OPEN INNOVATION IN SUPPLY CHAINS; OPEN SUPPLY CHAINS

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Abstract

The chapter starts with an overview of the origins of supplier-driven innovation, introducing central concepts and models including supply chain management, lean production and lean supply, tiered supplier structure, open supply chain, and networked innovation. Then, the evolution of supply chains, from OEM-centred to networked ones in the open innovation context is presented analytically. Particular attention is paid to the early supplier involvement perspective, exemplifying how it relates to OI and how it can be implemented and managed stepwise. How supplier involvement is related to the different stages of the life-cycle of a product and how this affects stakeholder engagement and supplier-buyer relationships for sustaining collaborative innovation over time, is then analysed. Finally, the practical implications of OI in supply chains are summarized, and two mini-cases featuring real-world examples of collaborative innovation in the supply chain are presented.

Prerequisite	Generic knowledge of operations management / supply chain management / logistics from an introductory course; Knowledge about the basics of Open Innovation, outbound, inbound and coupled innovation.
Objective of the lecture	Lecture targets are MSc students in engineering and management and MBAs in management, and the lecture aims at providing them with profound understanding of open innovation concepts and strategies in the context of supply chains.
Workload	4-6 teaching hours; 8 h self-study.
Learning outcomes	Understanding the evolving role of suppliers as partners in andcontributors to innovation and new product development. Understanding how OI has contributed and contributes to transforming industrial models in the global manufacturing industry, and how the supply chain is managed in order to leverage innovation. **Knowledge** **LO #2:** To explore concepts of collaborative innovation and apply them. **LO #17:** To learn to recognise the sources of innovation and operationalisation of these sources. **LO #38:** To identify the nature and characteristics of the innovation process. **LO #69:** To identify external sources of innovation. **Skills** **LO #41:** To analyse critically case studies related to innovation. **LO #42:** To analyse the innovation needs of a company. **Competences** **LO #1:** To recognise, design and analyse innovative business models. **LO #43:** To emphasise the strategic perspective of innovation management. **LO #46:** To recognise and exploit aspects related to open innovation.
Reading List	1. Open vs. closed supply chain – definitions and comparison (Marsh, 2011).

	2. Lean Production – the origins of OI in supply chains (Krafcik, 1988; Lamming, 1993). 3. Overview of product development process (Cooper, 2008). 4. Early supplier involvement (Dowlatshahi, 1998; Schiele, 2010). 5. Open R&D and processes for supplier-buyer integration (Enkel, Gassmann & Chesbrough, 2009; Manceau, Kaltenbach, Bagger-Hansen, Moatti & Fabbri, 2012; Karlsson et al. 1998). 6. Motivate and support supplier collaboration in OI (Antikainen, Mäkipää & Ahonen, 2010; Fawcett, Jones & Fawcett, 2012). 7. OI and industry dynamics (Christensen, 2014 in Chesbrough & Bogers, 2014). 8. Evidencing OI's suitability in industrial R&D practice (Chechurin, 2016 in Mention & Torkkeli, 2016).
European Qualifications Framework (EQF) Level	Levels 6, 7.

Lecture Content

Definitions

Supply chain – A network created by different companies producing, handling and/or distributing a specific product. Specifically, the supply chain encompasses the steps it takes to get a good or service from the supplier to the customer (Investopedia, 2016).

Supply chain management – Planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies (Council of Supply Chain Management Profe sionals, 2013).

Lean Production – A particular way of organising work, making use of technology, managing relationships between customers and suppliers, streamlining the product development process, dealing with customers, and so on. Lean production is 'lean' because "it uses less of everything compared with mass production - half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time. Also, it requires keeping far less than half the needed inventory on site, results in many fewer defects, and produces a greater and ever growing variety of products" (Womack, Jones & Roos, 1990, p. 13).

Lean Supply – A strategic model for assembler-supplier relationships that relies on the concept of equals' contributions to the strategic, tactical and operational goals of the supply chain. It targets at a particular innovation; the supplier must not only contribute to product technology via the medium of collaborative effort with the assembler, but also develop technologies independently of theassembler's requirements (Lamming, 1993)

Supply Chain Integration (SCI) – Integration in terms of forward physical flows between suppliers, manufacturers and customers, and backward physical flows of information and data from customers to suppliers (Frohlich & Westbrook, 2001). Further, the strategic position of the supply chain with regard to integration can be measured on the basis of two key dimensions: i) the direction of integration, i.e. towards customers or suppliers, and ii) the degree of integration, i.e. narrow or broad. The resulting concept is an "arc of integration" (Frohlich & Westbrook, 2001), which is presented below. Generally speaking, integration postulates the movement from conventional, arms-length and conflict-laden relationships to cooperative, long-term business partnerships and strategic alliances (Tsanos, 2016).

Early Supplier Involvement (ESI) – A form of vertical collaboration between supply chain partners

in which the manufacturer involves the supplier at an early stage of the product development process (Knowledge Brief Manage, 2016).

Closed Supply Chain (CSCH) – A highly integrated set of networks in which many of the techno ogies being applied are developed at least partially by the company orchestrating the system (Marsh, 2011).

Open Supply Chain (OSCH) – The emphasis is on standardised components that fit together in a modular fashion. In these systems, suppliers are generally encouraged to be the main innovators and sell the same components to a range of customers. OSCH is common in such industries as automotive, aerospace and many areas of consumer electronics (Marsh, 2011).

Open innovation (OI) – A distributed innovation process based on purposively managed knowledge flows across organisational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organisation's business model (Chesbrough & Bogers, 2014).

Open innovation (related to the supply chain) – The focus is on knowledge flows between su pliers and their customers, and between complementary or collaborating suppliers in the same tier, or across tiers in a given supply chain, with the objective of enhancing innovation in the final output. The focus is also on developing and implementing those pecuniary and non-pecuniary mechanisms that will ensure appropriate coordination, collaboration and integration in the supply chain so that the intended innovation outcomes can be reached.

Networked innovation (related to the supply chain) –Occurs "through relationships that are negotiated in an ongoing communicative process, and which relies on neither market nor hierarchical mechanism of control" (Swan & Scarborough, 2005, p.5). It is a hybrid form of an organisation with a specific purpose for collaboration and multiple actors involved in the innovation process. The collaboration covers both knowledge transfer and co-creation activities between the actors (Valkokari, Paasi, Lee & Luoma, 2009).

Process – A set of interrelated or interacting activities that use inputs to deliver an intended result (ISO, 2015), via certain workflow and decision-making practices, to reach strategic business objectives (Pellikka & Kajanus, 2015).

Project – Unique process, consisting of a set of coordinated and controlled activities with start and finish dates, undertaken to achieve an objective conforming to specific requirements, including the constraints of time, cost and resources (ISO, 2015).

Supplier quality assurance – Confidence that a supplier's product or service will fulfill its customers' needs (ASQ, 2016).

Theoretical background

The Origins of Supplier-Driven Innovation

The terms "supply chain" and "supply chain management" were first used in 1982 by Keith Oliver, a British top logistician and consultant, in an interview with Arnold Kransdorff for the Financial Times to describe the range of activities coordinated by an organisation to procure and manage supplies (Heckmann, Shorten & Engel, 2003). A supply chain is an integrated structure of activities that pr cure, produce and deliver products and services to customers. The chain starts with suppliers of the focal organisation – the assembler or Original Equipment Manufacturer (OEM), and ends with its customers. The widespread focus on the supply chain and suppliers as a source of enhanced efficiency, productivity and innovation has its roots in the introduction, diffusion and implementation of Japanese-inspired concepts, methods and tools in complex manufacturing businesses, which can be conveniently summarised under the notions of lean production (Womack, Jones, & Roos, 1990) and lean supply (Lamming, 1993).

The term "lean" was originally introduced as opposite to the term "buffered" (Krafcik, 1988). In his seminal Sloan Management Review paper, Krafcik specifies a buffered production system as having:

- high inventory levels buffering against unexpected quality problems;
- built-in buffers in assembly lines to keep production moving if equipment breaks down;
- legions of utility workers on the payroll to buffer unexpected periods of high absenteeism; and
- huge repair areas to buffer against poor assembly line quality, and so on.

Lean production systems, stated then by Krafcik as best exemplified by Toyota, show opposite conditions to buffered production systems: inventory levels are kept at an absolute minimum so that quality problems can be detected and solved quickly; bufferless assembly lines assure continuous flow of production; utility workers are no longer necessary; repair areas are tiny as a result of the belief that quality should be achieved within the process.

Relying on a global quantitative and qualitative research of production organisation in the world automobile industry, Womack, Jones and Roos (1990) have presented lean production, originally from Toyota, through five elements:

- running the factory,
- designing the car,
- coordinating the supply chain,
- dealing with customers, and
- managing the lean enterprise.

To understand lean production, every step in the process (not only final assembly) must be regarded. The study takes a global perspective and establishes that in 1990, lean production existed, i.e. lean design, lean supply, lean manufacturing, and lean sales management were regarded as fully developed at Toyota and Honda and as being extensively adopted by some Western manufacturers (e.g. Ford, mainly due to learning from their then alliance with Mazda).

Each lean production element is described through a comparison with classical mass production, and lean is argued to be superior to traditional mass production in all elements. This is supported by performance indicators such as product development lead time, assembly hours, assembly defects, and inventory. Womack, Jones and Roos (1990) conclude that the worldwide automotive industry needs to adopt the lean model. Its diffusion is discussed, but not its transferability. Finally, they introduce the notion of 'lean enterprise', which is the mechanism of coordination needed to bring all lean elements into harmony also on a global scale.

In the mid-1990s, lean production and lean supply principles were widely diffused and deeply implemented, often not without frictions, in the global automotive industry, and due to the important depth and breadth of the automotive supply chain, in the wider manufacturing industry in Europe and the US alike (De Banville, Barnerias, Deranlot & Chanaron, 1997; Helper, 1994; Karlsson & Åhlström, 1996; Karlsson et al., 1998; Ward, Liker, Cristiano & Sobek, 1995).

Based on these developments, the new 'lean' buyer-supplier relationships in industrial component supply can be summarised in three points (Soderquist, 1997):

- Notable reduction in the number of suppliers with whom the carmaker has direct contact;
- Increased innovation and product development responsibility for the remaining suppliers; and
- Tight coordination and control over the restructured supply chain, involving specific forms of trust.

Behind these changes lay the need for cost reductions, quality improvements, and lead-time reductions – both in terms of development and delivery lead-time, all of which were driven by the globalisation of competition and the emergence of Japanese products (i.e. cars) that showed higher performance in these three criteria[1], and that also enjoyed an extraordinary growth in the world-wide market share of passenger cars[2] .

At the level of industrial structures, these changes resulted in the development of a new industrial organisation; the pyramidal tier-structured supply chain. Coupled with this was a new sourcing strategy for the buying part; single or parallel sourcing. This supplier structure, defining the tier concept, is illustrated in Figure 1.

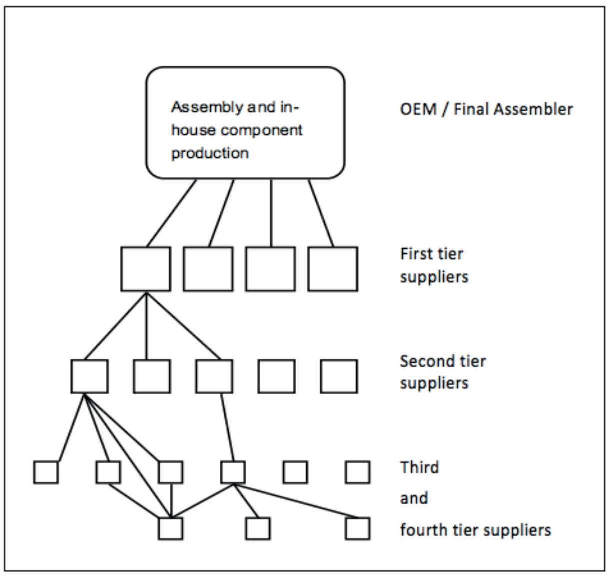


Figure 1. The tiered supply chain structure. Adopted from Soderquist (1997)

This illustration is of course simplified. It only assumes one final assembler, while in reality most suppliers, independent of their tier position, supply more than one customer – a higher level supplier or a final assembler. Moreover, it does not consider the complicated real-world pattern where one specific supplier can be first- and second-tier supplier at the same time, either in relation to different customers or in relation to different product groups.

1 For figures see Womack, J. P., Jones, D.T. & Roos (1990). Reduced development lead time becomes visible to the end-customer above all through quicker adaptation to switching trends in the demand.

2 From 3.6% to 25.5% between 1965 and 1989 according to the Motor Vehicle Manufacturers Association of the United States, quoted in (Dyer & Ouchi, 1993).

Lamming (1993) proposes another basis for suppliers' tier classification than physical supply, namely supply of know-how and development of intelligence for enhancing innovation. He introduces the notions of direct and indirect suppliers to illustrate this phenomenon. The following four situations are identified:

1. Direct supplier of components and know-how. This is typically a system supplier, integrating several components into a system, which is delivered to the assembly line ready for fitting into a final product.

2. Indirect suppliers of components (no intelligence links). They supply components to the direct suppliers on a contract.

3. Indirect/direct supplier. This kind of supplier has a direct relationship (components and knowhow) to the assembler and an indirect relationship through other direct suppliers. Depending on how aligned such a supplier is or would like to be with the OEM's industry (thus depending on the product/market strategy of the supplier), it will tend to move either towards more direct supply, taking on more technological responsibility, or be phased out from the direct supplier base by the OEM. It could also be possible for this kind of a supplier to maintain a dual role.

4. Indirect influential supplier. Suppliers of high-tech products or materials tend to have intelligence exchange with the OEM even though they supply their products to be incorporated (e.g. micro-processors) or transformed (e.g. composite materials) by another supplier to be of use to the assembler.

This typology is a big step towards a better understanding of the innovation potential in the supply chain as compared to the tier model. It indicates that it is theoretically irrelevant to talk about suppliers only in terms of tiers; both the supply of components and development of intelligence must be considered. Moreover, the degree to which a supplier is aligned with the industry of the OEM (e.g. cars, appliances, mobile phones/tablets...), in terms of the current situation and the strategy for the future, has to be analysed in order to understand the innovation potential.

KEY TAKE-AWAYS

• The widespread focus on the supply chain and on suppliers as a source of innovation has its roots in the introduction, diffusion and implementation of lean production, which, inspired by Japanese practices, was implemented across the Western manufacturing industry during the 1990s.

• Lean production as an integrated industrial model involving design, manufacturing supply chain and customer relations, presents lower inventory levels, uncovers and solves quicker and more systematically quality problems, ensures continuous flow of production and makes utility workers unnecessary, compared to traditional 'buffered' mass production systems.

• Lean drives changes in supplier relations and in SCM, in particular the implementation of the pyramidal tier-structured supply chain structure. It brings a reduced number of direct suppliers for the OEMs, increased innovation and product development responsibility for the remaining suppliers, and tight coordination based on trust.

• Direct and indirect supply concern the supply of both physical components and development of intelligence leveraging innovation. This can be illustrated in a typology of suppliers with four distinctive roles based on the relationship types.

From lean supply to open innovation in the supply chain

The increasingly open supply chains are a natural evolution of lean production and lean supply, especially as the main principles of lean have spread across industries, attaining also services, and the parallel open source movement has brought the ideas of lean – or agile - to the sphere of code writing and software development.

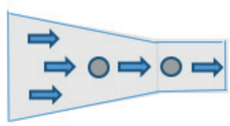
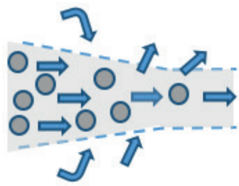
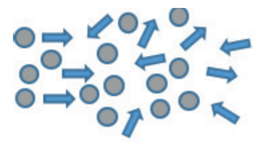
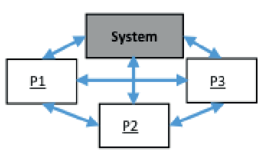
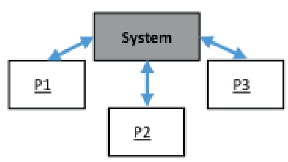
As regards component-intensive consumer product manufacturers, e.g. of cars, white and black goods[3], and technology products, as well as industrial equipment manufacturers (machines, tools, robots...), businesses have over the past 10 years been gradually opening up the productdevelopment process to new ideas hatched outside their walls by suppliers, independent inventors and university labs. Rapid technological development, shorter product life cycle, clockspeed competition, and increased outsourcing have prompted many firms to involve their suppliers early in their new product development activities and rely more on them as sources and even drivers of innovation (Sun, Yau & Suen, 2010).

Collaboration has extended in many directions, e.g. when companies pursue a new product, many of them consult suppliers, research providers and contract specialists, and test prototypes with their customers (Bughin, Chui & Johnson, 2008). Suppliers should be actively involved in all stages of the Product Life Cycle (PLC), as they need to be fully aware of customer feedback to integrate it into their innovation and development efforts.

In many sectors, suppliers understand the technology challenges and the manufacturability of their parts of the end product much better than the OEMs do. For example, in the design of a new generation of mobile devices through an open network of engaged customers, software engineers, and component suppliers, all working interactively with one another (Bughin, Chui & Johnson, 2008), the suppliers are instrumental both for integrating customer feedback in their component designs and for ensuring that the interfaces between the components allow for the final product architecture to materialize as intended by the OEM. The fundamental perspectives and strategies related to open innovation (OI) and supply chain management are presented in Table 1 below.

[3] Respectively refrigerators, stoves, washing machines, air conditioners..., and televisions, stereo / hi-fi equipment...

Table 1. Perspectives, strategies and focus on open innovation and supply chain management adapted from (Al, 2013)

Perspective, strategies and focus	Stage		
Innovation evolution	Internal R&D with closed innovation/ research	Open innovation	Networked innovation/ Coupled innovation
Illustration of flows of innovation Blankendaal (2016)			
Supply chain evolution and relation to innovation	Traditional supply chain. Suppliers mainly as subcontractors executing specifications. Arm's length price bargaining	Lean supply with emphasis on strengthening collaboration. Evolution towards Open Innovation in the Supply Chain with increasing supplier responsibility for innovation	Open supply chain established. Supplier driven innovation
Organisational structure	Formal		Informal
	Vertical integration Horizontal integration	Hybrid	Networked and increasingly virtual organisation
Product architecture	Dependent architecture 	Modular architecture 	
Focus	Individual organisation performance	Supply chain performance	Network performance
Relationship	Buyer – supplier	Trust in the chain	Equal partnership
Scope	1:1	1:N	N:N
Collaboration	Agreement upfront	Standards to confirm relationship	Pre-competitive standards

Open innovation can be understood as the antithesis of the traditional vertical integration approach, where internal Research and Development (R&D) activities lead to internally developed products that are then distributed by the firm.

The flows of knowledge in the open innovation logic may involve knowledge inflows to the focal organisation (leveraging external knowledge sources through internal processes), knowledge outflows from the focal organisation (leveraging internal knowledge through external commercialisation processes) or both (coupling external knowledge sources and commercialisation activities) (Chesbrough & Bogers, 2014). The building and leveraging of innovation capabilities of suppliers relied initially on knowledge outflows from OEMs to larger suppliers of systems and, in parallel, smaller expert suppliers. The latter are suppliers with an explicit strategy of supplying components which provide a value added function, largely dependent on their own R&D efforts. They could deliver the physical components both from the first and the second tier, but would keep knowledge exchange links with the OEMs. This outflow, accompanied by a management logic of focusing on core competences and outsourcing of secondary competencies, enabled suppliers to take increased responsibility for the functionality, cost and development lead-time, and, ultimately, to build innovation capability. The concept of black box engineering (Karlsson & Åhlström, 1996) was introduced to illustrate a new approach to supplier relations. It consists of OEMs generating overall requirements on product functionality and performance, cost targets, and development lead time, before communicating this information to suppliers that enjoy total design and development responsibility as long as they meet the general requirements. As the open innovation logic has evolved, the inside-out process aims to make the OEM more profitable also by commercialising intellectual property (IP) rights and even co-developing internally generated technologies with the suppliers (Enkel, Gassmann & Chesbrough, 2009). With the increasingly growing innovation capability of suppliers from the generalization of the black box engineering approach, the importance of inflows of independently generated supplier knowledge to OEMs increases.

Today, as the networked innovation model has emerged, the coupling of knowledge inflows and outflows, where inbound and outbound processes are applied at the same time, emphasising both more upstream research and concrete project-based new product development, is becoming the norm in technology and innovation –driven businesses. This can be achieved mostly by the cooperation of supplementary partners (joint ventures, alliances) (Enkel, Gassmann & Chesbrough, 2009). Coupled innovation refers to innovation in cooperation with supplemental partners (Karamitsios, 2013) on a basis of equal contribution to the innovation outputs of the network.

Accompanying the networked approach to innovation are the «dependent architecture» and «modular architecture»[4] approaches to component designed highlighted by Chesbrough (2003)

[4] For graphical presentation of dependence or modularity of the product or service see (Chesbrough, 2003, pp. 60-61).

Modular design enables easy assembly of components, "plug and play", whose interfaces are well specified as pre-competitive standards. Different suppliers, innovating in their component technology and architecture, can thus upgrade their components without having to pay attention to possible effects on other parts of the system. This is an important design- and collaboration-driven facilitator that enables innovation to flourish more freely than in a traditional system where the interfacing of components is a major challenge. Executives in a number of companies are considering the next step in this trend toward more structured supplier networks in the open innovation logic. They are looking at ways to delegating more of the management of innovation to networks of suppliers and independent specialists that interact with each other to co-create products and services.

Marsh (2011) discusses open and closed supply chains in a financial article, and illustrates it graphically on this Link (see also the reference list). He analyses two contrasting situations of an open and a closed supply chain:

(a) closed supply chain – with the OEM as a "hub" company situated close to specialist suppliers and exerting strong top-down control in the supply chain. An example is Apple, which drives and controls innovation top-down. The closed chain suppliers are dedicated to the hub OEM and are therefore also locked-in by its customer through tight control and execution of OEMdriven innovation specifications. The closed supply chain is vulnerable when parts of the system are disrupted by external events, as it is hard to replace the specialized and strictly controlled suppliers;

(b) open supply chain – with the OEM setting targets for component performance that suppliers are then free to reach by taking responsibility for their own innovation. Open chain suppliers focus on general components that are used in a wide range of products. They develop relations with direct and indirect supply of both components and innovation intelligence to a larger number of OEMs, including closed system hub OEMs.

KEY TAKE-AWAYS

• Increasingly open supply chains are a natural evolution of lean production and lean supply, as the main principles of lean have spread across industries, including services, and the open source movement has brought the ideas of lean – or agile - to the sphere of code writing and software development.

• The evolution of supply chains with an increasingly open and supplier-driven approach to innovation can be summarized in three phases: Internal R&D with closed innovation/research; Open innovation; and Networked innovation / Coupled innovation.

• Each of these phases represent different characteristics and approaches on a range of criteria including the relation to innovation, organisational structure, focus, relationship, and collaboration.

• The main driver and explanatory factor of this evolution is the relation to innovation in the supply chain, which has evolved along the types of open innovation: the Internal model relying on inside-out innovation, the Open model relying on inside-out innovation, and the Networked model relying on coupled innovation of equal contributors.

• A major facilitator of the networked model is the pre-competitive standard of 'plug and play' interfaces, allowing innovators to focus on core technologies instead of solving interface problems.

Supply chain evolution perspective

As explained above, the supply chain perspective has evolved from vertically integrated structures fully controlled by the OEM, to a network of suppliers focusing on core competences and contributing on an equal basis to innovation in the entire product system orchestrated by the OEM. Analysing this evolution in depth, Blankendaal (2016) illustrates an open supply chain system in the context of the flow logic of a product development process, e.g. the stage-gate or funnel logic (Cooper, 2008), see figure 2.

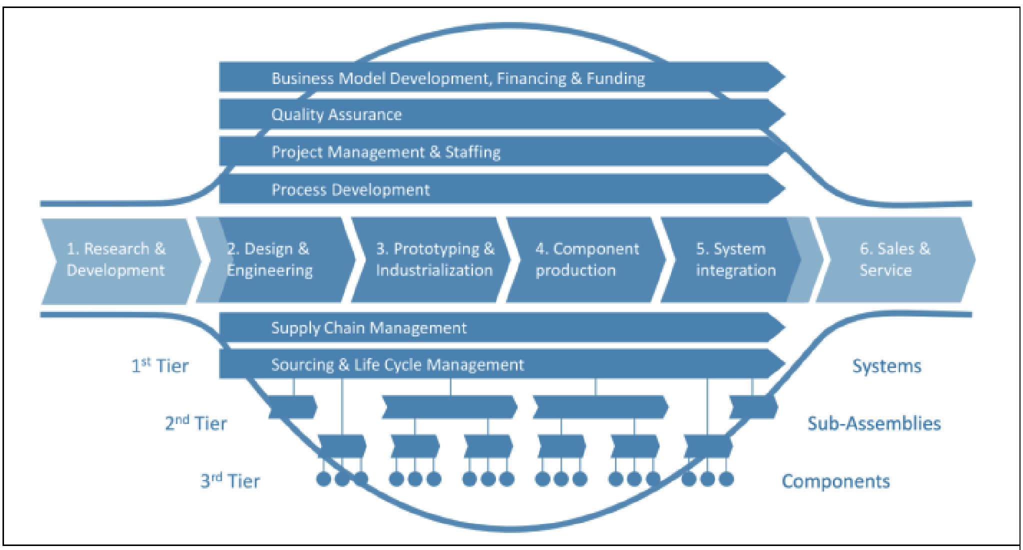


Figure 2. Open supply chain system in the context of the product development process (Blankendaal, 2016)

The picture is also accredited to Brainport 2020, see http://www.tapinto.nl/ about, and to Paul Mencke, see http://paulmencke.nl/2011/06/als-co-creatie-het-antwoord-is-watis-dan-de-vraag/

Figure 2 illustrates how suppliers of different tier levels contribute to innovation by engaging in the central activities of product development, from design and engineering to system integration. This means that they also contribute to and are part of the management of all the horizontal activities transcending the development steps.

Hence, a great untapped potential for innovation lies within organisations' supply chains. But the question remains: what is the best way to capture supplier-enabled or supplier-driven innovation? Procurement often faces difficulties when trying to tap into the more advanced capabilities of the suppliers (Rae, 2015). Important issues that have to be taken into account by procurement in all buying companies in an open supply chain, in order to capture supplier innovation, include (Short, 2015):

• Customer of Choice – the organisation has to make sure that its business is recognised as a Customer of Choice from the viewpoint of suppliers. This is normally not an issue in a tiered system, where the OEM is the final 'destination', at least of all physical flows. In a networked system, however, this becomes more critical, as a partner supplier, playing for example the role of an intermediary customer, may not necessarily be recognised at its full importance by the suppliers on whom it depends.

• Process – the procurement function has to involve also processes such as idea generation and idea implementation. Procurement must integrate these with established procurement processes – logistics and quality insurance - so that clear, structured approaches with key performance indicators and outputs are defined and implemented. This formalised approach ensures that the key stakeholders have the catalysts and frameworks needed to drive innovation.

• Internal stakeholder alignment – all information should be passed easily by expanding tools and authority to employees to enable them to make decisions without delay. The reduction of the traditional 'silo approach' to procurement is needed wherever possible. Supplier collaboration comes before supplier innovation, and for this to happen the internal stakeholders must be aligned.

• Supplier connectivity – procurement has to link the correct suppliers and their capabilities with the best internal stakeholders, which can leverage value and boost effectiveness significantly. Once the internal stakeholders are aligned, procurement can use its unique position to increase connectivity, alignment and collaboration with the chosen suppliers. This requires much tighter integration between innovation activities in engineering departments and the procurement activities managing the supplier relations.

• Technology – Information technology (IT) and information systems (IS) are key enablers for delivering supplier innovation. Businesses using technology, including data analytics, mobile and cloud applications, to enhance their processes and deliver a real Return on Relationships (ROR) are leagues ahead of those who do not. Concepts such as modular architecture, discussed above,can also be of decisive importance.

A case study of Electrolux (see the OI-NET case repository) describes the process used to capture innovation possibilities outside Electrolux and shows an example of supplier-enabled innovation where the innovation mechanism did not come from a supplier serving the relevant category, but from a different supplier that was only given the opportunity to work on the project because of the innovation programme of Electrolux.

KEY TAKE-AWAYS

• The open supply chain, in the context of the flow logic of the product development process (stage-gate or funnel logic), makes it possible for suppliers at all tier levels to engage in innovation activities along all the steps of the process, and also to take part in and contribute to horizontal activities, e.g. quality assurance, process development etc., transcending the development steps.

• In order to capture supplier-enabled and supplier-driven innovation, the procurement functions in all buying companies in an open supply chain need to strategize around and manage the following: recognition as a Customer of Choice; process integration of both innovation and procurement activities; internal stakeholder alignment; supplier connectivity mechanisms; and technological enablers for delivering supplier innovations.

Early supplier involvement and involvement in different life-cycle stages

Several models for external technology sourcing have appeared, including joint ventures, alliances, licensing, venture capital investments, and an orientation towards buyer–supplier relationships (Van de Vrande, Lemmens & Vanhaverbeke, 2006). Opening the process towards suppliers can be interpreted as a particular feature that institutionalises the open innovation approach through early supplier involvement - ESI (Schiele, 2010).

The ESI concept leverages the advantages of involving suppliers in cross-functional teams at the early stages of product development. It also formalizes the process for working with suppliers to ensure alignment and accountability throughout the product launch and innovation processes (Knowledge Brief Manage, 2016). ESI is applied across industries and enables supplier-driven innovation in cases such as automotive fuel injection by Bosch (Bosch worldwide, 2016), sun protecting and security glass by Saint Gobain (Saint-Gobain, 2016) and energy storage material development by BASF (BASF, 2015).

The ESI conceptual framework developed by Dowlatshahi (1998) provides quite a comprehensive list of areas of collaboration, focusing on ESI in product and process development through four building blocks:

Design (D) ► Procurement (P) ► Suppliers (S) ► Manufacturing (M)

Each set of tasks is grouped within its respective building block; however, the tasks should not be considered as mutually exclusive from the tasks of other building blocks. The collaboration and interrelationships of the requirements of these blocks determine the nature and scope of the ESI program. This means that some of the tasks are performed with the aid from other components, and information should flow freely between each component in order to form a seamless integrated supply chain.

A case study (Jiao et al., 2008) of the semiconductor industry shows how ESI can be applied in product and process development by using a modified framework based on Dowlatshahi (1998), consisting of eight steps:

1. Set up effective means of communication internally and externally;
2. Establish means to motivate suppliers;
3. Create a motivating environment, embrace continuous improvement;
4. Develop a formal process for selecting suppliers for partnerships;
5. Establish means of securing proprietary information;
6. Establish key performance indicators;
7. Establish clear goals and objectives; and
8. Set up a formal set of supplier selection criteria.

Once such a basic framework for early and substantial supplier involvement is established, open innovation organisations involve suppliers in various stages in the life cycles of their products — from the earliest, when the suppliers may provide design suggestions or even be given complete responsibility for the design, engineering and development of the new product, to later stages, when the suppliers may help commercialise the product and manage after-sales product quality. Involving suppliers in the product development process and using their skills and expertise in other, less formal, collaborative processes can create great benefits for the customer. These benefits include shortened product development cycle times, lower costs and higher-quality end products.

Supplier involvement in the product lifecycle is complemented by the involvement of end customers. In the context of open innovation, companies find the involvement of end customers in the product lifecycle as a valuable source of external knowledge for the innovation development process (Antikainen, Mäkipää & Ahonen, 2010). This has hitherto mainly concerned the OEMs, but gradually end-customer involvement becomes a reality for suppliers as well. Customer involvement in various lifecycle stages may include:

• specification of functional and performance requirements through the delivery of parts from suppliers to the manufacturer whose functional and performance characteristics are specified by the customer (Bigliardi, Bottani & Galati, 2010),

• online involvement, e.g. through crowdsourcing techniques and the use of social media to elicit customer preferences and requirements on new products,

• web-based testing of product prototypes, and

• elicitation of requirements through virtual communities of existing or potential customers. The last three points are examples of customer involvement not only with the OEM, but it also affects the entire supply chain.

KEY TAKE-AWAYS

• Early supplier involvement (ESI) is one way of institutionalizing an open approach to innovation.

• ESI leverages the advantages of supplier involvement and formalizes the process of working with suppliers in innovation and new product development.

• ESI affects the management of buyer-supplier relationships in design, procurement and manufacturing.

• ESI needs a basic framework for early and substantial supplier involvement including means of communication, motivation, supplier selection process, securing of propretarity information, and clear goal setting.

• Supplier involvement concerns all stages of the product lifecycle.

• In the context of open innovation, supplier involvement in the product lifecycle is complemen ed by the involvement of end customers.

Inter-organisational supply chain relationships and collaborative innovation

The increasing degree of the involvement of suppliers in the innovation process, as illustrated by concepts such as ESI, and in all stages of the product life cycle, suggests that collaboration among supply chain partners constitutes a core element of open innovation. The relationship between collaborative supply chain relationships and open innovation is mediated by the degree of integr tion across the supply chain. Recent research, e.g. (Tsanos, 2016), has shown that the development of collaborative supply chain relationships facilitates the attainment of a higher degree of integration across the supply chain.

On the other hand, it is accepted that poorly integrated manufacturing/production and information exchange processes, attenuated by poor relationship integration between the focal firm and its upstream and downstream partners, hampers the success potential of the supply chain (Bigliardi, Bottani, & Galati, 2010). This argument also applies to open innovation: successful participation of supply chain partners (but also of broader stakeholders) in the innovation process throughout the product/service lifecycle requires a substantial degree of production, information exchange and relationship integration.

The attainment of collaborative supply chain relationships for open innovation is strengthened by several behavioural factors that determine the conditions on which the relationships are built. These come on top of a basic framework for collaboration, as discussed through the eight points in the previous chapter. There is a wide debate on the effectiveness of power and coercion vs. collaboration and acquiescence in the creation and maintenance of successful relational exchanges. A line of thinking that is aligned with the concept of open innovation suggests that the formation of collaborative relationships is facilitated by factors such as:

- trust between the supply chain partners,
- relationship commitment, and
- mutuality and reciprocity of benefits stemming from the relational exchange.

All the above factors lead to relationships that can achieve a higher degree of integration across the supply chain. Indeed, empirical results support this argument (see for example Kwon & Suh, 2005; Tsanos, 2016). The impact of these behavioural factors, and especially trust, on open innovation is quite pronounced. For example, it has been strongly stated that "trust is at the heart of a collab rative innovation capability" (Fawcett, Jones & Fawcett, 2012) and examples of well-known companies (Honda; P&G; Wal-Mart) that reap the benefits of collaborative innovation through the establishment of trust in their relationships with strategic supply chain partners are available. Establishing and maintaining commitment to inter-organisational relationships associated with open innovation approaches is also identified as a challenge (Manceau, Kaltenbach, Bagger-Hansen, Moatti & Fabbri, 2012). Therefore, the perspective of collaborative interorganisational relationships/networks as a factor for fostering open innovation is important.

A case study of Faurecia – an automotive equipment supplier (see the OI-NET case repository) - describes an open innovation process which is used to bring highly innovative concepts to market. Each xWorks center researches its regional market closely, collaborating with various ecosystems that present different opportunities for the development of automotive seating in the regions.

As a final note, it is important to emphasise that new stakeholder engagement concepts are being championed, including 'Open Innovation 2.0', promoted by the European Commission (European commission, 2016), and the 'Quintuple Helix' model (Carayannis et al., 2012), where, beyond industrial and business partners in supply chains, also the government, academia, civil society and the natural environments of society and the economy are seen as drivers for innovation and cocreators of the future, far beyond the scope of what any one organisation or person could do alone. In the supply chain context, the focus of stakeholder engagement is on integrating external actors that do not only comprise supply chain partners (suppliers, customers) but also competitors, representatives of other industries, societal stakeholders and potential end users, as well as internal actors and knowledge sources in the innovation process. Stakeholder engagement models, such as Open Innovation 2.0 and the Quadruple/Quintuple Helix can serve as blueprints towards systematisation of the innovation process in the supply chain.

KEY TAKE-AWAYS

• The degree of integration mediates between collaborative supplier relationships and open innovation; weak integration hampers supply chain performance in general and supplier-driven innovation in particular.

• The attainment of collaborative supply chain relationships for open innovation requires the development of behavioural issues such as trust, commitment and mutuality/reciprocity on top of a basic framework for collaboration.

• Beyond industrial and business partnerships in supply chains, recently developed stakeholder engagement concepts such as 'Open Innovation 2.0' and the 'Quintuple Helix' model also emphasise the government, academia, civil society and the natural environments of society and the economy as drivers for innovation and co-creators of the future.

Practical implications

The issue of open innovation in the supply chain is essentially applied and practical. Hence, in the above sections, we have already referred to several examples of how the discussed concepts can be implemented and what their consequences on business practice can be.

To sum up the practical implications, three issues are of particular importance:

1. In nearly every sector, many of the ideas and technologies that generate products emerge from a number of participants in the value chain (Bughin, Chui & Johnson, 2008). This implies that an active process of scanning for new technologies and solutions in order to nurture the inflow of knowledge is a core capability for supply chain management. This has to be accompanied by strong structures, both procedural and more behavioural, i.e. based on trust and communication, in order to build long-lasting relationships that can leverage innovation.

2. Innovations were previously associated mostly with the application of new technologies to products and services, which was closely linked to their commercialisation according to existing business models. Open innovation means accessing new technology, delivering process improvements, and creating added value by tapping into capabilities of a broad range of partners, including suppliers

and customers. Thus, OI drives the development of new business models.

This implies that new approaches to collaboration become a key to innovation in an open context. Increasingly important is the ability to build virtual communities that also include non-traditional suppliers. As industries transform towards intelligent products, and eco-friendly and sustainable products and product systems, the role of non-traditional suppliers increases constantly.

3. As open innovation spreads in supply chains, the importance of supplier-driven innovation will increase, leading to new demands being raised on procurement and supply chain management.

This calls for mechanisms that ensure and facilitate collaboration, early supplier involvement and a climate of trust based on a network rather than a chain perception of the supply chain. Equal partnership is a basic condition that will enable strong integration supported by clear goals and ransparent structures for communication, shared rewards and responsibilities, and protection of intellectual property.

Finally, we propose two short case studies on practical implications as basis for classroom discussions.

Mini Case 1

Old Wine in New Bottles? Mercedes-Benz – Teldix - Bosch Mini Case on the development of ABS Braking Systems

The title of the case refers to the paper by Paul Trott and Dap Hartmann, entitled «Why 'Open Innovation' is Old Wine in New Bottles» (International Journal of Innovation Management, 2009). A little bit more about this after the case! The case simply illustrates that important innovations (the ABS breaking technology is considered to be among the most significant automobile innovations (cars.com, 2016)) are often the fruit of intensive collaboration, and that cases in the past can be seen as pre-forms of a more consistent and conscious open innovation approach in the supply chain.

Antilock brakes, or, originally in German, Anti Blockier System, were firstly introduced by Mercedes-Benz on larger-volume production cars in 1978 (cars.com). The first models were the top–of-the-line Mercedes S-class (w116 model, produced between 1971 and 1980), while the innovation relatively quickly democratised to be found on almost all cars on sale today, even the lowest-cost ones.

The ABS technology keeps the wheels from skidding when hitting the breaks, which enables faster stopping (not on snow), and above all the ability to steer when stopping on all surfaces. Particularly important in a panic situation, the ABS technology works with the regular braking system by automatically pumping it so that the brake fluid pressure, by means of an electronic control unit, changes automatically at each wheel to maintain optimum brake performance (NHTSA.gov).

Before the innovation breakthrough by Mercedes-Benz, many carmakers had been experimenting with similar systems, including Chrysler, GM, Nissan, and Toyota. Common for all these was that the innovation was the fruit of intensive joint R&D with entrusted suppliers, such as Bendix for Chrysler and Teldix and Bosch for Mercedes-Benz.

As an innovation, ABS was a risky venture, both from the technological and the commercial point of view. Being conceived strategically as a major active safety breakthrough, Mercedes put its world-class safety and performance/quality reputation at stake. That was the major reason why OEMs wanted to share the development effort with their key suppliers. In the case of Mercedes-Teldix-Bosch, this collaboration went back decades.

As stated on Daimler's media site devoted to the case (media.daimler.com), ABS is an example of the great effort required to bring an innovation up to production standard. The main challenge was to achieve full reliability of the mechanical wheel sensors. The first presentation to the public held in 1970 relied on the joint sensor solution by Mercedes and Teldix engineers in the shape of contactless speed pickups which operated on the principle of induction. The next challenge was to develop the electronic control unit in terms of reliability and performance. Here the expertise of Bosh was brought in, and during the eight years that followed, the prototypes were gradually evolving towards the degree of technical maturity and reliability required for large-scale production. This happened as the prototypes also incorporated new advances in electronics and digital control developed in intensive collaboration between the three key partners (media.daimler.com). A characteristic photo from a late pre-launch test in real driving conditions can be seen under the following link: https://www.mercedes-seite.de/wp-content/uploads/2012/08/959155C27511.jpg.

ABS development is ongoing, with recent advances including Electronic Brake force Distribution (EBD), the Electronic Stability Program ESP, emergency brake assist, or Electronic Stability Control (ESC). The complete control system is becoming more integrated, smaller, and ever more robust. It is thus not only a 'historical', but also a continuous example of open innovation in the supply chain. As stated on media.daimler.com, «If the anti-lock braking system is today taken for granted in virtually all cars of the majority of automotive brands throughout the world, we owe this to the commitment of the large number of engineers and technicians at Daimler-Benz and cooperation partners Bosch, TELDIX and Wabco, who searched for the best solution for this system which improves handling safety, avoids accidents and saves lives».

* * *

As indicated in the beginning of the case, its title refers to a paper by Paul Trott and Dap Hartmann, «Why 'Open Innovation' is Old Wine in New Bottles» (International Journal of Innovation Management, 2009), where the authors claim that some of the hype around open innovation ignores its early applications, its long evolution, and past contributions of others. Responding to the essence of this critique, i.e. «that there was no real change in innovation paradigms from Closed to Open» (Chesbrough & Bogers, 2014, p. 18), the latter claim that all OI work initiated by Chesbrough is indeed a novel synthesis of many previously disparate points in a context that is different, however. This context refers to «the erosion factors that influence the conditions under which innovation takes place (e.g., increased mobility of workers, more capable universities, declining US hegemony, and growing access of start-up firms to venture capital) have changed, giving rise to a new paradigm in which firms need to be and benefit more from being open for innovation» (Chesbrough & Bogers, 2014, p. 18).

Discussion topics and Questions:

1. The case refers to big companies collaborating in the development of an innovation. Search for examples of recent innovation in the automotive industry (e.g. hybrid cars, connected car...) and investigate if the nature of the collaborating suppliers is different. How can more recent collaboration examples be related to the erosion factors advanced by Chesbrough & Bogers (2014)?

2. Non-supplier innovation is sometimes referred to as an example where open innovation brings increased innovation to an industry. Search for information about BMW's iDrive control unit and relate this example to the ABS case. What OI conditions are similar and what differ between the ABS and the iDrive?

3. The car industry can be seen as an early example of open trends in innovation. What sectors are late adopters and why?

MINI CASE 2

Developing New Innovation Capabilities: Expert Suppliers Broadening their Innovation Capabilities

When facing the challenges of becoming more competent innovation partners in the supply chain, small and medium-sized suppliers run the risk of being 'downgraded' in terms of their position in the tier structure, therefore losing their direct interactions with the OEM. This is particularly problematic when system suppliers take on more and more of the supplier coordination activities as a result of OEMs reducing their direct supplier base.

This can be referred to as the 'tier dilemma' and it drives suppliers' need to widen their offers, i.e. to provide a more complete function, without falling into the trap of becoming a preassembly unit at the expense of engineering capability. The formulation of clear strategies on the part of the suppliers plays an important role in how this problem can be dealt with. When comparing the following two strategy formulations of two competing suppliers 'Extension of product functions should be done as a result of innovative design and not only as a result of integrating assembly', vs. 'The objective is to assemble parts in order to supply functions', it is obvious that in the latter case there is a risk of becoming more of a pre-assembly unit and less of a development-intensive expert supplier.

For the first supplier, which consciously took on the challenge of becoming an innovation partner, the way forward was to focus on an extended function from an engineering perspective more than from an assembly one, and to integrate the design of neighbour components to the core product. Thus, if assembly also needed to be developed it would be as a result of innovative design. In a context where extension of product functions is essential, the ability to rapidly undertake organisational modifications, and also modifications in the manufacturing equipment, becomes a significant competitive advantage for an expert supplier competing for the highest possible tier position.

The example of a successful extension of functional solutions in this case concerns a technical component that was traditionally assembled into a plastic cabinet. Both the supplier of the technical component and the supplier of the plastic cabinet were considered as experts by the carmaker customer. Nevertheless, the latter decided to reduce the couple to only one interlocutor. The most natural evolution would be to choose the plastic manufacturer, as the technical component had to be ready before being fitted into the cabinet. However, the other supplier responded by including the plastic cabinet in the design study, and succeeded in designing a cheaper overall solution with higher performance through this widening of the engineering activity. Concerning the design, both the technical component and the plastic cabinet were completely reconfigured. Instead of what happened previously, when the carmaker presented the technical component to the plastic manufacturer to find a solution, the supplier of the technical component succeeded in making the plastic cabinet an integral part of the function and not only an interface element. Besides employing their traditional design know-how, this supplier had to make an important investment in process and material technology scanning in order to ensure the possibility of manufacturing the new product at a reasonable cost. This meant that process development and manufacturing constraints became central problems in this development project, something that contributed to strong enhancement of technical competences and innovation capabilities.

As a result of this line of action, the supplier of the technical component has remained a direct expert. Naturally, it will be necessary to develop an assembly capacity for the integrated function, but this will happen as a result of innovative product design and is not only taken on as a necessary evil to stay in direct contact with the carmaker at any price.

Discussion Topics and Questions:

1. Discuss the pros and cons for the supplier as it took on the challenge of becoming an innovation partner. What is your opinion about the strategy selected?
2. Explain how the case relates to one of the important OI drivers, namely technology synergy.
3. The price that the OEM had to pay for the integrated component was higher than the price paid for the two separate components used before. It was still selected as a preferred solution. Why?

Content-related materials

Case studies

OI-NET portal case repository:
Faurecia – Open Innovation in Supply Chain http://oi-net.eu/m-public-library-front/m-repository-view/details/7/568/view-oi-cases-faurecia-%20-open%20-innovation%20-in-supply%20-chain.

Harvard Business School Cases

• Numico (A): Delivering Innovation through the Supply Chain, 2005. Carlos Cordon; Thomas E. Vollmann; Luis Vivanco.
• Numico (B): Transforming the Supply Chain to Support New Realities, 2005. Carlos Cordon; Thomas E. Vollmann; Luis Vivanco
• Three-Dimensional (3D) Printing: Jolts on Supply Chain Management and the Chinese Manufacturing Industry, 2016. Benjamin Yen; Yihong Yao.
• Quirky: A Business Based on Making Invention Accessible, 2013. David Hoyt; Michael Marks.
• AmTran Technology Ltd., 2015. Willy Shih; Jyun-Cheng Wang; Karen Robinson
• Apple Inc.: Managing a Global Supply Chain, 2014. Fraser P. Johnson; Ken Mark
• Muñoz Group: Sustaining Global Vertical Integration Through Innovation, 2015. Jose B. Alvarez; Annelena Lobb.

Other cases

• Jiao, Y.-Y., Du, J., Jiao, R. & Butler, D. (2008). Operational implications of early supplier involvement in semiconductor manufacturing firms: A case study. Journal of Manufacturing Technology Management, 19(8), 913 - 932.
• Brainport Industries case study: From managing supply towards managing innovation http://www.agoria.be/upload/agoriav3/waardecreatie%20John%20Blankendaal.pdf, (Blankendaal, 2016).
• Tesla Motors: A case study in disruptive innovation: http://blog.ihs.com/q14-tesla-motors-a-case-study-in-disruptive-innovation.

Blogs

• Open Innovation: More than Supply Chain Management (Garwoodblog, 2015). http://garwoodblog.corporateinnovation.berkeley.edu/open-innovation-as-more-than-supply-chain-management/.
• Accelerating Supplier-Enabled Innovation: What You Need To Know (Sharp, 2016) https://www.procurementleaders.com/blog/my-blog--rachel-sharp/accelerating-supplier-enabled-innovationwhat-you-need-to-know-620940.
• Focus helps Electrolux to clean up with Supplier-Enabled Innovation (Rae, 2015). http://www.procurementleaders.com/blog/my-blog--david-rae/focus-helps-electrolux-to-clean-upwithsupplier-enabled-innovation-569930.
• 5 Steps to Capturing Supplier Enabled Innovation (Short, 2015). http://blog.vizibl.co/5stepscapturing-supplier-enabled-innovation/.

Publications

The list of references contains essential readings that can be selected by instructors depending on the orientation they select for their course. The most recommended readings are listed in the Lecture Overview table at the beginning of the chapter.

Pedagogical guidelines

Interactive activities

Business Games that involve OI and SCM

• Open Innovation game, www.open-innovation-game.com.

Business Simulations that involve OI and SCM

• Open Innovation Management System Role Play Simulation, http://web.tuke.sk/simpro-ims/index_en.php.

Learning exercises

• The mini-cases in the chapter come with suggested discussion questions. For the cases listed, all Harvard Business School cases come with teaching notes.

• Other cases and blogs can be used as a basis for classroom discussion on the topics presented in this chapter, as well as other related issues around OI and SCM.

• The topics presented can be conveniently expanded by students in the form of an essay identifying, synthesising and analysing additional literature critically. In particular, an essay would be an effective learning exercise for achieving the knowledge learning outcomes (c.f. the Lecture Overview) by exploring concepts of collaborative innovation and how they are implemented, and reflecting on the sources of innovation in the supply chain and how the opening of innovation in the supply chain changes its nature and characteristics.

• Field work involving observations and data collection through interviews with supply chain and innovation managers can be effective exercises in order to achieve the learning outcomes related to skills and competences, for example, investigating how companies' innovation needs can be satisfied from supplier-driven innovation and supply chain collaboration, and investigating how business models change with increasing supplier innovation and how firms strategize in this dynamic context.

Self-study

After having studied the chapter and worked through the mini cases, students are encouraged to access the references in the Reference List and from reading and analysing abstracts and summaries select those for in-depth reading that provide most relevant additional insights depending on each individual learner's objectives.

Self-evaluation

Students are encouraged to work through the text actively with the help of the self-evaluation questions listed below.

Evaluation questions

The questions below are presented sequentially, according to the unfolding of the chapter text.

Self-Evaluation Questions

The Origins of Supplier-Driven Innovation

1. Explain the difference between 'lean' and 'buffered' production systems by comparing them on some key characteristics.

2. Explain why lean production is an integrated industrial model.
3. What are the new buyer-supplier relationships based on the development brought about by lean production?
4. Explain and illustrate the tier-structured supply chain.
5. Indicate and explain briefly the four buyer-supplier relationships based on the notions of direct and indirect supply.

From lean supply to open innovation in the supply chain

6. Give some examples that illustrate why «Increasingly open supply chains are a natural evolution of lean production and lean supply».
7. What are the three models of innovation evolution in the supply chain?
8. Illustrate graphically the three models of innovation evolution in the supply chain.
9. Explain each of the three models of innovation evolution in the supply chain by identifying key characteristics in the dimensions of relation to innovation, organizational structure, product, focus, relationship, scope, and collaboration.
10. What is 'black box engineering' and how does it relate to open innovation?
11. Explain how the different modes of open innovation - outbound, inbound and coupled - relate to and can partially explain the evolution of innovation in the supply chain.
12. What is the pre-competitive standard of 'plug and play' interfaces?

Supply chain evolution perspective

13. Indicate the six steps in the product development process. In what steps are suppliers mostly engaged?
14. Indicate the horizontal activities transcending the development steps.
15. Explain briefly the logic of supplier contribution to innovation from the perspective of an open supply chain system in the context of the product development process.
16. Indicate and explain briefly the five issues that have to be managed by all buying companies in an open supply chain in order to leverage supplier-driven innovation better.

Early supplier involvement and involvement in different life-cycle stages

17. Explain how Early Supplier Involvement can institutionalize open innovation.
18. What other mechanisms exist for external technology sourcing?
19. List and explain briefly the eight steps of the basic framework for early supplier involvement.
20. Indicate some customer involvement activities that may also affect suppliers.

Inter-organisational supply chain relationships and collaborative innovation

21. Explain the importance of the degree of integration between the partners in the supply chain.

22. What behavioural factors in collaborative supply chain relationships for open innovation come on top of a basic framework for collaboration?
23. Explain briefly how 'Open Innovation 2.0' and the 'Quintuple Helix' complement the core ideas of open innovation.

Questions for written exams

The Origins of Supplier-Driven Innovation

1. What is lean production? Exemplify how it differs from traditional mass production.
2. Is lean production an integrated industrial model, and if yes why is it seen as such?
3. What are the new buyer-supplier relationships based on the development brought about by lean production?
4. Explain and illustrate the tier-structured supply chain.
5. Explain the notions of direct and indirect supply. Exemplify some buyer-supplier relationships that illustrate these notions.

From lean supply to open innovation in the supply chain

6. Explain why increasingly open supply chains are a natural evolution of lean production and lean supply.
7. First describe and then contrast the three models of innovation evolution in the supply chain by selecting three of the characterising dimensions analysed in the text.
8. Why can open innovation be seen as a main driver and explanatory factor of the evolution of supply chain structure and relations? Consider how the different modes of OI have been/are used in supply chains.
9. How does the pre-competitive standard of 'plug and play' interfaces support the networked supply chain model?

Supply chain evolution perspective

10. By referring to product development steps and horizontal activities in the new product development process, discuss the logic of supplier contribution to innovation in an open supply chain system.
11. Select three of the five procurement management issues that buying companies have to attend to in open supply chains and explain briefly what they involve.

Early supplier involvement and involvement in different life-cycle stages

12. Explain why Early Supplier Involvement can be seen as a way to institutionalize open innovation.
13. Mention and explain briefly four of the eight steps of the basic framework for early supplier involvement.

14. Discuss supplier involvement across the product lifecycle and exemplify the suppliers' role in different stages.

Inter-organisational supply chain relationships and collaborative innovation

15. What role does the degree of integration between partners in the supply chain play for open innovation in the chain?
16. Discuss the behavioural factors in collaborative supply chain and the basic conditions needed to establish open supply chains.
17. Explain briefly how 'Open Innovation 2.0' and the 'Quintuple Helix' complement the core ideas of open innovation.

Individual work examples

The presented topics can be expanded conveniently by students in the form of an essay identifying, synthesising and analysing additional literature critically. By searching and analysing case studies from academic references, white papers and company websites, concepts of collaborative innovation and how they are implemented can be compared and thus understood better.

Field work involving observations and data collection through interviews with supply chain and innovation managers can be effective exercises in order to achieve the learning outcomes related to skills and competences.

Group work examples

Students work in groups of 3-5, depending on class size, and each individual selects / is assigned a specific industry where he or she will make an analysis of the supply chain structure and the extent and nature of supplier-driven innovation. Then, each student presents his/her case and comparisons are made and discussed in the group regarding OI in the respective supply chains, its advantages, difficulties and future trends. Students can be asked to develop an analysis framework initially in the group for easier and more effective cross-industry comparison. If time is limited, the instructor can provide such a framework depending on the focus envisaged in the course.

Students work in groups of 3-5, depending on class size, and each student selects / is assigned a specific challenge in open supply chain innovation where he or she will make an analysis of the nature of the challenge, what solutions companies have developed to cope with it, how effective the solutions are, and what could be ways of improving further management practices to come to better terms with the challenge. The challenges could include structures and mechanisms for collaboration, developing communication across different professional languages, building trust in open supply chains, joint creation and sharing of knowledge, fair sharing of innovation outcomes – IP rights, etc.

Teaching tips

Slides

Slides supporting this book will be added after 1st review
Brainport Industries. Towards the smartest supply chain http://www.agoria.be/upload/agoriav3/waardecreatie%20John%20Blankendaal.pdf.

Links to teaching material

Links are provided for most of the sources indicated.

Supporting case material

The list of supporting case material contains essential case studies (in the part Content-related material) that can be selected by instructors depending on the orientation they select for their course.

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