of existing products and create new technological opportunities [22]. We argue that technological turbulence will strengthen the positive impact of risk taking on radical innovation. When technological turbulence is low, few technological advances occur within an industry [63]. Even if a new venture is risk-taking, it will find few technological opportunities for radical innovation. Relative to risk taker, risk averter will feel more comfortable in familiar and stable environments. Thus, the relationship between risk taking and radical innovation is low.

In contrast, at a high level of technological turbulence, fast-changing technologies make existing products obsolete and radical innovations more possible. New ventures are able to identify more opportunities to significantly change components of the existing value chains through technological advances [66]. With the opening of windows of opportunity, risk-taking managers tend to launch R&D activities quickly. Therefore, opportunities brought by rapid technological advances will encourage risk-taking managers to introduce more radical innovations. Therefore, we suggest:

Hypothesis 4. *Technological turbulence moderates the effect of risk taking on radical innovation such that the positive effect is stronger when technological turbulence is higher than lower*.

2.6. A Moderated Mediation Model

There may exist a potential moderated mediation model when the relationship between the mediator and the dependent is simultaneously influenced by a moderator [72]. We expect that the second-stage moderating effect of technological turbulence on the relationship between risk taking and radical innovation will further moderate the indirect effect of EBT on radical innovation. At low levels of technological turbulence, risk taking enhanced by EBT is unable to trigger a new venture's radical innovations because there exist few technological opportunities. Thus, the mediating mechanism from EBT to radical innovation through risk taking is weak. With the increase of technological turbulence, there occurs more opportunities brought by rapid technological advances. New ventures tend to adopt radical innovations in order to capture these opportunities when their risk taking is also reinforced by EBT. The above arguments indicate that the indirect effect of EBT on radical innovation via risk-taking becomes stronger with the increase of technological turbulence. Thus, we suggest:

Hypothesis 5. *Technological turbulence positively moderate the indirect effect of EBT on radical innovation through risk taking*.

3. Methods

3.1. Participants and Procedure

Data for this present study were obtained through a survey of Chinese new ventures. We developed the questionnaire in the following steps. We firstly developed an English-version questionnaire based on previous research and modified related scales in order to fit the Chinese context. With the help of four PhD students, we translated the English version into a Chinese one. Before initiating the formal survey, we conducted a pilot test, which included a small number of entrepreneurs (n = 10). Through this pilot, we made some revisions according to their feedback to ensure clarity and conciseness of the questionnaire. Finally, we back-translated the Chinese-version questionnaire into English.

When considering the significant entrepreneurial differences between the coastal region and the inland area, we attempted to minimize potential regional bias by interviewing in both areas. In the coastal regions, we selected new ventures from three municipalities and five provinces; in the inland areas, we selected new ventures from seven provinces (see the Table A2 for detailed municipalities and provinces). Specifically, in each municipality or province, we randomly selected 40 ventures (younger than eight years) from the Yellow Pages. Self-employed sole entrepreneurs were excluded from our sample. Thus, 600 Chinese new ventures were randomly selected from these three municipalities and 12 provinces.

From February to September in 2013, our interviewers got in touch with entrepreneurs of these ventures through phone or email. We also promised a summary report in order to encourage their participation in this survey. Finally, of 600 new ventures, 332 entrepreneurs agreed. Interviews last 30 min on the average, and most of them happen at the offices of the respondents. Through face-to-face interviews, entrepreneurs scored related scales about entrepreneurial business tie, risk taking, radical innovation and other venture information. After deleting samples with missing data, we received responses from 322 new ventures, representing a response rate of 53.7%.

We used two methods to check whether there was potential non-response bias. On one hand, the differences between 322 respondents and 278 non-respondents on firm size and age were examined through t-tests. On the other hand, we compared the differences between 160 early responses and 172 late ones. We found no significant difference at the significance level of 0.05. The above two difference tests indicate that non-response bias was not a significant factor [73].

Another issue concerning the survey methodology is common method variance (CMV). Considering that the responses to EBT, risk taking, technological turbulence and radical innovation all came from a same respondent, a marker variable (MV) approach was used to examine CMV problems [74]. First, we chose legal inadequacy, which is theoretically unrelated to at least one of the above variables, and named as marker variable. Four items were used to measure the extent of legal inadequacy that a new venture faces [75] (Cronbach's $\alpha = 0.84$). Second, we calculated its correlations with other variables in this study and selected the lowest positive one, the correlation between legal inadequacy and industry ($r = 0.01$). Third, we recalculated the adjusted correlations and compared the statistical significance before and after the correlation adjustment [74]. As Table A1 reveals, each significant correlation remains significant, thus indicating no critical CMV issue.

As Table A2 shows, the demographic characteristics of our sample indicate a broad range of new ventures. Of the 322 new ventures, 69.9% belong to the services industry, while 30.1% belong to the manufacturing industry. Geographically, 53.7% come from coastal regions while 46.3% come from inland areas. All interviewed ventures are younger than six years, with an average age of 4.51 years.

3.2. Measurement

All measures were answered using a seven-point Likert scale, ranging from: (1) "strongly disagree" to (7) "strongly agree".

EBT was assessed by a three-item scale from Wang et al. [38]. These items characterize the extent to which entrepreneurs in the focal venture sustain connections with other business actors. Risk taking

has often been measured by the propensity or the behavior. We measure risk taking as a propensity that entrepreneurs take risks [21]. We developed three scales from previous entrepreneurial orientation research for risk taking, which reflects a venture's risk preference [76]. Radical innovation was assessed using a three-item scale, which asked respondents to estimate the extent to which their new products or services are radical [22,43]. A four-item scale was adopted to assess technological turbulence, which describes the degree of technological change in an industry [63].

The following variables were controlled. We adopted ownership as the first control variable. We coded state-owned ventures as 1 and others as 0. We used industry as the second control variable by coding 1 manufacturing ventures as 1 and service ventures as 0. Venture size served as our third control variable. We used the natural log of the number of employees to assess venture size. We also controlled the impact of venture age by calculating the number of survival years. The last control variable is the venture development stage from 1 to 4 (i.e., 1 for introduction stage).

3.3. Reliability and Construct Validity

We adopted Cronbach's alpha to estimate the composite reliability. As Table 1 shows, no Cronbach's alpha value is less than 0.8, making them much higher than the suggested threshold (0.7). So the requirements of reliability are satisfied.

Table 1. Construct measurement summary.

Factors	Item Description	Standardized Loadings
EBT $\alpha = 0.86$ AVE = 0.78	(1) Our entrepreneurs maintain strong relationship with suppliers. (2) Our entrepreneurs maintain strong relationship with customers. (3) Our entrepreneurs maintain strong relationship with peer companies.	0.91 0.87 0.86
Risk Taking $\alpha = 0.81$ AVE = 0.73	(1) Our venture, in general, tends to invest in high-risk projects (2) Our venture shows a great deal of tolerance for high risk projects (3) Our business strategy is characterized by a strong tendency to take risks	0.80 0.90 0.85
Technological Turbulence $\alpha = 0.84$ AVE = 0.68	(1) The technology in our industry is changing rapidly (2) A large number of new ideas have been made possible through technological breakthroughs in our industry (3) There have been major technological developments in our industry (4) The technological changes in this industry are frequent	0.84 0.86 0.84 0.74
Radical Innovation $\alpha = 0.84$ AVE = 0.76	In the past three years, relative to our principal competitors: (1) We created more radically new products than our competitors. (2) We often brought in radically new products to entirely new markets (3) The percentage of sales from radical product innovation.	 0.88 0.88 0.85

We used two procedures to examine the convergent validity. First, we calculated average variances extracted (AVEs) for EBT, risk taking, radical innovation and technological turbulence. Each AVE value excel 0.5, indicates that the error variance is less than the variance that the variable shares with its scales. Second, all of the 13 standardized loadings in Table 1 are more than 0.7, suggesting a satisfied construct validity [77]. Thus, all constructs have satisfactory reliability and convergent validity.

We took the following steps to examine discriminant validity. Firstly, a chi-square difference approach was adopted. We ran tests for every pair of latent variables and found that none were non-significant (e.g., EBT vs. risk taking, $\Delta\chi 2(1) = 8.32$, $p < 0.001$), indicating a satisfied discriminant validity [78]. Secondly, as shown in Table A1, the correlation coefficients (between-construct variance) are significantly lower than the square root of the AVE (within-construct variance) for every variable, providing additional support for discriminant validity [77].

4. Empirical Results

4.1. Test of Hypotheses

This present study use the OLS regressions to test our models (in Table 2). The variance inflation factor (VIF) for each of the regression coefficients is calculated to test problems with potential multi-collinearity. We find that the largest VIF value is 1.39, indicating no serious multi-collinearity issue in our analyses [79].

We then conducted a three-procedure regression analysis to examine the mediating effect (see Table 2). Before the formal step, we first regressed radical innovation on controls (Model 1). Firstly, we regressed radical innovation on EBT and the control variables to test the direct effect of EBT on radical innovation (Model 2). EBT is positively related to radical innovation ($\beta = 0.26$, $p < 0.001$). Secondly, we regressed risk taking on EBT and controls to analyze the impact of EBT on risk taking (Model 3). H1 was supported by the positive coefficient of EBT ($\beta = 0.43$, $p < 0.001$). Thirdly, we regressed radical innovation on both EBT and risk taking simultaneously (Model 4). H2 was supported by the positive coefficient of risk taking ($\beta = 0.27$, $p < 0.001$). Simultaneously, the coefficient and significance of EBT was greatly reduced ($\beta = 0.15$, $p < 0.01$). These results suggest that risk taking partially mediates the EBT- radical innovation relationship, supporting H3. Through a Sobel test, our results further indicate the mediating effect of risk taking ($z = 4.04$, $p < 0.001$).

Table 2. Mediation and moderation analyses.

Variables	Risk Taking		Radical Innovation		
	Model 3	**Model 1**	**Model 2**	**Model 4**	**Model 5**
Controls					
Ownership	0.01	−0.14 *	−0.10+	−0.10+	−0.09+
Industry	−0.08	−0.10+	−0.09+	−0.08	−0.07
Venture Size	−0.01	0.06	0.04	0.04	0.04
Venture Age	0.01	−0.01	−0.01	−0.01	−0.02
Venture Stage	0.02	−0.04	−0.06	−0.06	−0.06
Main effects					
EBT	0.43 ***		0.26 ***	0.15 **	0.13 *
Mediating effect					
Risk Taking				0.27 ***	0.22 ***
Moderating effect					
Technological Turbulence					0.17 **
Risk Taking* Technological Turbulence					0.12 *
R^2	0.19	0.03	0.10	0.16	0.19
Adjusted R^2	0.17	0.02	0.08	0.14	0.17
$\triangle R^2$			0.07	0.06	0.03
F Value	12.17 ***	2.14+	5.84 ***	8.37 ***	8.22 ***

n = 322, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

A hierarchical moderated regression analysis is conducted to test H4 (Model 5). To reduce potential multi-collinearity, we standardized risk taking and technological turbulence and then create the interaction term between risk taking and technological turbulence [80]. The positive interaction item between risk taking and technological turbulence ($\beta = 0.12$, $p < 0.05$) indicates that H4 is supported. Using Aiken and West's procedure [80], we conducted a simple slope test to better understand the interaction effect. We estimated regression slope coefficients at high and low levels of risk taking. As shown in Figure 1, the slope decreases from 0.94 ($p < 0.001$) to 0.65 ($p < 0.001$) when technological turbulence changes from high to low.

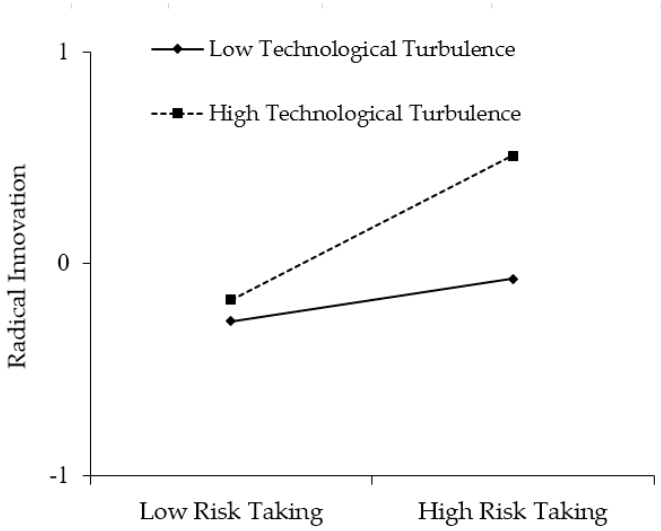

Figure 1. The interaction of risk taking and technological turbulence on radical innovation.

Employing Preacher et al.'s MODMED program [81], we further examined the moderated mediation effect. As shown in Table 3, a 5000-replication bootstrap sample with 95% confidence intervals (CI) revealed a conditional indirect effect of EBT on radical innovation when technological turbulence increase from low to high, the indirect effect of EBT on radical innovation has significantly increased (from 0.07 to 0.19), which suggests that risk taking significantly moderates the indirect effect of EBT on radical innovation through risk taking. Thus, H5 is supported.

Table 3. The conditional indirect effect in the presence of technological turbulence.

	The Conditional Indirect Effect of Technological Turbulence at = M ± 1 × SD		
	Boot Indirect Effect	**Boot SE**	**95% Bias Corrected CI**
M-1SD	0.07	0.05	[−0.04, 0.17]
M	0.12	0.05	[0.04, 0.22]
M+1SD	0.19	0.06	[0.06, 0.30]

Bootstrap = 5000; n = 322.

4.2. Robustness Checks

To check the potential relationship between radical innovation and corporate sustainability, we tested the correlation between radical innovation and product greenness. Product greenness was measured by a four-item scale (Cronbach's $\alpha = 0.87$) pertaining to the extent to which a firm's products decrease pollution, reduce resource consumption, and increase product recycling [82]. The correlation coefficient is positive and significant (b = 0.36, $p < 0.001$), suggesting that radical innovation is significantly positively associated with product greenness. This exploratory analysis provides additional empirical support to the link between radical innovation and corporate sustainability.

We also modeled the relationships through structural equation modeling (SEM) analyses to control measurement errors [83]. The results depicted in Figure 2 support our hypotheses with an adequate model fit ($\chi 2/df = 1.74$, CFI = 0.97, TLI = 0.96, RMSEA = 0.05, SRMR = 0.05).

H1 predicts a positive relationship between EBT and risk taking. The path coefficient from EBT to risk taking is significantly positive ($\beta = 0.49$, $p < 0.001$), supporting H1. H2 suggests a positive link between risk taking and radical innovation. As shown in Figure 1, H2 is supported ($\beta = 0.29$, $p < 0.001$). After inputting risk taking, the effect of EBT on radical innovation is reduced from 0.32 ($p < 0.001$) to 0.16 ($p < 0.05$), and the indirect effect of EBT on radical innovation is positive and significant ($\beta = 0.18$, $p < 0.01$), supporting H3.

To analyze the interaction effect of risk taking and technological turbulence on radical innovation (H4), we followed the guidelines introduced by Klein and Moosbrugger and adopted SEM with a maximum likelihood estimation [84]. In Step 1, without the interaction term, we build a linear effects structural model. In Step 2, we add the interaction term between risk taking and technological turbulence to the model. We compute the fit difference between the above two models and find an improved fit for the model with the interaction term path. We also find that the interaction effect on radical innovation is significantly positive ($\beta = 0.14$, $p < 0.05$), thus providing partial support for H4.

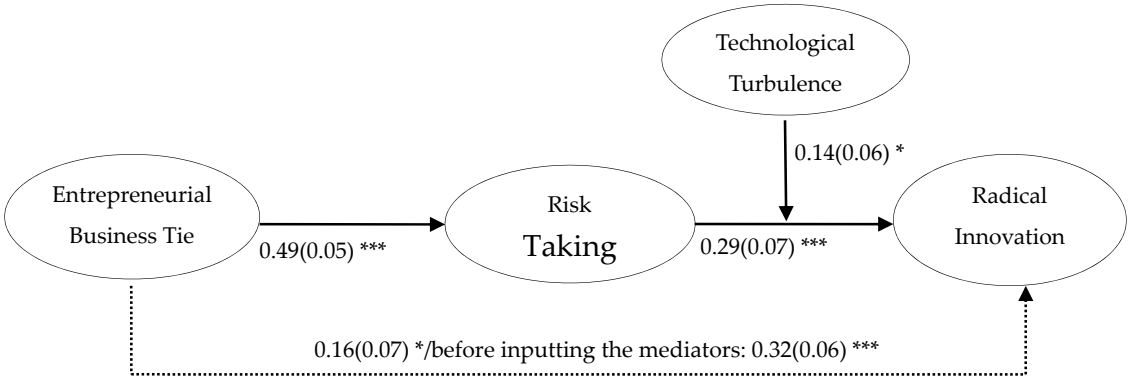

Figure 2. The results of structural path model. Controls: Ownership, Industry, Venture age, Venture size, and Venture Stage. For clarity, controls are not included in the figure. Standard errors in the parentheses.* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; $n = 322$.

As for H5, we employ the Monte Carlo Method (MCMAM) suggested by Selig and Preacher [85]. We conduct a parametric bootstrap analysis to test the conditional indirect effects between EBT and radical innovation via risk-taking at two levels of technological turbulence. We first split the whole sample into two sub-samples, high-technological turbulence sample (162 new ventures) and low-technological turbulence sample (160 new ventures). We then use bootstrapping to compute confidence intervals (CI) for the conditional indirect effect of risk taking on the EBT– radical innovation relationship at high and low levels of technological turbulence. In a 5000-replication bootstrap sample with 95% bias-corrected confidence intervals (CI), the indirect effect at high levels of technological turbulence ($\beta = 0.30$, 95% CI = [0.1552, 0.5494]) is significantly larger than at low levels of technological turbulence ($\beta = 0.06$, 95% CI = [−0.05437, 0.2099]), supporting H5 [86].

5. Discussion

5.1. Theoretical Implications

Recent corporate sustainability studies have emphasized the critical role of radical technological innovations [14,29]. In order to foster corporate sustainability, the aim of the present study was to open the black box of how and when EBT impels radical innovation. We were motivated by the prevalence and importance of EBT. Our empirical results confirm the impact of EBT on risk taking, the impact of risk taking on radical innovation, the indirect effect of EBT on radical innovation, and the moderating effect of technological turbulence. We further verify a moderated meditation model such that the indirect influence of EBT on radical innovation is stronger when technological turbulence is high.

Our study makes several research contributions. First, it contributes to corporate sustainability research by identifying key antecedents and boundary conditions of radical innovation. Existing research indicates that radical innovation has a great potential to solve the root causes of social and environmental issues through novel technologies, thus improving corporate sustainability [12,14,29]. Despite the high frequency of radical innovation in new ventures, the question of how to impel radical innovation is still understudied [10]. By focusing on how and when entrepreneurial

business tie promotes radical innovation, this study indirectly help to answer how to enhance corporate sustainability.

Second, it sheds new light on entrepreneurial research by investigating the effect of EBT on risk taking and radical innovation. Previous research has acknowledged the importance of entrepreneurial network tie and investigated its role in new venture growth. Nevertheless, despite the increasing importance of radical innovation, little research has explored the effect of EBT on this non-financial performance. Therefore, the current study provides more explanations about the value of EBT. In addition, recent research has begun to focus on how EBT influences new venture performance via resource management and opportunity capture [38]. Following this line of research, we investigate how EBT helps a new venture improve radical innovation through enhancing risk taking. Thus, it opens the black box between EBT and radical innovation, enriching the mediation mechanisms of EBT. Through a moderated mediation model, this study also presents a nuanced and clear picture of how and when EBT functions.

Third, this study contributes to risk taking research by exploring its antecedent, subsequent, and moderating effects in the entrepreneurial field. Relative to its antecedents, the outcomes of risk taking has been less studied [17]. Previous research has examined its effect on learning [56], product introduction [57], financial performance [54], and so on. Our study joins this research trend by investigating its effect on radical product innovation. In addition, we also identify an antecedent of risk taking by examining the effect of EBT on risk taking. Moreover, risk taking is often viewed as one dimension of unified entrepreneurial orientation [53]. Despite the call to investigate risk taking individually in the entrepreneurial field, existing research has paid less attention to this topic [21]. The current study thus echoes the call to study various dimensions of entrepreneurial orientation separately [18].

Finally, this study also contributes to the innovation ecosystem perspective by emphasizing the contingent effect of technological turbulence. Recent innovation ecosystem perspective indicates that various uncertainties pose severe challenges to entrepreneurs in radical innovation activities [10]. In contrast, our study finds that the effects of EBT and risk taking on radical innovation are stronger when technological turbulence is high. This finding indicates that technological turbulence not only poses challenges but also provides opportunities to entrepreneurs, providing a more complete picture of technological turbulence. The present study thus contributes to understanding the role of technological turbulence in the innovation ecosystem.

5.2. Managerial Implications

Our research also yields practical implications for Chinese entrepreneurs. First, we find that EBT has a positive impact on risk taking and radical innovation. With the increasing importance of corporate sustainability, entrepreneurs should realize the value of their business ties, and further leverage them to improve their radical innovation and corporate sustainability.

Second, we find that risk taking partially mediates the relationship between EBT and radical innovation. This finding indicates that there are two ways that EBT affects radical innovation. The common belief is that entrepreneurs can impel radical product innovation through directly obtaining knowledge and resources necessary for radical innovation. Entrepreneurs should also realize that they can utilize business ties to enhance their risk-taking capabilities and increase their risk preferences, indirectly promote radical product innovation.

Third, technological turbulence enhances the indirect influence of EBT on radical innovation. This finding indicates that the role of EBT in radical innovation activities is upon to external technological environment. In turbulent environments, entrepreneurs have more potential to realize the benefits of EBT. In contrast, in a stable environment, entrepreneurs are less likely to transmit their business tie into radical innovation through improving risk taking. Entrepreneurs should be aware of the influence of technological turbulence, and make best use of their business ties in different technological conditions.

5.3. Limitations and Future Directions

The present study could also be extended in the following aspects. First, our mediating mechanism is constrained by a cross-sectional methodology, which is difficult to avoid the inverse causality. Future research can solve this problem through a longitudinal design. Second, although recent corporate sustainability research has emphasized the critical role of radical innovation, we have not directly investigated the link between radical innovation and corporate sustainability. Future studies should provide more theoretical and empirical explanations about this relationship. Because of the economic transition and the policy imperatives, Chinese radical product innovation may produce a significant sustainability orientation. Future research can also examine and compare the relationship between radical innovation and corporate sustainability in other developing or developed countries. Third, we only focus on EBT due to its prevalence and importance in China. Given the critical role of family and friendship ties in the context of new ventures, future research may compare their effects on risk taking and further radical innovation. Some interesting results may occur since family members tend to prefer lower business risks [87]. Finally, there is a limitation because this study does not use a double-check procedure to validate the answers with the respondents. Future research can validate the interview results through some double-check procedures, such as employing a paired-questionnaire method to test the consistency of answers.

6. Conclusions

This study advances our understanding of how and when entrepreneurial business ties impel radical innovation through improving a new venture's risk taking in the conditions of various technological turbulence. In light of the importance of radical innovation in corporate sustainability, the intention of this study is to offer an alternative explanation for how entrepreneurial business ties promote corporate sustainability. We empirically examined related hypotheses through a sample of 322 Chinese new ventures. We found that entrepreneurial business ties significantly increase a new venture's risk taking and further radical innovation. The findings thus support the hypothesis that risk taking plays a mediating role in the relationship between entrepreneurial business tie and radical innovation. In addition, through a moderated mediation model, we also found that this mediating mechanism is moderated by technological turbulence. Specifically, the indirect effect of entrepreneurial business tie on radical innovation through risk-taking will be stronger when technological turbulence is high than when technological turbulence is low. We hope to improve understanding of the value of entrepreneurial business ties and the process of radical innovation.

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Appendix A

Table A1. Means, standard deviations, and correlations.

Variables	Mean	s.d.	1	2	3	4	5	6	7	8	9
1.Ownership	0.27	0.44	**1**	0.06	0.07	−0.12 *	0.02	−0.12 *	−0.06	−0.15 **	−0.15 **
2.Industry	0.30	0.46	0.07	**1**	0.03	−0.09+	0.06	0.00	−0.09+	−0.08+	−0.12 *
3.Venture Size [a]	4.38	1.48	0.08	0.04	**1**	0.02	0.24 ***	0.10 *	0.03	0.03	0.03
4.Venture Age	4.51	0.84	−0.11	−0.08	0.03	**1**	0.16 ***	0.00	0.01	0.08+	0.00
5.Venture Development Stage	2.52	0.57	0.03	0.07	0.25 ***	0.17 **	**1**	0.07	0.04	0.12 *	−0.05
6.EBT	5.24	1.03	−0.11	0.01	0.11	0.01	0.08	**0.88**	0.42 ***	0.28 ***	0.27 ***
7.Risk Taking	5.00	1.06	−0.05	−0.08	0.04	0.02	0.05	0.43 ***	**0.85**	0.40 ***	0.33 ***
8.Technological Turbulence	4.78	1.18	−0.14 *	−0.07	0.04	0.09	0.13 *	0.29 ***	0.41 ***	**0.82**	0.29 ***
9.Radical Innovation	4.67	1.38	−0.14 *	−0.11+	0.04	0.01	−0.04	0.28 ***	0.34 ***	0.30 ***	**0.87**
10.MV Marker	5.50	1.33	0.01	0.01	0.14 *	−0.09	−0.02	0.12 ***	0.21 ***	0.06	0.18 ***

n = 322; [a] Log-transformed; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Zero-order correlations are below the diagonal; Reliability coefficients are on the diagonal; adjusted correlations are above the diagonal.

Table A2. Sample profile (n = 322).

Characteristics	Number of Firms	Percentage (%)
1. Venture Age (years)		
One	1	0.3
Two	2	0.6
Three	34	10.6
Four	105	32.6
Five	154	47.8
Six	26	8.1
2. Geographic Location		
Coastal regions	173	53.7
Inland areas	104	46.3
3. Ownership		
SOEs	87	27.0
Non-SOEs	235	73.0
4. Industry		
Manufacturing	97	30.1
Services	225	69.9

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