

Linking outsourcing process and product development process: literature analysis

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Abstract: Rapid technological development, shorter product life cycle, clockspeed competition, and increased outsourcing have prompted many firms to involve their suppliers in their product development process. There are many papers approaches the importance of both involvement suppliers in product development process and outsourcing process for competitive of firms. The literature, however, does not help us understand the relationship in more detail between outsourcing process and product development process. This paper examines the involvement of the suppliers into the product development process and the relationship between the outsourcing process and the product development process.

Keywords: outsourcing process, product development process, involvement of suppliers in product development.

1. Introduction

There is increasing evidence that manufactures of complex systems, such as automobile assemblers and electronic industry, are delegating more product development responsibilities to the suppliers (BIROU & FAWCETT, 1994; BALDWIN & CLARK, 1997; MCIVOR et al., 2006).

The growing number of new technologies is giving some suppliers more responsibility in designing not only discrete parts but also whole systems. This coincides with the trend of multinational firms to reduce the number of suppliers in order to facilitate more effective supply chain management. This reduction of supplier base means that firms have to find innovative ways to cooperate with suppliers, and the carefully devise product architecture strategies (MIKKOLA, 2003).

The literature reveals the increasing number of works about outsourcing by manufactures and how it influences the boundary of the firms (FINE, 1999; HANDFIELD & NICHOLS Jr., 2002; KAMP, 2005) and the degree of supplier-buyer interdependence (BOZDOGAN et al., 1998, HSUAN, 1999, DYER & OUCHI, 1993). One of the main purposes of outsourcing is to have the supplier assume certain classes of investments and risks, such as demand variability. Due to greater complexity, higher specialization, and new technological capabilities, outside suppliers can perform many activities at lower cost and with higher value added than a fully integrated company can.

The literature also emphasizes the importance of early supplier involvement into the product development process as means to reduce the risks of outsourcing (BIDAULT et al., 1996; DOWLATSHAHI, 1999). There are many advantages why a firm involve supplier in its product development process. For instance, supplier participation in product development process reduces development lead times, and costs, improved perceived product quality and better manufacturability. The early supplier involvement into the product development process brings the supplier and firm closer in sharing not only risks, but knowledge and learning as well.

The product development process (PDP) is one of the business processes of the supply chain management (LAMBERT & COOPER, 2000) by which an organization transforms market and technical opportunities into information so as to produce a commercial product (CLARK & FUGIMOTO, 1991).

A reference model for the PDP was developed by ROZENFELD et al. (2006) and it stemmed from the marriage of methodologies, case studies, models and best practices developed and recorded in the last years. In reference model for the PDP, regarding outsourcing, the principal contributions indicate where some activities involving direct suppliers can take place.

The study of SANTOS & FORCELLINI (2005) and SANTOS et al. (2006a) show that reference model for PDP can help companies visualize how and when the suppliers will be able to become involved into PDP.

However, the study of supply chain management literature (SANTOS et al., 2006b) identified a lack of sufficient information relating to the implementation of supplier involvement in PDP, other aspects still need to be further explored. For instance, how the links the outsourcing strategy (main focus of literature supply chain management) with the modularization strategy (main focus of literature of product development)? Which are factors considered in the models of literature for supplier involvement in PDP?

The focus of this paper is examine the literature about involvement suppliers into the PDP and relationship between the outsourcing process and the product development process. Section two introduces the outsourcing process review. Section three presents criterions of research for review of literature about supplier involvement in PDP. Section four presents of analysis of the articles. Conclusions are further research directions present in section five.

2. Outsourcing process

Outsourcing decisions have their origins in make/buy alternatives, they are not new phenomena. Early accounting recommendations concerned the identification and comparison of the complex mix of incremental costs of the make or buy alternatives (DI SÉRIO & SAMPAIO, 2001; PIRES, 2004).

Recent literature on outsourcing however has emphasized the need to adopt a strategic focus. Various works make the point that a company's technology strategy drives its outsourcing strategy. This involves a focus on the most important product attributes, as perceived by customers, which become sources of competitive advantage and thus market performance.

QUINN & HILMER (1994) developed strategic outsourcing further suggesting it may contain two aspects. The first concentrates on a firm's set of core competencies where it can achieve definable pre-eminence and the second is for outsourcing other activities which are neither critical nor something in which the company has special capability. They suggest ways to determine what those core competencies are and consequently which activities are best performed externally. Other aspects which arise in outsourcing decisions include risks related to technological changes, predictability of competitor behavior and supplier behavior, and in global markets, exchange rates.

Based of the review of literature, we define strategic outsourcing as the firms are organized in supply chain for complete their specialized capabilities added value for stakeholders.

However, even with the great number of works published on outsourcing relatively little has been attention how companies actually ensure that strategic they can be done.

There is hardly any literature regarding practical models for managing the outsourcing of subcontracting as a whole, not only of the decision phase. VERNALHA & PIRES (2005) sought to fill this gap by proposing a four-stage model to manage the outsourcing process: motivation stage, decision-making stage, implementation stage, management stage.

This division in stages for outsourcing process was used a starting point for the literature review on outsourcing. This allowed the examination of the activities present in each stage, illustrated in Figure 1.

The motivation stage involves the reasons for implementing outsourcing, in other words, the motives to begin the outsourcing process. Though not the only ones, the development of products and the motives related to the cycles of technological life are primary reasons for the establishment of the business /supplier relationship relating to the launch of new products.

The decision-making stages involve strategic, technical, financial and logistical aspects. Table 1 illustrates several of the factors considered in different models for decision-making regarding outsourcing.

The models for decision-making regarding outsourcing found in the literature provide a greater or lesser degree of scope on the factors behind this phase of outsourcing, focusing more on some factors than others.

Implementation stage, which entails putting the process of decision-making to work in favor of outsourcing, can be divided into two other processes:

- Relationship management includes the relationship between suppliers and clients. The basic elements of the implementation are stimulated by contracts secured between the companies involved, which cannot be accessed indiscriminately (PIRES, 2004); and
- The change management is the comprehensive effort of planning the company's visualization, and communication in every sense, resource management resources and leadership of the change process (RENTES, 2000).

In this paper, outsourcing management is understood to be process usually referred to in the literature as the process of managing the relationship with the supplier. According to LAMBERT (2004), this is the process responsible for maintenance of the structure of the relationship with the suppliers. He separates the process of relationship with the suppliers in strategic and operational activities. The strategic activities are carried out by a multifunctional team with representatives from several areas of the company or even including those from the supply chain, the suppliers and clients. The operational activities are coordinated by the

Outsourcing process

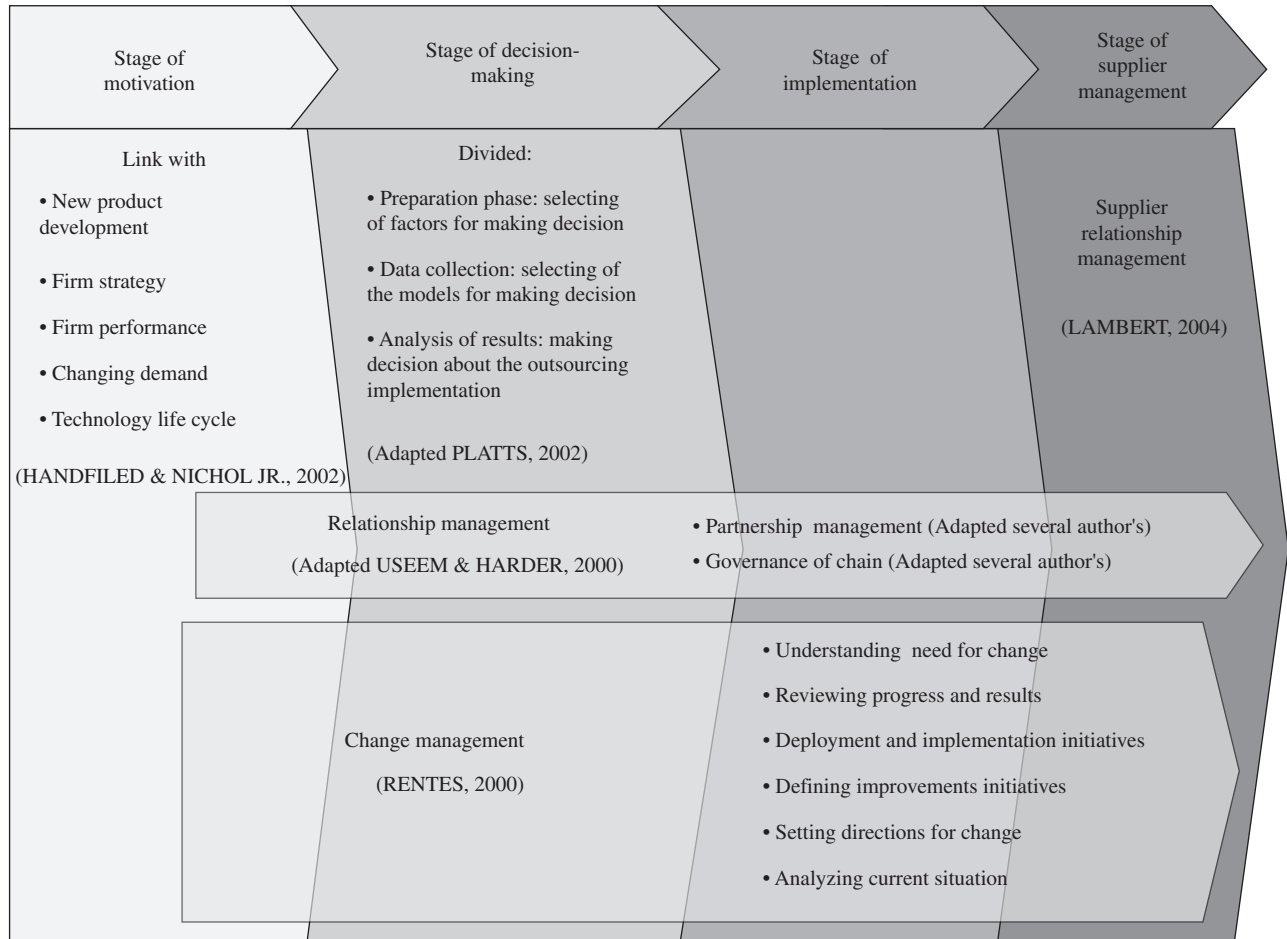


Figure 1. Outsourcing Process. Source: adapted of VERNALHA & PIRES (2005).

team that manages the relationship process with on a daily basis. One of the key points of this stage of outsourcing process is the supplier involvement in development and maintenance of common indicators of performance (company and supplier), with the objective of maintaining the relationship between both parties.

3. Criterion of research for literature analysis

The following criteria have been established for literature review: research approach that was used, hierarchical level of information, industrial sector approached, phase of the outsourcing process, presence of models to assist in the supplier involvement, and strategic or operational approach.

The articles were sorted into strategic and operational in order to identify the hierarchical level of the activities. The industrial sector was singled out so to separate the practices in the automotive sector from other sectors.

In regards to the outsourcing process the articles were classified according to their main contributions to the stages: motivation, making-decision, implementation and management. In the implementation stage the contributions were divided according to the partnership process and change process, and in strategic or operational activities.

The papers were also analyzed according to their main contributions to the PDP stages: pre-development, informational design, conceptual design, and detail design. Based in ROZENFELD et al. (2006).

4. Literature analysis

4.1. Analysis of articles

Thirty-six studies were select to evaluate supplier involvement in PDP, illustrated in Table 2. The main research focus points on supplier involvement in PDP were:

- Comparison among the practices of involvement of supplier in development of products among different countries and car industry. (CLARK, 1989;

Table 1. Factors considered in different models for decision-making regarding outsourcing.

| Factors | Description |
|---------------------------------|---|
| 1. Core competences | About which of the firm's activities really do. Preferably better than their contestants and their suppliers (QUINN & HILMER, 1994; COLLINS et al., 1997; FINE, 1999; MCDERMOTT & HANDFIELD, 2000; TAYLES & DRULY, 2001; ZHU et al., 2001; VERNALHA & PIRES, 2005) |
| 2. Geographical | Measured distance, location and information technology factors (COLLINS et al., 1997; FINE, 1999; VELOSO & FIXSON, 2001; VERNALHA & PIRES, 2005) |
| 3. Organizational | This is related to the established managerial levels, hierarchic levels in the organization. Moreover, it involves a functional and internal organizational structure or a vision for business-oriented processes. (FINE, 1999; MCDERMOTT & HANDFIELD, 2000; ZHU et al., 2001; VERNALHA & PIRES, 2005) |
| 4. Cultural | Cultural proximity captures the common linguistic elements, habits of the company, ethical and legal standards among others. (QUINN & HILMER, 1994; FINE, 1999; VERNALHA & PIRES, 2005) |
| 5. Information technology | The virtual or electronic aspect is manifested by means of email resources, electronic exchange of data, intranets and other ways that facilitate communication. (FINE, 1999; HANDFIELD & NICHOLS JR, 2002) |
| 6. Cost/financial | Costs of internal and external manufacture (cost of production and acquisition), the costs and investments in fixed assets and intellectual capital, licensing of technologies, returns on expected investments and costs of transactions (WILLIAMSON, 1991; COLLINS et al., 1997; MCDERMOTT & HANDFIELD, 2000; TAYLES & DRURY, 2001) |
| 7. Quality/continue improvement | Quality and reliability of the products. Quality programs (COLLINS et al., 1997; FINE, 1999; SWAN & ALLRED, 2003) |
| 8. Logistic | Capability of logistic system. (COLLINS et al., 1997; FINE, 1999; VELOSO & FIXSON, 2001) |
| 9. Technology/know how | Main Technologies (product and equipment), rate of technological change of the supplier, Technological alignment with the supplier. (COLLINS et al., 1997; FINE, 1999; ZHU et al., 2001; MCCARTHY & ANAGNOSTOU, 2004) |
| 10. Capability | The capacity to produce and to assist the variations of the demand. (COLLINS et al., 1997; FINE, 1999; MCDERMOTT & HANDFIELD, 2000) |
| 11. Firm's strategy | Decrease time: product development, manufacturing, logistics. (QUINN & HILMER, 1994; COLLINS et al., 1997; FINE, 1999; TAYLES & DRULY, 2001; VELOSO & FIXSON, 2001; ZHU et al., 2001; SWAN & ALLRED, 2003) |
| 12. Responsibility | Managing risks supply (VELOSO & FIXSON, 2001; ZHU et al., 2001; SWAN & ALLRED, 2003; VERNALHA & PIRES, 2005) |
| 13. Teams | Cross- functional teams have proved effective. (FINE, 1999; MCDERMOTT & HANDFIELD, 2000) |
| 14. Add value | Activities how add value for customer and stakeholders. (QUINN & HILMER, 1994; COLLINS et al., 1997; FINE, 1999; MCCARTHY & ANAGNOSTOU, 2004) |
| 15. Clockspeed | According to FINE (1999), each productive sector has its own evolutionary life cycle measured by speed in which new product, process and organizational structures are being introduced. |
| 16. Product life cycle | Maturity of product lifecycle on market (FINE, 1999; BIROU et al., 1997) |

CLARK & FUGIMOTO, 1991; CUSUMANO & TAKEKISHI, 1991; DYER & OUCHI, 1993; BIROU & FAWCETT, 1994; KAMATH & LIKER, 1994);

- Timing of supplier involvement in PDP (BIROU et al., 1997; BOZDOGAN et al., 1998; HANDFIELD et al., 1999); and
- Organizational of the development process. Table 3 presents the main contributions of the works with of organizational research focus

Other studies in the area of economy based on theory of firm and the theory of the industrial organization were also found. Primarily, these illustrate how industries minimize risks in commercial relations with suppliers, which are important factors in decisions regarding the involvement

of suppliers into PDP, but due to limitations of the research they were not included in the analysis.

Two other aspects analyzed in the articles relate to the sectors involved and approaches through time. Table 4 gives chronological review of the supplier involvement in PDP and different sector of industry.

The systematic supplier participation in product development originated in automobile industry Japanese following World War II. Um pyramidal hierarchic system was formed in which the buyer interacted with a small number of suppliers who, in turn, became interlinked with other sub-suppliers. This arrangement with links different in the productive chain that was recognized as being based on mutual trust and development. The buyers thus delegated

Table 2. Literature analysis.

| Authors | Approach | Level | Outsourcing stage | PDP Stage |
|---------------------------------------|----------------|-------------|-------------------|------------------------------|
| CLARK (1989), CLARK & FUGIMOTO (1991) | Comparison | Operational | Motivation | Pre-development |
| CUSUMANO & TAKEKISHI (1991) | Comparison | Operational | Motivation | Conceptual and Detail Design |
| GRIFFIN & HAUSER (1992) | Organizational | Operational | Implementation | Informational Design |
| DYER & OUCHI (1993) | Comparison | Strategic | Decision-making | Pre-development |
| BIROU & FAWCETT (1994) | Comparison | Operational | Motivation | Conceptual design |
| KAMATH & LIKER (1994) | Comparison | Operational | Motivation | Pre-development |
| BIDAULT et al. (1996) | Organizational | Strategic | Motivation | Pre-development |
| BALDWIN & CLARK (1997) | Organizational | Strategic | Implementation | Pre-development |
| HARTLEY et al. (1997) | Organizational | Operational | Implementation | Pre-development |
| MCIVOR et al. (1997) | Organizational | Strategic | Motivation | Pre-development |
| RAGATZ et al. (1997) | Organizational | Strategic | Implementation | Pre-development |
| BIROU et al. (1997) | Time | Strategic | Decision-making | All |
| BOZDOGAN et al. (1998) | Time | Strategic | Motivation | Conceptual design |
| HOLMEN & KRISTESEN (1998) | Organizational | Operational | Implementation | Informational Design |
| HANDFIELD et al. (1999) | Time | Strategic | Decision-making | All |
| HSUAN (1999) | Organizational | Operational | Implementation | Conceptual and Detail Design |
| HUANG & MAK (2000) | Organizational | Operational | Implementation | All |
| WYNSTRA & PIERICK (2000) | Organizational | Strategic | Decision-making | Pre-development |
| MCIVOR & MCHUGH (2000) | Organizational | Strategic | Implementation | Pre-development |
| ECHTEL & WYSNTRA (2001) | Organizational | Strategic | Motivation | All |
| WYNSTRA et al. (2001, 2003) | Organizational | Operational | Implementation | All |
| NELLORE (2001) | Organizational | Strategic | Implementation | Pre-development |
| CALVI et al. (2001) | Organizational | Strategic | Decision-making | Pre-development |
| AMARAL et al. (2002) | Organizational | Operational | Motivation | All |
| FARGERSTRÖM & JACKSON (2002) | Organizational | Operational | Implementation | All |
| RAGATZ et al. (2002) | Organizational | Strategic | Motivation | Pre-development |
| MIKKOLA & SKJOETT-LARSEN (2003) | Organizational | Strategic | Implementation | Pre-development |
| MCIVOR & HUMPHREYS (2004) | Time | Strategic | Implementation | Pre-development |
| OLIVER et al. (2004) | Comparison | Operational | Motivation | Pre-development |
| KOUFTEROS et al. (2005) | Organizational | Operational | Implementation | All |
| PERKS (2005) | Organizational | Operational | Implementation | Pre-development |
| PETERSEN et al. (2003, 2005) | Organizational | Strategic | Decision-making | All |
| LAKEMOND et al. (2006) | Organizational | Strategic | Decision-making | Pre-development |

several tasks to their suppliers, using them systematically as the main form of responding to the significantly increased demand. This approach led to actions to systematically involve suppliers in the product development process (AMARAL et al., 2002).

First level suppliers participated in the entire development process of their customers, presenting suggestions for the final product and taking responsibility for the detailing, tooling and prototyping of the parts of subsystems they would produce and deliver. In the meantime, on the western side, suppliers were involvement into PDP for tooling needed to product the product (WOMACK et al., 1992).

The research about the involvement suppliers into product development only began in the 80s. It was efforts

understand of the ‘Japanese miracle’ and practices that made Japanese companies more efficient and competitive. Researchers of several areas identified the relationship of Japanese buyers with their suppliers, including participation in product development, as one the main factors that justified the greater efficiency of Japanese companies.

The first research work that brought to light the importance of supplier involvement in process of product development was that of IMAI et al. (1985). This was soon followed by CLARK (1989) who, based on large amount of collected data, also presented important work reinforcing the importance o the theme, which was part of research work later published by CLARK & FUGIMOTO (1991). In 1995, BROWN & EISENHARDT (1995) present a review

Table 3. Main contributions of the works with organizational research focus.

| Authors | Aspects of product development management |
|---------------------------------|--|
| GRIFFIN & HAUSER (1992) | Interfaces within and between the involved companies. Use of QFD leads to more efficient communication with supplier. |
| BROWN & EISENHARDT (1995) | Building and motivation teams for product development, They show a relationship plan. |
| BIDAULT et al. (1996) | Analyze the motives for the adoption of ESI |
| BALDWIN & CLARK (1997) | A prerequisite for the strategy of involvement de suppliers into PDP is the modularity of products. |
| HARTLEY et al. (1997) | Identification of factors causing delays in co-development |
| RAGATZ et al. (1997) | Identification of success factors for supplier integration. |
| HOLMEN & KRISTESEN (1998) | Using the QFD for decision-making make/buy vs share. |
| HSUAN (1999) | The modularization strategies facilitate of involvement of suppliers in product development process. |
| MCIVOR & MCHUGH (2000) | To avoid problems during the development process, cultural changes in both companies must accompany successful collaborative relationship. |
| WYNSTRA et al. (2001) | Integrating purchasing functional area and product development functional area |
| NELLORE (2001) | The impact f visions for suppliers in outsourced product development |
| CALVI et al. (2001) | Model of supplier involvement portfolio |
| FAGERSTRÖM & JACKSON (2001) | Collaboration between main supplier and sub-suppliers |
| RAGATZ et al. (2002) | Supplier integration into new product development under conditions of technology uncertainty |
| MIKKOLA & SKJOETT-LARSEN (2003) | The degree of supplier involvement is dependent of product architecture type. |
| KOUFLEROS et al. (2005) | The importance of internal and external participants for create the integrated environment to involve supplier into PDP |
| PERKS (2005) | Synchronizing of activities in the dispersed product development process |
| PETERSEN et al. (2003, 2005) | Selection of suppliers for involve in product development |
| LAKEMOND et al. (2006) | Type of differentiated coordination typology for suppliers into PDP |

of the literature on product development, highlighted the importance of the relationship between buyers and suppliers among the most important areas for the study of product development.

The min-1990s the beginning of publication of a large numbers of articles approaches the importance of involvement of suppliers into PDP. Mainly approaches about of management of the product development process. Today, there is large concern in others sectors of industry about involvement of supplier into PDP in addition automobile sector. For instance: aerospace sector, (BOZDOGAN et al., 1998), electronics industry (MCIVOR & HUMPHREYS, 2004; OLIVER et al., 2004); and equipment for food industry (LAKEMOND et al., 2006).

In regards to the automotive sector, these sectors share the common difficulty of supplier involvement in PDP, even though this is a practice well disseminated by the automotive sector.

4.2. Analysis of articles - Stages of outsourcing process

Usually advantages and disadvantages of early supplier involvement in product development process are summarized in Table 5.

The factors that appear to be driving non-automotive manufactures to adopt the practice of early supplier involvement were research by BIDAULT et al. (1996). They divided a set of three major factors toward ESI adoption, illustrated in Figure 2. The external environmental

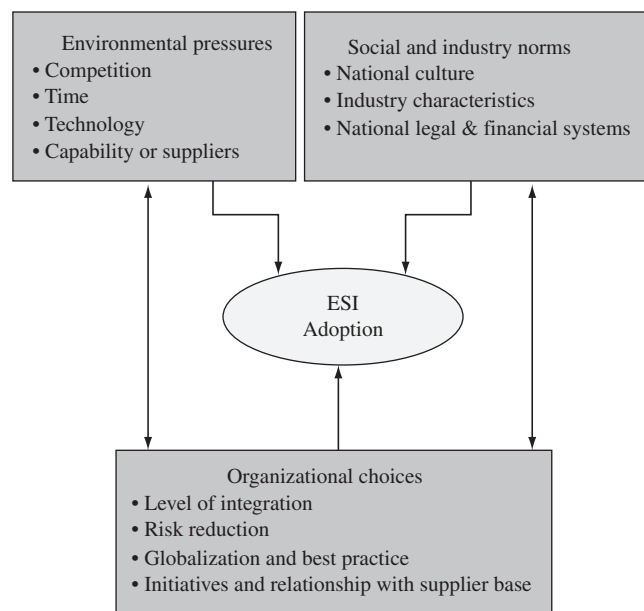


Figure 2. Major factors for ESI adoption. Source: BIDAULT et al. (1996).

Table 4. A chronological review of the literature involvement suppliers into PDP.

| Authors | Focus | Sector |
|-----------------------------|---|--|
| CLARK (1989) | Comparing different practices in Japan, Europe and America | Automotive |
| CUSUMANO & TAKEKISHI (1991) | Comparing different practices in Japan and America | Automotive |
| DYER & OUCHI (1993) | Comparing different practices in Japan, Europe and America | Automotive |
| BIROU & FAWCETT (1994) | Comparing different practices in Japan, Europe and America | Diverse sectors |
| KAMATH & LIKER (1994) | Comparing different practices in Japan, Europe and America | Automotive |
| BROWN & EISENHARDT (1995) | Review of the literature of involvement suppliers into PDP | Others sectors in addition of automotive |
| BIDAULT et al. (1996) | Analyze the motives for the adoption of ESI | Automotive |
| BALDWIN & CLARK (1997) | A prerequisite for the strategy of involvement de suppliers into PDP is the modularity of products. | Diverse sectors |
| HARTLEY et al. (1997) | Identification of factors causing delays in co-development | Automotive |
| RAGATZ et al. (1997) | Identification of success factors for supplier integration. | Diverse sectors |
| BIROU et al. (1997) | Timing of involvement of suppliers into PDP based product life cycle economics | Diverse sectors |
| BOZDOGAN et al. (1998) | Architectural innovation in product development thought early supplier integration | Aerospace |
| HOLMEN & KRISTESEN (1998) | Sharing of information's with supplier aided of QFD | Food |
| HANDFIELD et al. (1999) | The model for select supplier and involve into PDP | Diverse sectors |
| HSUAN (1999) | Modularization in Black-box design | Automotive |
| MCIVOR & MCHUGH (2000) | Approach of strategy purchasing integrated with PDP | Telecommunications equipment |
| WYNSTRA et al. (2001) | Integrating purchasing functional area and product development functional area | Diverse sectors |
| NELLORE (2001) | The impact f visions for suppliers in outsourced product development | Original equipment manufactures |
| MIKKOLA & LARSEN (2003) | Implications for new product development outsourcing and supplier-buyer interdependence | Diverse sectors |
| PETERSEN et al. (2003) | Model for integrating supplier based in purchasing sector. | Diverse sectors |
| MCIVOR & HUMPHREYS (2004) | Timing the supplier involvement in product development | Electronics |
| KOUFTEROS et al. (2005) | Concurrent engineering and external integration | Diverse sectors |
| PERKS (2005) | Synchronizing of activities in the dispersed product development process | Electronics |
| PETERSEN et al. (2005) | Continuation of the work of 2003, emphasis in the organization of PDP | Diverse sectors |
| ZSIDISIN & SMITH (2005) | Managing risks supply risk with early supplier involvement. | Automotive |
| LAKEMOND et al. (2006) | Research about coordinating supplier involvement in PDP | Equipment for food industry |

environment exerts a number of influences, as do the social and industry norms, as do the organizational choices a firm makes regarding the nature of its operations.

MCIVOR et al. (1997) argues that the maintenance of competitiveness can be divided into long term strategic objectives and short term operational objectives. Based on this, it is possible to divide the potential advantages of supplier involvement in the long and short term, as illustrated on Table 6.

Based on a study carried out with 224 companies with fewer than 500 employees (medium-sized companies), KOUFLEROS et al. (2005) reports that the use of

subsystems or components with the objective of producing innovations in new products need long term partnerships otherwise they can produce negative results, for example, the dependence on the supplier without the establishment of commitments.

For decision-making stage, part second this paper was list sixteen factors that are considered outsourcing literature for decision-making stage of outsourcing. Table 7 presents relationship these factors with models for involvement for supplier into PDP.

The HANDFIELD et al. (1999) model applied by PETERSEN et al. (2003, 2005) approaches the largest

Table 5. Advantages and disadvantages of early supplier involvement in PDP.

| Early supplier involvement in product development process | |
|---|--|
| Advantages | Shorter product development process lead times Improved perceived product quality Savings in project costs Better manufacturability Shared knowledge and learning Improved product development process efficiency and effectiveness Accessibility to supplier's technical capabilities |
| Disadvantages | Risks of losing proprietary knowledge Hollowing out internal competencies Eased accessibility for competitors to copy or acquire key technologies Increased dependence on strategic suppliers Increased standardization of components through specified interfaces |

Font: Mikkola & Skjoett - Larsen (2003).

Table 6. Advantages early supplier involvement in product development process at short-term and long-term perspective of involvement.

| Advantages of suppliers involvement in PDP | |
|--|--|
| Short-term perspective of involvement | Improved perceived product quality Cost reduction of product Shorter product development process lead times |
| Long-term perspective of involvement | Better manufacturability Shared knowledge and learning Improved product development process efficiency and effectiveness Accessibility to supplier's technical capabilities |

Table 7. Relationship between of factors for decision-making process outsourcing and suppliers involvement into PDP.

| Referências | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|------------------------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|
| DYER & OUCHI (1993) | | x | | x | | x | x | | x | x | | x | | x | | |
| HANDFIELD et al. (1999) | x | | | | x | x | x | | x | x | x | x | x | | x | x |
| WYNSTRA et al. (2001) | x | | | | x | x | x | | | x | x | x | x | | | |
| CALVI et al. (2001) | x | | | | | | | | x | x | x | | | | | |
| PETERSEN et al. (2003, 2005) | x | | | | x | x | x | | x | x | x | x | x | | x | x |

Legend: 1) Core Competences; 2) Geographical; 3) Organizational; 4) Cultural; 5) Information Technology; 6) Costs/Financial; 7) Quality/continue improvement; 8) Logistic; 9) Technology/Know how; 10) Capability; 11) Firm's strategy; 12) Responsibility; 13) Teams; 14) Add value; 15) Closskpeed; and 16) Product life cycle.

number of decision making factors. This model presents the ramifications of the activities from the strategic level to the operational level for deciding what form the relationship with the suppliers should take and when they should be involved in the PDP. However, geographical, cultural and logistical factors and added value are not explored in the model. FINE (1999) argues that failing to consider these factors may represent the failure of the supplier involvement in PDP. This is also evidenced at the implementation stage as barriers to supplier involvement in PDP.

In addition to these approaches, it was identified that all the articles placed special attention on the interdependence between buyers-suppliers. Based on review de literature, implementation stage was divided in quadrant square, illustrated in Figure 3.

The articles were sorted according to their contribution to the relative quadrant. Some studies also contribute

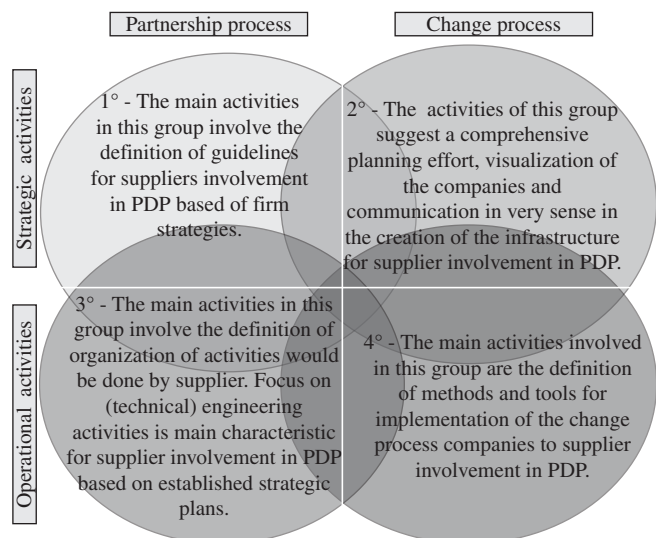


Figure 3. Conceptual model for implementation supplier involvement in PDP.

information to other quadrants. The articles were sorted in order to illustrate the activities involved in the implementation of supplier involvement in PDP.

The first quadrant focuses on strategy activities in the partnership process: the main activities in this group involve the definition of guidelines for supplier involvement in PDP based of firm strategies. The strategic alignment among partnerships is fundamental point for success of supplier integration into PDP (HANDFIELD & NICHOLS JR., 2002; MIKKOLA & SKJOETT-LARSEN, 2003). The product development process strategy should be aligned with other firm strategy, and also other partnership strategy in supply chain. HSUAN (1999), for instance, has shown that higher degree of modularization is possible when more collaborative forms of partnership are shared between the partners during the PDP.

LAMBERT (2004) argues that even the partnerships in black box and white box need the strategic alignment in partnership.

The black box situation, the supplier is asked to carry out the development independently. Product's design is primarily supplier driven, based on buyer's performance specification. In this situation, the buyer doesn't have the necessary skills to make a supervision of the supplier's work. The white box is characterized by low development risk. The client draws up technical or purchasing specifications and asks the supplier for advice as to whether there are any improvements that can be made to these, taking into account the production and assembly capacity of the supplier (CALVI et al. 2001).

MIKKOLA & SKJOETT-LARSEN (2003) argue firms formulate strategies to leverage the supply chain with product variety and customization. The suppliers are gaining more bargaining power whit the increasing state-of-art technology and process complexities embedded in the products. Standardization of interfaces of components in product architectures creates the option for firms to engage in component outsourcing, as it enables division of labor hence increased specialization of tasks. And then, the outsourcing and the subsequent supplier involvement is only possible when a system can be decomposed in such a way that interfaces of the components are well specified and standardized. It has dependence of product modularization strategy pursued by the firms.

The other approaches of literature, such as postponement and mass customization, also obtain with of product modularization strategy.

However, few studies in the literature point out the importance of implementing the modularization strategy as a way of promoting outsourcing in the supply chain or of involving the supplier in PDP. Most of the articles concentrate on visualizing and characterizing the partnerships on a strategic level.

The second quadrant focuses on strategy activities in the change process: the activities of this group suggest a comprehensive planning effort, visualization of the companies and communication in every sense in the creation of the infrastructure for supplier involvement in PDP.

In RENTES (2000) it was proposed the method *TransMeth*. It was created for the purpose of providing a formal planning and management infrastructure. It constitutes a structured engineering approach for managing change. Thus *TransMeth* helps identify the specific elements of a system that need to be changed. This research work reports the establishment of the vision for the change process in a clear and objective form, as a way of guiding implementation of the activity.

Few studies in the literature deal with the change strategy for the creation of the infrastructure to involve the supplier in PDP, mainly at the strategic level of decision-making.

In RAGATZ et al. (1997) are display of success factors for integrating suppliers into product development. The study identifies supplier membership on the product development team as the greatest differentiator between most and least successful integration efforts. It is identifies also the main barriers for supplier integration is resistance to sharing information. Overcoming these barriers also depends on asset sharing, including intellectual assets such as customer requirements, technology information, and cross-functional communication; physical assets such as linked information systems, technology, and shared plan an equipment; a human assets such as supplier participation on product development team and co-location of personnel.

MCIVOR & MCHUGH (2000) e MCIVOR & HUMPHREYS (2004) present the main barriers for the involvement of suppliers from the perspective of the integration of the purchase sector with the PDP. Aside from the barriers mentioned by RAGATZ et al. (1997), the authors point out the following:

- There is a lack of clarity and inconsistencies in the policy guidelines for the level of supplier involvement and time of supplier selection in design;
- Culture of 'people' in both the company and suppliers is a considerable barrier to the principles of ESI such as supply base reduction, cost information sharing and resource commitment from top management; and
- Not enough dedicated resource in the company to jointly work with key suppliers to achieve fully the benefits of ESI.

NELLORE (2001) explores the impact of visions for suppliers in outsourced product development. The results of the study suggest that the creation of visions for suppliers impacts the development process positively and thus better utilize the core capabilities of the buyer and supplier firms.

The third quadrant focuses on operational activities in the partnership process: the main activities in this group involve the definition of organization of activities would be done by supplier. Focus on (technical) engineering activities is the main characteristic for supplier involvement in PDP based on the established strategic activities.

WYNSTRA et al. (2001) define four management areas for the integration of the supplier in the product development:

- PDP Management: establish management policies and guidelines for the involvement of suppliers in the product development, and define the technological areas of collaboration;
- Management of the interface with the supplier: build an infrastructure or supplier network which can contribute to product development process;
- Design Management: manage the involvement of specific development designs; and
- Product Management: define the specifications by means of a developed product.

According to WYNSTRA et al. (2001, 2003), the basic objective of distinguishing the differences between the management areas above is to facilitate the definition of what to integrate.

In FAGESTRÖM & JACKSON (2002) was developed a model for aid understanding of integration between main and sub-suppliers. The main objective of model was describing the important interfaces for integration. The model has six interfaces:

- Interface 1 (between PDP and the order process): this interface covers a lot of dimensions to take into consideration, such as what should be integrated, when integration takes place, who is coordinated and whose work is integrated;
- Interface 2 (between product planning and the PDP): the planning product is a more strategic process for selecting and starting different product development projects. The main objective for interface is to clarify the project description and criteria for evaluation of the progress in the project;
- Interface 3 (between the technology development process and the PDP): the interface should support decisions for what type of new technology should be implemented and when it should be implemented in the product development project;
- Interface 4 (between upstream/downstream activities): this dimension describes when it should be implemented in the product development project;
- Interface 5 (between different organizational functions, which could be both internal and external. This dimension focus on organization task integration, related to the object, what is integrated. The interface also covers who is coordinated and whose work is

integrated; and

- Interface 6 (between different sub-systems ha similarities to the organizational structure. This dimension is related to product architecture and describes what is integrated.

Studies in this particular research area do not define what is being integrated. They usually make gradual recommendations for the involvement of suppliers in product development process. The author's argument for such distinctions is based on features of activities found in practice.

The studies of SANTOS & FORCELLINI (2005) and SANTOS et al. (2006a) show that modeling of PDP can assist the companies in identifying the subcontracting and control of the activities for the suppliers. However, the interfaces involved need to be better detailed.

The fourth quadrant focuses on operational activities in the change process: the main activities involved in this group are the definition of methods and tools for implementation of the change process companies to supplier involvement in PDP. The main characteristic is the use of the conventionally used methods and tools in the development of products of a single company, as a way to promote the integration of the supplier in product development.

According to the authors GRIFF & HAUSER (1992), HOLMEN & KRISTESEN (1998), the QFD can also assist in planning and determining which items will be bought and developed in conjunction with the suppliers.

FAGESTRÖM & JACKSON (2002) reports in their study that few methods of product design are used between the suppliers of first layer and those of second and third layer. The use of FMEA is highlighted as one of the few methods used among the suppliers.

4.3 Analysis of articles - Stages of product development process

Most of the articles concentrate on the planning and structuring of the initial phases of PDP for later supplier involvement. This explains the reason for the larger number of studies on the pre-development phase of the product. Illustrated in Figure 4.

In the pre-development phase the form and scope of the cooperation to involve the supplier in PDP are defined. MCIVOR & HUMPHREYS (2004) and MIKKOLA & SKJOETT-LARSEN (2003) argue that the main problems in this phase are the lack of common objectives between customers and suppliers. The main benchmarking practices for supplier integration to PDP (RAGATZ et al., 1997) in the different phases of the PDP are:

- Supplier membership/participation cross-functional team;
- Direct Cross- functional, intercompany communication;

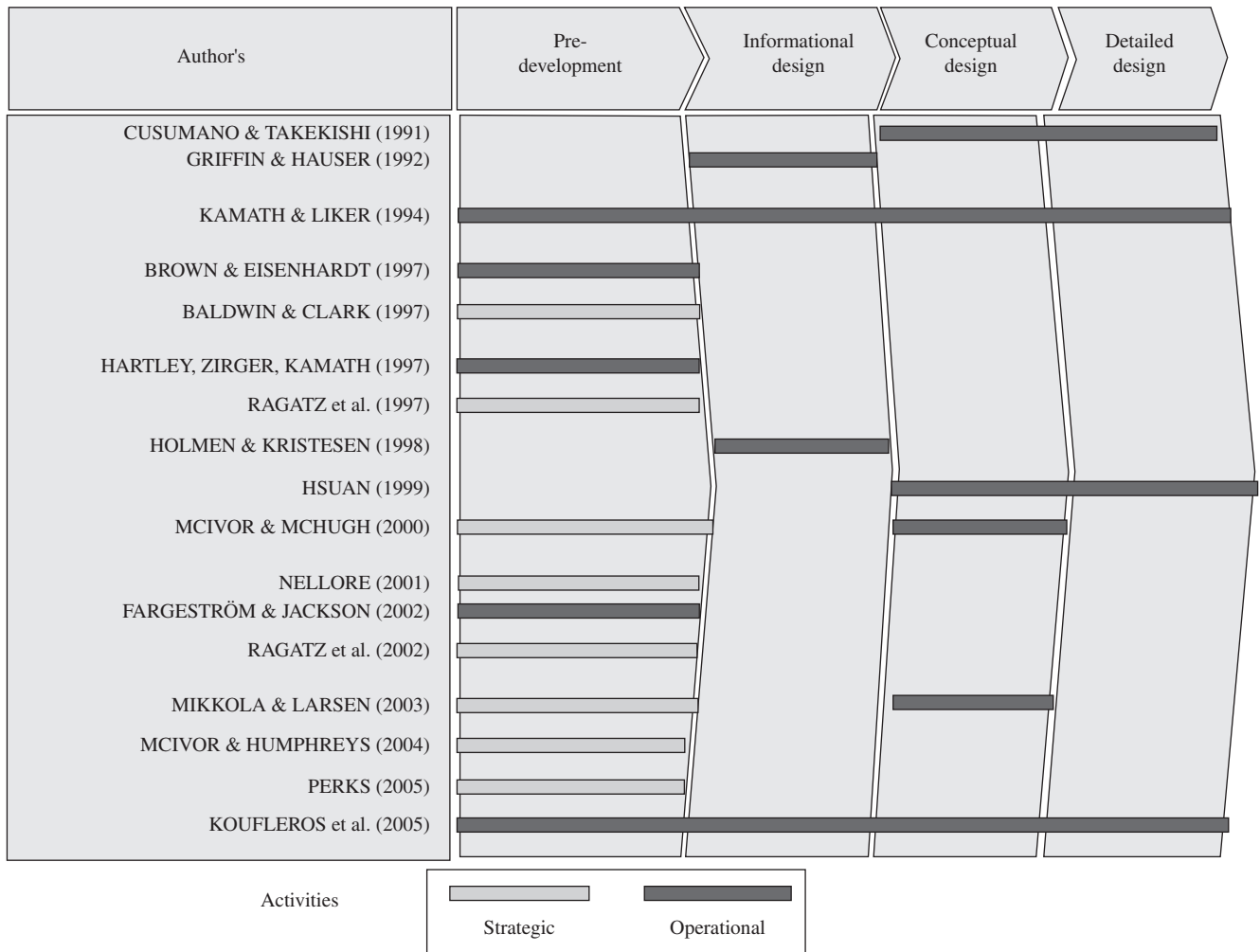


Figure 4. Supplier involvement in stages of PDP.

- Shared education and training;
- Common and linked information systems;
- Co-location of buyer/seller personnel;
- Technology sharing;
- Formal trust development processes/practices;
- Customer requirements information sharing; and
- Technology information sharing.

However, few articles that presented study cases presented them with the objective or as a form of involving the supplier in PDP. Additionally, many of these practices are being used after the product has been launched.

Three research areas and their respective research groups on supplier involvement in PDP have been identified:

- Strategy of modular product development (BALDWIN & CLARK, 1997; HSUAN, 1999; MIKKOLA & SKJOETT-LARSEN, 2003; MIKKOLA, 2003);
- Integration between the purchase functional area and PDP (MCIVOR & MCHUGH, 2000; MCIVOR & HUMPHREYS, 2004; HUMPHREYS et al, 2002); and

- Outsourcing Strategy (HANDFIELD et al., 1999; PETERSEN et al., 2003, 2005, RAGATZ et al., 1997, 2002).

A lack of studies that deal with the implementation of supplier involvement by means of assistance methods and tools was observed. As the QFD method to assist the improvement of the communication between customers and suppliers presented in the studies of GRIFFIN & HAUSER (1992) and HOLMEN & KRISTESEN (1998). The literature on supplier involvement concentrates mainly on reporting what is being done, hardly approaching how it is done.

According to FINE (1999), the Aerospace sector's lifecycle (BOZDOGAN et al., 1998) is long when compared with the Electronics sector (MCIVOR & HUMPHREYS, 2004). The automotive sector is at an intermediate level between these two sectors. However, the product's level of complexity and the need for technological innovations in the market cause the sectors to behave in similar ways concerning product innovation by means of their supply base.

Supplier involvement in product development process can take all stages. However, the greater the technological complexity of a product, the greater will be the need for partnerships, and implementation of the modularization strategy as a way to reduce development time and costs, and reduction of the risks involving the projection of the new product (MCIVOR & HUMPHREYS, 2004; MIKKOLA & SKJOETT-LARSEN, 2003)

The main difference between the supplier involvement in PDP and the ESI refers to the moment (in time) the suppliers are involved in PDP phases. In the ESI the suppliers would have been involved in the phases prior to the detailed project.

5. Conclusion and future work

In the first part of this article a review of the outsourcing literature was presented. Due to the difficulty of finding practical models in the literature for managing outsourcing of subcontracts as a whole, and not only at the decision making phase, VERNALHA & PIRES (2005) proposal was used as reference to explore the subject. A conceptual model for the outsourcing process was then prepared, as illustrated in Figure 1.

The information in the conceptual model for the outsourcing process was used as a starting point to review the studies on supplier involvement in PDP and to establish the relation between outsourcing and PDP.

Analysis of the literature on the supplier involvement in PDP allowed the identification of four main research focus points: comparison between the practices of supplier involvement in PDP, organization and theory of the firm. The theory of the firm (economic approach) was not explored due to the limitation of the research scope, making it an opportunity for future studies, mainly within the PDP context.

Most of the literature still focuses on the automotive sector, but currently there is a greater concern with other sectors (MCIVOR & HUMPHREYS, 2004; MCIVOR et al., 2006; LAKEMOND et al., 2006). Nevertheless, there is room for further studies, for example, the inclusion of particulars of the food and clothing sectors.

In relation to the motivation stage, the literature points out that there are contradictions in the short term objectives in relation to the activities carried out by the companies. For example, the contradiction of tracing short term objectives that can only be reached with the establishment of partnerships with the supplier in the PDP, which can only be reached in long term relationships.

Decision-making stage, in the first part of this chapter, 16 decision-making factors related to outsourcing has been listed, illustrated in Table 1. Table 7 establishes a relation between these factors and the decision-making approaches for the involvement of the suppliers in the PDP. It was

detected that the geographic, cultural, and logistical values and value adding are not lightly explored in the models. FINE (1999) argues that the non-consideration of these factors can represent the failure of supplier involvement in PDP. This is also evidenced in the implementation phase, where these factors can become barriers to supplier involvement in PDP.

Evaluation of the papers detected a concern with the questions related to the interdependence between purchaser-suppliers. However, one can notice that some studies deal with the subject in a superficial manner.

The greatest gaps in the literature were found in the implementation stage of supplier involvement. The literature reports what happens in the relations between companies and suppliers. A large volume of studies of empirical cases and few contributions to the implementation of supplier involvement in PDP were identified. Many studies present the barriers for the implementation of supplier involvement in PDP. However, few solutions are suggested to implement supplier involvement in PDP. When they do so, they concentrate on information technology. The studies of WYNSTRA et al. (2001), FAGESTRÖM & JACKSON (2002) define different interfaces for integration of the supplier to PDP. These can assist in the identification of different lines of research in the area.

The separation in four quadrants during the implementation phase assisted in the identification of possibilities for future research, integrating the outsourcing with the PDP. However, literature both on outsourcing and on PDP places greater attention on the process of relationship management, reporting very little on the importance of the change process.

The last stage refers to the supplier relationship management, which is dealt with in several studies.

The analysis of the articles regarding stages in the product development process pointed out the importance of pre-development for supplier involvement in PDP. On the other hand, there is a lack of research on the strategic activities deployment for the operational level, mainly referring to the change process.

With the objective of supplying a summary of the contents of this study, the Figure 5 was prepared.

The information in this research paper is being considered for a doctoral dissertation under the title 'Reference model for the product development process in a supply chain management environment'.

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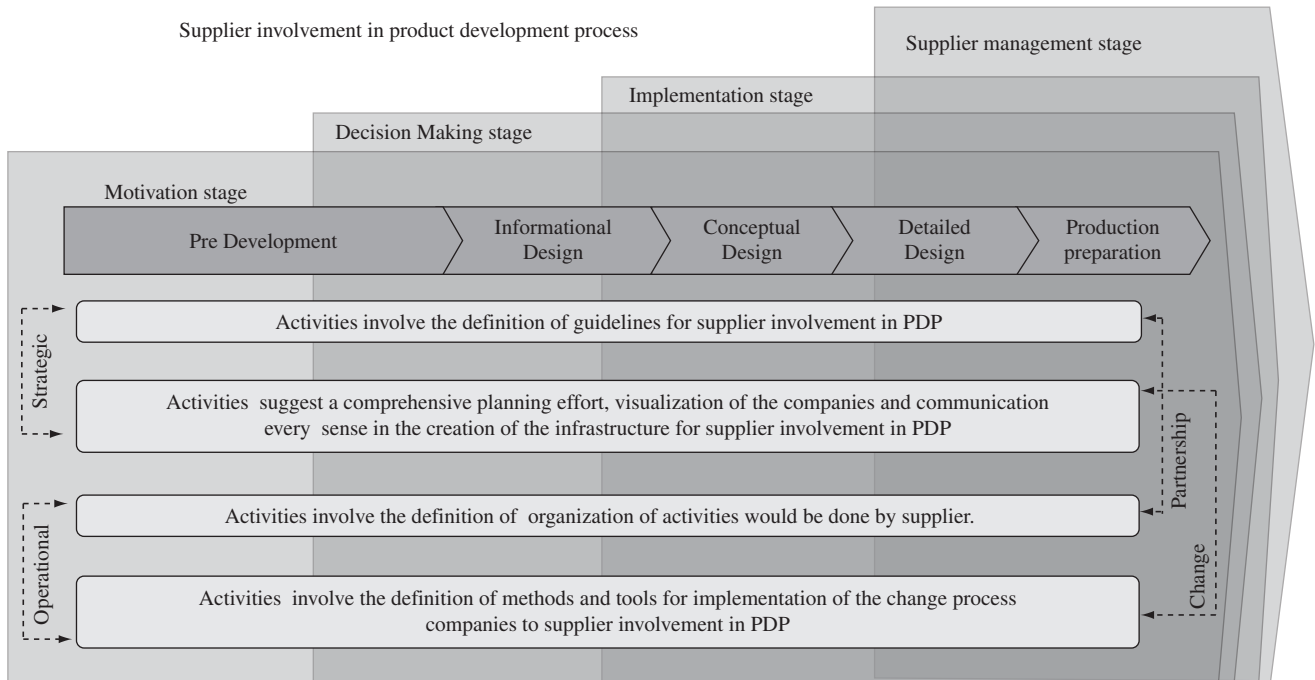


Figure 5. Linking outsourcing process and product development process.

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