Business ties and effectuation for radical innovation in small firms: the moderating role of competitive aggressiveness

Abstract

Purpose - Business ties play a key role in small firms' innovation. However, limited studies have addressed how business ties contribute to radical innovation in small firms. This study investigates the mediating role of effectuation in utilizing business ties in radical innovation by small firms. It also investigates the moderating effect of competitive aggressiveness on the focal association.

Design/methodology/approach – Based on survey data from 383 Iranian small firms, we used hierarchical regression analysis and structural equation modelling to test the hypotheses.

Findings – We found that experimentation and flexibility enable small firms to utilize their business ties in radical innovation while affordable loss and pre-commitment do not mediate the focal association. The study also found that small firms' competitive aggressiveness accentuates the positive impact of small firms' business ties.

Originality/value – This study contributes to understanding the role of business ties in radical innovation in small firms and highlights the importance of effectual mechanisms and competitive aggressiveness.

Keywords: Business ties, Effectuation, Radical innovation, Competitive aggressiveness, Small firms

1. Introduction

Innovation is a key for small firms to grow and achieve economic growth (Nguyen et al., 2019). It can be incremental, which refers to gradual and ongoing innovations; or radical, referring to radically different processes, technologies, or products (Sandberg and Aarikka-Stenroos, 2014). Due to liabilities of limited resources, some small firms rely on business ties as means for the creation or co-creation of radically innovative products (Waldkirch et al., 2021). Although a few studies have acknowledged the importance of social and business ties in small firms' radical innovations, the mechanisms through which such ties work are understudied.

Business ties with like-minded stakeholders play an important role in small firms' innovation by providing new ideas, supplementary knowledge, and other resources (Hao and Feng, 2016). In uncertain environments, business ties help run successful innovation projects by allowing firms to obtain supplementary resources and share strategic information to unpack environmental uncertainty. However, small firms need to apply certain mechanisms to activate their business ties and mobilize their resources toward their radical innovation aspirations (Sardari et al., 2024).

Effectuation theory provides a solid ground to explain networking and innovation in small firms with limited resources (Kerr and Coviello, 2020; Sardari et al., 2024). It explains how entrepreneurs utilize their limited resources, including social networks, to develop business ties and collectively co-create new artifacts (Karami et al., 2022; Sarasvathy, 2001). Effectuation process starts with existing means and explains a co-creative process through which self-selected stakeholders (both social and business ties) collectively make new products, services, and markets (Grégoire and Cherchem, 2020; Sarasvathy, 2022). Effectuation theory has received significant attention in innovation research (e.g., Sardari et al., 2024), exploring the role of the effectuation process in enabling small firms to co-develop innovative products.

Despite the growing body of research on small firms' innovation, little is known about the mechanisms through which business ties enable radical innovation (Lopez-Nicolas et al., 2020). Research suggests that applying effectuation logic enables small firms to overcome the liability of limited resources and newness (Szambelan et al., 2020) by turning business ties into strategic resources and providing mechanisms to share new ideas and access supplementary resources. Considering these liabilities, we apply effectuation theory to identify mechanisms

explaining how resource-poor small firms utilize their business ties to develop successful radical innovations. As such, we ask: *how do small firms apply their effectual logic to utilize their business ties in their radical innovation process?*

Competitive aggressiveness is defined as "beating competitors to the punch" (Miller, 1983), by challenging rivals and gaining a comparative advantage (Hughes-Morgan et al., 2018), and focusing on growth as a zero-sum game. Such strategic posture makes small firms look like opportunists who seek benefits in their networking activities (Rynarzewska et al., 2023). Thus, our second research question is: *does small firms' competitive aggressiveness moderate the relationship between their business ties and radical innovation?*

This study contributes to understanding radical innovation in the context of small firms by identifying mediation mechanisms that enable small firms to utilize business ties in their radical innovations. Our findings reveal that small firms apply effectual mechanisms to activate their business ties as a critical source of radical innovation. This study also shows that the competitive aggressiveness of small firms accentuates the focal association between business ties and radical innovation.

2. Theoretical background and hypotheses development

Radical innovation

Literature categorizes innovation in multiple ways. The degree of departure from existing technologies and practices is an established way of studying innovation (McDermott and O'connor, 2002). Radical innovation includes significant departures and changes from existing offerings, which radically change consumers' perceptions of the product (Sardari et al., 2024). Incremental innovation includes marginal changes such as using new supply sources and revising production processes (Bhaskaran, 2006). Innovation literature provides a rich picture of radical innovations in established firms identifying different factors that influence radical innovation, such as financial liabilities (Keupp and Gassmann, 2013), organizational culture (Naranjo-Valencia et al., 2017), human capital (Delgado-Verde et al., 2015), and entrepreneurial orientation (Ato Sarsah et al., 2020). The literature identifies some obstacles to radical innovation in small firms, such as a lack of resources (Sandberg and Aarikka-Stenroos, 2014). However, some small firms are remarkably innovative (Sardari et al., 2024) due to their radical innovation capabilities, which require the ability to transform

prevailing knowledge. Radical innovation capability enables small firms to experiment with new ideas by constant learning from market feedback (Bicen and Johnson, 2015). According to Subramaniam and Youndt (2005, p.452), radical innovation capability is defined as "the capability to generate innovations that significantly transform existing products and services." Thus, radical innovative capability is the capability to generate innovations that significantly transform existing products and services." As such, it is a dynamic capability that enables small firms to keep up with their changing environment and rapidly evolving customers' needs (Slater et al., 2013). However, the mechanisms that can develop such capabilities remains less studied (Rampa and Agogué, 2021), justifying more research on enablers and mechanisms of radical innovation in small firms.

Effectuation

Effectuation theory explains entrepreneurial action (Sarasvathy, 2001, 2024). It builds on the logic of control rather than the logic of prediction (Read et al., 2016). Effectuation theory does not look at control as only the result of prediction, but it considers prediction and control as diagonal (Read et al., 2016). As such, control is the core tenet of effectuation logic. It enables entrepreneurs to utilize their existing means to make their environment endogenous and collaborate with other like-minded market actors to insert control over their environment and collectively co-create a new future (Sarasvathy, 2022). The logic of control enables entrepreneurs to start with their existing means and seek access to complementary resources through social networking (Karami and Tang, 2022). The quality of ongoing interactions with self-selected stakeholders determines the level of commitment, which in turn provides access to necessary resources. Logic of control also increases the flexibility in dealing with unpredictable environments, which in turn enables entrepreneurs to identify emerging opportunities. The collective process of resource polling occurs through the pre-commitment of the self-selected stakeholders, sharing perceptions of environmental uncertainty and emerging opportunities, and working collectively to co-create new opportunities (Kerr and Coviello, 2020). As such, the effectuation process takes place through partnership, resource sharing, and collective action. Effectuation logic works under uncertainty, especially Knightian uncertainty, where the future is unpredictable (Cowden et al., 2023; Saraswathy, 2001). The logic of affordable loss is a key concept in effectuation theory, which explains a *doability* versus *scalability* mindset. Affordable loss allows entrepreneurs to experiment with their new ideas, gain feedback, learn, and fine-tune their ideas. By doing so, they make decisions under

uncertain situations where they cannot base their decisions on return on investment. They rather consider the affordability of loss in each situation; gaining commitment from other market actors increases the affordability of each partner, which in turn enables them to make better decisions pragmatically and co-create better opportunities (Karami and Hossain, 2024; Sarasvathy, 2022). However, it needs to be mentioned that experimentation is considered an effectual mechanism in some studies (e.g., Chandler et al., 2011), while others consider it as a causal mechanism (e.g., Sarasvathy, 2024).

Competitive aggressiveness

Competitive aggressiveness has been studied extensively in competitive dynamics (Hughes-Morgan et al., 2018) and entrepreneurial orientation literature (Boso et al., 2013). As an important part of entrepreneurial orientation, competitive aggressiveness explains how entrepreneurs aggressively search for new opportunities (Karami et al., 2021). Lumpkin and Dess (1996) defined competitive aggressiveness as a firm's "confrontational posture" in dealing with adversaries in their markets (Wales et al., 2011). The competitive dynamics literature defines competitive aggressiveness as the propensity to challenge competitors and enhance market position (Hughes-Morgan et al., 2018). A rich body of literature shows how competitive aggressiveness impacts firm performance. Conceptualizing it in terms of competitive volume, complexity, and heterogeneity, Hughes-Morgan et al. (2018) demonstrated that competitive volume enhances firm performance. Literature also reports inconsistent results regarding the association between firm size and its competitive aggressiveness. For instance, Chen and Hambrick (1995) observed that small firms are more likely to act more competitively while Crick et al. (2021) found a negative impact of competitive aggressiveness on small firms' performance. Figure 1 represents our theoretical framework explaining the process of radical innovation in small firms. As the model shows, small firms' business ties provide them with complementary resources which they utilize by applying effectual mechanisms to radically innovate their products and processes. The following section explains these relationships and develops hypotheses.

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2.1. Business ties and radical innovation

Radical innovation helps to attain a competitive advantage for firms to gain a prominent position in the market (Zhou and Li, 2012). However, small firms do not have the resources to assign to radical innovation projects (Chen et al., 2014). Business ties indicate the inter-organizational connections that firms develop with their key business partners to access a broader scope of resources, capabilities, and knowledge to perform innovation activities (Gupta and Malhotra, 2013). They are firms' relational connections with key stakeholders, such as customers, competitors, suppliers, and state organizations (Wang, 2022). Business ties are crucial for small firms to develop innovation by increasing social capital and proving access to new resources (Wang, 2022). More specifically, business ties provide market information, market relationships, marketing support (Gupta and Malhotra, 2013), and solutions to problems (Modi et al., 2024). Prior research finds that business ties contribute to small firm performance (Ingram and Roberts, 2000), product innovation (George et al., 2002), and identification of new market niches (Wind and Thomas, 2010). We know that radical innovation requires stronger ties with the stakeholders that possess important strategic resources (Wang et al., 2020) and are willing to take risks and commit their resources to their shared radical innovation ideas (Zhao et al., 2016). Research also suggests that collaborative networks focus more on innovation and enable firms to adapt to their competitive market environment (Fava Neves, 2007), while coordinated networks focus more on simple issues (Lay, Moore, and Word, 2009; Ventura-Fernández, et al., 2019). However, Yang et al. (2022) argued that overreliance on business networks may have negative impacts on smaller firms' innovations.; and Chen et al. (2014) observed an inverted U-shape relationship between business ties and radical innovation and called for further research to replicate the focal association in different transitional economies.

Radical innovation entails higher risk with uncertain outcomes and is typically beyond the firms' scope (Globocnik et al., 2022). As such, acquiring new knowledge is essential for radical innovation, and business ties are key to accomplishing it (Zhao et al., 2016). Business ties, complementing other types of ties, such as social ties, provide new knowledge and other supplementary resources, enabling specialized competence and synergistic developments. Furthermore, they provide access to external resources, which is especially important in emerging economies where small firms have difficulties in accessing finance (X; Zhao et al., 2016). Therefore, business ties enhance small firms' radical innovation performance (Ye et al., 2019).

H 1. There is a positive association between small firms' business ties and radical innovation.

2.2. Effectuation and radical innovation

Effectuation theory has been applied in innovation literature (Ryman and Roach, 2024), explaining innovation-related contexts, such as platform-based open innovation (Santoso, 2024), innovation performance, research and development (R&D), project management, new product development, and business model innovation (e.g., Karami et al., 2023). Effectuation logic enables small firms to manage uncertainty (Cowden et al., 2024) and take co-creative actions for innovation (Santoso, 2024). Sardari et al. (2024) observed that effectuation translates the autonomous motivation of managers in small firms into radical innovation. Nevertheless, studies on the role of effectuation on radical innovation are sparse. Considering that the determinants of innovation performance differ between small and large firms (Prajogo and McDermott, 2014), effectuation theory provides a strong theoretical basis for understanding innovation in small firms (Karami et al., 2023). Innovation activities entail risks and need valuable resources for which small firms mostly rely on their network (Sarasvathy, 2022). However, studies relating effectuation with business ties, innovation in general, and radical innovation, in particular, are limited, despite the importance of effectuation as a driver for transformation (Sarasvathy, 2022).

Effectual logic enables firms to look beyond causal reasoning to attain innovative outcomes. It includes principles applicable to making decisions under uncertainty by focusing on existing means and outcomes that can be gained under uncertainty (Sarasvathy, 2001). Effectual principles include affordable loss, experimentation, flexibility, and pre-commitment (Chandler et al., 2011; Roach et al., 2016). Effectuation principles represent an entrepreneurial mindset that aims to actualize entrepreneurs' general aspirations using available means and logic of control (Read et al., 2016; Sarasvathy, 2001). Effectuation starts with existing means and continues with partnerships among like-minded stakeholders who share their tangible and intangible resources in pursuit of a common aspiration. As such, it is proffered as a favorable decision-making approach for innovation (Brettel et al., 2012).

Affordable loss has a direct effect on firm performance (Roach et al., 2016). It is the core logic of control in effectuation theory which refers to the understating of what entrepreneurs can afford to lose at each step (Sarasvathy, 2001). Applying the logic of affordable loss allows small firms to make bold decisions at the affordable range for the constellation of the stakeholders and, at the same time, limit the risk of failure, by making quick and affordable experiments. Each action with affordable loss becomes a learning opportunity

contributing to the adjustment of the emerging shared goal (Crick and Crick, 2015). As such, affordable loss enables stakeholders to try innovative ideas for creating demand in the marketplace (Zhang et al., 2023).

Experimentation refers to trial and error with new business ideas (Brettel et al., 2012). Experimentation helps small firms focus on problem-solving by creating or selecting a possible solution and learning from the outcomes of each trial (Lopez-Nicolas, 2020). Effectual experimentation takes place within an effectual network where self-selected stakeholders commit their resources to an agreed new idea. Effectual experiments, therefore, cross out unpromising ideas earlier in the process and focus on more promising innovation ideas (Chandler et al., 2011). Research suggests that entrepreneurial experiences enable stakeholders to share and fine-tune their radical innovation ideas to enhance experimentation. Such experimentation with new ideas, tools, and processes enables small firms to launch radical innovations (Dean et al., 2022).

Flexibility is viewed as an advantage for smaller firms, whereas larger firms have developed a set of routines, procedures, and policies over time (Chandler et al., 2011), which slow them down in their reaction to changes in their environment. Flexibility in addressing the uncertainty of radical innovation decisions with a focus on affordable loss and welcoming unpredicted events as serendipity enables small firms to learn from each step and fine-tune their next action (Sarasvathy, 2001). Such flexibility allows them to consider surprise as a clue to create radically new products or new markets (Read et al., 2016), abandon unpromising experiments, and focus on more promising effects (Chandler et al., 2022).

Pre-commitment is a key mechanism in the effectuation process, which results in sharing resources and knowledge about the situation (Karami et al., 2023; Kerr and Coviello, 2020). Pre-commitment to the initial aspiration of developing innovative solutions enables stakeholders to share their knowledge and form a common perspective of the situation as a basis for building a new future through innovative solutions (Grégoire and Cherchem, 2020). It enables stakeholders to "reduce the uncertainty, minimize the cost of experimentation, and maintain flexibility" in the process of radical innovation (Chandler et al., 2011, p. 386).

Against this background, this study suggests the following hypotheses:

H 2. There is a positive association between effectuation and radical innovation

H 2.1. There is a positive association between affordable loss and radical innovation

H 2.2. There is a positive association between experimentation and radical innovation

H 2.3. There is a positive association between flexibility and radical innovation

H 2.4. There is a positive association between pre-commitment and radical innovation

2.3 Business ties and effectuation

Business ties are important external resources for the effectuation process (Galkina and Jack, 2022). Gaining access to complementary resources is a critical point in the effectuation process. While the effectuation process begins with existing social ties, small firm managers immediately start expanding their relationships with other stakeholders, including suppliers, distribution channel members, and other firms, to gain access to strategic resources (Karami and Tang, 2022). Establishing relationships with other businesses happens through the pre-commitment of business ties to the focal firm's general aspiration for innovative solutions, which requires a commitment of resources to fine-tune, further develop, and operationalize it (Galkina and Jack, 2022). As such, establishing business ties with other firms who own important supplementary resources enables radical innovation endeavors in small firms.

Using limited resources strategically is critically important for small firms. Experimentation with a small amount of committed resources is a way for partners to build trust, try to move on with their shared radical innovation ideas, and test the feasibility of their new ideas (Sardari et al., 2024). The humble and pragmatist approach to experimenting with new ideas within a network of business ties allows small firms to build trust with their business ties and collectively learn from each experimentation (Karami et al., 2023). Such an approach increases all parties' flexibility in dealing with environmental uncertainty and unplanned events (Chandler et al., 2011). Trust and commitment within the business network of small firms enable such flexibility (Johanson and Vahlne, 2017).

Affordable loss is the core mechanism that enables business network expansion, experimentation, and flexibility. Affordable loss in small firms' business networks is a logic of control that facilitates decision-making by each stakeholder at each stage. Affordable loss logic encourages resource commitment and active participation of stakeholders in more experimentation and learning by doing (Chandler et al., 2011). Prior research indicates that

experimentation and affordable loss have a U-shape association with R&D alliances (Fischer et al., 2021), meaning that firms must find the optimal point of effectuation to run successful R&D projects.

Against this background, we argue that business ties are positively associated with effectuation in general and its components in particular.

H 3. There is a positive association between small firms' business ties and effectuation.

H 3.1. There is a positive association between small firms' business ties and experimentation.

H 3.2. There is a positive association between small firms' business ties and flexibility.

H 3.3. There is a positive association between small firms' business ties and pre-commitment.
H 3.4. There is a positive association between small firms' business ties and affordable loss.

2.4 Effectual mechanisms mediate the association between business ties on radical innovation

Effectuation logic enables small firms to utilize their social and business ties and transform shared knowledge and other resources within their business networks into innovative ideas (Scazziota et al., 2020). Dyadic or network-level partnerships with supplier firms, customers, competitors, marketing service providers, and technology providers (Boso et al., 2013) are key mechanisms in the effectuation process in providing complementary resources and further developing new opportunities. Under uncertainty, effectual logic encourages small firms to initiate and strengthen interactions with like-minded, strong, and close ties (Kerr and Coviello, 2020) to make sense of the situation and collectively develop new situations. Radical innovation is associated with high uncertainty for small firms (Sardari et al., 2024), explaining why effectuation provides a useful mediation mechanism for small innovative firms to utilize their business ties in radical innovation under such conditions (Sardari et al., 2024). Effectuation logic provides mechanisms to unpack uncertainty within the network and turn the unpredictability of radical innovations into new opportunities in the innovation process (Karami and Tang., 2022).

Experimentation represents the process of entrepreneurs building a mental framework for businesses (Chandler et al., 2011) with considerable benefits in diversification (Deligianni et al., 2022). Both poor and fruitful experimentations are useful for entrepreneurs in learning

what went right or wrong so the experiential learning gained from experimentation adds to the means set of the effectual entrepreneurs (Scazziota et al., 2020). As such, experimentation utilizes resources within business networks to test new ideas early in the process, learn from failure, and move on with successful ideas (Zhang et al., 2023), putting supplementary resources of business ties to strategic use.

Affordable loss is a way to reach the market with minimum resources instead of considering expected returns on investment (Sarasvathy, 2001). Small firms' managers apply the affordable loss logic to control risk and avoid spendthrift (Brettel et al., 2012), which enables them to encourage their business ties to invest as much as they can afford and participate in the process of innovation without assuming too much risk. As such, affordable loss logic allows decision-makers to try affordable, innovative ideas emerging within the network, see the results, and adjust the initial idea (Sarasvathy, 2001). This reflective controlled process leads to the most promising innovative ideas and crosses out the unpromising ones early in the process.

Flexibility reflects contingencies that help leverage new innovation opportunities (Chandler et al., 2011), such as a flexible supply base and flexibility of organizational slack. Flexibility entails diverse and adjustable means provided by business ties that allow stakeholders to think of diverse solutions (Galkina and Jack, 2022). collective endeavor in business networks enables decision-makers to absorb uncertainty, be open to unexpected events, and turn them into profitable radical innovation opportunities (Chen et al., 2014). As such, it enables small firms to minimize the risk of wasting resources provided by business ties in unsuccessful experiments (Sapienza et al., 2004), increasing trust within business networks.

Pre-commitment within business and social networks means the establishment of partnerships for co-creating innovation opportunities (Brettel et al., 2012). Commitment development plays a central role in transforming business ties into new resources (Johanson and Vahlne, 2017). When self-selected stakeholders (e.g., business ties) develop pre-commitments to the general aspiration for radical innovation, they commit their knowledge, market information, time, money, and other required resources, and thus collectively create and actualize innovative ideas (Sarasvathy, 2022).

H 4. Effectuation logic mediates the association between business ties and radical innovation

H 4.1. Experimentation mediates the association between business ties and radical innovation

H 4.2. Affordable loss mediates the association between business ties and radical innovation

H 4.3. Flexibility mediates the association between business ties and radical innovation

H 4.4. Pre-commitment mediates the association between business ties and radical innovation

2.5 The moderating effect of competitive aggressiveness

Competitive intensity is an important characteristic of some markets that impacts small firms' efforts to activate business ties in their innovation endeavors (Chen et al., 2014), which requires entrepreneurial orientation. Competitive aggressiveness is one of the key dimensions of entrepreneurial orientation. It refers to "the type of intensity and head-to-head posturing those new entrants often need to compete with existing rivals" (Lumpkin and Dess, 1996, p. 139). Competitive aggressiveness determines how firms react to trends and demands prevalent in the existing market. In other words, it is about intensely challenging existing competitors to enter a market or outperform the competition and improve the market position (Lassen et al., 2006). High-performing firms frequently embrace competitive aggressiveness (Covin and Covin, 1990), affecting the performance of small firms.

Competitive aggressiveness determines how the firms perceive the competition and address demand and trends in their market (Lumpkin and Dess, 1996). Competitive aggressiveness, therefore, activates unconventional methods rather than classical ones in competition (Lumpkin and Dess, 1996). It is argued that due to the liability of newness (Stinchcombe, 1996), small firms are more likely to fail, and therefore, an aggressive stance in the market is critical for their survival (Dayan et al., 2016). While it is argued that competitive aggressiveness reduces cooperation for radical innovation (Zahra, 1996), and Chen et al. (2014) observed that competitive intensity along with demand uncertainty dampens the positive impact of business ties on radical innovation; others have considered competitive aggressiveness an enabler of radical innovativeness, because it indicates that small firms do everything to retain their market presence (Alonso-Dos-Santos and Llanos-Contreras, 2019). Porter (1985) observed several approaches to competitive aggressiveness, two of which can be related to innovativeness in small firms, that is, doing things differently, and repositioning the market offering and its channels. As such, small firms' competitiveness encourages them to radically innovate to develop products and services that are difficult for their competitors to duplicate (Aramburu and Sáenz, 2010).

H5. Small firms' competitive aggressiveness moderates the mediated association between business ties and radical innovation.

3. Method

3.1 Sample

The data was collected from founders and managers of small firms across different industries in Iran. Small firms are important players in Iran's sanctioned economy, contributing significantly to the national economy. This study defines small firms as businesses with fewer than 50 employees, which makes our findings comparable with small firms in Europe (European Commission, 2005). This study used Iran's Chamber of Commerce database to identify small firms across different industries. Dealers and agents of large businesses and retailers were excluded, and the study focused on both manufacturing and service provider businesses. The database provided a list of 920 small firms. The authors investigated the identified small firms' websites and other social media platforms and reduced them to 766 firms due to the incomplete information about those firms on their websites. The authors then telephoned them to check if they were interested in participating in our study. A total of 286 firms did not want to participate in our study, leaving us with 480 small firms with expressed interest. Among the participating firms, 97 firms did not complete the survey after three telephone reminders, resulting in the final sample of 383 completed answers yielding an effective response rate of 50 percent (383 out of 766). The relatively high response rate was partly due to the familiarity of the two of our Iranian co-authors with the context of our study and their presence in the field, which facilitated the process of contacting the target firms and encouraged them to complete the survey (Shepherd et al 2020).

3.2 Data collection

Surveys have been considered an established way of collecting data in entrepreneurship and small business research, which enable measuring complex latent constructs using multi-item scales. Data was collected between April 2021 and January 2022. Founders and managers of small firms, as the key informants, filled out the questionnaires. Top managers of a firm significantly influence the strategic decisions and actions of small firms (Hambrick and Mason, 1984). The Chamber of Commerce's comprehensive database allowed us to effectively cover the small firm population in Iran and reduce the risk of unrepresentativeness in our sample (Sills and Song, 2002). Two techniques were used to reduce the nonresponse bias. First, the

authors used the independent t-test to compare three types of firms in terms of firm size and age: those who did not show any interest in our study, those who initially showed interest but did not complete the survey, and the ones who completed the survey. The result showed no significant difference between the three, indicating that there was no major risk of nonresponse bias. The early and late responses also were compared using t-tests, and the results revealed no significant differences between the two groups (Armstrong and Overton, 1977). The authors also conducted Harman's single-factor analysis to control common method variance (CMV) (Podsakoff et al., 2012). All items were entered in one exploratory factor, and Varimax principal rotation and Principal axis factoring extraction techniques were used. Six factors emerged, explaining 58 percent of the total variance. The first factor accounted for 17.95 percent of the total variance, this result revealed that no single factor explained the majority of the total variance. Second, SPSS 28 was employed to analyze the marker variable effect.

3.3 Measures

Effectuation. The study used Chandler et al.'s (2011) scale to measure the decision-makers' effectual logic. Following Chandler et al. (2011) effectuation was conceptualized as a four-dimensional construct including experimentation, affordable loss, flexibility, and pre-commitment. "We focus on developing alliances with other people and organizations", and "Our partnerships with outside organizations and people play a key role in our ability to provide our product/service" were dropped from the scale due to the feedback from the experts and the results of the pilot study.

Business ties. Following Dubini and Aldrich (1991), the survey used a formative scale including five important business ties of small firms, namely good connections with supplier firms, customer firms, competitor firms, marketing agencies, and technological collaborators. 'Marketing-based collaborators' was dropped from the scale after the pilot study.

Radical innovation. Subramaniam and Youndt's (2005) scale was used to measure small firms' radical innovation capability.

Competitive aggressiveness. Three competitive aggressiveness items from Boso et al.'s (2013) entrepreneurial orientation scale were adopted to measure small firms' competitive aggressiveness. A 7-point Likert scale was used (1 as "Strongly disagree" and 7 as "Strongly agree") for measuring all of the constructs. The appendix presents the scales' items and their factor loadings.

Control variables. The study also controlled several important variables with potential impact on our substantive variables. *Firm age* was controlled for two reasons. First, older firms have more experience and expertise, which may help them successfully apply effectual logic in their decision-making (Sarasvathy, 2001). Second, firm age can influence SMEs' performance (Cucculelli et al., 2014). The study measured firm age by asking, "In what year was this firm established?" *Firm size* was also controlled, assuming that the size may influence firms' access to resources (Zahra et al., 2000), and their performance. We measured the firm size in terms of the number of its employees. *Industry type* was measured as an open question: "What is your firm's main industry," assuming that the substantive associations in our study might differ across industries (Boso et al., 2013). We also measured *export percentage.* The question was, "On average, approximately what proportion of your firm's sales has come from international markets over the *last three years?"* Finally, we measured the *causal logic of decision-making (*Candler et al., 2011), considering that the decision-makers of small firms may apply the causal logic of decision-making under different conditions (Sarasvathy, 2001).

4. Analysis and Results

4.1 Validity and reliability

The authors assessed the validity and reliability of our measures. First, SPSS 28 was used to conduct an exploratory factor analysis. Principal component analysis extraction and a Varimax with Kaiser normalization technique were used. Bartlett's test of sphericity and Kaiser–Meyer–Olkin (KMO) test of sampling adequacy produced satisfactory results for our substantive constructs as follows. Business ties construct (explaining 47.41 percent of the total variance, KMO .67, and Bartlett's test $\chi 2$ 179.20; df 6; Sig. 0.00), effectuation construct (explaining 58.97 percent of the total variance, KMO .80, and Bartlett's test $\chi 2$ 2803.56; df 105; Sig. 0.00), radical innovation capability construct (explaining 87.87 percent of the total variance, KMO .76, and Bartlett's test $\chi 2$ 933.79; df 3; Sig. 0.00), and competitive aggressiveness (explaining 83.37 percent of the total variance, KMO .72, and Bartlett's test $\chi 2$ 1121.55; df 3; Sig. 0.00). Second, SmartPLS v.4.0.9.6 was used to run a confirmatory factor analysis. As a result, all items were loaded to their relevant factors, and the final multi-item scales were satisfactory (SRMR= .07, and NFI= .80) (Henseler et al., 2014).

Third, the authors assessed construct validity in several steps: the composite reliabilities (CR) were calculated to assess the internal consistency of the major measurement scales. All CR scores were above the accepted threshold of 0.7 (Hair et al., 2013). Fourth, the authors

assessed the convergent validity through the average variance extracted (AVE). The AVE of all major constructs was above the accepted level of 0.5 (Hulland, 1999). Fifth, the authors also assessed the discriminant validity of the major scales. The authors used the Fornell-Larcker criterion and calculated the square root of the AVE scores, and all values were higher than the related values in both rows and columns—the diagonal in Table 1 (Birkinshaw et al., 1995). Heterotrait-Monotrait Ratio (HTMT) was also used to assess the discriminant validity of the major scales. As a result, the HTMT values were significantly below the critical value of 0.9 (Franke and Sarastedt, 2019). Table 1 illustrates the means, standard deviations, correlations, CRs, AVEs, and the square root of the AVE scores of the key variables.

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4.2 Structural model

The authors used the structural equation modelling technique to assess the explained variance, significance, and size of coefficients in our model's structural paths (Figure 2). SmartPLS v.4.0.9.6 was used and the authors used the nonparametric bootstrapping technique (with 500 subsamples) (Hair et al., 2013) to test the precision of the structural paths in the model (Efron and Tibshirani, 1993). Hypothesis one proposed a positive association between small firms' business ties and their radical innovation. The path between the two variables was significant ($\beta = .22$, $t = 3.49$, $p < .01$). Hypothesis two proposed a positive association between four elements of effectuation and radical innovation. The path between experimentation and radical innovation ($\beta = .24$, $t = 3.81$, $p < .01$), and the path between flexibility and radical innovation were significant ($\beta = .15$, $t = 2.19$, $p < .01$). However, the path between affordable loss and radical innovation ($\beta = -.02$, $t = .33$, n.s), and the path between pre-commitment and radical innovation were insignificant ($\beta = .05$, $t = 1.05$, n.s). Hypothesis three proposed a positive association between small firms' business ties and four elements of effectuation. The path between business ties and experimentation ($\beta = .52$, $t = 12.93$, $p < .01$), the path between business ties and pre-commitment ($\beta = .47$, $t = 11.70$, $p < .01$), and the path between business ties and flexibility were significant ($\beta = .54$, $t = 14.34$, $p < .01$). However, the path between business ties and affordable loss was insignificant ($\beta = -.12$, $t = 1.90$, n.s.). Hypothesis four proposed a mediation role for effectuation elements in the association between business ties and radical innovation. Following Baron and Kenny's (1986) advice, the study considered four

conditions for a mediation relationship as follows: (a) the independent variable is significantly correlated with the dependent variable; (b) the mediator is significantly correlated with the dependent variable; (c) the independent variable is significantly correlated with the mediator; and (d) after entering the mediator into the model, the significant association between the dependent and independent variables become insignificant. Our results for hypotheses 1–3 met the conditions a, b, and c. The mediators then were entered into the model. As a result, the significant relationship between business ties and radical innovation became insignificant (β =.10, t = 1.56, n.s.). Finally, hypothesis six proposed a moderation effect for competitive aggressiveness in the focal relation between business ties and radical innovation. The result confirmed the moderation effect for competitive aggressiveness (β = .15, t = 3.50, p < .01). As a result, the path between business ties and radical innovation became stronger (β = .12, t = 1.89, p < .10). The simple slope plot (Becker et al., 2023) presented in Figure 3, shows that (green line) there is a stronger relationship between business ties and radical innovation in small firms with higher competitive aggressiveness.

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Insert Figure 2 about here

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Insert Figure 3 about here

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4.3 Robustness checks

We conducted two robustness checks. First, data were checked for possible multicollinearity. As a result, the highest variance inflation factor (VIF) was 1.70, well below the accepted threshold value of 5. Second, we used a hierarchical regression analysis to replicate the moderated mediation model of the study and replicate our structural equations modelling results. SPSS (28, IBM) was used to run the model. Table 2 presents the results of the regression analysis. As shown in Model 2, small firms' business ties were positively related to radical innovation by those firms (β .17, p < .01), establishing a significant relationship between the independent and dependent variables. Model 3 shows the significant mediation role of effectual experimentation (β .28, p < .01) and flexibility (β .17, p < .01) in the focal association between business ties and radical innovation (β .07, n.s.). Finally, Models 4 and 5 show the moderating

effect of small firms' competitive aggressiveness on the association between their business ties and radical innovation. The moderation effect is positive, indicating that small firms' competitive aggressiveness accentuates their radical innovation (β; business ties x competitive aggressiveness .76 $p < .01$). Figure 4 illustrates the moderation effect.

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Insert Table 2 about here

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Insert Figure 4 about here

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5. Discussion

A growing body of research existed addressing the process of radical innovation by small firms. In line with Wang et al. (2020), who emphasize that radical innovation requires strong business ties with key stakeholders, our findings suggest that business ties play a central role in small firms' radical innovation performance. Our findings suggest that business ties enable radical innovation by providing access to complementary resources, capabilities, and knowledge to boost their radical innovation capabilities. This becomes more important for small firms with liabilities of limited resources.

The findings show that experimentation and flexibility are two important mechanisms for translating small firms' business ties into radical innovation capabilities. Experimentation with new ideas shared within business networks enables small firms to try new ideas in problem-solving efforts early in the innovation process, learn from experience, and increase their success rate. The flexibility of small firms in rearranging their resources and processes enables them to accommodate surprise, learn from failure, and take corrective actions. This aligns with Scazziota et al.'s (2020) observation that the experiential learning gained from experimentation adds to the means set of the effectual entrepreneurs, and that flexibility enables entrepreneurs to build on contingencies that help leverage new opportunities (Chandler et al., 2011).

However, our findings did not show a significant mediating role for pre-commitment and affordable loss. This is an important observation because both of these variables are important in effectuation theory. As this study reveals, affordable loss does not result in radical

innovation, which may imply that focusing on affordable loss keeps decision-makers busy with the downside of their radical innovation aspirations and takes them away from radical ideas. This is in line with Szambelan et al.'s (2020) observation that affordable loss is negatively associated with firm innovation performance. This is understandable considering the limited amount of resources that small firms own. In other words, radical innovation requires considerable risk-taking with uncertain outcomes, which requires trust and commitment to compensate for the risk (Johanson and Vahlne, 2017). Pre-commitment also did not play a mediation role in radical innovation, confirming the findings of Deligianni et al. (2022). It can be understood in terms of the constraining nature of pre-commitment within some business networks. Radical innovation requires risk-taking, which might be constrained by the more conservative members of the business networks (Ruiz-Ortega et al., 2022).

Finally, competitive aggressiveness accentuates the association between business ties and radical innovation, highlighting the importance of competitiveness for resource-poor small firms that emphasize radical innovation for their survival and growth. These findings align with Porter's (1985) emphasis on the positive impact of competitive aggressiveness on innovation. It is also in line with Alonso-Dos-Santos and Llanos-Contreras (2019) and adds to Aramburu and Sáenz's (2010) observation that a small firm's competitiveness enables it to radically innovate its products and services. This result may imply that competitive aggressiveness, which is present in entrepreneurial-orientated small firms (Boso et al., 2013), interferes with trust and commitment to their business ties. This is in line with Lumpkin et al.'s (2010) observation that competitive aggressiveness contradicts a firm's long-term orientation, that is, developing and maintaining useful business ties requires a long-term perspective. Ye et al. (2019) also observed that business ties have negative interaction effects with competitor orientation on innovation.

5.1 Theoretical implications

Our findings have several important scholarly contributions. Overall, this study contributes to the understanding of radical innovation in small firms by identifying two effectual mechanisms that enable small firms to utilize their business ties as a source of their radical innovation. Second, this study contributes to effectuation theory by decomposing it into its four components and explaining how experimentation and flexibility enable small firms to be flexible in their relationships within their business networks, collaborate with their business ties, and mobilize their resources in experimenting with new ideas for radical innovation

processes. Finally, this study theorizes the contingent impact of the competitive aggressiveness of small firms on their radical innovation capabilities. These are interesting findings as they allow us to see which components of effectuation logic work in innovative small firms, and how competitive aggressiveness accentuates the role of these mechanisms, elaborating on the theory by fine-tuning its boundary conditions (Ryman and Roach, 2024).

5.2 Practical implications

This study offers several implications for entrepreneurs and managers of small firms. First, it suggests that business ties are important for radical innovation. Therefore, small firms need to strengthen their business ties and consider them a source of new ideas and supplementary resources for radical innovation. Such an approach requires a long-term trust-based relationship with key business partners. Second, this study finds that experimentation and flexibility play a key role in utilizing business ties in radical innovation. Hence, small firms should develop their organizational structure to have flexibility in collaborations with their business ties. Small firms should also consider experimentation as part of their innovation strategy to learn what aspects of their ideas work and revise their radical innovation process quickly and efficiently to facilitate the innovation process. Third, competitive aggressiveness may have a double-edged impact. It can keep small firms proactive in their innovation process and enhance their innovation performance. However, small firms should be cautious when they work with their business ties, as it may signal opportunism and weaken trust within their business networks. Finally, our findings can inform curriculum development. Courses on small firms can consider business networking, flexibility, and experimentation as three non-predictive strategies available for resource-poor small firms.

5.3 Limitations and future research directions

Several limitations in our research provide opportunities for future studies. First, as a cross-sectional study, this research was unable to capture the impact of time on the entire model. A longitudinal study can help capture the dynamics of effectual decision-making over time. A longitudinal study can explain the trust and commitment development process within small firms' business networks over time. Business ties also are dynamic and change over time. Future studies may want to use longitudinal designs to capture the dynamics of mediation and changes in our model. Second, this study used Chandler et al.'s (2011) scale to measure effectuation. The scale considers experimentation as an effectual mechanism but does not

include some critical aspects of effectuation, such as effectual partnership. As such, our results should be interpreted cautiously regarding the effectuation theory. Future research may take other scales, such as Roch et al.'s (2016), to measure all principles of effectuation theory. Third, this study focused only on business ties and did not consider other types of networks as well as the network-driven and network-dependent nature of effectuation. Fourth, although CMV was tested, we acknowledge the limitations of this method. Future studies could consider obtaining data from different sources to measure independent and dependent variables. Fifth, this study did not test the impact of radical innovation on small firms' performance. As such, it is unclear whether radical innovation by small firms enhances their financial or overall performance. Future research may include performance to provide more strategic results for small firms. Finally, this study did not provide detailed dynamics and nuances of the mediation mechanisms. Future research may apply a qualitative case study method to provide more details.

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Table 1 Descriptive statistics and pairwise correlations for comparison analysis

Variable	CR	AVE	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12
1. Firm age	-	-	2.76	1.05												
2. Firm size	-	-	2.60	1.42	.45**											
3. Export percentage	-	-	1.74	1.17	.07	.05										
4. Hi-Low Tech	-	-	1.69	.46	.33**	.23**	.09									
5. Causation	.95	.72	4.94	1.18	-.16**	-.09	.09	-.26**								
6. Business ties	.78	.48	4.95	1.06	-.05	-.02	.08	-.24**	.59**	(.69)						
7. Experimentation	.84	.58	3.96	1.23	-.14**	-.23**	-.03	-.27**	.40**	.40**	(.76)					
8. Affordable loss	.93	.82	4.81	1.38	.09	-.11**	-.06	.05	-.04	-.03	-.16**	(.91)				
9. Pre-commitment	.78	.50	4.71	1.07	-.10	.01	.11*	-.07	.34**	.50**	.18**	-.00	(.71)			
10. Flexibility	.90	.71	5.09	1.10	.30**	-.34**	.01	-.30**	.64**	.46**	.47**	.10*	.30**	(.84)		
11. Radical innovation	.96	.88	3.07	1.44	-.20**	-.24**	.04	-.36**	.31**	.31**	.45**	-.04	.17**	.41**	(.94)	
12. Compet aggressiveness	.96.	.88	3.56	1.54	.05	.11*	-.03	.06	-.07	-.15**	-.04	.10	.00s	-.05	.12*	(.94)

* Correlation is significant at the 0.05 level. ** Correlation is significant at the 0.01 level. Two-tailed test.

Table 2 Results of hierarchical regression analyses

	Radical innovation capability				
	Model 1	Model 2	Model 3	Model 4	Model 5
Firm age	-.01	-.02	-.01	-.01	-.02
Firm size	-.15**	-.16**	-.07	-.09	-.08
Export percentage	.05	.04	.06	.07	.07
Hi-Low tech	-.27**	-.25**	-.21**	-.21**	-.21**
Causation	.22**	.12*	-.03	-.03	-.04
Business ties		.17**	.07	.11	-.25**
Experimentation			.28**	.27**	.26**
Affordable loss			-.00	-.02	-.01
Pre-commitment			.03	.01	.01
Flexibility			.17**	.16**	.17**
Compete aggressiveness				18**	-.53**
Compete aggr x Bus ties					.76**
Δ R^2	.20	.02	.09	.03	.02
Adjusted R^2	.19	.21	.29	.32	.34
Δ F	19.21	8.49	11.37	17.25	12.97

Standardised coefficents are reported * $p < .05$ ** $p < .01$

Figure 1 Conceptual model

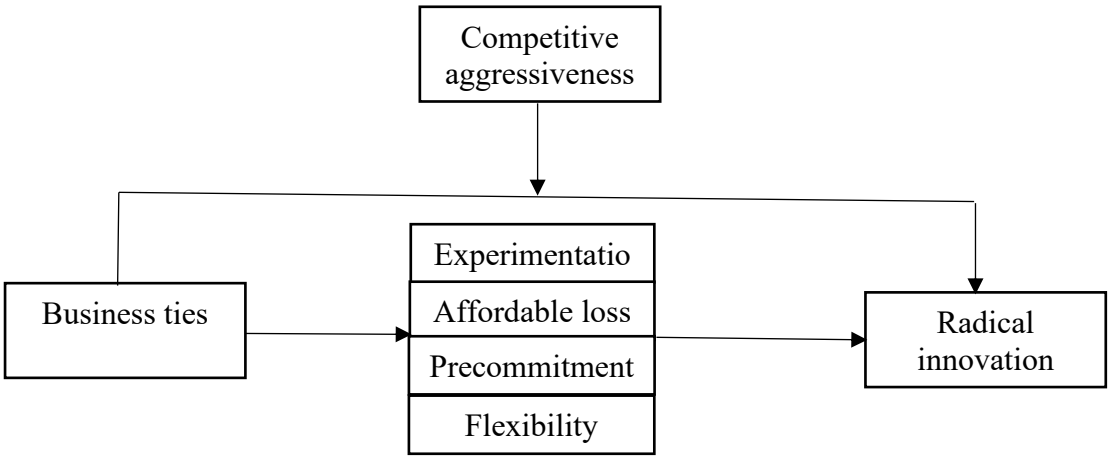


Figure 2 Structural equation model (standardized parameter estimates are shown with *p* values)

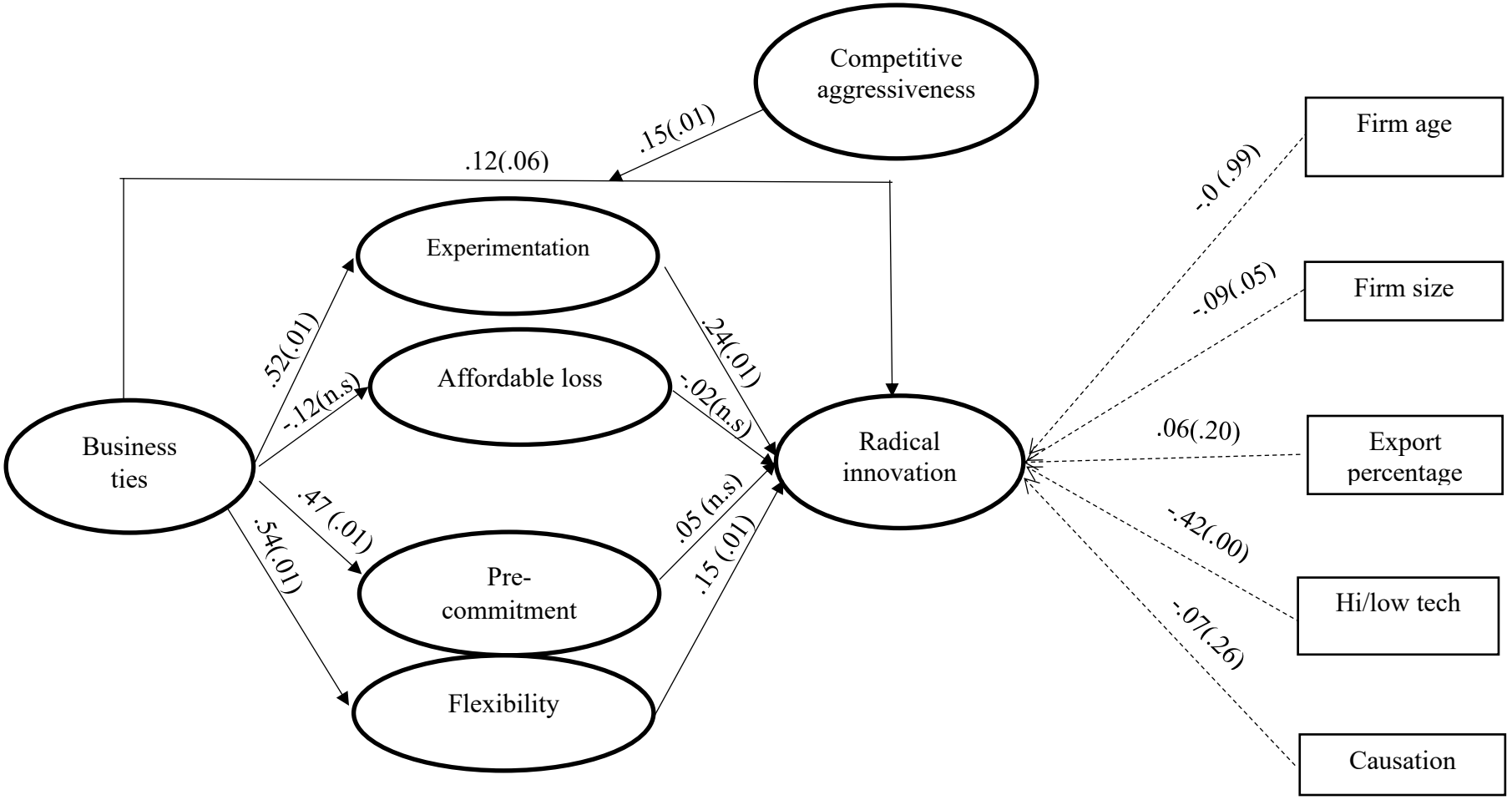


Figure 3 Simple slope analysis

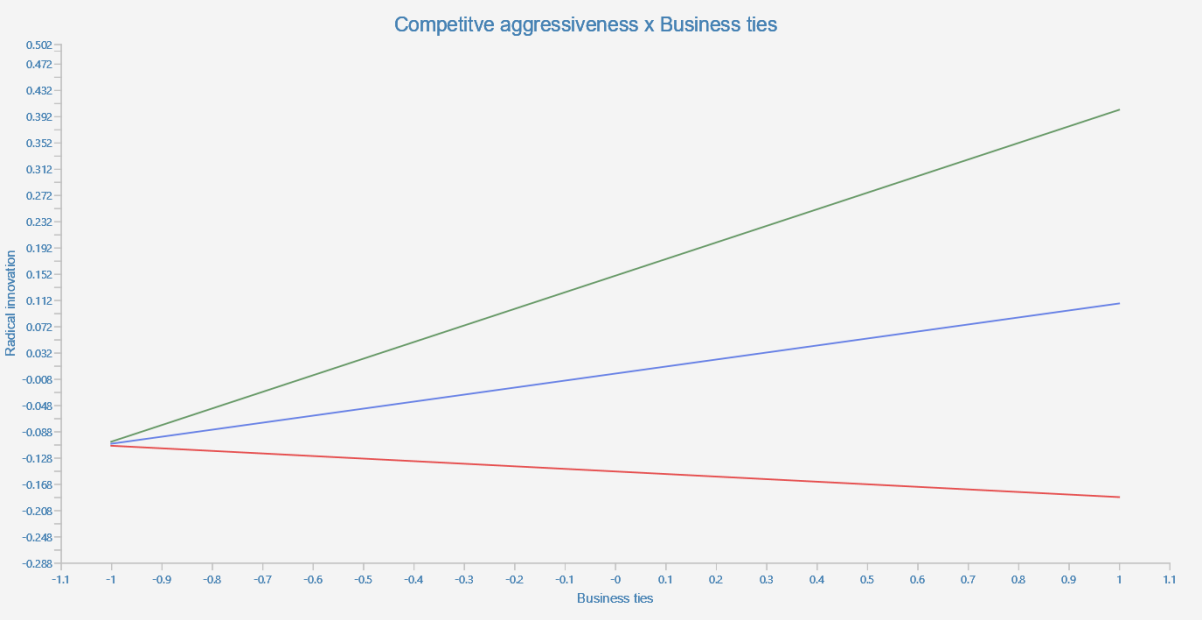
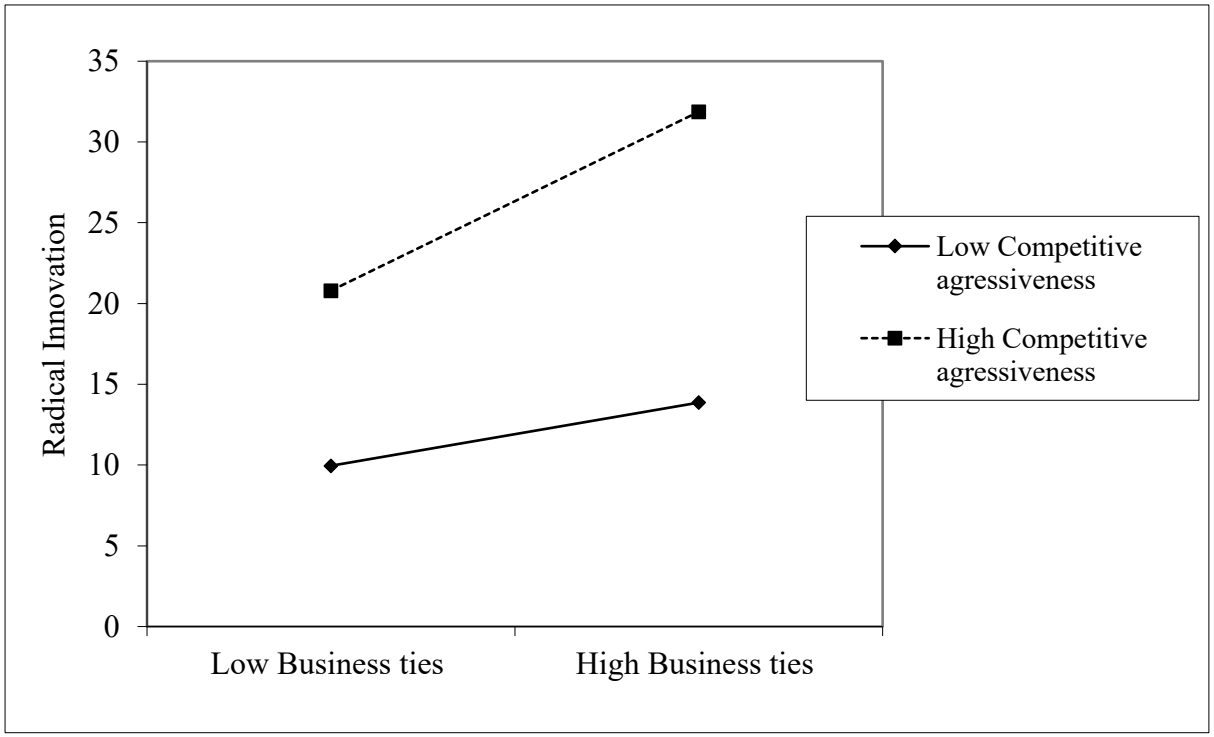


Figure 4 Radical innovation capability as a function of business ties and competitive aggressiveness



Appendix

Measures

Scale	Factor loading
Experimentation	
We experiment with different products and/or business models.	.75
The product/service that we now provide is essentially the same as originally thought when at the start-up phase.	-.65
The product/service that we now provide is substantially different than we first imagined.	.84
We try a number of different approaches until we find a business model that works.	.81
Affordable loss	
We are careful not to commit more resources than we could afford to lose.	.83
We are careful not to risk more money than we are willing to lose with our initial idea.	.87
We are careful not to risk so much money that the company would be in real trouble financially if things didn't work out.	.80
Pre-commitments	
We use a substantial number of agreements with customers, suppliers, and other organizations and people to reduce the amount of uncertainty.	.66
We use pre-commitments from customers and suppliers as often as possible.	.65
Our network contacts provide low-cost resources.	.81
By working closely with people/organizations external to our organization, we have been able to expand our capabilities greatly.	.77
Flexibility	
We allow the business to evolve as opportunities emerge.	.79
We adapt what we are doing to the resources we have.	.48
We are flexible and take advantage of opportunities as they arise.	.84
We avoid courses of action that restrict our flexibility and adaptability.	.73
Business Ties	
Top managers at our firm have built good connections with managers at supplier firms.	.63
Top managers at our firm have built good connections with managers at customer firms.	.75
Top managers at our firm have built good connections with managers at competitor firms.	.71
Top managers at our firm have built good connections with managers at technological collaborators.	.66
Radical innovation	
Innovations that make your prevailing product/service lines obsolete.	.93
Innovations that fundamentally change your prevailing products/services.	.93

Innovations that make your existing expertise in prevailing products/services obsolete.	.95
Competitive aggressiveness	
We typically adopt a “kill the competition” posture in our target markets.	.80
We take hostile steps to achieve competitive goals in our target markets.	.95
Our actions toward competitors can be termed as aggressive.	.97