Strategic Management Journal
Strat. Mgmt. J., **35**: 578–595 (2014)
Published online EarlyView 21 March 2013 in Wiley Online Library (wileyonlinelibrary.com) DOI: 10.1002/smj.2110
Received 24 July 2010; Final revision received 31 July 2012

RESEARCH NOTES AND COMMENTARIES

FROM CORE TO PERIPHERY AND BACK: A STUDY ON THE DELIBERATE SHAPING OF KNOWLEDGE FLOWS IN INTERFIRM DYADS AND NETWORKS

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We study 892 Italian motorcycle industry projects carried out via 184 different buyer–supplier and supplier-supplier relationships to provide evidence on the knowledge dynamics occurring in dyads and networks and to understand the underexplored but important (perhaps even dominant) leading role that some firms play in the evolution of networks and interfirm learning processes. We develop a multiphase model which, from a multilevel perspective addressing different relational subsets, suggests how firms can best organize to generate and exchange knowledge efficiently. We argue that extant theoretical perspectives can profitably draw on our findings to strengthen their dynamic components and help them explain the widely diffused 'exploring through partner' strategies more effectively. Copyright © 2013 John Wiley & Sons, Ltd.

INTRODUCTION

Both executives and academics have recently identified knowledge as one of the most important factors contributing to firms' ability to achieve sustainable competitive advantage (Dyer and Singh, 1998; Dyer and Nobeoka, 2000; Zhao, Anand, and Mitchell, 2005). At the same time, a growing body of research has come to consider networks as an appropriate unit of analysis (Powell, Koput, and Smith-Doerr, 1996; Kogut, 2000) and to examine the question of where a firm should draw its boundaries (Parmigiani and Mitchell, 2009) on the understanding that 'where boundaries are drawn affects the value placed on knowledge and its usefulness' (Argote, McEvily, and Reagans, 2003: 574). This work has shown how knowledge and other critical resources increasingly span firm boundaries so that the advantage of a single firm is often linked to those of the network of ties in which it is embedded (Dyer and Singh, 1998). In particular, research rooted in innovation literature (Powell *et al.*, 1996; Zhao *et al.*, 2005) and in buyer–supplier relationships (Kotabe, Martin, and Domoto, 2003) has emphasized the increasing importance of networking, alliances and idiosyncratic interfirm relations (Martin, Mitchell, and Swaminathan, 1995), and the advantages of adopting a cooperative mode for knowledge creation (Mesquita, Anand, and Brush, 2008). Strategic literature's focus on knowledge creation and management has been expanding in unprecedented fashion, so that the key knowledge-based questions companies face are not only how to organize themselves to exploit their already developed

Keywords: knowledge exchange and creation; interfirm networks; core and peripheral firms; knowledge-enhancing practices; motorcycle industry
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knowledge or capabilities, but also 'how to organize to efficiently generate knowledge and capability' (Nickerson and Zenger, 2004: 617).

Our multiple case, inductive study (Eisenhardt, 1989) attempts to answer the above question. We present a multiphase model of interfirm knowledge creation and exchange across dyads and networks and discuss the important (perhaps even dominant) role that buying firms play in the evolution of networks and of interfirm learning processes, which has hitherto been underexplored in the strategic literature. We posit that networks become viable organizational forms for sharing and generating valuable knowledge when a set of purposefully implemented knowledge-enhancing practices—which we define as distinctive patterns of action and interaction between core firms—'buyers'—and peripheral firms—'suppliers'—that enable the exchange, recombination, and co-creation of specialized knowledge—allow firms to leverage knowledge located beyond their organizational boundaries.[1] In particular, we focus on a total of 892 projects associated with the design and/or manufacture of components for motorbikes and/or scooters in the Italian two-wheeler industry. These projects involved 17 leading motorcycle manufacturers—core buyer firms who were responsible for setting up and subsequently 'orchestrating' dyads and networks (Dhanaraj and Parkhe, 2006)—and their (peripheral) first-tier suppliers.

CONCEPTUAL BACKGROUND

Although prominent firm perspectives have contributed greatly to explain how firms achieve sustainable competitive advantage, they still overlook the fact that, increasingly, even unique resources span firm boundaries and can be selectively tradable through a network of firms (Kogut and Zander, 1992; Gulati, 1999). Even contributions that have significantly extended resource-based reasoning (Barney, 1991; Peteraf, 1993) and are rooted in knowledge and capability-based views in strategy (Kogut and Zander 1992; Conner and Prahalad, 1996; Teece, Pisano, and Shuen, 1997; Felin and Hesterly, 2007) share a main focus on *intrafirm* transfers of existing knowledge (Hansen 1999; Tsai 2001; Reagans and McEvily, 2003; Levin and Cross, 2004) and are less well equipped to analyze knowledge transfer and creation *across* fully independent entities (which have become significantly more common over a wide range of industries, from automobiles to semiconductors) (Nickerson and Zenger, 2004; Hansen, Mors, and Løvås, 2005; Mesquita *et al.*, 2008). A growing number of empirical studies rooted in innovation literature (Powell *et al.*, 1996; Zhao *et al.*, 2005), and especially those adopting a relational perspective (Dyer and Singh, 1998), explicitly consider the collaborative network, rather than the single firm, as the locus for learning and innovation. In particular, research on buyer–supplier networks in the automobile industry (Dyer, 1996; Osborn and Hagedoorn, 1997; Argote *et al.*, 2003) has shown how the extensive involvement of suppliers in product and process development has given lead assemblers faster product development cycles, lower costs, better end product quality (Womack, Jones, and Roos, 1990; Dyer and Nobeoka, 2000), and faster problem solving (Takeishi, 2001). The idea that networks are critical for knowledge creation and exchange is corroborated by studies conducted from knowledge transfer perspectives (Tsai, 2001; Reagans and McEvily, 2003; Inkpen and Tsang, 2005). Systematic evidence from this research stream indicates that networks with substantial knowledge transfer mechanisms between manufacturers and suppliers out-innovate relational sets with less well-developed knowledge-sharing routines.

Following Kogut (2000), we see networks as the outcomes of generative rules of knowledge coordination, which constitute capabilities (e.g., speedy response to change, resource orchestration, etc.) generating relational rents, which can be subject to private appropriation. Our study focuses on multiple transactions and on those deliberate and purposeful actions designed to facilitate knowledge generation and mobility across networks' boundaries, which are central to their ability to co-innovate and so co-create value (Zhao *et al.*, 2005). While most studies focus on ties with generically defined content, we disentangle the intertemporal processes of knowledge creation and exchange between organizations and adopt a multilevel perspective that addresses three different subsets

[1] Throughout the article, we make use of the core periphery pattern to convey the particular situation in which core firms, which possess prominence gained through relational skills and their central position in network structures, leverage their position to harness the knowledge dispersed among peripheral firms.

of relationships—R&D, operations, and other up- and downstream activities. We also investigate learning processes and knowledge-related activities involving both sides of the dyad and consider them as both knowledge transmitters and recipients. Although several studies have included bilateral (buyer and supplier) analyses (e.g., Zander and Kogut, 1995; Takeishi, 2001; Kotabe *et al.*, 2003), they have considered knowledge flows only as unidirectional—one unit providing and one receiving—and such perspectives clearly limit our understanding of cases where firms both provide and receive knowledge. Finally, we show how the effective creation and extraction of network value hinges on the purposeful enactment by core firms of practices designed to lead and facilitate knowledge sharing and deployment.

METHODS

Research design, setting, and sample construction

Our inductive, multiple case study (Eisenhardt, 1989) examines the Italian powered two-wheeler industry, which we deemed appropriate for several reasons. First, product architecture: motorcycles and scooters[2] are made of dozens of modules and subassemblies whose development and manufacture requires diverse and specific know-how and expertise (Helfat, Lipparini, and Verona, 2011). Second, the level of product innovation involved is appropriate: manufacturers are continually challenged by the introduction of new materials—plastics, titanium, carbon fibers, light alloys, etc.—into frames and components, as well as the need to meet changing environmental regulations (Helfat *et al.*, 2011). Third, the intense industrial process innovations, which require manufacturers to adopt state-of-the-art equipment and R&D practices and to base their manufacturing activities on leading-edge technologies (Gavetti, 2001). Fourth, the size of Italy's domestic market—the largest in Europe in terms of powered two-wheeler production (nearly 55%), registrations (26.7%), and numbers of motorcycles in use (26%)—and its competitive position as Europe's leading exporter, headed only by Japan and Taiwan in world rankings (ACEM - Association des Constructeurs Européens de Motocycles, 2010).

Our study included core motorcycle firms (assemblers) that sold products in Italy (regardless of their country of origin) and peripheral firms (suppliers) localized in Italy that specialized in the design and/or manufacture of industry components. Both of these types of firms work within a network structure of non-equity, long-term cooperative buyer/supplier relationships. We selected core firms on the basis of lists supplied by the Italian Ministry of Transportation (from www.trasporti.gov.it) and the trade association (www.ancma.it), and we used Italian market sales performance figures for 2007, the most recent year for which comprehensive statistics were available. We contacted representatives at the full list of 25 core firms specializing in scooter and/or motorcycle design and/or production, and 17—covering nearly 85 percent of Italian market sales—agreed to participate. In selecting peripheral firms, we first used business publications to identify relevant groups of two-wheeler components and modules, each including multiple, often specialized, subcomponents (thus, 'body' includes frame, suspension, forks, etc.; 'brakes' include drums, cylinders, pads, shoes, etc.). Working from publicly available sources (e.g., motorcycle and spare parts catalogs, national and international exhibition business directories, online bikers' communities, etc.), we identified a list of 43 component suppliers. Checking this list with our full core firm group, we identified 19 suppliers who each had links with at least seven core firms: 13 of them agreed to participate and supplied details about their ties to core firms.

Data collection and analyses

To avoid restrictive theoretical or empirical lenses (Santos and Eisenhardt, 2005), we defined knowledge broadly, as encompassing both easily codifiable and transmittable information and complex and more difficult to codify know-how. The interaction patterns we noted implied the existence of ties between two entities, which we define as *voluntary collaborative arrangements of strategic significance between independent organizations, based on written contracts and aimed at sharing tacit and explicit knowledge*. Our study employed

[2] A scooter is a small-engined, two-wheeled motor vehicle with certain design characteristics such as a step-through frame, small wheels, and an automatic transmission.

several data sources: quantitative and qualitative data from semi-structured interviews with executives from both tie partners; archival data (press releases, annual reports, corporate documents, etc.); direct observations, including visits to the R&D units, plants, and headquarters of nearly all core firms and every peripheral firm; and e-mails, phone calls, and follow-up interviews. In particular, we conducted 81 face-to-face on-site interviews (totaling nearly 170 hours) over a 28-month period in 2007, 2008, and 2010 with 52 different executives from both core and peripheral firms. Respondents were selected according to several criteria (Yin, 1994): long tenure in the company; direct involvement in knowledge-related decisions; and functional and hierarchical variety. This use of multiple internal sources helped mitigate the potential biases of any individual respondent (Kumar, Stern, and Anderson, 1993).[3]

We began our interviews at the core firms. Each consisted of three main parts: background information on the firm and its business strategy; description of key events in the formation and evolution of the firm's ties (if any) with our sample suppliers; and direct questions about knowledge exchange/creation, including details of development projects for new scooter/motorcycle components core firms had with each listed supplier. The first interview round (2007 to 2008) focused on projects from 2004 to 2007, and the second round (2010) focused on 2008 to 2009 projects. We queried the types of knowledge exchanged with each supplier and the main direction of knowledge flows, which might be simple—mostly outbound flows of information and know-how toward suppliers or return flows to core firms—or more advanced—bidirectional and intertwined interactions that might contribute to the cogeneration of knowledge. Lastly, we asked core firms about the practices they had implemented to support such knowledge flows and any that facilitated flows between their suppliers. We used interview techniques such as 'event tracking' to gain accurate information (Eisenhardt, 1989) and repeated the process later with peripheral firms. We triangulated our interview data with observation and archival data to improve its accuracy and completeness, combining contemporary and retrospective data to improve both external and internal validity (Leonard-Barton, 1990).

We selected key peripheral firm informants on the same criteria as for core firms and followed the same basic interview structure so that the responses complemented our core firm data. We asked supplier executives to report about the specific projects identified by the core firms—about the levels of relevant information and know-how they had received from their buyers, the knowledge they had returned to them embedded in components or services, and about bidirectional flows and joint knowledge creation. They also reported on knowledge flows between them and other peripheral firms promoted by a common core firm. In all, we collected data on 892 projects enacted via 184 dyads connecting 17 core firms and 13 peripheral firms: more specifically, on 776 projects carried out via 163 buyer–supplier ties and 116 stemming from 21 supplier-supplier relationships. All these collaborations (58 of which involved racing) were based on written contracts and (as our interview analysis revealed) could be categorized into one of three broad functional areas: R&D, operations, and other up- and downstream activities, which we identified as the industry's focal organizational areas for knowledge exchange and creation. Figure 1 highlights the whole pattern of ties between core and peripheral firms (solid lines), as well as between peripheral firms (dotted lines). Table 1 highlights the main activities carried out by the core firms and the components/groups supplied by peripheral firms.

Our data analyses were structured according to established procedures for theory building from inductive research, working recursively between multiple cases and theory (Eisenhardt, 1989; Yin, 1994). We included all the interviews and archival and observational data in a report of approximately 550 pages (including quotes), beginning with in-depth analyses, synthesizing the data for each project and dyad into individual case histories, and noting knowledge flows, their dominant directions, and the practices underlying them. We then moved to cross-case analyses, which produced consistent patterns and common themes (Eisenhardt and Graebner, 2007): initially we compared varied pairs of cases (e.g., specific knowledge transfer occurrences seen from the core and peripheral firms' perspectives) and added other interfirm knowledge-enhancing practices as patterns emerge to identify more robust

[3] The composition of our sample firms, their product ranges, and the position of each company's interviewees is available online See Appendix S1.

DOI: 10.1002/smj

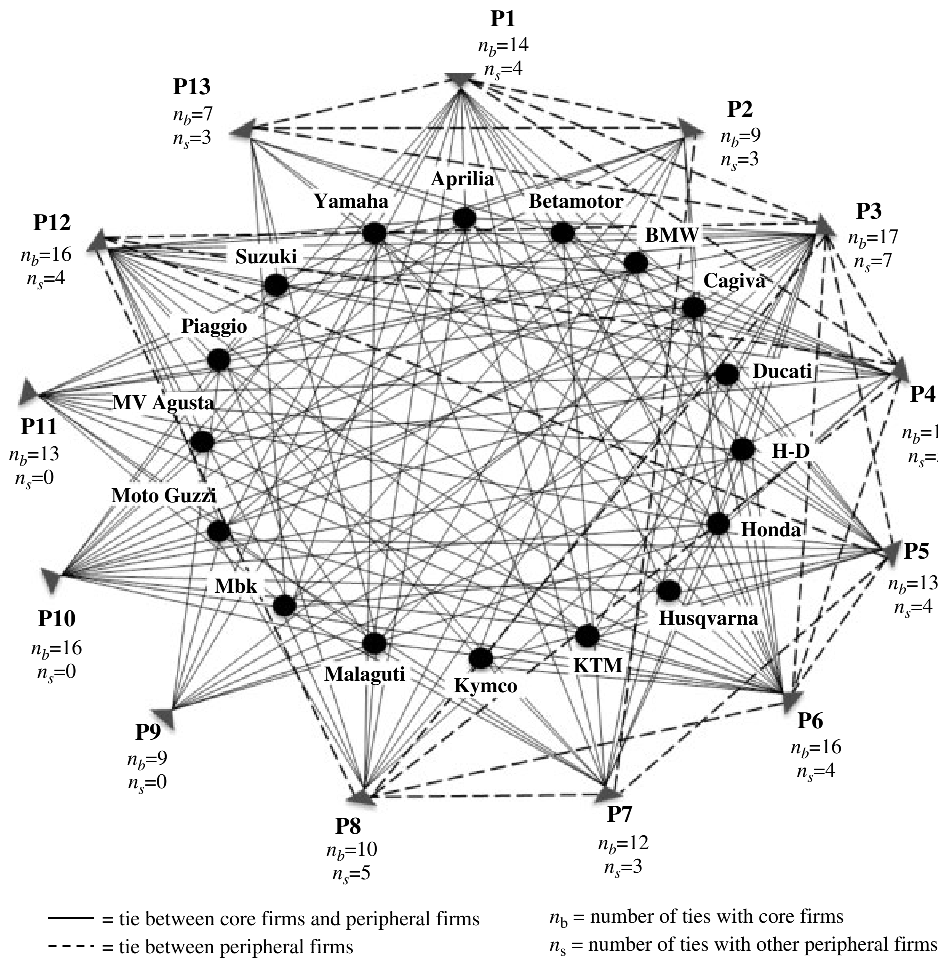


Figure 1. Ties between Italian top two-wheeler buyers (or 'core firms') and key component suppliers (or 'peripheral firms' - P). $N = 184$.

causal and temporal relationships (Eisenhardt, 1989).

We structured our analysis of knowledge-enhancing practices using a 'temporal bracketing' strategy (Langley, 1999), organizing the data into successive 'phases,' defined so that there is continuity in the activities within each phase but discontinuities at their frontiers (Langley and Truax, 1994). As Langley (1999: 703) notes, 'many temporal processes can be decomposed in this way, at least partly, without presuming any progressive developmental logic.' Our data analysis allowed us to develop a four-phase conceptual model of how core firms deliberately shaped knowledge practices to stimulate interfirm knowledge exchange and creation, at both the dyad and network levels. Our firm informants helped us identify and validate the four phases and the knowledge flows involved.

THE SHAPING OF KNOWLEDGE EXCHANGE AND CREATION IN DYADS AND NETWORK: A FOUR-PHASE MODEL

The interfirm exchange and co-creation of knowledge in the Italian motorcycle industry network we investigated can be portrayed in four phases. In Phase 1, knowledge flows are mainly from core to peripheral firm, the former channeling information and know-how to a number of selected suppliers. In Phase 2, knowledge flows reverse this direction, moving mainly to core firms from peripherals, who return some of the knowledge they originally received in more refined forms and transfers some of their own proprietary knowledge to the core firms. Once knowledge transfer channels have been established, Phase 3 sees bidirectional flows,

DOI: 10.1002/smj

Table 1. Core and peripheral firms (activities and components/groups supplied)

Core firms	Activities
Aprilia	Scooter and motorcycle design and production
Betamotor	Motorcycle design and production
BMW	Motorcycle design and production
Cagiva	Motorcycle design and production
Ducati	Motorcycle design and production
Harley-Davidson	Motorcycle design and production
Honda Motor	Scooter and motorcycle design and production
Husqvarna	Motorcycle design and production
KTM	Motorcycle design and production
Kymco	Scooter design and production
Malaguti	Scooter design and production
MBK	Scooter design and production
Moto Guzzi	Motorcycle design and production
MV Agusta	Scooter design and production
Piaggio	Motorcycle design and production
Suzuki	Scooter and motorcycle design and production
Yamaha	Scooter and motorcycle design and production
Peripheral firms	**Specialized components/groups**
P1	Electronic ignition and battery recharging system
P2	Electronic carburetors/oil pumps/ throttle bodies
P3	Brakes
P4	Wheels
P5	Steel and light alloy precision frameworks
P6	Forks - shock absorbers
P7	Front suspensions
P8	Shock absorbers - fuel pumps and valves
P9	Plastic - rubber
P10	Turn indicators - lights
P11	Tail lights - indicators - reflectors
P12	Light alloy cast components and integral wheels
P13	Design and development

with core and peripheral firms exchanging knowledge simultaneously, making it difficult to identify a predominant direction. In Phase 4, knowledge flows between peripheral firms that are linked to the same core firm, and learning extends from dyads to the network.

These phases do not represent 'stages' in the sense of being a predictable and sequential process and do not imply a progressive life cycle logic as found in many normative change theories. Specifically, they allow us to constitute comparative units of analysis to explore theoretical ideas (Langley, 1999)—and are especially useful in illustrating how the actions in one period affect those undertaken in the next. Figure 2 illustrates the temporal structuring of the different phases, showing how an example core firm (Honda Italia) maintains a portfolio of ties with different peripheral firms. Each core firm will have such a portfolio of ongoing projects with each supplier, which may be at different phases and may relate to R&D, operations, or upstream/downstream activities alone, or to them all. This example case shows Honda's portfolio of eight projects (related to the many versions of its scooters and bikes) in which it collaborates with P12 (a steel alloy body supplier) and their different learning phases. Thus, Project A (the heavyweight CBR1000RR bike entirely designed and manufactured in Italy) entered Phase 1 in Q1, 2003 and Phase 2 in Q2, 2004, and has been in Phase 3 since Q2, 2006. Project B (developing and manufacturing frames for top-selling scooters, e.g., the SH300) spent more than two years in Phase 1, had been through Phase 2 (with inbound flows overlapping the Phase 1 outbound flows by a considerable margin), and entered Phase 3 in Q1, 2009. At the time of the survey, it was expected to enter Phase 4 in Q2, 2012, as the peripheral firm P12 starts collaborations with two other suppliers to develop a frame for next-generation scooters. Project C (developing steel alloy frame for scooters like the Foresight 250) has been in Phase 1 since Q1, 2003: Honda Japan had already developed definitive engineering details, and suppliers were invited to exploit Honda's innovation to add value for both partners. But Phase 4-type information and know-how flows have been taking place between the frame maker and partners supplying braking systems and wheels (three highly interdependent components) since Q2, 2008. At the time of the survey, Project C was expected to enter Phase 2 in Q3, 2012, with inbound knowledge flows from P12 constituting the platform for Honda engineers' future design activities.

Phase 1—Knowledge flows from core firms to peripheral firms

Core firms are channeling knowledge (information and know-how) to peripheral firms in different forms and at different codification levels, leading to spiraling interactions between tacit and explicit knowledge (Nonaka, 1994). Table 2 reports some

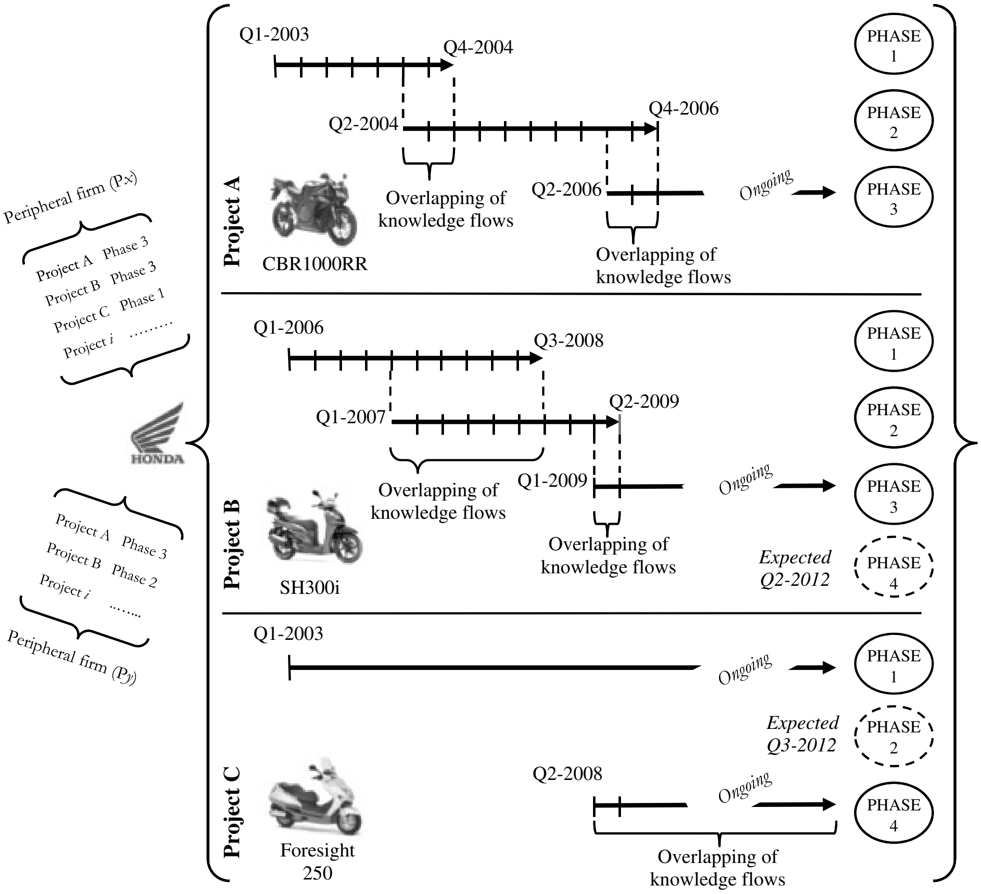


Figure 2. Example of knowledge flows between core firm (Honda Italia) and peripheral firm (P12-steel alloy frames for bikes and scooters).

practices that shape outbound flows and the main benefits (peripheral) recipients perceive from those flows. With respect to R&D (Table 2, Phase 1), in 301 projects, we found core firms sharing information about development cycles with peripheral firms to ease prototype development and gain time/cost efficiencies. Core firms transferred information and techniques on product concepts and assembly designs to suppliers in nearly one-third of the projects we studied, and they also (to a lesser extent) shared detailed blueprints and offered specific training about product concepts and design-for-assembly logics and techniques. Other core firm practices we observed included: preparing manuals outlining practices and rules for R&D interactions, supporting purchasing costs of R&D tools, and licensing proprietary technologies to peripheral firms. Transferring tacit knowledge effectively requires extensive personal contact and trust and the supplier developing codification processes to transform it into explicit knowledge. At the operations level (Table 3, Phase 1), practices supporting outbound knowledge flows included: sharing detailed production schedules with suppliers, checkup visits to their company and plant, organizing and delivering training about production methods and working practices (such as just-in-time and lean production principles) to align and synchronize manufacturing and assembly processes. Core firms also arranged training on statistical quality control methods and quality performance indicators to assist suppliers with quality assurance and quality certification, as well as on ICT and enterprise resource planning (ERP) platforms, inventory management techniques, and plant management principles. A number of practices covered other upstream and downstream activities (Table 4, Phase 1). For instance, core firms revealed proprietary information about market forecasts and trends to their

Table 2. The knowledge flows-enhancing practices related to R&D. $N = 776$ for Phases 1, 2, and 3; $N = 116$ for Phase 4

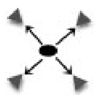
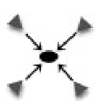
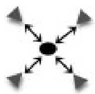
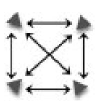
Phase 1	Practices aimed at shaping knowledge flows from core firms to peripheral firms	N	% on total projects ($N = 776$)	% on proj. in Phase 1 ($N = 362$)	Main benefits (as perceived by peripheral firms)*
	Sharing of information on development cycles	301	38.8	83.1	Cost and time savings - process synchronization
	Transfer of information and techniques on product concept and design for assembly	263	33.9	72.7	Knowledge transfer effectiveness - process improvements
	Sharing of detailed blueprints	209	26.9	57.7	Quality improvement - time savings
	Specific training to align (or realign) reciprocal R&D competencies	188	24.2	51.9	Improved coordination - unleashed human capital potential
	Realization and delivery of manuals with explication of practices and rules for interaction	166	21.4	45.9	Aligment of practices - effective interactions
	Support in the purchasing of tools for R&D-related activities	132	17.0	36.5	Alignment - Time savings - increased efficiency
	Licensing of proprietary technology	119	15.3	32.9	Increased competitive potential - reduced search costs
Phase 2	**Practices aimed at shaping knowledge flows from peripheral firms to core firms**	**N**	**% on total projects ($N = 776$)**	**% on proj. in Phase 2 ($N = 213$)**	**Main benefits (as perceived by core firms)***
	Transfer of specialized knowledge and technical information on state-of-the-art technology	176	22.7	82.6	Quality improvement - effectiveness of knowledge transfer
	Component and module design-in activities	169	21.8	79.3	Alignment with buyers' product architecture - cost advantage
	Sharing of proprietary technology and know-how	143	18.4	67.1	Satisfy customers' demand of uniqueness - unleash knowledge potential
	Internal training to develop design-sharing capabilities	140	18.0	65.7	Improve the evaluation of design alternatives - time savings
	Use of rapid prototyping techniques	123	15.9	57.7	Cost reduction - time savings
	Simulation-driven design/Off-the-shelf mechanical simulation software	112	14.4	52.6	Reduction of engineering costs - more effective design analyses
	Development of unique technical solutions for racing activities	91	11.7	42.7	Enabling the technology's potential - learning by racing effects

Table 2. Continued

Phase 3	Practices aimed at shaping bidirectional knowledge flows (between core and peripheral firms)	*N*	% on total projects ($N = 776$)	% on proj. in Phase 3 ($N = 201$)	Main benefits (as perceived by parties in a dyad)*
	Structured meetings on a weekly basis	143	18.4	71.1	Identification of how to fix problems - fast response
	Implementation of components and modules codesign and co-engineering activities	132	17.0	65.7	Cost reduction - time savings
	Guest engineers at the customer's and the supplier's plant	116	14.9	57.7	Sharing of capab. in concurrent develop. - learning from others
	Joint tests on a regular basis	115	14.8	57.2	Quality improvement - improved reliability
	Joint training on value engineering/value analysis activities	98	12.6	48.8	Unleashed technology's potential - time savings
	Regular confrontation on how to synchronize and update CAD models	94	12.1	46.8	Updating of tools - time savings
	Buyer–supplier trial centers for racing experiences	65	8.4	32.3	Shaping of knowledge advancements - fast response
Phase 4	**Practices aimed at shaping knowledge flows between peripheral firms**	***N***	**% on total projects ($N = 116$)**		**Potential benefits (expected by core firms)***
	Training provided by core firms to improve first-tier suppliers' team-working skills	69	59.5	-	Development of relational capabilities - higher effectiveness
	Transfer of methods/techniques to stimulate codesign activities among first tiers	58	50.0	-	Sharing of practices - higher efficiency and effectiveness
	Regular seminars and workshops on R&D's organizing principles at the network level	36	31.0	-	Effective know. generation, transfer, and access - time savings
	Assistance in the identification of second tiers with complementary R&D capabilities	29	25.0	-	Access to unique R&D capabilities - network effectiveness

Note: Dots refer to core firms/buyers (circle) and peripheral firms/suppliers (triangles). Arrows connecting dots highlight the main directionality of knowledge flows.
* Only the two most highly cited benefits from field interviews are reported.

Table 3. The knowledge flows-enhancing practices related to operations. $N = 776$ for Phases 1, 2, and 3; $N = 116$ for Phase 4.

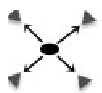
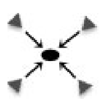
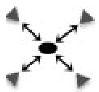
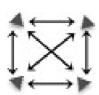
Phase 1	Practices aimed at shaping knowledge flows from core firms to peripheral firms	N	% on total projects ($N = 776$)	% on proj. in Phase 1 ($N = 362$)	Main benefits (as perceived by peripheral firms)*
	Sharing of detailed production scheduling programs	324	41.8	89.5	Time savings - improved planning capabilities
	Company and plant visits for checkup	309	39.8	85.4	Cost efficiencies - fast recovery
	Training on production methods and working practices (e.g., just-in-time and lean production)	254	32.7	70.2	Cost and time savings - increased productivity
	Consultancy related to quality assurance	196	25.3	54.1	High reliability - cost savings
	Training related to ICT and ERP platforms	168	21.6	46.4	Time efficiencies - improved communication
	Support provided for quality certification	156	20.1	43.1	High reliability - impact on suppliers' reputation
	Technical support in buying equipment/machinery	132	17.0	36.5	Cost savings - high reliability at the process level
	Training on inventory management techniques and principles of plant management	127	16.4	35.1	Cost efficiencies - waste reductions
Phase 2	**Practices aimed at shaping knowledge flows from peripheral firms to core firms**	**N**	**% on total projects ($N = 776$)**	**% on proj. in Phase 2 ($N = 213$)**	**Main benefits (as perceived by core firms)***
	Investment on highly specialized finishing processes and treatment	164	21.1	77.0	High quality - cost savings
	Delivering of updated production scheduling programs	147	18.9	69.0	Quick ramp-up to required output level - high flexibility
	Investment on the development of production quality capabilities	121	15.6	56.8	Augmented productivity and quality - cost savings
	Preventive maintenance of the machines	118	15.2	55.4	Cost and time savings - high quality
	Dedicated tool manufacturing/CNC machines/CAD-CAM stations/flexible mfg. stations	109	14.0	51.2	Flexibility and reliability - time and cost efficiency
	Homologation trials relative to products supplied by the customer	97	12.5	45.5	High quality - reliability
	Static/dynamic product liability and material composition tests in the many stages of production	96	12.4	45.1	High conformity and quality - increased product durability
	Investment in robotized work units/laser cutting stations/die-casting foundry	83	10.7	39.0	Time efficiency - quality improvements

Table 3. Continued

Phase 3	Practices aimed at shaping bidirectional knowledge flows (between core and peripheral firms)	N	% on total projects ($N = 776$)	% on proj. in Phase 3 ($N = 201$)	Main benefits (as perceived by both parties in a dyad)*
	Monthly meetings for a constant assessment of the pull logic (in response to demand)	155	20.0	77.1	Alignment - lower coordination costs
	Joint assessment of principles and techniques of lean manufacturing and value stream mapping	143	18.4	71.1	High efficiency of cost and time - discovery of opportunities
	Joint optimization of warehouse stock volumes, joint orders for purchasing materials	128	16.5	63.7	Cost savings - reduction of opportunity costs
	Joint investment for the implementation of integrated enterprise resource planning (ERP)	122	15.7	60.7	Scheduling and monitoring of production - high efficiency
	Activation of quality circles to reduce defects, scraps, and waste	101	13.0	50.2	Cost savings - development of recovery capabilities
	Joint initiatives for faster delivery of spare parts, improving the quality of repairing services	90	11.6	44.8	Time efficiency - impact on reputation
	Constant confrontation on statistical quality control methods and quality performance indicators	85	11.0	42.3	Cost savings - high conformity
	Initiatives to support the full integration of logistic processes of both parties	85	11.0	42.3	Cost and time efficiency - fast responses
Phase 4	Practices aimed at shaping knowledge flows between peripheral firms	N	% on total projects ($N = 116$)		Potential benefits (expected by core firms)*
	Initiatives (e.g., workshops and coaching) to extend effective SCM and mfg. practices to the whole network	49	42.2	-	Network efficiency and effectiveness - high productivity
	Transfer of methods/techniques to stimulate coordination of mfg. activities among first tiers	39	33.6	-	Improvements of manufacturing capabilities - network efficiency
	Training on the diffusion of planning tools (e.g., software systems) from initial order to delivery	27	23.3	-	Improved planning capacity - better plant utilization
	Assistance by buyer firms in the initial stages of their relationship with other suppliers	22	19.0	-	Increased networking capacity - network responsiveness

Note: Dots refer to core firms/buyers (circle) and peripheral firms/suppliers (triangles). Arrows connecting dots highlight the main directionality of knowledge flows.
* Only the two most highly cited benefits from field interviews are reported.

DOI: 10.1002/smj

Table 4. The knowledge flows-enhancing practices related to upstream and downstream activities. $N = 776$ for Phases 1, 2, and 3; $N = 116$ for Phase 4

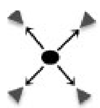
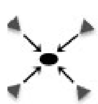
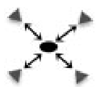
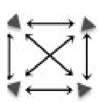
Phase 1	Practices aimed at shaping knowledge flows from core firms to peripheral firms	N	% on total projects ($N = 776$)	% on proj. in Phase 1 ($N = 362$)	Main benefits (as perceived by peripheral firms)
	Managerial support provided to suppliers for market forecasts and market trends	159	20.5	43.9	Improved planning capacities - operational effectiveness
	Training on the breakdown of costs (suggesting ways that suppliers can seek to reduce costs)	133	17.1	36.7	Cost savings - opportunities for new investments
	Training suppliers on management/strategy tools in support of the dyad	120	15.5	33.1	Accurate seizing of markets - assessment of resources
	Financial support to the supplier's procurement of tools and equipment	118	15.2	32.6	Cost efficiencies - opportunities for new investments
	Communication initiative in favor to suppliers to enlarge their spare market	109	14.0	30.1	Better assessment of markets - additional resources
	Privileged access to resources (e.g., talented employees) via benefit-rich ties	102	13.1	28.2	Improved capability base - access to distinctive capab.
	Support in the preparation of an export plans (for those suppliers who want to export overseas)	98	12.6	27.1	Strategic effectiveness - improved managerial foresight
	Training on marketing and relational capabilities to enlarge the supplier's customer base	85	11.0	23.5	Reduced dependence by core firms - learning from others
Phase 2	**Practices aimed at shaping knowledge flows from peripheral firms to core firms**	**N**	**% on total projects ($N = 776$)**	**% on proj. in Phase 2 ($N = 213$)**	**Main benefits (as perceived by core firms)***
	Detailed breakdown of prices and transparency of the various offerings	131	16.9	61.5	Improved capacity in value analysis - trust consolidation
	Support in the preparation of technical specifications and documents for final users	129	16.6	60.6	Increased reliability - impact on core firm's image
	Sharing of information relatives to complementary sources of components and technology	105	13.5	49.3	Efficiency increases - assesment of supply markets
	Seizing opportunities to customers (e.g., lower emissions and respect of regulations)	98	12.6	46.0	High reliability - distinct positioning on final market
	Deliberate transfer of 'learning from others' related to the portfolio of ties in the industry	93	12.0	43.7	Import of best practices - cross-fertilization
	Suggestions for the mastering of the buyer's business capabilities	79	10.2	37.1	Capability improvements - new business opportunities

Table 4. Continued

Phase 3	Practices aimed at shaping bidirectional knowledge flows (between core and peripheral firms)	N	% on total projects ($N = 776$)	% on proj. in Phase 3 ($N = 201$)	Main benefits (as perceived by both parties in a dyad)*
	Joint assessment of end user profiles	109	14.0	54.2	Customized responses - impact on competitive positioning
	Joint participation in projects for fund-raising	101	13.0	50.2	Resource availability - opportunities discovery
	Periodical checks for efficiency in interfirm communication and transfer of information	96	12.4	47.8	Efficient knowledge transfer - effective recovery
	Joint evaluation of changes in business models (e.g., selling through the Internet)	91	11.7	45.3	New business opportunities - sensing of market opport.
	Joint relations with core research institutions and other relevant actors	58	7.5	28.9	New business opportunities - capability development
	Definition of coordinated responses to opportunistic behaviors from partners in the network	43	5.5	21.4	Reduction of threats of know. leaking - network identity
Phase 4	**Practices aimed at shaping knowledge flows between peripheral firms**	**N**	**% on total projects ($N = 116$)**		**Potential benefits (expected by core firms)***
	Organization of confrontational sessions among fir[st] tiers on market forecasts	54	46.6	-	Effectiveness - improved assessment capacity
	Brainstorming sessions for the joint identification of synergies across different alliances	51	44.0	-	Capability development - discovering of opportunities
	Structuring and management of joint archives on potential partners or lessons learned	47	40.5	-	Time efficiency - opportunity creation
	Coaching sessions with first tiers involved in common projects to reinforce collaborative culture	32	27.6	-	Network effectiveness - network adaptability
	Sponsoring events with fir[st] tiers suppliers for goals alignment and continuous improvement	29	25.0	-	Network effectiveness - increased sense of community
	Assistance in the definition and implementation of 'network contract' (recently introduced in the Italian legislative framework)	26	22.4	-	Network identity - effective responses

Note: Dots refer to core firms/buyers (circle) and peripheral firms/suppliers (triangles). Arrows connecting dots highlight the main directionality of knowledge flows.
*Only the two most highly cited benefits from field interviews are reported.

peripheral firms, thus improving their planning capacities and operational effectiveness, and also gave training on cost breakdowns and on management and strategy tools to help suppliers improve their efficiency, even providing financial support to help them buy tools and equipment. Core firms also established communication initiatives aimed at helping suppliers find new markets to increase their abilities to identify and enter new markets (often related to racing events) to help improve their financial stability: shaping joint visions and seizing market opportunities allowed these partners to develop joint dynamic capabilities.

Phase 2—Knowledge flows from peripheral firms to core firms

Peripheral firms relying simply on markets to access specialized assets and acquire technology are likely to see their capabilities deteriorate (Teece, 1986) and to remain stuck in passive, dependent postures (Rosenberg, 1982). Peripherals that purposefully supply core firms with return knowledge turn their relationships into partnerships, making it harder for core firms to switch to other suppliers. In terms of inbound R&D knowledge (Table 2, Phase 2), our study depicts peripheral firms as providing specialized knowledge and technical information: by sharing proprietary technology and know-how, including alerting their partners about advances in state-of-the-art technologies and proposing design alternatives to allow them to fulfill their customers' unique demands more completely. Other practices included: organizing training sessions to develop design-sharing capabilities, developing rapid prototyping techniques, and using simulation-driven design to give core partners with significant engineering cost benefits and more effective design analysis. At the operations level (Table 3, Phase 2), suppliers shaped their knowledge flows to core firms by investing in highly specialized finishing processes and treatments, a practice we observed in nearly one-fifth of the projects and which benefitted a wide range of activities including product and process feasibility, surfacing, structural analysis, and prototype engineering. Peripheral firms also transferred knowledge embedded in updated production scheduling programs, made considerable investments in developing quality production capabilities, and offered preventive maintenance of core firms' production machinery—flows that were enabled by their possession of dedicated manufacturing tools, CNC machines, CAD-CAM working stations, and flexible manufacturing systems. Such inbound flows also extended to other upstream and downstream activities (Table 4, Phase 2). Peripheral firms provided core firms with detailed price breakdowns and supported the preparation of technical specifications and documents for final users, building core firms' reliability and reputation. Their practices extended to sharing information about complementary sources of components and technology, which may seem to be counterintuitive behavior, but was aimed at reinforcing network potential and effectiveness and supporting core firms' reactions to market opportunities, e.g., by speedy response to changing vehicle emissions regulations.

Phase 3—Simultaneous, bidirectional knowledge flows between core and peripheral firms

In Phase 3, firms reciprocally exchange knowledge and cocreate 'collaborative knowledge' (Simonin, 1997), a prerequisite for virtuous relational learning. In terms of R&D at this phase (Table 2, Phase 3), design engineers on both sides of the dyads recognized the value of working together on projects to share expertise, foster problem solving, and improve the efficiency and quality of product development: the interaction inherent in these knowledge-enhancing practices nourished virtuous cycles of reciprocal learning. In the projects we studied, we observed structured meetings to exchange information and know-how to fix problems rapidly, as well as recurrent codesign and co-engineering activities at component and module levels, joint testing, and the systematic parallel updating of partners' CAD models to reduce design times and costs, allowing both parties to rapidly assess concept, development, and total lead times via interfirm ties. Hosting partners' engineering teams supported simultaneous knowledge exchanges, and our data also revealed a significant number of relational platforms (or 'customer trial centers,' as one core company labeled them) where teams of engineers from core and peripheral firms interacted to solve specific problems. Joint participation in racing also enhanced both parties' knowledge and supported their R&D activities, as many innovations developed for racing bikes were later featured in retail production

DOI: 10.1002/smj

models. At the operations level (Table 3, Phase 3), monthly meetings were arranged in one-fifth of the projects we studied, allowing them to constantly assess the 'pull' logic, increasing core/periphery alignment and time efficiency and lowering coordination costs. We also noted how parties interacted to jointly assess lean manufacturing principles and techniques and employed value stream mapping to raise their cost and time efficiency and their effectiveness in attaining manufacturing goals. Other practices supporting bidirectional knowledge flows included: synchronizing purchasing orders and optimizing warehouse stock volumes, jointly implementing integrated enterprise resource planning (ERP), and using 'quality circle' initiatives to cut defects and waste. In the 'other activities' sphere (Table 4, Phase 3), we saw evidence of joint assessment of end user profiles to improve response effectiveness and participation in fund-raising projects to increase resource availability. Coevolutionary alignment took the form of the periodic updating of communication and information flows needed to respond quickly to environmental jolts or to competitors' moves.

Phase 4—Knowledge flows between peripheral firms

In the fourth model phase, we observed knowledge flowing between different peripheral firms, whose connection had been promoted and supported by a common core firm. Largely unexplored by strategic literature, this guided evolution of learning processes from dyads to networks yields significant insight into how core firms connect alters to gain informational (Burt, 2000) and other difficult-to-replicate network-specific advantages. Redeploying knowledge dispersed across collaborative networks requires that core firms possess (or develop) learning and teaching capabilities across organizational boundaries, as this targeted coordination of knowledge mobility is central to a network's ability to co-create value and innovation (Zhao *et al.*, 2005). As for R&D (Table 2, Phase 4), we observed knowledge exchange and creation between peripheral firms being accomplished by: training suppliers on improving team working skills for greater effectiveness across dyads and networks, transferring methods and techniques to stimulate co-design activities among first-tier suppliers, and organizing workshops and seminars on R&D organizing principles at the network level. Core firms supported such intersupplier knowledge flows by identifying second-tier suppliers with complementary R&D capabilities. At the operations level (Table 3, Phase 4), core firms extended effective supply chain and manufacturing activities across their networks by organizing workshops and coaching sessions, transferring methods and techniques to stimulate coordination among first-tier suppliers, and providing training to diffuse planning tools covering a range of activities from initial orders to delivery. To a lesser extent, we also saw core firms play active roles in helping peripherals manage the initial stages of their interrelationships, such as helping develop joint manufacturing plans. In other areas (Table 4, Phase 4), core firms organized sessions between peripheral firms on market forecasts and identified synergies across different alliances. Core firms' ability to lead by sharing strategy also hinged on them sharing lessons learned, databases, and potential partner profiles to create further opportunities for their suppliers. Core firms ran coaching sessions to reinforce the network's goal alignment and helped suppliers elaborate 'network contracts' to give them unique identities in fund-raising applications.[4]

DISCUSSION AND CONCLUSION

We present a structured framework that takes a multilevel perspective to address different relational subsets, depicting knowledge flows at dyad and network levels. We found core firms that took charge of the processes of interfirm learning from firms to dyads, and from dyads to networks, and of knowledge-enhancing practices all needed to nurture the transfer, recombination and creation of specialized knowledge. Such practices are favoring the affirmation of higher-order organizing principles (Grant, 1996), the idiosyncratic learning processes (Kotabe *et al.*, 2003), and the interfirm knowledge-sharing routines (Dyer and Singh, 1998). The network we studied combined the advantages of common identity and language normally associated with hierarchical forms (Kogut and Zander, 1992; Conner and Prahalad, 1996) with the learning incentives that typically occur in dyads and networks. Having multiple

[4] Key quotes from our interviews across the four phases are available online See Appendix S2.

DOI: 10.1002/smj

actors involved in defining the rules governing cooperation decisions (Kogut, 2000) led the network to develop stronger shared identity and language, lowering the costs of communication and knowledge exchange, establishing rules and principles for coordination, and influencing the direction(s) of both searching and learning. The whole network, thus, becomes more expert at capturing opportunities, developing new products, and extracting technical and organizational capabilities both from current ties and from dormant or unexpected contacts (Kane, 2010). In our setting, the threat of opportunism appears to have been more than outweighed by the advantages of: learning from other partners (Lorenzoni and Lipparini, 1999), including developing joint 'interaction routines' (Nelson and Winter, 1982), making it easier for firms to modify existing behavior patterns as needed and improving transactive knowledge—about who knows what—to better enable information transfer (Reagans, Argote, and Brooks, 2005). These incentives help firms perceive networks as 'safe places' where ideas and knowledge can be exchanged, but with reduced risk of knowledge spillovers to competitors who share the same partners (Lester and Piore, 2004).

Our findings suggest that all else being equal, the most successful learning processes will accrue in dyads and networks where both sources and recipients possess the requisite knowledge transfer capacity. A company's capacity to effectively deploy knowledge is only as strong as the weakest partner in its innovation value chain, so unilateral flows of knowledge to third parties do not guarantee the sustainability of any advantage. We contribute to explaining why some dyads and networks succeed in learning faster than their competitors (Dyer and Nobeoka, 2000), enabling their partner firms to achieve their strategic objectives (Zollo, Reuer, and Singh, 2002). Our study also contributes to clarifying the role of firm capabilities in alliances and, in particular, the capabilities they need when entering alliances. Extant contributions have carefully examined alliance (Kale, Dyer, and Singh, 2002), relational (Lorenzoni and Lipparini, 1999) or boundary-bridging (Takeishi, 2001) and orchestration capabilities (Dhanaraj and Parkhe, 2006), and we add to this list the capacity for transferring and creating knowledge (Smith, Collins, and Clark, 2005) which we show is needed by all parties in dyads and networks. Future research could refine and build on this study in several directions: it could empirically determine which network structure dimensions are most likely to influence project outcomes, as well as examine the relationship between project phases, knowledge-enhancing activities, and outcomes. Equally interesting would be to study whether informal, distant, or infrequent relationships—rather than strong recurring ties among a small number of buyers and suppliers—lead to more or less efficient knowledge sharing (Hansen *et al.*, 2005). It would also be interesting to consider 'negative ties' (Labianca and Brass, 2006), given that many of the core firms in our sample are competitors. As to this, it could be interesting to examine how competitive relationships between core firms might influence, for instance, choices about forming ties with specific peripheral firms that are already tied to rivals (Gimeno, 2004), therefore gaining a deeper understanding of both the 'structure of cooperation' (Ahuja, 2000) and the structure of competition.

ACKNOWLEDGEMENTS

We received valuable insights from Will Mitchell and from two anonymous reviewers. We thank Jon Morgan of Paraphrase for expert copyediting and Lois Gast for effective management of this manuscript. We express our appreciation to all the firms, respondents, and interviewees who participated in this study. We acknowledge support from the Strategy & Organization Center at the University of Bologna. The authors alone are responsible for errors and omissions.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article:

Appendix S1. List of core and peripheral firms (product mix and company's interviewees)

Appendix S2. Typical quotes illustrating patterns of interaction in the Italian motorcycle industry (excerpts from the interviews)

DOI: 10.1002/smj