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R&D MANAGEMENT

Multiple dimensions of power influencing knowledge integration in supply chains

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This study investigates how multiple dimensions of power each facilitate knowledge integration within innovation projects in supply chains and their interrelationships. Adopting a process perspective of knowledge, we offer an alternative to much of the existing debate, which has focussed on the possession of resources. We collected data from four case-study Original Equipment Manufacturers and six associated suppliers and analysed these using Template Analysis and cross-case analysis. Our findings reveal how the power of the system, operationalized through relative performance measures, performance measurement mechanisms and the individuals in-charge of them, provides a facilitative context within which other dimensions of power operate. Here, the power of resources (expert and legitimate power), processes (associated with raising issues, cross-functional teams, early supplier involvement and reviews) and meaning (creating legitimacy through reviews) interact to support knowledge integration within innovation projects in supply chains. This, we argue, emphasises the plurality of power dimensions deployed and importance of their interrelationships in facilitating knowledge integration within hierarchical supply chain networks.

1. Introduction

Knowledge integration can be problematic for product innovation and manufacture within and across organisations (Rebolledo and Nollet, 2011). Combining and applying distributed knowledge from different knowledge domains in joint decisions and actions for the development of new products (Eisenhardt and Santos, 2000), knowledge integration brings together different internal and external stakeholders whom, it has been argued, may try to own and shape innovation processes according to their specific knowledge and concerns (Newell et al., 2009). The relationship between knowledge integration and power is important in supply chains (Jean et al., 2012). Yet, despite clear indications in the literature regarding the connectedness between knowledge integration and power (Newell et al., 2009), few studies have considered this in relation to hierarchical networks such as supply chains (Müller-Seitz and

Sydow, 2012), a recent call (Reimann and Ketchen, 2015) highlighting the need for such research. This article responds to this call, examining how multiple dimensions of power influence knowledge integration within innovation projects in supply chains through four aerospace industry case-studies.

Studies examining knowledge integration, transfer or sharing in supply chains (Becker and Zirpoli, 2003; Jayaram and Pathak, 2013) have typically adopted a knowledge-as-possession view (Nonaka, 1994). This has been criticized for side-lining power (Newell et al., 2009), defined as 'a force that effects outcomes, while politics is power in action' (Hardy, 1996, p. S3), existing in firms (Foucault, 1977) and in supply chains (Halley et al., 2010). Where research has considered the role of power in knowledge integration, it has focused either on power of resources (Jean et al., 2012) neglecting the multidimensionality of power in relation to knowledge integration (Becker and Zirpoli, 2003); or, where considering different dimensions of power and knowledge integration, only inferred applicability to supply chains (Swan and Scarbrough, 2005). Little is therefore known regarding the facilitative role of power in knowledge integration within supply chains, or the interrelationships between its different dimensions as part of a 'socially mediated and highly politicised' process (Newell et al., 2009, p. 197). This suggests two research questions:

1. How do multiple dimensions of power each facilitate knowledge integration in supply chains?
2. What interrelationships between different dimensions of power facilitate knowledge integration in supply chains?

We commence with an overview of literature on knowledge perspectives, power and knowledge integration in supply chains; highlighting Hardy's (1996) power framework. This, we argue, enables exploration of 'the multifaceted way in which power works' (Hardy and Leiba-O'Sullivan, 1998, p. 452) regarding knowledge integration. We then introduce our four case-study organisations and method. Our findings extend existing research highlighting how power of the system provides a facilitative context within which the power of resources, processes and meaning influence knowledge integration in innovation projects in supply chains. Of particular importance is how dimensions of power interrelate to facilitate knowledge integration. We conclude with a discussion of our findings and, acknowledging limitations of our study, offer directions for future research.

2. Knowledge, power and supply chains

Knowledge management research comprises two views: knowledge-as-possession and knowledge-as-practice. The former assumes knowledge can be treated as a resource, converted from tacit to explicit and *vice versa*, easily acquired, accumulated, and transferred between places (Marabelli and Newell, 2014). Yet, this may be problematic. Treating knowledge as a resource requires application if it is to be advantageous to organizations (McDermott, 2000) and also side-lines the influence of power (Newell et al., 2009) existing in supply chains (Halley et al., 2010).

In contrast knowledge-as-practice emphasizes knowing, arguing it is a social and organizational activity (Newell et al., 2009). Knowing is considered a sense-making process, where individuals in specific social contexts negotiate understandings (Weick, 2001). Such knowledge is both ambiguous and dynamic, being dependent on distinctive meanings and interpretations that alter as individuals and contexts change. Improvements and innovations therefore rely on individuals' social and political interests and interpretations to make sense of, create and legitimize knowledge; and on how activities, individuals and contexts merge (Clark and Staunton, 1989).

Supply chain literature focuses mainly on resource dependence. Within this, power is considered a resource that is exercised over others (Marabelli and Newell, 2014); being a property of firms in procurement (Cox, 2014), of exchange in buyer-supplier relationships (Cheng et al., 2001), or attributed to individuals in negotiations (Bonoma and Johnston, 1978). Associations have been identified between supply chain performance and the influence of power-bases (Benton and Maloni, 2005) as well as linkages between power-bases, agency and information sharing (Byrne and Power, 2014). However, a need remains to explore the processes, meanings and systems dimensions of power. These emphasize the socially and politically facilitated nature of knowledge, including the notion of power to act (Luhmann, 1975). Here power can be exercised by involving or excluding others from decision-making, through organizational symbols, and through legitimizing selected activities that influence decision-making and knowledge integration (Newell et al., 2009). Yet, although a few studies have considered different power dimensions (Smith et al., 2009), none offer explicit insight into the deployment of multiple dimensions of power in supply chains.

Hardy's (1996) framework comprises four dimensions that allow power in supply chains to be viewed as multidimensional:

- *Power of resources*—using resources residing in organisational relationships to influence decisions and produce preferred behaviours (Hardy and Dougherty, 1997). This is operationalized through rewarding (reward power), punishing (coercive power), knowledge and skills (expert power), identification with another (referent power) and an individual's right to influence others (legitimate power) (French and Raven, 1958).
- *Power of processes*—creating awareness by including individuals in decision-making and opening such processes to new issues and agendas (Hardy, 1996). This is operationalized through inter- and intra-organisational linkages in reporting relationships and departments' jurisdictions, as well as associated agendas, criteria, participation and information flows of decision-making (Hardy and Dougherty, 1997).
- *Power of meaning*—creating legitimacy and justification for arrangements, actions and outcomes so they are never questioned (Hardy, 1985). This is operationalized through the use of symbols to signify support (Hardy and Dougherty, 1997), highlight important issues and express meaning (Hardy, 1985).
- *Power of the system*—reflecting the taken-for-granted power deeply ingrained in organisational systems. This is operationalized through relative performance measures, performance measurement mechanisms and individuals in-charge of them. These create 'truth' about the aspect being measured (Carter and Scarbrough, 2001), providing a context of surveillance (Foucault, 1977) within which other dimensions are enacted (Hardy, 1996).

Supply chain research on power of resources and, in particular, expert power is reasonably wide ranging, including research specifically within the aerospace industry (Rose-Anderssen et al., 2008). Conceptual work has suggested, often from a knowledge-as-possession perspective, that incorporation of partners' expertise could support innovation and cost reduction (Miles and Snow, 2007). Empirical work has indicated the importance of sharing expertise to facilitate integration and relationships (Frohlich and Westbrook, 2001). Yet, research regarding the impact of legitimate power on knowledge integration in supply chains is contradictory. Some have suggested negative influences, highlighting contextual challenges in shared service centres such as power battles, resource dependencies and knowledge integration management (Knol et al., 2014); arguing it does not support knowledge integration (Becker and Zirpoli, 2003). Others have suggested positive influences, identifying accelerated decision-making (Ireland and Webb, 2007) and a facilitative role for formal control mechanisms (Canonico et al., 2012). However, we could find little research regarding how expert power actually influences knowledge integration in supply chains.

With regard to power of processes, research has emphasized how using reviews can instil a sense of urgency (Eisenhardt and Tabrizi, 1995), enabling risk to be controlled and resources prioritized and allocated (Schmidt et al., 2009). This has highlighted the positive influence of involving cross-functional teams in decision-making-processes (Swan and Scarbrough, 2005), particularly through face-to-face meetings (Schmidt et al., 2001), emphasising the importance for knowledge integration of joining different expertise (Huang and Newell, 2003). In relation to this, Huet et al. (2007) have argued that reviews can explicate major collaborative decisions and their justifications, suggesting their importance for power of meaning. However, whilst resultant performance benefits of reviews and early supplier involvement have been acknowledged (Bozdogan et al., 2002), the under-researched nature of such collaborative processes has also been noted (Langner and Seidel, 2009).

Research considering power of the system has highlighted plant managers' political skills (Smith et al., 2009), revealing how dominant relations defined knowledge (Carter and Scarbrough, 2001). Work across different organizations has also revealed how the power of the system influenced absorptive capacity and knowledge dissemination (Easterby-Smith et al., 2008), and that knowledge integration increased efficiency of activities within projects (Swan and Scarbrough, 2005) suggesting its wider applicability. However, this research has neglected supply chains.

Consequently, although researchers have, in aggregate, considered Hardy's (1996) power dimensions in relation to networked innovation, including knowledge integration (Swan and Scarbrough, 2005), their focus has rarely been on multiple dimensions within supply chains. This virtual absence of supply chain studies incorporating multiple dimensions of power with knowledge integration and the need to develop explanatory theory prompts our first research question:

1. How do multiple dimensions of power each facilitate knowledge integration in supply chains?

Table 1. Interview participants in case-study organisations

Case	Organisations	Number of respondents	Average duration of interviews	Example roles of interviewees across cases
Case study 1	Original Equipment Manufacturer of aircraft: Aerocomp A	19	70 minutes	• Senior vice president of a component/product group • Heads of different intra-organizational departments
	Supplier: Aerosup A	2		
	Supplier: Aerosup B	4		
	Total number of respondents	**25**		
Case study 2	Original Equipment Manufacturer of aero-engines: Aerocomp B	22	63 minutes	• Procurement managers • Project managers • Engineering managers
	Supplier: Aerosup C	1		
	Total number of respondents	**23**		
Case study 3	Original Equipment Manufacturer of aerospace defence systems: Aerocomp C	5	68 minutes	• Systems engineers • Flight physics engineers • Supply chain managers
	Supplier: Aerosup D	1		
	Supplier: Aerosup E	5		
	Total number of respondents	**11**		
Case study 4	Original Equipment Manufacturer of satellite systems: Aerocomp D	6	59 minutes	• Managing directors • Directors of specific organizational activities
	Supplier: Aerosup F	2		
	Total number of respondents	**8**		
Overall	Total number of respondents	**67**	66 minutes	• Customer account managers

The omission of a multidimensional power framework is also evident in much of the absorptive capacity literature. This emphasises one or two aspects such as resource allocation (Todorova and Durisin, 2007), managerial agency (Jones, 2006) or episodic and systemic power (Easterby-Smith et al., 2008). More recently, Müller-Seitz (2012) has identified how power-related mechanisms influence absorptive/desorptive capacity, highlighting implicitly how such mechanisms facilitate joint knowledge interpretation. Yet, despite Marabelli and Newell's (2014) recommendation for the inclusion of power over/power to in absorptive capacity research, little work examines knowledge integration using multiple power dimensions. Hence, our second research question:

2. What interrelationships between different dimensions of power facilitate knowledge integration in supply chains?

3. Method

3.1. Context

Following Koulikoff-Souviron and Harrison (2006), who note the utility of case-studies in developing better and more complete theories for supply chain research, we adopted a multiple case-study design. Multiple case-studies offer rich empirical descriptions of particular instances of a phenomenon (Yin, 2014), from which theory can be developed by recognising patterns and relationships (Eisenhardt and Graebner, 2007). They are therefore appropriate for answering 'how' questions, data from the multiple cases providing replications of, and extensions to, the emergent theory (Eisenhardt and Graebner, 2007). Data were collected from four Original Equipment Manufacturers (OEMs) of differing aerospace products and six associated suppliers providing manufacturing/design services. Each was involved in successful collaborative innovation projects developing aircraft or other airborne equipment. Being selected from an industry in which any one organisation is unlikely to contain all the specialist know-how required for product innovation (Jordan and Lowe, 2004), and focussing on innovations crossing intra and inter-organizational boundaries (Table 1), together these provided a theoretical sample (Yin, 2014) considered likely to reveal how the multiple dimensions of power and their interrelationships facilitate knowledge integration.

3.2. Data collection

Semi-structured interviews were undertaken with those involved directly in innovation projects and associated inter-organizational supply chain activities in all organisations (Table 1). Noting the difficulty of accessing concealed populations such as those involved in supply chain relationships, participants were selected using snowball sampling (Peck, 2005; Swan and Scarbrough, 2005). Initial participants introduced additional internal contacts and counterparts in suppliers with whom they had worked with on various innovation projects. Interview questions ensured data were collected on internal and external interactions; understandings of innovation project-related requirements and activities, conflicts and decision-making processes. Participants provided insights regarding the contexts, explanations, interactions between individuals, deployment of different dimensions of power, decision-making situations, conflict situations and processes of knowledge integration. Where practicable these data were corroborated using organizational secondary data including reports, scorecards and business process documents.

3.3. Data analysis

Following transcription, interviews within each case were analysed using Template Analysis (King, 2012). Initial lower order codes were derived from research questions, the literature reviewed and interview transcripts. Using NVivo these codes were attached to segments of the transcript data and, where necessary, revised. They were then combined to create higher order codes representing a template of significant themes. Each template was re-checked against associated transcripts, which were read thoroughly four times allowing a confident decision to be made to cease coding (King, 2012). NVivo was also used to link text segments to company documents.

Cross-case analysis (Yin, 2014) was undertaken subsequently to aggregate findings (King, 2012). This allowed themes associated with power and knowledge integration to be compared and contrasted and patterns to emerge. Patterns and relationships identified in individual cases were tested and either confirmed or disregarded by segments of data from other cases, replication allowing more robust theory (Eisenhardt and Graebner, 2007) to emerge. A final template (Table 2), comprising higher and lower order codes developed for the dimensions of power and knowledge integration identified across cases, was validated through discussion with participants (Miles et al., 2013).

4. Findings

Cross-case analysis revealed that resources, processes and meaning dimensions of power facilitated knowledge integration within supply chains. These operated within, and were contextualised by, the power of the system. In response to our two research questions we consider first the facilitative role of each of the resources, processes and meaning dimensions of power. We then consider their inter-relationships, in particular the context-providing role of power of the system.

4.1. Power of resources

Power of resources, in particular expert and legitimate power, was found to influence knowledge integration through both improved understandings and interventions to resolve conflicts. Across case-studies (Table 3), expert power influenced knowledge integration, as individuals from different knowledge domains in both OEMs and suppliers were consulted directly concerning various engineering and commercial situations. This allowed shared understandings to develop, expert power facilitating knowledge integration (Table 4, statement 1).

Senior managers used their legitimate power to resolve conflicts associated with financial or lead-time impacts, in particular project management, customer-related and multiproject issues; their interventions facilitating knowledge integration by removing deadlocks and minimizing project interruptions (Table 3). Legitimate power therefore supported developing shared understandings in light of renegotiated financial/lead-time parameters of innovation projects (Table 4, statement 2).

4.2. Power of processes

Cross-case analysis highlighted the importance of reviews, raising issues, cross-functional teams and early supplier involvement within power of processes. These facilitated joint working, developing shared understandings, superior product development and questioning. Reviews in particular enabled project-stakeholders to question, understand and influence innovation project-related discussions and decisions. Raising issues increased the likelihood of knowledge integration as individuals, particularly those with relevant expert knowledge (and power), were made aware of current and future project-related and engineering matters. Where such issues were interpreted jointly and, if necessary, expert guidance offered, this had a positive impact on cost, lead-times and product quality (Table 4, statement 3).

Across all case-studies awareness of functional interests, functional requirements and knowledge was developed through cross-functional teams. These facilitated knowledge integration, associated linkages enabling those involved to understand the wider implications of decisions made in one area for elsewhere in the supply chain (Table 4, statement 4). In

Table 2. Final template analysis coding scheme

Higher-order codes (themes)	Lower-order codes	Focus of statements to identify lower order codes
Power of resources		
	Expert power	
		Making use of someone's expertise Respecting someone's judgement involving an expert to resolve a problem
	Legitimate power	
	(Senior management involvement)	Right to make a decision/tell someone what to do
		Accepting someone's request/recommendation/decision
Power of processes		
	Raising issues	Communicating issues/problems Raising issues/problems
	Early supplier involvement	
		Involving suppliers early in decision-making processes Opening up decision-making situations/events to suppliers early Participation of suppliers early in decision-making processes
	Cross-functional teams	
		Cross-functional teams in relation to decision-making processes
		Multi-functional teams in relation to decision-making processes
		Cross-functional teams in relation to problem solving situations
	Reviews	
		Nature of involvement of individuals in periodical meetings/reviews
		Reviews
		Project meetings
		Decisions being made at reviews
		Discussions at reviews
Power of meaning		
	Process of justifying decisions (in relation to reviews)	Ways and processes of how decisions/actions were justified
	Activities/processes for justifying decisions	
	(in relation to reviews)	Activities/processes that were used to justify and legitimise decisions/actions
	Symbolic actions	
	(in relation to reviews)	Symbolic actions (e.g. any event, act, etc. that expresses meaning) as a result of which individuals may be encouraged to exercise agency

Table 2. (*Continued*)

Higher-order codes (themes)	Lower-order codes	Focus of statements to identify lower order codes
Knowledge integration process		
	Intended outcomes	
		What individuals set out to do at the beginning (i.e. usually talked about at the beginning of a success story/event/example)
		What individuals/teams intended to or needed to accomplish
	Outcomes	
		Successfully developed, implemented and improved components/products
		How a project has to progress
		Guidance regarding the resolution of problems
		Successful delivery of projects
		Understanding, for example customer and engineering requirements
		Resolution of problems
Power of the system		
	Relative performance measures	
		Ways in which relative performance is measured
		Meeting quality, cost, delivery (QCD) requirements
		Meeting airworthiness requirements
		Risk identification, assessment and mitigation
		Meeting customer requirements
		Meeting quality requirements
		Sales and delivery as performance indicators
		Heritage (whether a component/product has been used in space previously)
		Multi-project performance targets
	Measurement mechanisms	
	(reviews)	Measurement mechanisms
		When performance was measured
		Events/occasions when performance measurements were discussed
	Individuals in-charge of measuring	
		Individuals in-charge of measuring
		Independent review panels being in-charge of measuring performance
		Customers providing feedback on product performance
		Senior management measuring performance

making project-related decisions, team members needed to negotiate and translate their functional requirements across knowledge domains. In all cases interviewees argued cross-functional teams were necessary for knowledge integration due to the complexity of products being developed.

Cross-case findings also highlighted the impact of early supplier involvement on knowledge integration,

Table 3. Cross-case analysis results

Power dimensions	Power dimensions deployed through	Case study 1	Case study 2	Case study 3	Case study 4
Power of resources	**Expert power**	Independent panel members utilized their expert power to evaluate and assess progress of innovation projects. Knowledge integration outcomes: Negotiate joint understandings of project progress. Offering guidance.	Engineering and manufacturing from the supplier 'educated' Aerocomp B. Knowledge integration outcome: Changes of the initially requested requirements and the activities.	Expert power from engineers. Knowledge integration outcome: Helped supplier understand engineering requirements.	Project manager identified intra- and inter-organisational individuals. Knowledge integration outcomes: Joint interpretation and resolution of engineering problems. Development of an improved component.
Power of resources	**Legitimate power – senior management involvement**	OEM-supplier conflicts emerged due to engineering, financial and lead-times issues. Senior management at Aerocomp A and the supplier realign the trajectory of innovation projects. Knowledge integration outcome: OEM and supplier can re-engage in developing joint interpretations concerning innovation project without conflict.	Components had to go through a second engineering cycle. Knowledge integration outcomes: Senior management decision to determine appropriate cause of action for customers. Successful delivery of projects by re-allocating resources.	Budget and engineering resource constraints; senior management re-allocates resources internally (multi-project organization). Knowledge integration outcome: Enhances sharing and negotiating of joint interpretations on certain projects and vice versa.	Innovation project at the verge of being delayed due to cross-functional disagreements on best cause of action. Senior management resolve cross-functional disagreements. Knowledge integration outcome: Removal of deadlocks regarding the shared interpretation of project related issues.
Power of processes	**Raising of issues**	Component change requests by customer were raised and negotiated supplier. Knowledge integration outcome: Feasibility of change requests was jointly interpreted and appropriate solutions were suggested to customer.	Suggestions by a range of stakeholders regarding potential engineering resolution for component design problems. Knowledge integration outcome: Joint development of an improved component.	Involvement of different stakeholders to raise issues during product testing phase. Knowledge integration outcome: Issues jointly interpreted and resolved prior to entering manufacturing phase.	Customer requirements for a spacecraft identified as unrealistic by supplier. Knowledge integration outcome: Initial customer requirements were re-negotiated and jointly re-developed.

Table 3. (*Continued*)

Power dimensions	Power dimensions deployed through	Case study 1	Case study 2	Case study 3	Case study 4
Power of processes	**Cross-functional teams**	Cross-functional team from different engineering domains developed composite-based materials. Knowledge integration outcome: Superior product was developed as would have been possible by working in isolation.	Fuel consumption and the weight had to be improved on engine. Use of cross-functional team (different engineering disciplines). Knowledge integration outcome: Team developed a new production method.	Spin recovery systems problem. Cross-functional engineering-team used. Knowledge integration outcome: Development of a joint solution.	Cross-functional team was deployed to interpret, assess and translate customer in a proactive way for the supplier. Knowledge integration outcome: Revised customer requirements documents, which had been influenced by the interests of various internal stakeholders at Aerocomp D.
Power of processes	**Early supplier involvement**	Transition of manufacturing activities by acquainting the supplier early on with production processes. Knowledge integration outcome: Sharing and translating innovation project-related production activities from OEM to supplier.	Aerocomp B involving Aerosup C early in innovation process. Supplier heavily involved in designing and developing structure of engine components. Knowledge integration outcome: Developing the best solution from a cost perspective for particular engine components.	Early involvement of Aerosup E for developing safety critical equipment in a short period of time. Knowledge integration outcome: Approved equipment developed within required timeframe.	Early involvement of suppliers for developing product for more flexibility in orbit. Knowledge integration outcome: Translation of product requirements among the involved organizations. Misunderstandings regarding requirements avoided.
Power of processes	**Reviews***	Reviews were vital in relation to developing shared understandings of the progress of innovation projects and problems. Knowledge integration outcome: Reviews enabled stakeholders to question, understand and influence project related decisions.			
Power of meaning	**Reviews***	Reviews were a means to make major collaborative decisions and their justifications explicit. Knowledge integration outcome: Review panel provided justified guidance and decisions regarding how to advance innovation projects. Legitimized review panel decisions.			
Power of the system	**Relative performance measures**	A variety of performance indicators were mentioned across case studies: Meeting quality, cost, delivery requirements; meeting airworthiness requirements; risk identification, assessment and mitigation; meeting customer requirements; sales and delivery as performance indicators; multi-project performance targets.			Besides the performance measurements indicated on the left, 'heritage' was only important in case study 4.
Power of the system	**Performance mechanisms**	Key relative performance measurement mechanisms across all cases were innovation project reviews*.			
Power of the system	**Project stakeholders**	Across all organizations independent review panels, customers and regulatory authorities (e.g., Civil Aviation Authority and Military Aviation Authority) were in-charge of measuring performance.			

*Reviews were associated with the power of processes, meaning and the system. This is because (1) reviews were used as means to involve different stakeholders into decision-making processes (power of processes); (2) reviews were used as procedures to convey meanings (power of meaning) and (3) reviews were used as a mechanism to assess innovation project performance (power of the system).

Table 4. Selective case data regarding the dimensions of power

Statement number	Case number	Power dimension	Power dimensions deployed through	Illustrative participant statements
1	3	Power of resources	Expert power	*'It means that the buyer, the purchasing person, does not necessarily get involved with the detail and nor do they have experience and knowledge to understand detail and that detail affects the overall program so I think they are happy for us to have a direct contact as long as they are kept in the loop and it is not going to affect the contractual element to what purchasing or trying to do'.*
2	1	Power of resources	Legitimate power (Senior management involvement)	*'So where we have had sort of elements of conflict, where it has not been able to be settled at a local level, then it has been escalated to our seniors so that they can have a discussion with essentially the same guys that we deal with'.*
3	2	Power of processes	Raising of issues	*'We have these specialists involved in the product development process and they bring up a bunch of issues that could cause problems later on'.* *'The way we see it, it is good to raise issues during innovation projects because this tells us where we are along the innovation process. If, for instance, certain performance shortcomings are raised as part of a number of tests an engine has to go through, that is fine, because we know now that we need to make changes to the engine to get it to the desired level of performance, so it meets either safety requirements or specifications of our customers after the next round of tests'.* *'Usually what happens is, when an engine fails certain tests, these issues are discussed in the project team. Different individuals chip into such discussions and this helps to come up with a solution to improve the engine before it is tested again'.*
4	4	Power of processes	Cross-functional teams	*'Most of the technical problems we face are quite complex and require the consultation of a number of specialists in our cross-functional teams. It's not good if, let's say, if someone from Equipment Procurement [these guys deal with fairly expensive, complex and difficult to specify units, which are the core of our products] makes a decision that is OK for the components he is in charge of without discussing this decision with, for example, one of our Major Spacecraft Component Leaders [these are technical experts and are the owners of all product and component specifications] and other engineers. Because at the end of a project, it does not matter whether we have developed the best satellite components in an isolated fashion; if the overall satellite systems would not fit together and does not meet customer requirements and does not get approved, we have to go through another development cycle or would not win the contract'.* *'The permanent involvement and consultation of our various specialists is necessary to find out about the needs of our colleagues from different areas and also to make sure that the development of the overall product is viable'.*
5	3	Power of processes	Early supplier involvement	*'...he involves the manufacturer at an early stage to actually develop the requirements'.*

Table 4. (*Continued*)

Statement number	Case number	Power dimension	Power dimensions deployed through	Illustrative participant statements
				'It is important to get our suppliers on board early,…, it takes a while for them to get used to how we do business, if they are completely new to Aerocomp C. Also because, you know, we rely a lot on the design and manufacturing input of our suppliers, some of them are suppliers of specialist components and we do not know much about these components, the details I mean. So when we get the product requirements from our customers, we usually involve our suppliers right away, so we can assess and decide together whether and how we can deliver these requirements or whether we have to go back to our customer and ask him to make adjustments, if that is possible'.
6	1	Power of meaning	Legitimacy, Justification	*'At these reviews the different teams simply present what they have done since the last review to an independent panel. In many cases problems were identified at a previous review and teams, you know, they have to report back to this independent panel of how they resolved these problems. Then the panel discusses whether progress was good enough and we reach a decision of how to move the project on'.* *'These are quite heated discussions we have at the reviews, but I guess it is important to have such discussions, so the MFTs [multi-functional teams] know whether they have reached their project milestones for a project phase or whether they need to rework maybe some of the components they have worked on. It is all very requirements driven'.* *'Yeah, once a decision was made at a review, that is final. The team has got to do it, it is important'.*
7	1	Power of the system	Individuals in-charge of measuring performance, Performance measurement mechanisms	*'…each member of the multi-functional team will stand up in front of the review panel and the review panel is independent of the program. This review panel has nothing to do with Product Y. Right. So, it could be someone from Product Z, it could be someone from Product A, it could be someone from Product B. And they have not seen anything of our design. Okay, they may know what it looks like. All they know is that they are gonna come over to the review and evaluate the design, the manufacturability, etc., all day. And make recommendations of what needs to be done next'.*
8	2	Power of the system	Relative performance measures	*'I always have the customer in mind, my thought is first of all whatever happens it is customer protection first. Whatever the situation is, what is our customer protection plan? Protect the customer first and then look at the corrective action plan afterward'.*
9	3	Power of the system	Relative performance measures	*'I have a risk and performance register. So I look at the risks as well. When I look at top-level risks in the business, be it financial risk for the supplier, delivery risks, environmental risks. I will evaluate that risk and if that risk is relatively low then I might not do anything about it, but certainly at my level if there is a high risk I will look at what mitigation plans are in place and then we have an action list and we monitor the actions'.*

enabling suppliers to influence component/product developments early in innovation projects (Table 3). This allowed suppliers and OEMs to understand jointly customer requirements and, where necessary, re-negotiate potential concerns regarding cost, lead-time and quality. It also facilitated joint product development by combining expertise (Table 4, statement 5).

4.3. *Power of meaning*

Participants identified reviews as conveying power through meaning as well as processes. Such meaning legitimized subsequent actions, helping clarify and justify major collaborative decisions. In all cases independent functional experts were used as part of review panels to examine projects, discussing their different facets (Table 3). Subsequently, these panels provided justified guidance and facilitated decision-making processes for advancing their particular innovation projects. Power of meaning operationalized through these panels' symbolically open, transparent, critical and inclusive nature, helped legitimize decisions made, supporting knowledge integration (Table 4, statement 6).

4.4. *Power of the system and its contextualising role*

Interviews revealed power in innovation projects in supply chains was derived from systems of widely used relative performance measures, performance measurement mechanisms, and the stakeholders in-charge of measuring performance. These provided the context through which power of processes, resources and meaning were utilized (Table 3). Regular project reviews drew together information, operating as performance measurement mechanisms through which independent panels, not directly involved in a project under review, evaluated innovation project performance (Table 4, statement 7). Involvement of project stakeholders in such reviews created new awarenesses, suggesting clear linkages with power of processes (Table 3). Reviews served also as devices to justify and explicitly legitimize project-decisions. Within these stakeholder discussions, joint sense-making and subsequently making decisions through independent review panels, also indicated a legitimizing role for the power of meaning (Table 4, statement 6).

Deployment of relative performance measures facilitated knowledge integration, stimulating the need for joint understandings and actions. Performance shortfalls, for example, triggered the power of processes through using cross-organizational teams to resolve engineering problems and of resources through utilizing expertise (Table 3). For all cases, meeting customer (Table 4, statement 8) and regulatory authority requirements involved working with individuals in-charge of measuring performance. Engineering and health and safety requirements were considered equally important. Interviewees in all cases highlighted meeting airworthiness requirements, identifying, assessing and mitigating risk (Table 4, statement 9), alongside sales performance and multi-project performance targets.

5. Discussion and conclusion

Our article has addressed two questions regarding the influence of different dimensions of power on knowledge integration in innovation projects in supply chains. These concerned how each dimension of power, and which interrelationships between different dimensions of power, facilitate knowledge integration. Recognising that such relationships were more likely to be clearly visible in sectors where single organisations were unlikely to contain all the specialist know-how required for product innovation we explored these questions through four case-study aerospace OEMs and six associated suppliers. Drawing on what we believe to be the first study of knowledge integration for innovation projects in supply chains using a multi-dimensional power conceptualization we now outline our theoretical framework regarding these relationships (Figure 1).

Our research revealed the facilitative role of the four dimensions of power (Hardy, 1996) within knowledge integration for innovation projects in supply chains and their inter-dimensional relationships, thereby also addressing a call for empirical studies of innovation facilitators in supply chains (Zimmermann et al., 2016). It confirms Swan and Scarbrough's (2005) suggested applicability of the power of the system to knowledge integration in supply chains. However, unlike previous research it emphasises how the power of the system can, through performance measurement mechanisms, relative performance measures and project stakeholders create the context within which other dimensions of power operate. The range of relative performance measures used, define truth regarding performance. In combination they provide the base upon which joint understandings are developed and actions, as well as decisions leading to knowledge integration, are stimulated across organizational boundaries. Various project-stakeholders, including customers and regulatory authorities, set such performance requirements that, where necessary, deploy other dimensions of power subsequently to address performance shortfalls. The associated

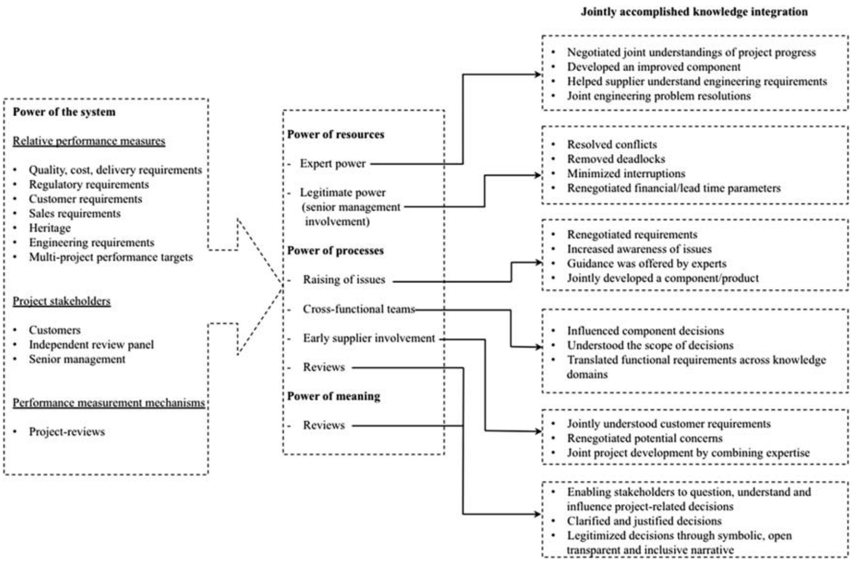

Figure 1. Theoretical framework of the influence of multi-dimensional power on knowledge integration in supply chains.

measurement mechanisms are formalized through reviews. These justify explicitly as well as further legitimize project-decisions providing processes through which corrective actions can be initiated, resulting in knowledge integration.

Regarding Hardy's (1996) power of resources dimension our research revealed expert and legitimate power are particularly important to knowledge integration within supply chains. Findings indicated positive influences of expert power, residing both within and outside of organizations, on knowledge integration. The application and combination of such expertise in our case-studies indicates this is not just transfer of expertise, as evident in supply chain research focusing on the knowledge-as-possession perspective (Miles and Snow, 2007). Rather, deployment of expert power in supply chains also concerns developing shared improved understandings and, being socially facilitated, highlights the process-perspective of knowledge. Findings, as suggested by Ireland and Webb (2007), also indicate a positive influence for legitimate power operating together with the raising of issues. Consequently, our framework highlights how senior management uses legitimate power (of resources) to become involved and resolve conflicts through the raising of issues (power of processes), thereby assisting generation of shared understandings.

Research on power of processes and their facilitation of knowledge integration in supply chains varies regarding reviews, raising of issues, cross-functional teams and early supplier involvement. Although our findings support a role for reviews within the power of processes, emphasing particularly their importance for knowledge integration (Huang and Newell, 2003), they also emphasize reviews facilitate raising of concerns. Within our framework reviews allow subsequent joint interpretation, increasing the likelihood of knowledge integration. Moreover, through creating an awareness of different stakeholder requirements and enabling joint interpretation, reviews (and the related raising of issues) are also associated with the power of meaning. We return to this cross-dimensional influence below.

Previous findings regarding the importance of the power of processes within cross-functional teams (Swan and Scarbrough, 2005) are supported. Within our case-studies awareness of functional interests, requirements and knowledge was developed through cross-functional teams, these supporting knowledge integration through improved understandings across the supply chain. Although not included explicitly in Hardy's (1996) power of processes dimension, our case-studies support findings regarding performance benefits (Bozdogan et al., 2002) of early supplier involvement in innovation projects to enable and facilitate knowledge integration. Our framework therefore incorporates such involvement as enabling suppliers to influence component/product development decisions early on and, if necessary, re-negotiate potential concerns such as cost, lead-time and quality.

We have already considered briefly Hardy's (1996) power of meaning dimension in our earlier discussion of reviews in relation to the power of processes and now explore this further. Our framework extends existing research regarding the importance of reviews (Huet et al., 2007), incorporating the social and political features of reviews' questioning that facilitate understanding for knowledge integration. Unlike previous research, it highlights an interrelationship between expert power from the power of resources dimension and raising of issues through reviews from the power of processes dimension to help convey meaning regarding different stakeholders' needs. With regard to the power of meaning dimension, reviews enable decisions to be understood, justified and legitimized, thereby supporting knowledge integration.

Although our research focussed on the aerospace industry, our framework is likely to offer insights relevant to other industries; revealing the contextualising role of power of the system through provision of performance measures, project stakeholders and performance mechanisms. This emphasises the importance of managers responsible for innovation projects in supply chains of understanding the impact of industry-specific, to some extent externally imposed, relative performance measures, and opportunities to influence these measures through their legitimate power (of resources) and their expert power.

Power of processes and meaning dimensions reveal how managers might deploy such power to enable knowledge integration in supply chains. Power of processes highlights the need for managers to develop both cross-functional and supplier involvement early in the process to enable issues to be raised and resolved jointly. Reviews through power of processes and of meaning allow questioning, enabling clarification and understanding as well as legitimising subsequent decisions.

To conclude, our theoretical framework (Figure 1) reveals how the inter-relatedness of power dimensions can facilitate knowledge integration in innovation projects in supply chains. Drawing on four case-studies involved in successful collaborative innovation projects in an industry where collaboration is the norm revealed how each of Hardy's (1996) dimensions of power facilitates knowledge integration, the power of the system providing the context within which the power of resources, processes and meaning operated. We represent these using solid black lines in Figure 1. Within supply chains knowledge integration is mediated through deploying the power of resources, processes and meaning. Rather than these dimensions operating in isolation, they interact within the broader context provided by the power of the system; this being represented by the arrow between the power of the system and the grouping of the remaining dimensions in one box. As such, our framework offers a fuller understanding of the influence of power on knowledge integration in supply chains. Compared with much of the existing supply chain literature, focusing on the knowledge-as-possession view, our framework testifies to the importance of the process-perspective of knowledge. In doing this we highlight the deployment of different dimensions of power influencing decision-making and knowledge integration in innovation projects in supply chains.

As a qualitative piece based on industry-specific case-studies, our research was not designed to offer statistical generalizability. Further research adopting a process-perspective is needed to examine the influence and interactions of dimensions of power identified concerning knowledge integration within other industries' supply chains. There is also a need to consider the extent to which influences of power on knowledge integration alter temporally as stakeholders change. Despite this, we consider our findings and associated theoretical framework, offer useful new insights regarding the inter-relatedness of multiple dimensions of power in enhancing knowledge integration.

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