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EXAMINING DRIVERS OF COLLABORATIVE INBOUND OPEN INNOVATION: EMPIRICAL EVIDENCE FROM AUSTRALIAN FIRMS

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Knowledge-based competition is leading to collaboration with partners and even competitors as firms pursue appropriate knowledge for innovation which has become a strategic imperative. Inbound open innovation helps increase the innovativeness of the firm by monitoring the operating environment and enabling it to source knowledge from collaborative partners. On the basis of in-depth interviews with senior managers and the knowledge-based view of the firm, this study examines the extent to which inbound open innovation activities contribute to collaborative innovation. Then, using a sample of 224 surveys representative of a cross-section of medium to large firms involved in collaborative ventures, the theoretical model is empirically examined. The results show that collaborative creativity, learning and knowledge stock are critical core inputs of collaborative innovation, with the support of formal coordination mechanisms and internal search processes, such as structural centralisation, formality and absorptive capacity.

Keywords: Inbound open innovation; collaboration; creativity; learning; knowledge.

Introduction

The unique challenges of the modern borderless business landscape mean 'business as usual' is a dead end (Bhide, 2010). The past decade has witnessed an increase of interest in open innovation as a new source of business success (Chesbrough, 2003; Gassmann *et al.*, 2010; Lichtenthaler, 2008b; Spithoven *et al.*, 2011). To complement in-house innovation, firms may open up their innovation processes on two dimensions (Chesbrough and Crowther, 2006; Lichtenthaler, 2009b): The first, referred to as inbound open innovation (outside-in process) focuses on enriching the firm's own knowledge base through the collaboration

with partners, customers, and external knowledge sourcing; the second, referred to as outbound open innovation (inside-out process) involves bringing ideas to market and multiplying technology by transferring ideas to the outside environment (Enkel *et al.*, 2009; Lichtenthaler, 2009b). While open innovation has recently received substantial attention from researchers (Enkel *et al.*, 2005; Lichtenthaler, 2008a, 2008b, 2009b; Spithoven *et al.*, 2011; Van de Vrande *et al.*, 2006), extant literature is in need of an extension of the knowledge-based view with respect to the main theoretical premise underlying open innovation (Vanhaverbeke *et al.*, 2007).

Our paper makes two major contributions. First, we add to the literature on the inbound open innovation by examining the contribution of creativity, learning, and knowledge stock to collaborative innovation. Central to inbound open innovation is the use of external knowledge to accelerate collaborative innovation (Chesbrough *et al.*, 2006). Indeed, firms increasingly rely on external knowledge to foster innovation and to enhance their performance (Ireland *et al.*, 2002; Lichtenthaler, 2009a, 2009b; Zollo *et al.*, 2002). However, prior research on inbound open innovation underscores the importance of creativity, learning, and knowledge stock in collaborative innovation. The knowledge-based view of the firm depicts firms as repositories of knowledge and competencies (Kogut and Zander, 1992; Spender, 1996; Yli-Renko *et al.*, 2001) of which creativity, knowledge generation, and learning are inseparable competitive dimensions for further innovation (Hitt *et al.*, 2000; Kazanjian *et al.*, 2000). Understanding how these dimensions matter in this context will assist in determining approaches for better management of external knowledge exploitation for collaborative innovation.

Second, we examine how formal coordination mechanisms (e.g., centralisation and formality) and internal search processes (e.g., absorptive capacity) influence inbound open innovation activities (e.g., creativity, learning, and knowledge stock). Currently, there is little empirical evidence regarding these relationships despite the important role of formal hierarchical structure in affecting the initiation and implementation of innovation (Damanpour, 1987, 1991; Jansen *et al.*, 2006). Extant research has also called for examining the role of absorptive capacity as a pre-condition for organising open innovation activities (Spithoven *et al.*, 2011).

We begin this study by proposing a theoretical framework that amalgamates collaborative innovation, collaborative creativity, collaborative learning, knowledge stock, formal coordination mechanisms, and absorptive capacity into an integrated model (Fig. 1).

We then propose a set of hypotheses and a research design. Next, we report the results of an empirical study using data from 224 medium and large firms. We conclude by discussing the findings of our study and suggesting theoretical and managerial implications.

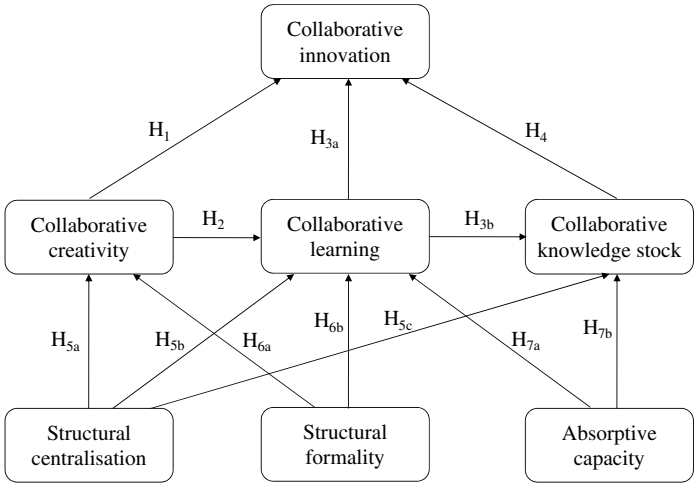

Fig. 1. Coordination mechanisms and key drivers of inbound open innovation.

Theory Development and Hypotheses

Collaborative innovation

Measures of innovation in collaborative settings usually depend on the outcome of the collaborative process, which has aimed at producing novel solutions with social or economic potential (Powell *et al.*, 1996). Therefore, the locus of innovation is the collaboration rather than the single firm, which implies that if partners interact, they can mobilise their collaborative resources and accelerate their innovation. As the number and scope of interfirm collaborations grows across industries, interest shifts from the firm as the centre of information processing and problem solving to information flows, learning and knowledge accumulation (stock), as well as the emergence of new ideas (creativity) (Powell *et al.*, 1996). Innovation thus is affected by creativity, learning (Mumford and Gustafson, 1988) and knowledge, and *collaborative innovation* refers to a novel solution derived from the interfirm environment that has social or economic value.

Impacts of collaborative creativity, collaborative learning, and collaborative knowledge stock on collaborative innovation

Because it is a core concept across multiple disciplines, from the arts to psychology to management, many models exist to explain creativity, creative behaviour and creative processes (Ford, 1996). Wallas's (1926) four-stage model was among the first to emphasise that though the creative process is fundamentally individual, the deliberate first and final stages (i.e., preparation and validation)

imply the influence of social and contextual surroundings. These stages may include brainstorming (Osborn, 1953), problem solving (Parnes, 1992), strategic planning (Bandrowski, 1985), and processes of creation (Fritz, 1991). Such models advance thinking about the creative process, though they do not identify an explicit link between creativity and innovation.

More recent models bridge this gap by theorising that creativity has a direct impact on innovation in firms. For example, Amabile (1988) argues that creativity extends beyond the individual to the firm level and therefore transforms individual domain-relevant skills, creativity skills and task motivation into resources in the task domain, skills in innovation management and the motivation to innovate, which operate at the firm level. Beyond this conceptual connection, empirical demonstrations show that creativity correlates with innovation at the firm level (Amabile, 1988) and in collaborative settings (Gudergan *et al.*, 2002).

The resulting notion of collaborative creativity considers interaction theories (Woodman and Schoenfeldt, 1990) and refers to the process of generating new ideas that reflect surrounding social and contextual influences (Woodman *et al.*, 1993). With regard to firm-level creativity, resources are critical for creativity but are not transferable across domain boundaries (Amabile, 1988), so the range of factors that influence creativity may be specific to the collaborative level and should be considered separately to understand the process of collaborative creativity (Drazin *et al.*, 1999). For example, group members, prior experience and information availability constitute key social influences, and the group's activities and work setting are main contextual factors. These social and contextual factors in turn determine situational evaluations and behavioural adjustments to align with relevant settings and desired outcomes.

Collaborative creativity is the integration of social and contextual influences to generate unique ideas and solutions in an interfirm context. At the collaborative level, creativity refers to the process of developing novel and appropriate solutions to problems (Amabile, 1990). Although creativity is not the same as innovation (Wycoff and Snead, 1999), it is a source of new ideas and a building block of the broader model of innovation, through which new ideas become implemented (Amabile, 1996; Woodman *et al.*, 1993). In collaborative arrangements, innovation potential depends on the capacity to develop, synthesise and distribute ideas (Powell *et al.*, 1996). Therefore, we hypothesise that:

H1: *Collaborative creativity has a positive impact on collaborative innovation.*

Ideas generated in the creative process through collaboration still demand assessment though. In this sense, collaborative creativity is inevitably linked to collaborative learning, obtained through the evaluation of ideas, acquisition of

information and production of knowledge that has been generated by and evolves within the collaboration. Creativity promotes learning and problem exploration, which in turn leads to new ideas and solutions (Tannenbaum, 1997). Furthermore, the process of collaborative, creative problem solving creates opportunities for the development of new combinations of information that strengthen the link to learning (Larson and Christensen, 1993; Reynolds, 1994). Therefore, we hypothesise that:

H2: *Collaborative creativity has a positive impact on collaborative learning*.

Learning is a central, ongoing concern for firms (Cyert and March, 1963), because it represents a process for developing knowledge and insights that influence behaviour (Huber, 1991). Learning is critical for the continuous acquisition of new information, skill renewal and the enhancement of competencies (Inkpen, 1998). Firm learning entails experience-based improvements in firm performance (Argyris and Schon, 1978) and has a clear link to innovation performance (Aragon-Correa *et al.*, 2007; Baker and Sinkula, 2007).

In a collaborative structure, unique contextual considerations affect learning. Collective learning usually is conceptualised as network or team-based, and it depends on a set of shifting and interlocking relationships with malleable boundaries (Araujo, 1998), which allow members to develop alternative means of learning in relation to their work (Powell *et al.*, 1996). In particular, *collaborative learning* is the acquisition and development of information and skills among people from a specific community in a collaborative business partnership. A network learning approach requires flatter structures than those characteristically found in traditional firms, to enable members to form teams marked by effective communication and innovative practices. The emphasis, therefore, shifts when delegating tasks, from individual- to team-based approaches (Bouwen and Fry, 1992). Internal and external actors with varying skill sets may constitute a collaborative team and act on the basis of their own theories and interests, within the environmental context (Araujo, 1998). Thus, the network-learning approach focuses on team learning that occurs as a result of social interaction, not just individual cognitive aspects. Network learning literature clarifies the role of individual members as transferors of knowledge; teams are the vehicles through which learning occurs and knowledge gets accumulated, translated and disseminated (Benders and van Hootegem, 1999).

In collaborative relationships, learning is a complex process linked to the distribution and storage of knowledge, which must be flexible and durable to enhance innovation (Imai *et al.*, 1985; Powell *et al.*, 1996). The collaborative arrangement comprises representatives of partners who form a team, each contributing unique

skills and experiences, who can produce novel solutions (Ancona *et al.*, 2002), which together constitute knowledge stock but are beyond the capabilities of individuals operating alone (Imai *et al.*, 1985). The process of learning encourages the transformation of information (Walz *et al.*, 1993) and increases knowledge stock (Huber, 1991; Chen *et al.*, 2009). Learning in collaborative settings, therefore, is critical for collaborative innovation, because it allows for knowledge and skill transfers among members and facilitates process development (Cohen and Levinthal, 1990; Mumford and Gustafson, 1988). Therefore, we hypothesise that:

H3a: *Collaborative learning has a positive impact on collaborative innovation.*
H3b: *Collaborative learning has a positive impact on collaborative knowledge stock.*

At the firm level, efficiency is a function of the ability to integrate and implement specialised knowledge (Grant, 1997), which is a critical resource for competitive advantages (Quinn *et al.*, 2005) that has been linked to firms' innovation capability (Subramaniam and Youndt, 2005). However, there is limited understanding of the role of knowledge in the collaborative process of innovation creation. Similar to related constructs, knowledge at the collective level differs from knowledge at the firm level and is more than the aggregate of individual knowledge (Nahapiet and Ghoshal, 1998).

Innovation requires the application of multiple, specialised knowledge areas; the bounded capabilities of individual firms prompt collaborative initiatives to integrate existing knowledge stock with new knowledge assets (Grant, 1997), which increases competitive potential. To explain knowledge stock in firms, prior research considers both tacit and explicit knowledge (Kogut and Zander, 1992; Nonaka, 1991; Polanyi, 1962). The former is unarticulated; the latter is codified and readily imitable. Because tacit knowledge includes factors derived from personal beliefs, experiences and values, it is difficult to communicate and tends to be inferred. Accordingly, firms cannot acquire tacit knowledge easily. In contrast, it is easy to communicate explicit knowledge through codified processes or data. To disseminate knowledge and make the best use of its knowledge stock, as well as avoid competence substitutions, a firm must integrate and balance its tacit and explicit forms of knowledge (Inkpen, 1998).

Links of knowledge with learning usually reflect the goal of achieving flexibility and adaptability in complex environments (Hardy and Phillips, 2003). Because knowledge resource and capability assets require renewal to maintain a sustainable advantage (Teece *et al.*, 1997), the firm must undertake learning processes, and then store its assets in tacit and explicit knowledge stock. The combination of tacit and explicit knowledge makes imitation difficult (Zack,

1999), but it requires the acquisition of external knowledge that the firm then integrates with internal processes, such as problem solving and decision making, to create new knowledge stock (Soo, 1999). The extent of such activity relates to the firm's absorptive capacity (Cohen and Levinthal, 1990).

In a collaborative setting, knowledge stock refers to the accumulation of tacit and explicit knowledge in collaborative settings. Collaborations encourage knowledge sharing and the construction of refreshed knowledge repositories, which is important for innovation (Carmona-Lavado *et al.*, 2010). Furthermore, knowledge stock relates closely to core competencies (Prahalad and Hamel, 1990) and dynamic capability creation (Teece *et al.*, 1997). The level of knowledge stock affects the extent to which the firm can adapt to change (Cohen and Levinthal, 1990) and directly influences the renewal of resources (Grant, 1997), as well as improving innovation performance (Carmona-Lavado *et al.*, 2010). Therefore, in line with the knowledge-based view, knowledge generation, application and stock accumulation may be sources of innovation (DeCarolis and Deeds, 1999). Therefore, we hypothesise that:

H4: *Collaborative knowledge stock has a positive impact on collaborative innovation.*

Impacts of formal coordination mechanisms, and absorptive capacity on collaborative creativity, collaborative learning, and collaborative knowledge stock

A collaborative venture differs characteristically from other organisational forms, in that it involves new interpersonal relationships and formal coordination mechanisms (e.g., centralisation and formality) that influence the collaborative team's activities and movement patterns. *Structural centralisation* refers to the concentration of decision making within the members of a collaborative team. Structural centralisation implies governance by firm-level decision making (Wallach, 1983), which can be centrally controlled by a small group or dispersed across organisational levels (Floyd and Wooldridge, 1994; Fredrickson, 1986). In less centralised settings, members receive wider-ranging inputs that support integration, which should encourage creativity (Leenders *et al.*, 2003). Low centralisation also facilitates information exchange and interaction, which helps generalise meaningful information and interpretations (Senge, 1990). In contrast, high levels of centralisation might produce conflicting perspectives and hinder progress (Fiol, 1994; Wildavsky, 1979). Greater structural centralisation restricts decision making to a designated set of people, limits interaction and information exchange among members, and inhibits learning by collaborative team members.

That is, higher levels of centralisation are less conducive to learning and building knowledge stock, whereas low levels of centralisation encourage collaborative team members to share existing knowledge and integrate perspectives to produce new ideas, which have a positive impact on creativity. Therefore, we hypothesise that:

H5: *Structural centralisation has a negative effect on* (a) *collaborative creativity*, (b) *collaborative learning*, *and* (c) *collaborative knowledge stock*.

Structural formality is a mechanistic, inflexible system of control governing the collaborative team. Firms are either mechanistic (formal) or organic in their governance approach (Burns and Stalker, 1961). Although formal methods are appropriate in stable environments that do not require change (Burns and Stalker, 1961), they also are characterised by rigid guidelines that demand conformity. People under such controls adopt mechanistic approaches to their work, interactions and problem solving (Burns and Stalker, 1961), though in modern business environments, these formal mechanistic governance systems seem less effective, because they maintain closed systems and inflexibility (Bartlett and Ghoshal, 1991). Although some degree of control is necessary for efficient management, excessive or inappropriate control may hinder a team's creativity; lower levels of formality thus should benefit creativity (Seely-Brown and Duguid, 1991).

Organic structures make allowances for organisational slack and allow members to interact relatively freely. Therefore, they are suitable for dynamic firms that require adaptation, such as those in evolving and unsettled environments that must respond flexibly to cope with continuous change (Burns and Stalker, 1961). In contrast, structural formality imposes restrictions and rigidity and limits interaction opportunities, which reduces learning potential and hinders creativity. Therefore, we hypothesise that:

H6: *Structural formality has a negative effect on* (a) *collaborative creativity*, *and* (b) *collaborative learning*.

Finally, absorptive capacity refers to an firm's ability to identify the value of new external knowledge and assimilate, apply and exploit it for commercial gain (Cohen and Levinthal, 1990; Zahra and George, 2002). The role of absorptive capacity in relation to knowledge is particularly emphasised by economists (Mangematin and Nesta, 1999) because of its influence on the extent of knowledge production, exchange and use in the selection or rejection of creative actions and innovations (Ford, 1996). More recently, the link between absorptive capacity and learning has been considered a potential impact on firm innovation (Chen *et al.*,

2009). A firm's level of absorptive capacity influences the extent to which it can learn and reproduce new knowledge (Tsai, 2001), which can lead to innovations (Daghfous, 2004). According to this logic, low absorptive capacity hinders knowledge transfer and accumulation (Szulanski, 1996), whereas firms with high absorptive capacity can produce more innovations (Chen *et al.*, 2009; Cohen and Levinthal, 1990). The extant literature on collaborative innovation suggests that innovative ideas are often at the nexus of collaborative partnership links (Tsai, 2001). Indeed, firms have substantially increased their use of external knowledge to foster innovation and to enhance their performance (Lichtenthaler, 2009a,b; Ireland *et al.*, 2002; Zollo *et al.*, 2002). This is because a firm's ability to acquire knowledge from the external environment is a by-product of its own innovations (Lane *et al.*, 2006). As such, the ability to exploit external knowledge is critical driver of collaborative innovation (Cohen and Levinthal, 1990). An organisational unit's absorptive capacity relates positively to its knowledge stock accumulation and thus to innovation. Therefore, we hypothesise that:

H7: *Absorptive capacity has a positive effect on* (a) *collaborative learning and* (b) *collaborative knowledge stock.*

Method

Data

The data used to test the hypotheses come from a quantitative survey of senior collaborative managers from a cross-industry sample of Australian firms. The original sample of 2,000 firms was randomly drawn from a mailing list supplied by a large Australian mailing house, which included industries such as manufacturing, education, professional services and health. Following existing guidelines (e.g., Kumar *et al.*, 1993) the initial solicitations requested responses from key informants with prior experience in managing interfirm collaborative ventures for their current employer. Key respondents are valuable because they possess more detailed knowledge of daily operations and strategic objectives than do other potential respondents (Borg and Gall, 1989). For the questionnaire, informants selected a single collaborative venture as their reference point.

Three weeks after the original distribution of questionnaires, reminder letters were faxed and questionnaires resent to informants who indicated that they had not received a questionnaire but were willing to participate. The 224 useable questionnaires received generated a response rate of 20%. A comparison of the first and second wave data, as a test of non-response bias, revealed no significant differences between samples.

The resulting sample represents a cross section of medium to large sized firms that have engaged in at least one simple alliance or collaboration.[1] It includes a roughly equivalent proportion of firms operating in IT-specific industries, transportation, manufacturing, professional services, engineering, government, and primary industries. The diverse sample allowed for sufficient variance in the data, and assisted in examination of relationships proposed in this study.

Questionnaire development

To develop the questionnaire, prior literature offered a starting point, and then in-depth interviews with directors of firms involved in collaborative ventures confirmed the practical significance of the conceptual issues. The development process also verified the face validity of the conceptual model and construct operationalisation. Following this initial step, a pre-test conducted with a small selection of key informants indicated some minor rewording and repositioning of a few items in the instrument.

Measures

All constructs used multi-item scales, mainly previously tested scales applied to the specific setting with minor modifications (Churchill, 1979); in cases in which prior scales did not exist, new ones were created on the basis of prior literature and the in-depth interviews (Fornell and Cha, 1994). Because collaborative innovation, collaborative learning and collaborative knowledge stock are heterogeneous from a respondent's perspective and form a set of categorical responses (Rossiter, 2002), their measures employ formative scales (see Appendix 1). Collaborative innovation, adapted from Soo (1999), includes 11 items, such as, 'in comparison to competitors, we develop new products that are new to the market' and 'we make significant modifications to existing products or services', all measured on seven-point Likert scales ranging from 'not at all' to 'very frequently'. Because collaborative learning cannot be measured directly, this scale refers to the level of effort expended by collaborative team members in ongoing learning activities. It features eight items measured on seven-point Likert scales, ranging from 'people do not spend any effort learning about...' to 'people spend a lot of effort learning about...' managerial techniques, policies, technology, marketing and so on. Similarly, the measure of collaborative knowledge stock uses eight items and a seven-point Likert scale ranging from 'compared with competitors we have significantly less/

[1](where a simple alliance may include co-marketing, production, manufacturing, R&D partnership, or education alliance).

more knowledge in...' political and legal aspects, technology, marketing, customers, competitor products and so on.

The remaining constructs used reflective scales, such that factor analysis served to purify each scale, and it was possible to calculate reliability scores (Bagozzi and Yi, 1991). These measures were anchored by a seven-point Likert scale, ranging from 'strongly agree' to 'strongly disagree'. Collaborative creativity consists of the four-item scale ($\alpha = 0.89$) from Menon *et al.* (1999) scale. The three-item structural formality scale ($\alpha = 0.75$) came from Michaels *et al.* (1988) scale for organisational formality and Wetle *et al.* (1976) scale for interorganisational relations. Structural centralisation also used a three-item scale ($\alpha = 0.69$) from Garfinkel (1967). Finally, the six-item absorptive capacity scale ($\alpha = 0.82$) came from Soo (1999).

Analysis and Results

Measure validation

Prior to testing the proposed model, we examined the validation of both first-order reflective and formative constructs which are shown in Table 2 and Appendix 1. With respect to reflective constructs (creativity, structural formality, structural centralisation, and absorptive capacity), a series of tests established the unidimensionality of the measures. First, the reliability of constructs and item-to-total correlations served to assess the measure validity. Items with low item-to-total correlations were omitted. Table 1 summarises the latent variable intercorrelation matrix, which demonstrates acceptable correlations among the variables. With the exception of structural centralisation, with its negative, low correlations with all other variables, the variables reveal positive correlations. The middle to high range of correlations among learning, knowledge and innovation reflect the formative nature of the constructs.

Table 1. Latent variable intercorrelation matrix.

	V1	V2	V3	V4	V5	V6	V7
V1. Innovation	1.000						
V2. Creativity	0.461	1.000					
V3. Learning	0.622	0.423	1.000				
V4. Knowledge	0.430	0.300	0.601	1.000			
V5. Formality	0.129	0.208	0.210	0.171	1.000		
V6. Centralisation	−0.163	−0.371	−0.252	−0.075	−0.417	1.000	
V7. Absorptive capacity	0.484	0.498	0.498	0.340	0.170	−0.211	1.000

Table 2. Parameter estimates for reflective measurements.

Measure	Loading
Creativity ($\alpha = 0.904; \text{CR} = 0.850; \text{AVE} = 0.703$)	
Experiment with non traditional methods in our decision making	0.71 (25.99)
Brainstorm for out-of-the-square solutions	0.88 (83.52)
Have a positive attitude towards creativity	0.88 (97.36)
Have novel solutions during decision-making	0.88 (65.20)
Structural formality ($\alpha = 0.75; \text{CR} = 0.580; \text{AVE} = 0.386$)	
People in this collaboration rely on formal policies to guide decision making	0.84 (2.02)
People in this collaboration must rigidly follow procedures	0.84 (1.64)
This collaboration is hierarchically organised	0.71 (2.50)
Structural centralisation ($\alpha = 0.785; \text{CR} = 0.785; \text{AVE} = 0.554$)	
Top level management makes all the important decisions and the delegates tasks	0.82 (7.15)
In this collaboration, important decisions are made only at high management levels	0.86 (11.92)
Individual decision makers at all management levels have wide latitude in making job-related choices	0.70 (23.72)
Absorptive capacity ($\alpha = 0.82; \text{CR} = 0.876; \text{AVE} = 0.540$)	
This collaboration has processes in place to readily apply newly acquired knowledge to existing work situations	0.80 (40.63)
This collaboration has structures for recording and sharing knowledge	0.81 (25.35)
This collaboration organises training programs (workshop, self directed, etc) to update skills	0.70 (38.11)
This collaboration provides opportunities for informal networking to source knowledge	0.71 (22.33)
This collaboration utilises IT-based knowledge infrastructure	0.69 (20.38)
In this collaboration information moves freely between partner organisations	0.69 (24.94)

Notes: *t*-statistics from un-standardised solution are presented in parentheses next to loadings; α denotes the Cronbach's alpha score; CR denotes composite reliability; and AVE denotes average variance extracted.

Second, a confirmatory factor analysis performed to confirm the uni-dimensionality of multi-item reflective constructs produced the results in Table 2, which demonstrate convergent validity, in that the item loadings that correspond to each construct range from 0.69 to 0.88, and all loadings are significant ($p < 0.05$).

Regarding formative constructs (collaborative innovation, collaborative learning, and knowledge stock), the validation of these formative constructs also

Table 3. Formative indicator testing results.

Construct	χ^2	d.f.	*p*-value
Collaborative innovation	106.13	44	0.0000
Collaborative learning	51.23	20	0.0001
Collaborative knowledge stock	53.07	20	0.0001

Note: $\alpha = 0.05$.

included confirmatory tetrad analysis (Bollen and Ting, 2000), in which equivalence between the product of a pair of co variances and the product of another pair confirms a vanishing tetrad implied by the model. The construct, therefore, cannot be reflective and, by default, is formative. The reported chi-squares, degrees of freedom, and *p*-values suggest some conclusions. As summarised in Table 3, all constructs indicate significant results at $p < 0.001$.

Path analysis results

The results of the tests of the structural model in Table 4 demonstrate support for the hypothesised relationships. The variance explained score ($R^2 = 0.438$) indicates good explanatory power for this exploratory model. The relationships between innovation and collaborative creativity ($ß = 0.238; p < 0.001$), collaborative learning ($ß = 0.479; p < 0.001$) and collaborative knowledge stock ($ß = 0.070; p < 0.05$) are all positive and significant.

In addition, collaborative creativity ($R^2 = 0.516$) is negatively influenced by structural centralisation ($ß = -0.343; p < 0.001$), whereas structural formality has an insignificant effect. Collaborative learning ($R^2 = 0.247$) receives a positive impact from absorptive capacity ($ß = 0.373; p < 0.001$), but both structural formality and centralisation indicate insignificant effects. Finally, the collaborative knowledge stock is positively affected by structural centralisation ($ß = 0.088; p < 0.05$) but not by absorptive capacity.

Hypothesised relationships

Having confirmed that the measurements are appropriate, this study proceeded with testing the structural model (Fig. 1). Because the variables are both reflective and formative, it is not possible to calculate the traditional fit indices, which focus on explaining co variation among measures (Chin, 1998). To gauge fit quality using partial least squares (PLS) analyses, Chin (1998) recommends reporting the loadings, weights, R^2 values and the significance of structural paths. Tenenhaus *et al.* (2004) also offer a solution to the lack of an overall fit index in PLS with

Table 4. Summary of regression results.

Construct	ßeta	Standard Error	*t*-Statistic	*p*-value	sig.
Effects on Collaborative Innovation ($R^2 = 0.438$)					
Collaborative creativity	0.238	0.058	4.677	$p < 0.001$	***
Collaborative learning process	0.479	0.062	6.263	$p < 0.001$	***
Collaborative knowledge stock	0.070	0.0567	1.993	$p = 0.047$	*
Effects on Collaborative Creativity ($R^2 = 0.516$)					
Structure — formality	0.065	0.085	0.473	$p = 0.637$	n.s.
Structure — centralisation	−0.343	0.049	6.736	$p < 0.001$	***
Effects on Collaborative Learning ($R^2 = 0.247$)					
Collaborative creativity	0.196	0.041	5.628	$p < 0.001$	***
Structure — formality	0.077	0.055	0.127	$p = 0.899$	n.s.
Structure — centralisation	−0.069	0.055	1.268	$p = 0.206$	n.s.
Absorptive capacity	0.373	0.048	7.412	$p < 0.001$	***
Effects on Collaborative Knowledge Stock ($R^2 = 0.453$)					
Collaborative learning	0.591	0.046	14.782	$p < 0.001$	***
Structure — centralisation	0.088	0.033	2.040	$p = 0.043$	*
Absorptive capacity	0.064	0.048	1.060	$p = 0.290$	n.s.

Notes: Statistics generated using bootstrapping with 500 samples. All tests are two-tailed. $*p < 0.05$. $**p < 0.01$, $***p < 0.001$. n.s. = not significant.

their global goodness-of-fit (GoF) index, which takes the square root of the multiplied means of communality and R^2; the GoF index for the proposed model is 0.4. However, there is no inference-based threshold to judge the statistical significance of such values (Esposito Vinzi *et al.*, 2010). The paths as shown in Fig. 2 are positive and significant, in support of H1–H4. As Table 4 indicates, the model explains 43.8% of the variance of innovation in collaborative settings.

The results pertaining to formal coordination mechanisms and absorptive capacity indicate some divergence from the hypothesised relationships though. For example, structural centralisation has a negative and significant effect on collaborative creativity, in support of H5a, but a non-significant effect on collaborative learning provides no support for H5b, and the positive and significant impact on collaborative knowledge stock contradicts H5c, as well as indicating a novel finding that conflicts with prior literature. Structural formality does not yield a significant impact on collaborative creativity, collaborative learning, and collaborative knowledge stock, rejecting H6 in its entirety. Finally, absorptive capacity

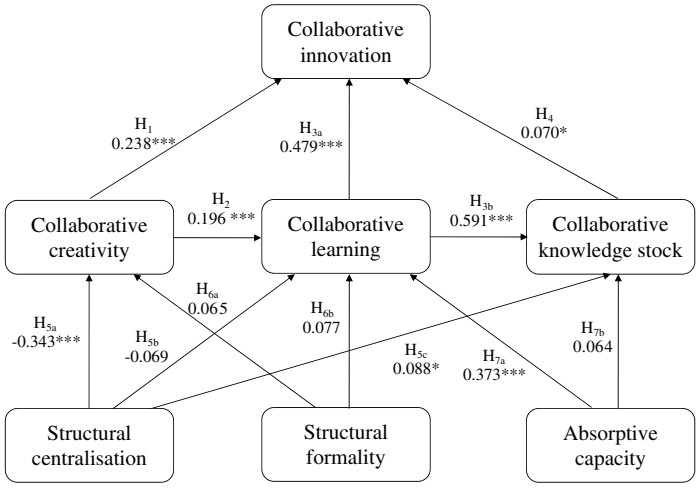

Fig. 2. Hypothesised relationships and results.

has a positive and significant effect on collaborative learning but a non-significant effect on collaborative knowledge stock, which suggests support for H7a but not for H7b.

Discussion and Implications

This study proposes a theoretical framework for studying the contribution of inbound open innovation activities to collaborative innovation. Data collected from a cross-section of medium to large firms in Australia offer results that support proposed relationships. Inbound open innovation activities include collaborative creativity, learning and knowledge stock as critical primary inputs for collaborative innovation, supported by formal coordination mechanisms and internal search processes, such as structural formality, centralisation, and absorptive capacity. The findings in turn offer guidelines for researchers and practitioners regarding the key variables involved in the process of innovation in collaborative settings.

The knowledge-based view of the firm suggests that knowledge is one of the most strategically significant resources for successful innovation (Cohen and Levinthal, 1990; Kogut and Zander, 1992; Lane and Lubatkin, 1998). As competition is becoming more knowledge-based, collaboration with partners and even competitors to obtain appropriate knowledge for innovation has become a strategic imperative. Inbound open innovation helps increase the innovativeness of the firm by monitoring the environment of the firm to source knowledge from collaborative partners (Chesbrough and Crowther, 2006; Spithoven *et al.*, 2011). Building on

the knowledge-based view of the firm, this study extends the literature on inbound open innovation by examining three key drivers of innovation in collaborative settings and the impacts of formal coordination mechanisms and internal search processes on these drivers. This effort is theoretically important, because a prior lack of integration has resulted in disjointed knowledge building in isolated areas that support only narrow, piecemeal progress. This article provides a focused and purposeful review, integration and synthesis of relevant multidisciplinary literature to elucidate constructive connections among prior innovation research. Furthermore, the development of a conceptual model of innovation in collaborative settings, with the knowledge-based view of the firm as its foundation, emphasises the importance of identifying innovation as a continuous process and understanding the factors involved in renewal. The core variables, including collaborative creativity, learning and knowledge stock, represent empirically validated links in the inbound open innovation, which are instrumental to the process of collaborative innovation. Furthermore, findings show that structural formality does not have a significant effect, whereas structural centralisation demonstrates a negative influence on creativity and a positive effect on knowledge stock. Therefore, a controlled environment appears to restrict collaborative creativity but can help build and maintain knowledge stock. This unexpected finding contributes to prior literature by offering a clearer understanding of the role of structural issues in collaborative settings related to innovation. Finally, absorptive capacity has a direct and significant effect on learning, though in contrast with prior literature and the proposed hypotheses, it has no significant effect on knowledge. This positive contribution for absorptive capacity clarifies its role as an impact on learning, which should give researchers an impetus to extend the scope of absorptive capacity studies to include learning.

From a practical perspective, the relevance of innovation to firms has been well demonstrated, and its identification is critical to the success of the modern economy (e.g., Bhide, 2010). As examples, Apple, Google and Intel exemplify the significant impact of collaborations; their notable innovations result from the contributions of thousands of workers, suppliers and consumers. Furthermore, the modern economy has made change routine and no business can afford to stagnate (Bhide, 2010). In support of firms' efforts to gain increased access to innovation, the proposed model of the drivers of collaborative inbound open innovation brings to light the essential components that firms must account for in collaborative ventures geared toward innovative outcomes. That is, in collaborative innovation, creativity, learning and knowledge stock are critical links. Because collaborative activity demands unique structures, firms also must clarify structural and decision-making details to increase their potential to absorb new knowledge and, ultimately, produce new solutions. The model is thus a useful and valuable tool for firms that

seek to become more competitive, as well as those simply struggling to survive, because understanding the process of innovation is a strategic imperative.

Generating innovative activity is a complex task though, often inhibited by the structures and processes of firms and compounded by insufficient internal resources. Thus, when firms position themselves to gain access to additional resources and skills, the locus of innovation increasingly centres on networks of collaboration. This study contributes to an understanding of the core antecedents of this process, which should reduce the costs of misunderstanding and mismanagement among such endeavours, particularly as the need for innovation gains ever more momentum. Future research should examine the proposed model in collaborative settings in specific industries to determine the specific needs of diverse groups, and thus derive managerial guidelines for the effective management of the dynamic process of innovation in specific collaborative contexts. Such an effort is vital for promoting more accessible innovation processes and advancing knowledge about the process of innovation in complex settings.

Other potential research directions emerge from some limitations of this study. For example, the cross-industry sample that provides the data was one-sided; a dyadic study could give a more balanced perspective. Moreover, the key informants were selected on the basis of their specialised knowledge of a collaborative venture in their firm. This method is common in organisational research, but it creates the potential for social desirability bias and common method variance, because it collects all the data at one time. This study attempted to minimise these concern by measuring each construct separately to ensure validity and using a balance of positive and negative items to minimise the detection of inconsistent responses. Because the data collection consisted of just one instance, this study constructed a latent variable correlation matrix (Table 1), which indicates no apparent inflated skew among the variables; therefore, common method variance does not appear to be a threat in this study. However, additional research should minimise such limitations further by collecting data from key informants and collaborative team members over multiple instances.

Appendix 1: Formative Constructs

Collaborative Innovation
In comparison to your competitors, *how frequently does your collaboration produce the following innovations*:
New product prototypes (still in the development stage)
New products or services introduced to the market which are new to the market or the firm
Significant modification to existing products or services

Appendix 1 (*Continued*)

New/modified production or manufacturing techniques
New/modified administration or managerial techniques/practices/policies
New/modified marketing (inc advertising and distribution) techniques
Patents either applied for, pending or obtained
Publications in academic, scientific or technical journals by people in the collaboration
Formal presentations at conferences or seminars
Licenses or technology rights sold
Licenses or technology rights purchased

Collaborative Learning

This section is about the learning activities that are prominent in this collaboration. Please circle the number that fits best. (*seven-point Likert-type scale ranging from* '*People do not spend any effort in learning about*' … *to* '*People spend considerable effort in learning about*'…)

Administration or managerial techniques/practices/policies
Political and legal aspects
Cultural aspects
Marketing techniques
Product related technologies
Competitor products
Customers
Production/manufacturing

Collaborative Knowledge Stock

This section is about the knowledge levels that are prominent in this collaboration. Please circle the number that fits best (*seven-point Likert-type scale ranging from* '*Compared to competitors, we have significantly less knowledge in*'… *to* '*Compared to competitors, we have significantly more knowledge in*'…)

Administration or managerial techniques/practices/policies
Political and legal aspects
Cultural aspects
Marketing techniques
Product related technologies
Competitor products
Customers
Production/manufacturing

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