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Bricolage effects on new-product development speed and creativity: The moderating role of technological turbulence☆

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ABSTRACT

This study provides a theoretical account of bricolage effects on two critical new-product advantages. Survey data from 222 firms reveal that bricolage hastens new-product development (NPD), but has an inverted U-shaped relationship with new-product creativity. However, under high technological turbulence, bricolage has an enhanced positive association with NPD speed. Consequently, this study contributes to bricolage theory and practice by revealing how bricolage influences new-product advantages and identifying boundary conditions for successful NPD.

1. Introduction

Developing new products successfully is vital for firms to generate and maintain competitive advantage in a competitive marketplace (Sheng, Zhou, & Lessassy, 2013; Zhou & Li, 2012), especially for firms in emerging economies such as China, striving to be globally influential innovators (Liu, Ding, Guo, & Luo, 2014). However, many firms from emerging economies face turbulent technological and market competition, often lack sufficient resources (Gao, Xie, & Zhou, 2015; Yi, Li, Hitt, Liu, & Wei, 2016), and have less-developed external capital market accessibility (Hoskisson, Eden, Lau, & Wright, 2000).

One strand of the literature posits that a firm's resource construction activities can provide viable solutions under resource constraints (Baker, Pollock, & Sapienza, 2013; Salunke, Weerawardena, & McColl-Kennedy, 2013; Steffens, Senyard, & Baker, 2009). Among them, *bricolage*, defined as "making do with whatever is at hand by reuse and recombination" (Baker & Nelson, 2005, p. 333) has been identified as an approach to new-product development (NPD) (e.g., Cunha, Rego, Oliveira, Rosado, & Habib, 2014; Senyard, Baker, Steffens, & Davidsson, 2014). However, the exact relationship between bricolage and new-product outcomes remains the topic of an ongoing debate (Bechky & Okhuysen, 2011; Ciborra, 1996; Lanzara, 1999).

On one hand, bricoleurs remedy resource constraints, help firms enhance innovation by improvising (Baker, Miner, & Eesley, 2003), and gather new materials and knowledge for meeting time demands (Garud & Karnøe, 2003). For instance, through bricolage, small and medium enterprises (SMEs) can improvise ways to cope with difficulties and hasten new information system development (Ferneley & Bell, 2006). On the other hand, since bricolage is usually embedded in local, uniplex networks and focuses on immediate local needs (Baker, 2007), it has gradually leveling positive effects on innovation; the positive effects may turn negative for a lack of heterogeneous resource and knowledge (Senyard et al., 2014).

We argue that one notable reason for these mixed results is that existing studies have failed to explicitly identify the role of bricolage on two new-product advantage (NPA) dimensions: *NPD speed* and *new-product creativity* (NPC) (Chen, Damanpour, & Reilly, 2010; Im & Workman, 2004), two strategic determinants of new product success (Cui, Wen, Xu, & Qin, 2013; Sheng et al., 2013). In fact, bricolage brings different process knowledge, product knowledge, and critical resources that may influence these two NPA dimensions differently. However, previous studies have not considered this issue.

Therefore, the present study contributes to existing literature by focusing on two shortcomings. First, it hypothesizes and empirically validates how and why bricolage influences two dimensions of NPA differently: NPD speed and NPC. Specifically, this study integrates the theoretical argument that superior skills or superior resources affect positional advantages (Day & Wensley, 1988) and bricolage literature (Baker, 2007; Baker & Nelson, 2005; Senyard et al., 2014) to argue

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that bricolage contributes positively to NPD speed, but has an inverted U-shaped relationship with NPC.

Additionally, this study provides both the direct linkage and the moderating route by which bricolage differentially affects these NPA dimensions. Specifically, drawing on the contingency view, it explores how bricolage value is contingent on the level of *technological turbulence*, which influences firm's resource decisions and behaviors (Ciborra, 1996; Fisher, 2012) and creates unique opportunities and challenges for NPD (Sheng, Zhou, & Li, 2011; Zhao, Cavusgil, & Cavusgil, 2014). Technological turbulence reflects the rate of innovation in the industry and pushes firms to adjust their NPD pace to cope with external competition, thus representing a critical force that can alter the value of bricolage activities. In that, the present study shows that both the firm's bricolage activity and external technological conditions may interactively influence NPA. Consequently, it highlights the relevance of creating new value from existing resources that prior business managers and the academic communities have generally missed. This study also informs that managers should properly recombine resources at hand to gain NPA rather than wait for external and expensive resources, especially when technology changes rapidly. However, these decision makers should also be aware that appropriate responses to resource constraints depend on the understanding that diverse NPA goals require different bricolage strategies.

2. Theoretical background and hypotheses development

2.1. Bricolage as a neglected source of NPA

This study uses the "source-position" framework (Day & Wensley, 1988) and perceives bricolage as a *source* of NPA. This framework shows that "a firm's superior skills/resources yield positional advantages" (Day & Wensley, 1988, p. 3). Superior skills allow firms to perform more effectively or adapt more responsively to market changes than competitors. Superior resources can also give long-term positional advantages in providing superior value for customers.

This framework has been used to examine the antecedents of NPD positional advantages. For example, Kim and Atuahene-Gima (2010) suggest that exploratory and exploitative market learning as two types of superior capability are sources of advantage, which can leverage new knowledge and best use existing knowledge to bring two types of positional advantages, namely, new-product differentiation and new-product cost efficiency. Ahmadi, O'Cass, and Miles (2014) find that the interaction between marketing resources and capability, or the interaction between technology resources and capability are different sources of advantages which can complement with each other to acquire positional advantages, namely: first-product differentiation and first-product cost efficiency. Although this line of research is valuable in revealing the potential impact of resources or capacity on positional advantages, it offers limited insights into specific ways to build positional advantages when firms' internal resources are constrained.

Meanwhile, emerging bricolage literature suggests that bricolage can provide advantages when resources are constrained (Baker et al., 2013; Salunke et al., 2013; Steffens et al., 2009). For example, new ventures under resource constraints can use and recombine resources at hand to gain advantageous strategic positions (Steffens et al., 2009). As such, service firms can use bricolage to find heterogeneous value in ostensibly identical resources to enhance service innovation and acquire favorable competitive positions (Salunke et al., 2013). Similarly, resource-constrained organizations may skillfully use bricolage strategies to resist and change cognitive institutions to gain competitive advantages (Baker et al., 2013). Extending this logic, bricolage could be a source of NPA.

Innovation and strategy literature explains that firms gain NPA when they continuously strive to assure that their products are competitively superior (Day & Nedungadi, 1994; Day & Wensley, 1988). NPA can take many forms, including new-product quality, reliability, creativity, cost efficiency, and uniqueness (e.g., Ahmadi et al., 2014; Im & Workman, 2004; Kim & Atuahene-Gima, 2010). Base on the framework of "source–position", this study focuses on both competitor and customer viewpoints and emphasizes that NPD speed and NPC are key dimensions of positional NPA, in agreement with previous studies (e.g., Chen et al., 2010; Im & Workman, 2004; Zhao et al., 2014). Although NPD speed and NPC may correlate (Ganesan, Malter, & Rindfleisch, 2005; Parker, Krause, & Covin, 2015), they often have different antecedents and consequences (Ganesan et al., 2005; Sheng et al., 2013), and many studies take them as independent variables (e.g., Cui et al., 2013; Zhao et al., 2014). Therefore, this study explores why and how one type of antecedents may have differential effects on NPD speed and NPC (Cui et al., 2013; Fang, 2008).

NPD speed refers to "the speed with which new products are developed" (Ganesan et al., 2005, p. 57). Time-based competition, first-mover advantage, and fast-followers literature (e.g., Kessler & Chakrabarti, 1996, p. 1143; Menon, Chowdhury, & Lukas, 2002, p. 324) all indicate that NPD speed may be beneficial for competitive advantage. Under rapidly changing business environments, competitive advantages often depend on whether firms can provide the required value in the least amount of time and ahead of their main competitors (Cankurtaran, Langerak, & Griffin, 2013).

NPC, another key reflection of NPA (Im & Workman, 2004), refers to the ability to introduce novel products or think of original features (Ganesan et al., 2005). New-product innovativeness is critical because customers are compelled to buy innovative products that may be a better fit for their needs (Langerak, Hultink, & Robben, 2004). Although NPD speed and NPC require different types of knowledge and resources, they are both important in assuring that new products will be successful (Cankurtaran et al., 2013; Sheng et al., 2013). Therefore, firms must consider how and when they can best improve NPA under resource-constrained environments. As such, firms can use bricolage to gain positional advantages under resource constraints (Baker et al., 2013; Salunke et al., 2013; Steffens et al., 2009). Their bias for action and improvisation can help hasten NPD, while heterogeneity of knowledge and methods of creative recombination may affect NPC (Garud & Karnøe, 2003; Senyard et al., 2014). Subsequently, this inspects the specific effects of bricolage on NPA's two dimensions.

2.2. The specific effect of bricolage on NPA

The source-position framework suggests that a firm's superior skills yield positional advantages, allowing the firm to perform more effectively or adapt more responsively to market changes than competitors (Day & Wensley, 1988). As such, bricolage is an important source of advantages, which can help a firm build appropriate skills to quickly reconstruct resource combinations under resources constrained contexts (Baker et al., 2013; Salunke et al., 2013; Steffens et al., 2009). NPD speed is one type of positional advantage, which focuses on time based competition with competitors (Kessler & Chakrabarti, 1996; Menon et al., 2002), and this study shows how bricolage can positively affect NPD speed for the following reasons.

First, NPD speed often depends on the timely accumulation of process knowledge (Ganesan et al., 2005) for prototypes and manufacturing designs (Millson, Raj, & Wilemon, 1992). Through trial-and-error, bricolage can bring intimate manufacture and process knowledge from handy resources in a timely manner that hastens NPD (Baker & Nelson, 2005). For example, a study of Moroccan farmers shows they use bricolage to successfully adapt their knowledge of drip irrigation in a short time (Benouniche, Zwarteveen, & Kuper, 2014).

Second, bricolage entails a refusal to enact limitations and help the firm test critical materials and technologies for rapid NPD (Garud & Karnøe, 2003). Bricoleurs use amateur skills to provide timely technology supplies (Baker & Nelson, 2005) and recombine internal and external workable methods to hasten NPD (Banerjee & Campbell, 2009). For example, during the development process of Danish wind turbines, firms use handy resources such as wood and lorry gears and other unstandardized resources, and refuse to enact limitations to construct technologies from users, evaluators, and regulators to hasten NPD (Garud & Karnøe, 2003).

Third, hastening NPD may depend on an organization's ability to improvise (Ganesan et al., 2005), which means simultaneous planning and execution (Miner, Bassof, & Moorman, 2001). Bricolage's bias for action promotes improvisation (Baker et al., 2003) for testing and validating new products in short cycles (Cunha et al., 2014). For example, a study of SMEs shows that internal and external actors improvise to hasten the development of new information systems and rapidly satisfy firm and customer needs (Ferneley & Bell, 2006). Therefore,

H1. Bricolage is positively related to NPD speed.

Bricolage is often associated with "second best solutions, maladaptation, imperfection, inefficiency, incompleteness" (Lanzara, 1999, p. 347), where "the outcomes of it are sometimes hybrid, imperfect, transient artifacts" (Lanzara, 1999, p. 347). However, others have argued that bricolage may create brilliant results (Garud & Karnøe, 2003; Lévi-Strauss, 1967). Given these inconsistencies, Senyard et al. (2014) speculate that bricolage and innovativeness may have an inverted U-shaped relationship, but only with partly empirical validation. They point out potential negative effects of bricolage: "(1) wasted efforts; (2) ad hockery, satisficing; and associated lack of cumulative development; and (3) failure to engage with competent suppliers and demanding customers" (Senyard et al., 2014, p. 5). Therefore, bricolage may have declining marginal returns on innovativeness. Extrapolating from Senyard et al. (2014), this study explores whether bricolage has an inverted U-shaped relation to NPC.

Bricolage methods of creative recombination of handy resources may provide idiosyncratic knowledge and ideas that help NPC. However, it can make it difficult to construct more heterogeneous resources (Lanzara, 1999; Senyard et al., 2014), which impair NPC and NPD speed, to a lesser extent, because the latter depends more on quick resource constructs (Ferneley & Bell, 2006; Lanzara, 1999), while NPC improvement depends more on constructing heterogeneity knowledge (Banerjee & Campbell, 2009; Garud & Karnøe, 2003). Consequently, this study shows that bricolage has an inverted U-shaped relation to NPC as follows.

First, NPC improvement often depends on acquiring adequate product knowledge (Ganesan et al., 2005). Bricoleurs may use existing networks across industry, domains, and departments to bring new-product concepts, ideas, and materials to improve NPC (Banerjee & Campbell, 2009; Garud & Karnøe, 2003). Given that bricoleurs are often embedded in local, uniplex networks, and mainly focus on local immediate needs (Baker, 2007; Baker & Nelson, 2005; Senyard et al., 2014), engaging in more bricolage may reduce the heterogeneity of acquired product knowledge, and have a gradual negative marginal return on NPC (Cui et al., 2013; Fang, 2008).

Second, NPC improvement depends on effective product concept testing that provides insights into new-product ideas (Ganesan et al., 2005). By experimenting with existing resources, bricoleurs (Baker & Nelson, 2005; Guo, Su, & Ahlstrom, 2015) create unique solutions by developing diverse troves to test new-product concepts. The bricolage process of experimenting with existing resources often accompanies trial-and-error learning (Duymedjian & Rüling, 2010), which helps match product ideas with handy resources to enhance NPC. However, given bricolage's potential negative effects of "ad hockery" and "satisficing" (Senyard et al., 2014), excess may tinker with existing resource and impair NPC.

Third, NPC depends on skillfully recombining new and old components (Alnuaimi, George, & Schillebeeckx, 2014). Past combinative experience can decrease the likelihood of failure in combinations, and new technological components provide potential for breaking through recombination (Banerjee & Campbell, 2009; Garud & Karnøe, 2003). Therefore, recombining new and old resources successfully will lead to higher product creativity. Bricolage brings material, ideational, or human inputs from inside and outside the firm, improves the chance of recombining new and old resources, and thus improves NPC. However, too much bricolage will reduce resource novelty from locally constructed networks and the chance of further successful recombining of new and old resources. Over time, the probability of detecting novel combinations from locally constructed resources diminishes due to less novelty can be detected (Galunic & Rodan, 1998). These arguments suggest a declining marginal return of bricolage's positive effect on NPC. Therefore,

H2. Bricolage and NPC have a curvilinear relationship: bricolage has an initial positive effect on NPC, but the positive influence flattens and subsequently declines at high bricolage levels.

2.3. Moderating effects of technological turbulence

Technological turbulence is defined as "the rate of technological change in the industry" (Jaworski & Kohli, 1993, p. 57). A rapidly changing technological environment is characterized by "short product development cycles and fast technological obsolescence" (Atuahene-Gima & Li, 2004, p. 583; Zhao et al., 2014, p. 1060), which may create opportunities for firms to "build superior competitive positions by changing or upgrading their products" (Sheng et al., 2011, p. 4), and may also create challenges that uncertainty leads to high failure rates (Cunha et al., 2014; Ciborra, 1996). Fast-changing environments require firms to access new knowledge and provide new solutions faster to maintain competitive advantage (Cankurtaran et al., 2013). Therefore, unstable technological environments compel firms to rely on more resource construction strategies such as bricolage to conduct NPD.

We posit that technological turbulence positively moderates the effect of bricolage on NPD speed. First, bricolage enhances the ability to quickly respond to NPD opportunities under high levels of technological turbulence by bringing intimate manufacture and process knowledge in a timely manner (Baker & Nelson, 2005), continuously modifying product designs as changes occur (Zhao et al., 2014), and hastening prototype development and manufacturing design (Millson et al., 1992). Moreover, accelerated technology changes constantly reallocate opportunities and threats, shift industrial standings, and reshape market power (Afuah, 2001), and it may be inefficient to rely only on using standard resources for NPD. Instead, bricolage should be treated as a critical choice, highlighting its enhanced value. Therefore, under high technological turbulence, bricolage hastens NPD. Therefore,

H3. The level of technological turbulence positively moderates the relationship between bricolage and NPD speed.

We also propose that technological turbulence positively moderates bricolage effects on NPC. First, it can strengthen the positive effects of bricolage on NPC, as rapid technological changes offer new-product opportunities that "firms can use to appeal to and expand their customer bases" (Sheng et al., 2011, p. 4), but such opportunities may be quickly obsolete (Atuahene-Gima & Li, 2004). Through increased bricolage, new ideas can be conceived and materials used to devise creative new products and seize NPD opportunities from technological changes (Banerjee & Campbell, 2009; Garud & Karnøe, 2003). Furthermore, under high technological turbulence, technology becomes more multi-disciplinary and dynamic (Zhao et al., 2014), and the firm may rely on suppliers, customers, or handy resources to attain NPD necessary know-how (Cui et al., 2013; Fang, 2008; Stanko, Molina-Castillo, & Harmancioglu, 2015). Moreover, the refusal to enact limitations of bricolage helps construct more heterogeneous product knowledge and unique solutions to improve NPC (Banerjee & Campbell, 2009; Garud & Karnøe, 2003).

Second, technological turbulence attenuates the potential negative effects of too much bricolage on NPC. High technological turbulence disrupts the current balance between resource needs and available

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resources and skills (Atuahene-Gima & Li, 2004), stimulating firms to find new services from existing resources. Therefore, this situation may attenuate the negative effects of resource heterogeneity reduction for local network over embeddedness. This also force firms to conduct constant testing or more trial-and-error learning to construct more resources and solutions (Duymedjian & Rüling, 2010). Furthermore, rapid technological obsolescence may give bricoleurs opportunities to utilize existing technological resources deemed obsolete by competitors (Baker & Nelson, 2005; Garud & Karnøe, 2003). Thus, this may attenuate the negative effects of new technological resource reduction for over-embedding. Overall, this study contends that bricolage can be used to enhance NPC under high technological turbulence (Stanko et al., 2015). Therefore,

H4. The level of technological turbulence positively moderates the relationship between bricolage and NPC.

Fig. 1 shows the conceptual framework: The model assumes that bricolage has different effects on NPD speed and NPC. Additionally, technological turbulence strengthens these effects.

3. Methodology

3.1. Data collection and sample description

A survey was conducted in 2014 using a list provided by the Chinese Ministry of Commerce, and focused on firms located in Guangdong and Zhejiang provinces, both pioneering areas of China's policy of reform and opening, with rapidly growing economies and resource constraints.

The scales in the questionnaire were adapted from English (Ganesan et al., 2005; Jaworski & Kohli, 1993; Senyard et al., 2014), translated into Chinese, and retranslated to double check meaning (Brislin, 1980). Top managers were interviewed regarding scale appropriateness to the Chinese context, and the questionnaire was modified accordingly. Subsequently, researchers performed a pilot test on 30 corporate CEOs to verify and refine the questionnaire, whose data were excluded from the final study.

PhD students with entrepreneurship and innovation knowledge assisted. First, 1200 random firms received a letter of introduction and a request to participate in return for feedback reports. Interest was confirmed telephonically, and the questionnaire was sent by self-addressed return envelope, and could be mailed or emailed back. Three hundred firms responded, but 78 provided incomplete answers to the questionnaire, with an overall response rate of 18.5% (222/1200).

In the final sample, 14.9% of the firms have existed for a maximum of 3 years; 27.9%, for 3–8 years; 29.7%, for 8–15 years; and 27.5%, for >15 years. Regarding sales, 32.4% had sales of 30 million RMB or less; 42.8% had sales of 30–300 million RMB; and 24.8%, >300 million RMB. The businesses are classified according to their core business development stages (Miller & Friesen, 1984): the birth stage occurs in the first three years (Senyard et al., 2014); the growth stage occurs when sales growth exceeds 15%; the mature and stable stage occurs when sales growth is <15%; the decline stage occurs when core profitability starts declining (Miller & Friesen, 1984). In the final sample, 15.3% of firms are in the birth stage; 53.6%, in the growth stage; 23.4%, in the mature and stable stage; and 7.7%, in the decline stage. Regarding research and development (R&D) expenditures to sales ratio (Cohen & Levinthal, 1990), 14.9% had zero R&D; 17.6% had 0–1% R&D; 28.8% had 1–3% R&D; 25.2% had 3–10% R&D; 9.5% had 10–30% R&D; and 4.1% had >30% R&D.

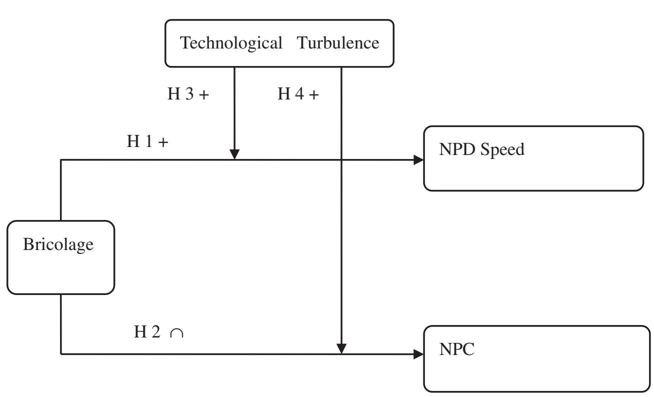

Fig. 1. Conceptual model.

A *t*-test conducted to examine non-response bias shows no significant differences between early- and late-responding firms (Armstrong & Overton, 1977) in firm age, sales, R&D intensity, and stage. The *t*-test comparison between those who responded by mail or email also showed no significant differences.

3.2. Measures

3.2.1. Dependent variables

The dependent variables are *NPD speed* and *NPC*. Building on Ganesan et al. (2005), four items are used to measure *NPD speed* and five to measure *NPC*. Responses are on a five-point Likert scale: 1 = *strongly disagree* or *very low*; 5 = *strongly agree* or *very high*.

3.2.2. Independent variables

Eight items from Senyard et al. (2014) are used to measure the extent to which firms fully use *bricolage*; that is, they use resources at hand to cope with new problems and opportunities. Responses were on a five-point Likert scale.

Following Jaworski and Kohli (1993), three items are used to measure *technological turbulence*; that is, the rate of change and instability of the technology environment. Responses were on a five-point Likert scale. Table 1 provides the measures of all variables.

3.2.3. Controls

Control variables are firm age, firm sales, firm stage, R&D intensity, and competitive intensity. Table 1 shows *competitive intensity* items that impact NPD (Kim & Atuahene-Gima, 2010).

3.3. Reliability and validity

Exploratory factor analysis (EFA) is used to identify the underlying relationships between measured variables, results showing no cross-loading between different factors and five suitable factors: (1) bricolage (BR), eight items; (2) NPC (NC), five items; (3) NPD speed (NS), four items; (4) competitive intensity (CI), three items; (5) technological turbulence (TU), three items. Eigenvalues of the five factors are 1.08–8.13, with 70.53% of total variance explained. Table 1 shows items, EFA factor loadings, percentage of variance explained, and factor reliabilities (i.e., alpha values).

First, to assess variable reliability, Cronbach's alpha was used to estimate inter-item consistency. As Table 1 shows, the alpha values are 0.74–0.93, all exceeding the 0.7 threshold value (Nunnally, 1978). Second, MPLUS 7 was used to run confirmatory factor analysis (CFA): the five-factor model (including all multi-item scales) had a good fit (Table 2) with all item loadings significantly on the predicted latent factors (Table 1). Table 3 shows that composite reliabilities (CR) range from 0.74 to 0.93, which further verify variable reliability.

The CFA factor loadings estimate convergent validity. Most factors loadings in Table 1 are higher than the 0.7 criteria (Nunnally, 1978), with only four items lower than 0.7; the lowest is 0.65, but all loadings are significant (DiStefano & Hess, 2005). Only one variable has an average variance extracted (AVE) of 0.49; the other variable's AVEs exceed the 0.5 benchmark (Fornell & Larcker, 1981). Therefore, CFA results demonstrate convergent validity.

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Table 1
Factor analysis results of the survey.

Factors and items	EFA loadings[a]					CFA loadings
1. Bricolage (BR)						
(a) We are confident of our ability to find workable solutions to new challenges by using our existing resources	**0.74**	0.22	0.06	0.10	−0.05	0.72**
(b) We gladly take on a broader range of challenges with our resources than others would be able to	**0.78**	0.13	0.11	0.04	0.01	0.77**
(c) We use any existing resource that seems useful to responding to a new problem or opportunity	**0.82**	0.10	0.03	−0.00	0.02	0.78**
(d) When dealing with new problems or opportunities, we take action by assuming that we will find a workable solution	**0.77**	0.15	0.09	0.02	0.04	0.75**
(e) When dealing with new problems or opportunities, the firm take action by assuming that it will find a workable solution	**0.68**	0.12	0.18	0.02	−0.12	0.66**
(f) By combining our existing resources, we take on a surprising variety of new challenges	**0.75**	0.17	0.14	−0.10	0.09	0.76**
(g) When we face new challenges, we put together workable solutions from our existing resources	**0.78**	0.18	0.14	−0.04	0.03	0.79**
(h) We combine resources to accomplish new challenges that the resources were not originally intended to accomplish	**0.77**	0.12	0.12	−0.08	0.09	0.76**
2. NPC (NC)						
(a) Our new product is very novel for our industry	0.22	**0.78**	0.33	−0.03	0.07	0.88**
(b) Our new product offering new ideas to our industry	0.23	**0.80**	0.34	−0.04	0.02	0.90**
(c) Our new product is creative	0.21	**0.82**	0.33	−0.05	0.04	0.90**
(d) Our new product is interesting	0.19	**0.81**	0.24	−0.00	0.02	0.79**
(e) We are capable of generating ideas for other products	0.31	**0.75**	0.23	0.04	0.05	0.77**
3. NPD speed (NS)						
(a) NPD time is far ahead of our project timeline	0.20	0.39	**0.77**	−0.07	0.09	0.85**
(b) We develop new products faster than the industry norm	0.15	0.32	**0.86**	−0.03	0.03	0.91**
(c) We develop new products is much faster than it's expected	0.22	0.33	**0.83**	0.02	0.03	0.92**
(d) We develop new products faster than its typical product development time	0.15	0.32	**0.73**	0.05	−0.04	0.72**
4. Competitive intensity (CI)						
(a) There are many "promotion wars" in our industry	−0.02	0.09	0.04	**0.86**	−0.02	0.78**
(b) Anything that one competitor can offer, others can readily match	0.01	−0.05	−0.08	**0.80**	−0.01	0.65**
(c) Price competition is a hallmark of our industry	0.00	−0.08	0.03	**0.86**	0.11	0.81**
5. Technological turbulence (TU)						
(a) Technologies in our industry are changing rapidly	0.01	0.08	0.06	0.07	**0.82**	0.75**
(b) It was very difficult to forecast technological developments in our industry	0.01	−0.13	0.07	0.00	**0.81**	0.66**
(c) Newly developed technologies and processes in our industry can easily become out of date	0.04	0.17	−0.07	0.01	**0.80**	0.69**
% variance explained	22.00	16.81	13.56	9.33	8.33	
Alpha	0.91	0.93	0.91	0.79	0.74	

Note. The rotation method is Varimax, with Kaiser normalization. Bold figures are the highest factor loadings of indicators on factors from EFA; alpha total = 0.8890; total variance = 70.530; KMO = 0.893; Bartlett spherical test = 3231.590; significance = 0.000.
[a] The extraction method for EFA is principal component analysis.
** $p < 0.01$.

Three methods are used to assess discriminant validity (Farrell, 2010, p. 326). First, CFA examines the discriminant validity of the five-factor model (Liang, Farh, & Farh, 2012; Wang & Takeuchi, 2007). Table 2 shows that the five-factor model (BR, NC, NS, CI, TU) had a good fit compared with four-factor, three-factor, two-factor, and one-factor models, which indicates good discriminant validity between all variables. CFA was also used to further examine the discriminant validity of two dependent variables. The two-factor (NPC, NPD speed) model has a good fit (χ^2 (26) = 91.54, $p < 0.001$, CFI = 0.96, TLI = 0.95, RMSEA = 0.11, SRMR = 0.04) compared with the one-factor (combined NPC and NPD speed) (χ^2 (27) = 366.96, $p < 0.001$, CFI = 0.80, TLI = 0.73, RMSEA = 0.24, SRMR = 0.08), showing good discriminant validity.

Second, AVE exceeds other variables' squared correlation to assess discriminant validity (Table 3) (Hair, Black, Babin, Anderson, & Tatham, 2006). Third, AVE versus shared variance test was used to examine discriminant validity (Fornell & Larcker, 1981). Table 3 shows that maximum shared variance (MSV) value and average shared variance (ASV) values were lower than AVE (Hair, Black, Babin, & Anderson, 2014, p. 605). Overall, the results indicate good discriminant validity between constructs.

3.4. Common method bias

Regarding common method bias (CMV), first, Harman's one-factor test (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003) shows that no single

Table 2
Model comparison in CFA analysis.

Model	χ^2	df	$\Delta\chi^2$	CFI	TLI	RMSEA	SRMR
Model 1 five-factor model	388.08	220		0.95	0.94	0.06	0.04
Model 2 four-factor model (BR, NC, NS, CI + TU)	538.25	224	150.17(4)**	0.90	0.89	0.08	0.07
Model 3 four-factor model (BR, NC + NS, CI, TU)	663.15	224	275.07(4)**	0.86	0.84	0.09	0.06
Model 4 four-factor model (BR + NC, NS, CI, TU)	1020.71	224	632.63(4)**	0.75	0.71	0.13	0.11
Model 5 four-factor model (BR + NS, NC, CI, TU)	1001.42	224	613.34(4)**	0.75	0.72	0.13	0.11
Model 6 three-factor model (BR + NC + NS, CI, TU)	1302.44	227	914.36(7)**	0.66	0.62	0.15	0.12
Model 7 three-factor model (BR + NC + CI, NS, TU)	1220.37	227	832.29(7)**	0.68	0.65	0.14	0.12
Model 8 three-factor model (BR, NC, NS + CI + TU)	735.14	227	347.06(7)**	0.84	0.82	0.10	0.09
Model 9 two-factor model (BR + NC + NS, CI + TU)	1452.49	229	1064.41(9)**	0.61	0.57	0.16	0.13
Model 10 two-factor model (BR + NC, NS + CI + TU)	1367.66	229	979.58(9)**	0.64	0.60	0.15	0.13
Model 11 one-factor model (BR + NC + NS + CI + TU)	1646.07	230	1257.99(10)**	0.55	0.50	0.17	0.14

Note. N = 222. + indicates factor combined.
** $p < 0.01$.

Table 3
Reliability and validity.

Variables	CR	AVE	MSV	ASV
Bricolage	0.91	0.56	0.250	0.108
NPC	0.93	0.72	0.545	0.203
NPD speed	0.91	0.73	0.545	0.183
Competitive intensity	0.79	0.56	0.009	0.003
Technological turbulence	0.74	0.49	0.018	0.011

factor explains most of the covariance among variables, which means no significance (Podsakoff et al., 2003). Second, CFA was run to test the research model (Mossholder, Bennett, Kemery, & Wesolowski, 1998). As Table 2 shows, the one-factor model, including the dependent, independent, moderator, and control variable, did not fit as well as the five-factor measurement models. Therefore, CMV is an unlikely threat.

4. Results

Table 4 shows variable summaries and pair-wise correlations. Bricolage, independent variable, is positively correlated with NPD speed and NPC, providing initial support for further data analysis. R&D intensity (R&D expenditures to sales ratio during the previous year) is positively related with bricolage in the current year, suggesting that a firm could take two actions simultaneously (Banerjee & Campbell, 2009, p. 474).

All variables are averaged, and independent and moderating variables are centralized to avoid multicollinearity (Aiken & West, 1991). A multicollinearity test using variance inflation factor (VIF) analysis (Neter, William, & Kutner, 1985) shows VIF to be 1.03–1.63, below the 10 benchmark (Neter et al., 1985). Therefore, multicollinearity is not a threat.

Hierarchical regressions are used to test the hypotheses (Table 5). Control variables are entered in Model 1. In Model 2, bricolage positively affects NPD speed ($\beta = 0.36$; $p < 0.001$), supporting H1. Model 3 shows the interaction between bricolage and technological turbulence ($\beta = 0.21$; $p < 0.01$). The addition of the interaction term in Model 3 increases the R-square value significantly compared with Model 2 ($\Delta R^2 = 0.03$, F (1, 213), $p < 0.05$), supporting H3.

To further test H3, Hayes's (2013) method is used to estimate the relationship between bricolage and NPD speed at higher (+1 SD) and lower levels (−1 SD) of technological turbulence. Under higher technological turbulence, bricolage has a stronger effect on NPD speed (simple slope = 0.68, SE = 0.15, 95% CI = 0.366, 0.956); under lower technological turbulence, bricolage has a lower effect on NPD speed (simple slope = 0.33, SE = 0.11, 95% CI = 0.111, 0.532). The simple slope is significantly different between high and low technological turbulence (simple slope differ = 0.35, SE = 0.18, 95% CI = 0.004, 0.705), supporting H3.

To further clarify moderating effects, Cohen, Cohen, West, and Aiken (2006) suggest plotting the effects of an independent variable on the dependent variable for high and low conditions of the moderate variable. Fig. 2 clearly shows the plot of bricolage interaction with technological turbulence, suggesting that bricolage is an effective way to hasten NPD under high technological turbulence.

In Model 5, bricolage positively affects NPC ($\beta = 0.32$; $p < 0.001$); bricolage squared negatively affects NPC ($\beta = -0.39$; $p < 0.01$), supporting H2. In Model 6, bricolage positively affects NPC ($\beta = 0.33$; $p < 0.001$); bricolage squared negatively affects NPC ($\beta = -0.35$; $p < 0.05$); but the interaction term between the squared term for bricolage and technological turbulence shows that technological turbulence does not have a statistically significant moderating effect ($\beta = 0.08$; *ns*), failing to support H4.

To clarify the curvilinear relationships in H2, unstandardized parameter estimates are used to depict the effects. Fig. 3 clearly shows that bricolage has an increasingly positive effect on NPC, but its impact on NPC declines after a certain point. These results fully support H2.

5. Discussion

NPD research calls for considering the effects of resource constraints on product innovations (Cunha et al., 2014; Senyard et al., 2014). In this study, survey data from 222 Chinese firms are used to examine bricolage activity in positional NPA and validate resource construction strategy hypotheses in NPD. Particularly, a framework is proposed to investigate bricolage impacts on NPD speed and NPC, with technological turbulence as a moderator.

First, the results show that bricolage positively correlates with NPD speed. Meta-analysis has suggested that availability of resources and facilities is positively related to fast NPD (Cankurtaran et al., 2013). Therefore, when resources and facilities are unavailable, firms cannot rely solely on standard resources to hasten NPD (Garud & Karnøe, 2003), but can rely on bricolage to construct the resource quickly and hasten NPD.

Second, low or moderate bricolage helps enhance NPC, but excess is detrimental to creativity. Thus, proper level of bricolage is essential, as excess reduces resource heterogeneity. Similar to previous studies, the present study finds that firms can impair creativity by overly using managers' personal resources (Cui et al., 2013) or existing customers' networks (Fang, 2008).

Third, although firms facing resource constraints may see technological change as a threat, technological turbulence can actually enhance the positive impact of bricolage on NPD speed. Under high technological turbulence, firms can use more bricolage to creatively recombine resources, improve the efficiency of processes and procedures, and improvise to hasten NPD. This study also hypothesizes that technological turbulence may play a positive role in the inverted U-shaped relationship between bricolage and NPC. However, the empirical results do not support this hypothesis. Consequently, technological turbulence may fail to provide an ideal context to use bricolage to improve NPC (Atuahene-Gima & Li, 2004; Song & Montoya-Weiss, 2001) and may not damage the fit between resources and product development projects or constrain creative innovation (Stanko et al., 2015).

Table 4
Descriptive statistics and correlation matrix.

Variables	Mean	SD	1	2	3	4	5	6	7	8
1. Firm age	2.70	1.03								
2. Firm sales	1.92	0.75	0.55**							
3. Firm stage	2.23	0.80	0.37**	0.17*						
4. Competitive intensity	3.89	0.85	0.09	0.16*	0.17*					
5. R&D intensity	3.09	1.33	0.02	0.07	−0.14*	−0.10				
6. Bricolage	3.75	0.62	0.00	0.10	−0.11	−0.01	0.16*			
7. Technological turbulence	3.09	0.84	0.02	0.02	−0.09	0.06	0.11	0.06		
8. NPD speed	2.93	0.85	−0.01	0.05	−0.09	−0.01	0.28**	0.39**	0.08	
9. NPC	3.38	0.87	−0.03	0.13	−0.12	−0.03	0.29**	0.48**	0.11	0.70**

Note. $N = 222$.
* $p < 0.05$ (two-tailed).
** $p < 0.01$ (two-tailed).

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Table 5
Results of regression analysis.

Variables	NPD speed			NPC		
	Model 1	Model 2 (H1)	Model 3 (H3)	Model 4	Model 5 (H2)	Model 6 (H4)
Firm age	−0.09	−0.08	−0.12	−0.18	−0.19	−0.21*
Firm sales	0.10	−0.08	−0.08	0.25**	0.25**	0.24**
Firm stage	−0.17	0.12	0.12	−0.08	−0.01	−0.01
Competitive intensity	0.03	0.08	0.06	0.06	−0.12	−0.11
R&D intensity	0.31***	0.24***	0.24***	0.30**	0.16**	0.15**
Bricolage		0.36***	0.37***		0.32***	0.33***
Bricolage squared					−0.39**	−0.35*
Technological turbulence		0.11	0.08		0.14	0.09
bricolage × technological turbulence			0.21**			0.09
Bricolage squared × technological turbulence						0.08
F	3.46***	5.08***	5.14***	4.51***	6.28***	6.26***
R^2	0.15	0.24	0.27	0.16	0.40	0.41
Adjusted R^2	0.11	0.19	0.22	0.13	0.33	0.34
R^2 change		0.09***	0.03*		0.24***	0.01

Note. $N = 222$. Significance levels are based on two-tailed tests for all models and coefficients.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

5.1. Contributions

This study makes three theoretical contributions. First, for a more nuanced understanding of the bricolage-NPA relationship, this study highlights the need to consider different NPA (e.g., Bechky & Okhuysen, 2011; Lanzara, 1999) by proactively examining the differentiating effects of bricolage on NPD speed and NPC. The findings extend the proposition that bricolage hastens innovations (Nelson, Stinchfield, Rodriguez-Lluesma, & Companys, 2014) by adding NPD to the accelerated processes. This study also refines the proposition that innovations through bricolage are likely to be incremental and minor (Nelson et al., 2014) by showing that low or moderate levels of bricolage enhance NPC, while high levels hamper it, which also complements the perspective that more bricolage may undermine innovativeness (Senyard et al., 2014). Collectively, the findings add clarity on whether bricolage actually benefits NPD (Bechky & Okhuysen, 2011; Ciborra, 1996; Lanzara, 1999).

Second, despite the need to identify contingencies determining the effects of bricolage on NPD, few studies examine varying bricolage benefits on NPD across technological conditions. Environmental uncertainty through technological turbulence affects whether bricolage potentially enhances NPD speed and NPC. Consequently, this study negates that environmental dynamism impairs positive effects of bricolage (Senyard, 2015), and provides additional empirical support indicating that NPD outcomes depend on technological turbulence, resource mobilization, resource synergy, and resource integration (e.g., Gao et al., 2015; Song & Montoya-Weiss, 2001; Zhao et al., 2014). Rapid technological change interacts with timely knowledge reconstruction for critical effects on NPD speed, but rapid technological obsolescence and recombination of "new" and "old" resources do not interact to enhance NPC. Therefore, the findings reveal the appropriate contextual fit between bricolage and technological conditions for a deeper understanding of the value of bricolage in NPD.

Third, the study contributes to the source-position framework, focusing on superior skills and resources that determine positional advantages, such as market orientation, market learning, and product resource-capability complementarities (Ahmadi et al., 2014; Day & Wensley, 1988; Kim & Atuahene-Gima, 2010). A key insight is that firms can acquire positional advantages through bricolage when internal resources are constrained. Furthermore, past studies focused on product-related positional advantages, such as new-product differentiation, new-product cost efficiency, first-product differentiation, first-product cost efficiency, and NPC (e.g., Ahmadi et al., 2014; Im & Workman, 2004; Kim & Atuahene-Gima, 2010). In line with these studies, the present study focuses on NPC, but further introduces NPD speed as a product-related positional advantage. Therefore, rather than combining NPD speed and NPC into a single NPA construct, they should be examined separately (Nakata, Im, Park, & Ha, 2006; Song & Montoya-Weiss, 2001), because one source of positional advantage may have different effects on different NPA dimensions.

Managers are advised to properly recombine resources at hand to gain NPA rather than wait for new resources, especially when technology changes rapidly. However, the appropriate response to resource constraints depends on the firm's goals regarding NPA. That is, if they seek to acquire NPD rapidly, they should fully use their network and resources to build knowledge rather than wait for standard resources or quit. Conversely, if their objective is to create creative new products, they should be cautious to fully use the strengths and avoid the drawbacks of bricolage.

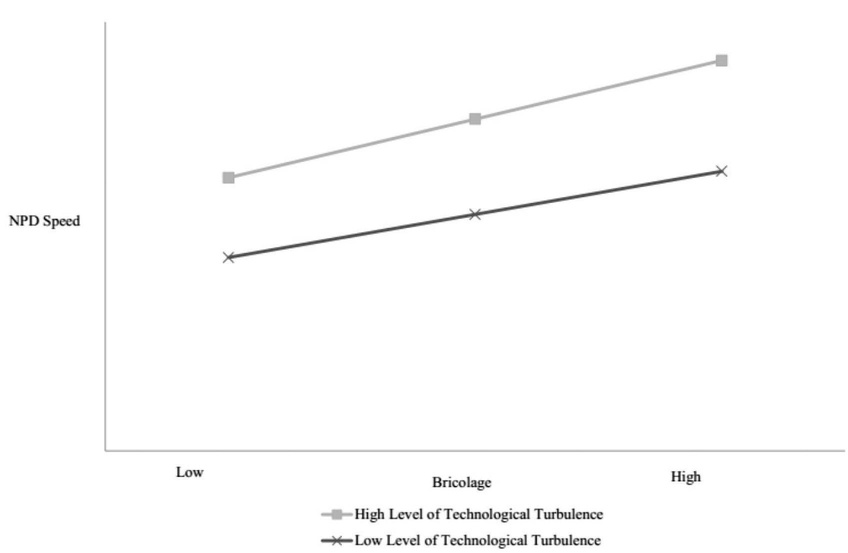

Fig. 2. The moderating role of technological turbulence on the bricolage-NPD speed relationship.

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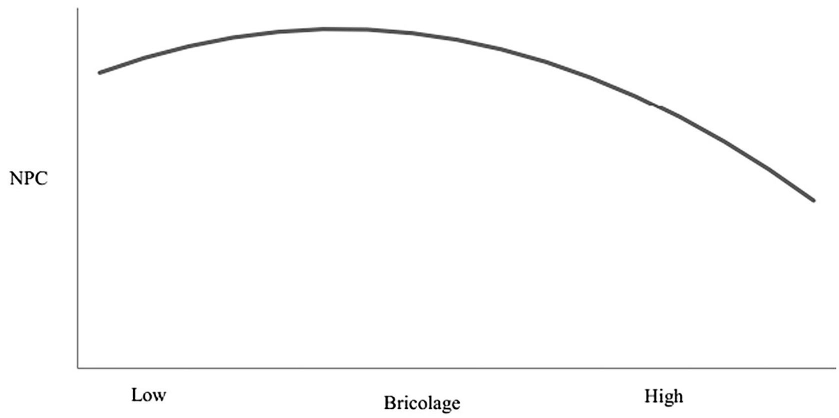

Fig. 3. The curvilinear relationship between bricolage and NPC.

5.2. Limitations and future research directions

Future research should overcome several limitations of this study. First, although China is appropriate for examining bricolage effects on NPA in the emerging economy context, survey data from other emerging economies should be collected. Second, other bricolage dimensions such as inputs, customer/markets, and institutional and regulatory environments (Baker & Nelson, 2005) may also affect NPA and should also be examined. Third, cross-sectional data may prohibit drawing causal relationships (Banerjee & Campbell, 2009), and hence, a future study should use longitudinal research to examine dynamic changes between bricolage and NPA. Fourth, other environmental conditions that may influence the bricolage-NPA relationship should be considered, such as market turbulence, competitive intensity, and regulatory volatility (Chelariu, Bello, & Gilliland, 2006; Jaworski & Kohli, 1993; Kim & Atuahene-Gima, 2010). In summary, this study shows that bricolage effects depend on specific goals a firm sets in pursuing new products and the technological turbulence the firm faces. Ideally, research should motivate further evaluations of bricolage in critical NPD processes.

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