

The Supplier's Role in New Product Development Initiatives: An Assessment of Research Efforts

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ABSTRACT

The authors review the literature on the impact suppliers may have on the new product development (NPD) process to show the benefits of integrating suppliers within a firm's NPD design team. In the tables, the authors have categorized the research studies examined, as either case based or empirical and reference some key findings to help future researchers in their efforts to examine early supplier involvement in new product development activities.

INTRODUCTION

Today's competitive world requires firms to work diligently to build relationships to help the firm succeed. Additionally customers expect new products even more quickly than before and in this environment a manufacturing company must explore all available opportunities. If a firm's suppliers can be encouraged to take a more active role in the design of new products, then the manufacturer can use the supplier's expertise early in the design stage of the product to shorten the time-to-market for new products. Moreover, markets are becoming more fragmented which further necessitates working with suppliers to respond to these market challenges. Unfortunately, manufacturers may understand "why" they should form supplier collaborations but probably not "how" to effectively integrate suppliers into the product development effort (Handfield et al., 1999; Monczka et al., 2000). Research related to processes that help integrate suppliers into the design process are needed, therefore effort is needed to evaluate the research on supplier involvement in NPD.

Many researchers have examined the issue of supplier involvement in new product development efforts. The Japanese example has been used previously to clearly identify the benefits of early supplier involvement (Clark, 1989; Clark and Fujimoto, 1991; Kamath and Liker, 1994), but companies in the US and several European countries (e.g., U.K., Italy, Germany) have also experimented with early supplier involvement (Littler et al., 1995; Spina et al., 2002; Walter, 2003). In this article, we review the relevant NPD literature.

Benefits/Risks of Early Supplier Involvement in the NPD design team

There are several stated benefits associated with ESI, the first is decreasing project costs. Other benefits include reduced project length and, of course, an improved product. Some researchers report findings that putting suppliers on the NPD design team results in a diminished product, increased project costs, and a slower development process. However these findings are not always achieved.

When firms involve suppliers in their design process they may realize an improved market position, since researchers have found that this can increase a firm's chance of being first-to-market with a new innovation and also may increase the number of new products the firm produces (Bonaccorsi and Lipparini, 1994; Loch et al., 1996). Better design decisions can be made when key suppliers are part of the team because the suppliers are knowledgeable of their cost structure to readily recognize performance trade-offs. Furthermore, suppliers may introduce other components that could be used more cost effectively, thus improving the supplier's operational performance (Bonaccorsi and Lipparini, 1994). Suppliers also offer another pair of eyes to identify potential problems before the product is too far along the development process (Wasti and Liker, 1999) which decreases the need of reworking parts (Clark and Fujimoto, 1991). The number of innovations can also be improved when suppliers collaborate with manufacturers (Chung and Kim, 2003). Supplier early involvement helps the manufacturing firm create a better product because it often provides access to new skills, functionality, or technology, especially when a high level of innovation is a priority (Bower, 1993; Littler et al., 1995; Muffatto and Panizzolo, 1996; Swink et al., 1996).

Since supplier resources are being used in the design this results in cost reduction by sharing risks and development costs (Bonaccorsi and Lipparini, 1994; Littler et al., 1995; Swink et al., 1996). Furthermore, the use of standardized components across multiple products, including standardization of future components results in cost savings (Bonaccorsi and Lipparini, 1994; Hutcheson et al., 1995; Muffatto and Panizzolo, 1996). Using existing supplier equipment extends the usefulness of the supplier's equipment which can be beneficial for new development activities (Bonaccorsi and Lipparini, 1994; Muffatto and Panizzolo, 1996).

Early involvement provides suppliers more lead-time to make prototypes available earlier and to ensure on-time allocation of scarce supplier production capacity (Bonaccorsi and Lipparini, 1994; Muffatto and Panizzolo, 1996). Effective communication among team members is critical to ensure all parties acknowledge any changes in the product development plan.

Recent studies have shown that integrating suppliers has decreased both time-to-product and time-to-market (Petersen et al., 2003; Dröge et al., 2004). Littler et al. (1995) offer an additional benefit when they found that some suppliers had distribution channels that were unique to the partnership (e.g., providing access to foreign markets) and were willing to utilize them on their customers' behalf in order to decrease the time-to-market. Furthermore, the speed benefits of concurrent engineering are well established (Raman and Chhajed, 1995), and researchers have confirmed that these benefits may also be obtained by managing several development cycles across multiple companies (Bonaccorsi and Lipparini, 1994). Petersen et al. (2003) found indications that supplier involvement is vital in situations involving complex technologies or any technology where the manufacturing firm lacks internal expertise.

Risks

While there are a number of benefits to ESI, it is important to consider the risks. There is a fear of creating a competitor by unwittingly transferring knowledge or technology during ESI activities (Bower, 1993; Littler et al., 1995; Zirger and Hartley, 1996). A design team which includes members from multiple companies results in less control over the NPD process by the manufacturer and a potential shift in team objectives or goals toward maintaining cohesiveness of the collaboration (Bower, 1993; Littler et al., 1995). There is also a risk in relying too much upon a specific supplier as it reduces their negotiating power (Zirger and Hartley, 1996). Furthermore Chung and Kim (2003) argue that research has not consistently established that involvement does increase product quality across countries.

In contrast, several researchers have found that early supplier involvement may actually increase NPD time by increasing the size of the team (Eisenhardt and Tabrizi, 1995), especially if the managers are inexperienced in collaborative efforts (Swink, 1999). Furthermore, while differing business cultures can be difficult for domestic collaborators to adjust to, as the supply base extends across different countries, communication difficulties and other cultural differences can cause problems for the design team (Eisenhardt and Tabrizi, 1995; Littler et al., 1995). The coordination of decision-making across firms can be expensive and time consuming and may actually add some costs to the design process due to the increased overhead of managing the collaboration (Littler et al., 1995).

This article offers two tables which comprise the case and empirical research examined during the course of the creation of this article. These tables offer brief summary of the findings of the studies along with the study's focus, which provided a basis for the more specific categories discussed during this article.

Case studies are typically more in-depth evaluations of the firm and its relationships. In Table One, we offer a summary of number of case studies conducted in the last fifteen years. The goal is to increase reader awareness about research being conducted using this robust methodology as well as improve understanding regarding the issues of concern in NPD.

Table 1. Summary of Case Study Findings

Researcher(s)	Focus	Findings
Anderson, Oliver, and Anderson (2001)	16 automotive component makers and two car makers based in the UK	UK automakers are increasing their dependence on the product development capabilities of the suppliers but are also demanding price decreases. Case study suggests several crucial factors needed to enable sustainable supplier advantage for a firm: partner selection and evaluation systems, proximity of supplier network, mutual support, continuity and stability of relationship, and technical synchronization within concurrent development processes.
Bonaccorsi and Lipparini (1994)	One capital equipment firm and its suppliers (70 companies were interviewed)	In high-risk, high-innovation markets, it is common for suppliers (biotech firms) to be the innovators and let the larger firms (pharmaceuticals) manage the rest of the business.
Bower (1993)	Pharmaceutical and biotech firms (3 companies and their network)	Specific product development steps are needed and information needs to be conveyed to the participants to improve acceptance of concurrent engineering efforts.
De Toni and Nassimbeni (2003)	54 small and medium sized firms in the Italian eyewear industry	Suppliers were responsible for most of the process innovation in the Systemic stage; that is, once the industry matured.
Hutcheson, Pearson, and Ball (1995)	Ethylene manufacture	Study showed that Japanese automakers managed first-tier suppliers in four distinct manners. Kamath and Liker classified these as Partner, Mature, Child, and Contractual and explain how a firm should treat suppliers differently depending upon their needs and the supplier's characteristics.
Kamath and Liker (1994)	Automotive suppliers (over 143 Japanese firms and 189 U.S. firms studied)	The success of collaborative product development efforts is achieved when clear parameters of the relationship and objectives are agreed to in advance.
Littler and Leverick (1995)	UK information and communications firms	

Researcher(s)	Focus	Findings
Mabert, Muth, and Schmenner (1992)	Six distinct companies	The advantages of supplier early involvement, including being part of the firm's parallel development processes were seen as high - if the buyer signed a firm commitment with the supplier.
McIvor, Humphreys, and Huang (2000)	A single strategic business unit (SBU) of a global telecommunications equipment manufacturer and its key suppliers	The buyer-supplier relationship has increased in importance and purchasing is now seen as an opportunity to improve new product development and cost reduction efforts. An internal collaborative mindset is needed before efforts to collaborate with suppliers will be successful.
Muffatto and Panizzolo (1996)	Italian motorcycle industry (Eight Italian and Japanese firms)	A firm's market strategy impacts their supplier relationships. Volume producers tend toward a co-design relationship, with some parts purely designed by the firm and with no core parts purely designed by the supplier. Specialist producers are more flexible and utilize all types of suppliers.
Sobrero and Roberts (2002)	50 different supplier-manufacturer relationships within a single firm in the European Major Home Appliances industry	Contractual and organizational arrangements for the governance of supplier-manufacturer relationships in new product development projects. Relational outcomes depend on the type of joint activities, both short and long term and how specific the joint activities are for both parties.
Swink, Sandvig, and Mabert (1996)	Five distinct companies, each with over 50 years of NPD experience	Suppliers should be involved in the design process in the early stages in two situations: 1) when product cost is a high priority and 2) when a high level of innovation is a priority and the supplier is a technical expert or source of relevant technology.
Zirpoli and Caputo (2002)	Fiat (an Italian automotive company)	Not all of the best practices regarding relationship development have been applied even though Fiat has extensive early supplier involvement in the new product development process.

Table Two also summarizes research conducted in the last fifteen years; however these studies use empirical methodologies which typically resulted in higher sample sizes indicating more relationships were examined per study.

Table 2. Summary of Empirical Findings

Researcher(s)	Focus	Findings
Bruce, Leverick, and Littler (1995)	106 UK companies in the Information and communication technology sector	Determining the success of the collaboration can be difficult to determine. Therefore careful attention to the entire collaboration process is needed along with senior level commitment to improve chances of success.
Bruce, Leverick, Littler, and Wilson (1995)	UK suppliers for the Information and communication technology sector	The findings acknowledged possible negative outcomes of collaboration; such as increased costs or longer development time. The need for increased control of the information exchange process and establishment of clear parameters and objectives for the relationship was identified.
Chung and Kim (2003)	83 automobile and 45 electronics firms	A higher level of supplier involvement especially during the design stage significantly increases suppliers' innovation and cash-flow rate.
De Cerio (2003)	965 Spanish manufacturers (across a variety of industries)	A significant relationship exists between the level of quality management efforts and the operational performance metrics of cost, quality, and flexibility.
Dröge, Jayaram, and Vickery (2000 and 2004)	57 North American automobile suppliers	Synergistic integration and supplier closeness, as antecedents to timing ability, were both found to be significantly related to development and introduction time minimization ability.
Eisenhardt and Tabrizi (1995)	Computer firms from U.S., Europe, and Asia (72 projects, 36 companies)	For the entire sample and for the subsample of unpredictable markets, supplier involvement was significantly associated with <i>increased</i> development time. For the subsample of predictable markets, supplier involvement was not significant.

Researcher(s)	Focus	Findings
Hartley, Zirger, and Kamath (1997)	Assembly industry firms, mostly small to medium-sized companies (79 firms)	Suppliers on-time performance was shown to significantly impact the buyer's overall project time. However, the study did not find significant relationships between supplier performance and firm (buyer) management as measured by earlier involvement, increasing supplier responsibility, or more face-to-face communication between parties.
Kamath and Liker (1990)	172 Vice Presidents of Marketing or Research & Development of Original Equipment Manufacturers	Buying firms need to understand the supplier's capabilities and share information to ensure the suppliers understand the innovation objectives.
Krause, Handfield, and Scannell (1998)	84 firms	Companies have two significant modes of handling suppliers - strategic and reactive. Companies tend to be reactive in their supplier management until the supplier has proved themselves and move to a strategic mode as the supplier's performance improves.
LaBahn and Krapfel (2000)	422 component suppliers	Results show that customer power advantage decreases customer promise and customer adherence to agreements.
Liker, Kamath, Wasti, and Nagamachi (1996)	189 US suppliers and 143 Japanese suppliers	In a comparison of US and Japanese suppliers both were found to have similar opportunities to participate in the design process, but the Japanese firms used several additional techniques to control suppliers, including target pricing, performance monitoring, and mutual dependence.
Little, Leverick, and Bruce (1995)	Information technology and telecommunications firm (106 UK companies)	Collaboration with other firms (including suppliers) has major risks and may be less efficient than no collaboration at all. There are specific collaboration factors that were significantly associated with more successful collaborative projects: ensuring partners fulfill expectations, perceived equality of benefits received, and building trust.
Loch, Stein, and Terwiesch (1996)	Electronics firms in the U.S., Japan, and Europe (95 companies)	Involving suppliers in the design process significantly increases the innovation rate.
McCutcheon, Grant, and Hartley (1997)	79 Product design engineering managers	The buyer and supplier activities during the component development stage was more important than the actual technical outcomes of the project. Responsiveness, cooperativeness, and customer service were considered critical to the success of the supplier/buyer relationship.
McGinnis and Vallopra (1999)a	271 National Purchasing Association Members	Purchasing plays a major role in process development/improvement in many industries, which can contribute to a firm's competitive advantage.
McGinnis and Vallopra (1999)b	252 National Purchasing Association Members	Purchasing needs to actively manage suppliers during the new product development process and to coordinate and integrate their involvement to achieve success.
Petersen, Handfield, and Ragatz (2003)	88 paired (least and most successful suppliers) across a variety of industries and countries	Increased knowledge of the supplier and increased information sharing are needed to improve supplier involvement and to achieve NPD goals. Supplier involvement critical when manufacturing firm lacks some technological expertise.
Ragatz, Handfield, and Petersen (2002)	83 US firms	The findings suggest that under conditions of technology uncertainty there is a negative impact on cost results, but no direct effect on quality or cycle time.
Ragatz, Handfield, and Scannell (1997)	60 US firms	Integrating suppliers into the NPD process can result in improved quality, reduced costs, and access to and better utilization of technology.
Spina, Verganti, and Zotteri	67 Italian manufacturers	Structural factors, such as firm size and the degree of vertical integration were found to influence the success of the co-design efforts.
Stump, Athaide, and Joshi (2002)	296 small to medium size firms in the high tech industry	Joint new product development reduced the negative effect of product customization on seller satisfaction and enhanced customization's positive effect on relationship continuity.

Researcher(s)	Focus	Findings
Swink (1999)	91 manufacturing firms producing discrete, fabricated and assembled products	Results suggest that project complexity and increased levels of design outsourcing are associated with poorer new product management, while product newness and project acceleration are associated with better NPM.
Walter 2003	247 German suppliers	The role of relationship promoter is vital to achieve close supplier relationships necessary for supplier involvement in new product development efforts.
Zirger and Hartley (1996)	Electronics firms (44 companies)	Surprisingly, decreasing the number of suppliers significantly <i>increases</i> the development time in this study. The study also found no significant relationship between supplier involvement in design and development time.

RESEARCH STILL NEEDED

While Tables One and Two provide a significant level of information regarding NPD activities, it is important to realize that more information is still desired. For example, future researchers may consider the vital contribution longitudinal research can provide. This type of research could be designed to capture how relationships develop over time. More companies and researchers alike are recognizing the need to understand this development. Researchers are also being called upon to more closely identify those factors that are mutually beneficial so the participants in the collaboration activities can more readily address these points. Additionally future studies may target the type and frequency of information exchange and the impact it has on the long term viability of the relationship. Gentry and Savitskie (2008) started to address this need with a review of the known benefits and risks of early supplier involvement in the new product development process, but this is just one of many vital factors in successful product development. Consequently, it is important to identify the specific objectives of relationship development, such as information exchange, and clearly state the priority it has in the collaboration activities. Firms also need to ensure their employees have the encouragement and support of upper management and the training needed to foster relationship development and research which is another avenue of study.

CONCLUSION

In the last fifteen to twenty years there has been much written about the new product development process but there is still a need to better understand the new product development effort. Effective collaborative relationships are critical to a manufacturing firm's efforts especially given the long distance, multi-cultural relationships often required to get a new product to market in timely manner. Improving the development process may provide firms with a competitive advantage in accessing new markets in a cost effective manner.

Supplier involvement appears to increase innovation, especially when the suppliers are technology leaders and/or the industry is mature. In mature, or maturing, industries, manufacturers have typically achieved the innovations that are intuitive to their mindsets and appear to be more receptive to the different perspectives, and suggestions, offered by suppliers.

This article provides a summary of research on the new product development process. Researchers embarking on efforts related to NPD will find this article useful as they create their new studies. Additional NPD research is critical given the challenge of meeting customer expectations in today's competitive environment. This requires more collaborative manufacturing efforts with managers that may or may not understand.

As researchers continue to examine the topic of early supplier involvement in new product development activities, we offer future researchers insight into previous research efforts and should suggest some directions for future research for this interesting and timely topic.

REFERENCES

- Anderson, J., Oliver, N., Anderson, J., 2001. Collaborative new product development in a multi-customer context: challenges for western auto component suppliers. *International Journal of Automotive Technology and Management* 1(2/3), 169-182.
- Bonaccorsi, A., Lipparini, A., 1994. Strategic partnerships in new product development: an Italian case study. *The Journal of Product Innovation Management* 11 (2), 134-145.
- Bower, D.J., 1993. New product development in the pharmaceutical industry: polling network resources. *The Journal of Product Innovation Management* 10 (5), 367-375.
- Bruce, M., Leverick, F., Littler, D., 1995. Complexities of collaborative product development. *Technovation* 15(9), 535-552.
- Bruce, M., Leverick, F., Littler, D., Wilson, D., 1995. Success factors for collaborative product development: a study of suppliers of information and communication technology. *R&D Management* 25(1), 33-44.
- Chung, S., Kim, G.M., 2003. Performance effects of partnership between manufacturers and suppliers for new product development: the supplier's standpoint. *Research Policy* 32(4), 587-603.
- Clark, K.B., 1989. Project scope and project performance: the effect of parts strategy and supplier involvement on product development. *Management*

Science 35(10), 1247-1263.

- Clark, K.B., Fujimoto, T., 1991. *Product Development Performance*, Harvard University Press, Boston, MA.
- De Cerio, J.M., 2003. Quality management practices and operational performance: empirical evidence for Spanish industry. *International Journal of Production Research* 41(12), 2763-2786.
- DeToni, A., Nassimbeni, G., 2003. Small and medium district enterprises and the new product development challenge: evidence from Italian eyewear district. *International Journal of Operations & Production Management* 23(6), 678-697.
- Dröge, C., Jayaram, J., Vickery, S.K., 2000. The ability to minimize the timing of new product development and introduction: an examination of antecedent factors in the North American automobile supplier industry. *Journal of Product Innovation Management* 17(1), 24-40.
- Dröge, C., Jayaram, J., Vickery, S.K., 2004. The effects of internal versus external integration practices on time-based performance and overall firm performance. *Journal of Operations Management* 22(6), 557-573.
- Eisenhardt, K.M., Tabrizi, B.N., 1995. Accelerating adaptive processes: product innovation in the global computer industry. *Administrative Science Quarterly* 40(1), 84-110.
- Gentry, L., Savitskie, K., 2008. *Understanding the Supplier's Role in New Product Development: How to Achieve Competitive Advantage in the Supply Chain*. Academy of Taiwan Business Management Review, Vol. 4(1), 17-27.
- Handfield, R.B., Ragatz, G.L., Petersen, K.J., Monczka, R.M., 1999. Involving suppliers in new product development. *California Management Review* 42(1), 59-82.
- Hartley, J.L., Zirger, B.J., Kamath, R.R., 1997. Managing the buyer-supplier interface for on-time performance in product development. *Journal of Operations Management* 15(1), 57-70.
- Hutcheson, P., Pearson, A.W., Ball, D.F., 1995. Innovation in process plant: a case study of ethylene. *The Journal of Product Innovation Management* 12(5), 415-430.
- Kamath, R.R., Liker, J.K., 1994. A second look at Japanese product development. *Harvard Business Review* 72(6), 154-170.
- Kamath, R.R., Liker, J.K., 1990. Supplier dependence and innovation: a contingency model of supplier's innovative activities. *Journal of Engineering and Technology Management* 7(2), 111-127.
- Krause, D.R., Handfield, R.B., Scannell, T.V., 1998. An empirical investigation of supplier development: reactive and strategic processes. *Journal of Operations Management* 17(1), 39-58.
- LaBahn, D.W., Krapfel, R., 2000. Early supplier involvement in customer new product development: a contingency model of component supplier intentions. *Journal of Business Research* 47(3), 173-190.
- Liker, Jeffrey K., Rajan R. Kamath, S. Nazli Wasti, and Mitsuo Nagamachi (1996), "Supplier Involvement in Automotive Component Design: Are There Really Large US Japan Differences?," *Research Policy*, Vol. 25, No. 1, pp. 59-89.
- Littler, D., Leverick, F., 1995. Joint ventures for product development: learning from experience. *Long Range Planning* 28(3), 58-67.
- Littler, D., Leverick, F., Bruce, M., 1995. Factors affecting the process of collaborative product development: a study of UK manufacturers of information and communications technology products. *Journal of Product Innovation Management* 12(1), 16-32.
- Loch, C., Stein, L., Terwiesch, C., 1996. Measuring development performance in the electronics industry. *The Journal of Product Innovation Management* 13(1), 3-20.
- Mabert, V.A., Muth, J.F., Schmenner, R.W., 1992. Collapsing new product development times: six case studies. *The Journal of Product Innovation Management* 9(3), 200-212.
- McCutcheon, D.M., Grant, R.A., Hartley, J., 1997. Determinants of new product designers' satisfaction with suppliers' contributions. *Journal of Engineering and Technology Management* 14(3/4), 273-290.
- McGinnis, M.A., Vallopra, R.M., 1999. Purchasing and supplier involvement: issues and insights regarding new product success. *Journal of Supply Chain Management* 35(3), 4-15.
- McGinnis, M.A., Vallopra, R.M., 1999. Purchasing and supplier involvement in process improvement: a source of competitive advantage. *Journal of Supply Chain Management* 35(4), 42-50.
- McIvor, R., Humphreys, P., Huang, G., 2000. Electronic commerce: reengineering the buyer-supplier interface. *Business Process Management Journal* 6(2), 122-132.
- Monczka, R., Handfield, R., Frayer, D., Ragatz, G., Scannell, T., 2000. *New Product Development: Supplier Integration strategies for Success*, ASQ Press, Milwaukee, WI.
- Muffatto, M., Panizzolo, R., 1996. Innovation and product development strategies in the Italian motorcycle industry. *The Journal of Product Innovation Management* 13(4), 348-361.
- Petersen, K.J., Handfield, R.B., Ragatz, G.L., 2003. A model of supplier integration into new product development. *Journal of Product Innovation Management* 20(4), 284-299.
- Ragatz, G.L., Handfield, R.B., Petersen, K.J., 2002. Benefits associated with supplier integration into new product development under conditions of technology uncertainty. *Journal of Business Research* 55(5), 389-400.
- Ragatz, G.L., Handfield, R.B., Scannell, T.V., 1997. "Success factors for integrating suppliers into new product development. *Journal of Product Innovation Management* 14(3), 190-202.
- Raman, N., Chhajed, D., 1995. Simultaneous determination of product attributes and prices and product processes in product-line design. *Journal of Operations Management* 12(3,4), 187-204.
- Sobrero, M., Roberts, E.B., 2002. Strategic management of supplier-manufacturer relations in new product development. *Research Policy* 31(1), 159-182.
- Spina, G., Verganti, R., Zotteri, G., 2002. Factors influencing co-design adoption: drivers and internal consistency. *International Journal of Operations & Production Management* 22(12), 1354-1366.
- Stump, R.L., Athaide, G.A., Joshi, A.W., 2002. Managing seller-buyer new product development relationships for customized products: a contingency model based on transaction cost analysis and empirical test. *Journal of Product Innovation Management* 19(6), 439-454.
- Swink, M., 1999. Threats to new product manufacturability and the effects of development team integration processes. *Journal of Operations Management* 17(6), 691-709.
- Swink, M.L., Sandvig, J.C., Mabert, V.A., 1996. Customizing concurrent engineering processes: five case studies. *The Journal of Product Innovation Management* 13(3), 229-244.
- Walter, A., 2003. Relationship-specific factors influencing supplier involvement in customer new product development. *Journal of Business Research* 56(9), 721-733.
- Wasti, S., Liker, J., 1999. Collaborating with suppliers in product development: a U.S. and Japan comparative study. *IEEE Transactions on Engineering Management* 46(4), 440-460.
- Zirger, B.J., Hartley, J.L., 1996. The effect of acceleration techniques on product development time. *IEEE Transactions on Engineering Management* 43(2), 143-152.
- Zirpoli, F., Caputo, M., 2002. The nature of buyer-supplier relationships in co-design activities: the Italian auto industry case. *International Journal of Operations & Production Management* 22(12), 1389-1410.