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Supplier involvement in new product development and innovation: Taking stock and looking to the future

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ABSTRACT

This paper provides a comprehensive and critical review and synthesis of the current state of empirical research into supplier involvement in new product development (NPD). The paper begins by defining supplier involvement in NPD and evaluating the rationale for supplier involvement in NPD. This suggests that early and extensive supplier involvement in NPD projects has the potential to improve NPD effectiveness and efficiency, however, existing research remains fragmented and empirical findings to date show conflicting results. The paper takes stock of the research on supplier involvement in NPD, tracing the origins of the literature to the late 1980s, and evaluating the development of the field up to the present day. From this broad base of empirical research the analysis identifies a set of factors affecting the success of supplier involvement projects. The paper concludes with a discussion of two emerging themes: (1) supplier relationship development and adaptation; (2) supply network involvement in product innovation.

1. Introduction

As more and more companies are outsourcing parts of their new product development (NPD) activities to suppliers, it is not surprising to find that research into how to manage supplier involvement in NPD and innovation has greatly expanded during the last 30 years. Several definitions of supplier involvement in NPD have been suggested; fundamentally it concerns the integration of the capabilities that suppliers can contribute to NPD projects (Dowlatshahi, 1998), the tasks they are able to carry out on behalf of the customer, and the responsibilities they assume for the development of a part, process or service (Van Echtelt et al., 2008, p. 182). Supplier involvement in NPD is important, therefore, because suppliers possess specialized product and process capabilities, which are critical as products are becoming increasingly complex. Indeed there is much evidence to suggest that involving suppliers extensively and early in NPD can improve NPD performance in terms of reduced costs and time to market and improved quality (e.g. Ragatz et al., 2002), and it has been used as a key factor in explaining the 'Japanese advantage' (e.g. Clark, 1989).

However, despite the apparent benefits of supplier involvement in NPD, research remains fragmented. Although there is a substantial body of research emerging in this field using a range of different research methodologies, empirical findings regarding performance benefits differ quite significantly. There are also uncertainties as to the situations in which supplier involvement will reap the expected benefits. For example, supplier involvement in products of high technological uncertainty, i.e. radical innovation has been investigated by several authors, but the results are contradictory. Furthermore, although research has increasingly investigated the conditions for successful supplier involvement, there is still a lack of consensus as to what makes for successful long-term supplier involvement efforts. This paper seeks to provide a rigorous and critical analysis of the state-of-the-art empirical research on supplier involvement in NPD. To ensure that only the highest quality research is considered, the analysis focuses specifically on articles published in major English-language North American and European journals. This means that the analysis considers mainly journal articles that are included as 'four stars' on the latest Association of Business Schools (ABS) ranking (Harvey et al., 2008) plus a few seminal journal articles and contributions that are widely accepted as having provided major contributions to the field. The ABS ranking draws from several other highly regarded journal quality rankings; journal articles ranked as four stars represent the highest tier of business and management journals and include top journals such as Journal of Operations Management, Journal of Product Innovation Management, Academy of Management Review, and Strategic Management Journal. These journals tend to have a high citation impact factor (measured by the Institute for Scientific Information—ISI) of at least 2.0. Although any journal ranking is inevitably controversial, the ABS ranking is widely viewed as providing a reliable measure of research rigour and quality.

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The implications of focusing on these particular journals are discussed at the end of the paper.

2. Empirical research into supplier involvement in NPD

This section of the paper provides a chronological review of the literature on supplier involvement in NPD. The first empirical research to focus on the role of suppliers in NPD can be traced to a few internationally influential studies in the 1980s. As this section will show, the field has developed significantly since then, having become much more sophisticated in terms of research methods as well as industrial and regional context. The analysis of the literature in this section is therefore designed around a set of tables, which helps to structure the analysis, divided into the 1980s, the early 1990s, the late 1990s, early 2000, and the latest research since 2005. As the tables show, a large set of high-quality contributions to the field have been analyzed, drawing out the methods employed, the context in terms of industry and region, the focus and objectives of the studies, the underpinning theory, any performance measures applied (if at all), the key results and contributions of the studies, and finally the nature of the publication including the journal acronym.

2.1. Early beginnings: 1980s

The first research that focused specifically on supplier involvement in NPD was the study by Imai et al. (1985) and Takeuchi and Nonaka (1986). As shown in Table 1 these two early contributions to the field were based on the same set of seven in-depth case studies within five major Japanese companies. Describing the commitment of dedicated supplier networks to so-called 'lead manufacturers', the authors explained the superior performance of the Japanese companies by their extensive supplier involvement in NPD projects. The later 'Harvard automotive study' by Clark (1989) and Clark and Fujimoto (1991) further explored the role of supplier involvement in explaining major performance gaps between Japanese and Western auto companies, in terms of reduced time to market, improved quality and productivity. Their research provided an extensive account of the use of black-box and detail-controlled (white box) parts, coupled with cross-functional teams, overlapping development stages and other internal development factors. Womack et al. (1990) capitalized on and consolidated the work by Clark (1989) and Clark and Fujimoto (1991) in the International Motor Vehicle Programme (IMVP). They labeled the Japanese (especially Toyota's) system as 'lean' and reached a much wider non-academic audience with their book 'The Machine that Changed the World'. Overall, these empirical studies demonstrated in a convincing manner a significant performance gap between Japanese and Western manufacturers in terms of new product quality, cost and time to market; supplier involvement in NPD was highlighted as a key explanatory factor.

It should be noted that the early studies were generally driven by empirical data from the automotive industry. The studies provided extensive benchmarks that have since been used not only across the global automotive industry, but also filtering into a range of other sectors. Inevitably these early studies have to be understood in their specific industrial, cultural and temporal context; the studies have provided much inspiration for improvement outside this original context, but much of the research that followed nevertheless continued to focus heavily on the automotive industry.

2.2. Expanding the field: the early 1990s

A series of publications in the early 1990s elaborated on the findings from the automotive industry (Cusomano and Takeishi, 1991; Lamming, 1993; Nishiguchi, 1994; Kamath and Liker, 1994), further analyzing the performance gap between Japanese and Western manufacturers; in these landmark studies supplier involvement was seen as a key explanatory factor in superior Japanese NPD performance. As Table 2 indicates the research was still at that point heavily focused on comparative studies of the

Table 1
Early supplier involvement research: 1980s automotive studies.

Study	Method	Context	Focus	Theory	Performance measure	Key results and contributions	Journal/ discipline
Imai et al. (1985), Takeuchi and Nonaka (1986)	Case studies of 7 NPD projects	5 Japanese companies, cross-industry	Explores entire supplier networks committed to a lead manufacturers	Limited: very empirically grounded	Speed; flexibility and high rate of innovation	Supplier involvement partly explains superior performance of Japanese companies. Importance of resident design engineers	Book, HBR
Harvard Auto Study: Clark and Fujimoto (1991), Clark (1989)	Comparative case studies of 29 NPD projects within 20 auto companies	20 firms in auto industry: US, Japan and Europe	Typology of supplier involvement: supplier proprietary parts, black box and detail-controlled parts. Cross-functional teams, overlapping stages and other internal factors	Limited: very empirically grounded	Speed; quality; productivity	Performance gap between Japanese and US manufacturers. Higher Japanese reliance on suppliers for NPD and higher proportion of black-box parts. Supplier involvement accounts for 1/3 of significant Japanese advantage, i.e. reduced time to market, improved quality and productivity.	Book: Operations Management & Management Science
IMVP study Womack et al. (1990)	Harvard study and consolidated data: US, Japanese and European auto comparisons	Same as Harvard study	Coordination and delegation of design and development of modules to 1st tier suppliers, in turn cascading throughout supplier network	Limited: very empirically grounded	Mainly speed, quality, productivity	Success factors: contract/ ground rules to ensure commitment; price, quality, and delivery conditions, proprietary rights; mutual relationships; risk and reward sharing arrangements	Book-Operations Management

Table 2
Supplier involvement research: early 1990s.

Study	Method	Context	Focus	Theory	Performance measure	Key results and contributions	Journal/ discipline
Cusumano and Takeishi (1991)	Survey of 10 US and automakers plus 72 interviews with suppliers and transplants in US	US and Japanese automakers, including Japanese transplants in US	Comparison of supplier relations and management in US and Japan, including the role of supplier in NPD	Limited: very empirically focused	Quality, cost	Increasing adoption of 'Japanese model' in US automakers. US suppliers involved *early*, but Japanese involved *more* in design. Heavy Japanese reliance on black-box parts (96%). Japanese select suppliers later than US companies.	SMJ
Lamming (1993)	Building on IMVP auto study	Global automotive industry: Japanese and Western comparisons	Response by Western auto manufacturers to Japanese competitors through implementation of partnership supplier relations	Part of IMVP research, building on innovation theory and buyer–supplier relationship literature		Characteristics of Japanese buyer–supplier parent/child relationships: Ways of implementing lean supply in Western context: relationship assessment, cost transparency and supplier/supply development.	Book
Nishiguchi (1994)		Japanese electronics and automotive? industry	Documents 'alps' (tiered) supply chain structure in Japan and discusses Japanese supply chain and industry characteristics			Disputes assumption that Japanese manufacturers exploit their suppliers and identifies support structure. Argues that cooperative attitudes toward suppliers cannot purely be explained by Japanese culture, but by industry characteristics and company priorities.	Book
Kamath and Liker (1994)	Case studies of 3 automakers and suppliers; survey of 143 suppliers & 189 US suppliers	Japanese auto industry	Examines supplier roles in NPD highlighting differences between Japanese and US companies, and pre-conditions for supplier involvement	Limited: very empirically grounded	–	Hierarchical typology of Japanese suppliers: partner, mature, child, and contractual. Japanese suppliers better qualified to support their customers in NPD.	HBR
Bonaccorsi and Lipparini (1994)	Single case study	Italian food processing & packaging	Distinguish 3 models of supplier involvement: traditional model: Japanese model; Advanced/ partnership model	Influenced by Harvard study, IMVP, and network theory/IMP	Speed, cost, quality	Integration of suppliers in NPD allowed shortening of product cycle and increased rate of successful new product programs	JPIM
Eisenhardt and Tabrizi (1995)	Survey of 72 NPD projects	36 Asian, US and European computer firms	Rapid 'adaptive processes'. Distinguishes between 'compression' (predictable) and experiential (unpredictable) strategies.	Considers Harvard study and IMVP, but builds on wider organizational theory e.g. Weick (1993)	Speed	Mixed results: Technologically predictable projects showed positive effect of supplier involvement; less predictable projects showed no significant effect of supplier involvement.	ASQ

Japanese and the European/North American automotive industry. Cusomano and Takeishi (1991) examined the adoption of the 'Japanese model' in US automakers and found that US suppliers were involved *early*, but Japanese supplies were involved *more* in design. They also documented a heavy Japanese reliance on black-box parts (96%) and that Japanese manufacturers leave supplier selection later than US companies. Lamming's monograph (1993) examined the response by Western auto manufacturers to Japanese competitors through implementation of what was now becoming known as partnership supplier relations. More theory-driven than many other contributions in this period, Lamming's work examined the characteristics of Japanese buyer–supplier parent/child relationships and suggested ways of implementing what he coined 'lean supply' in a Western context, including the need for supplier relationship assessment, cost transparency and supply development. Nishiguchi (1994) introduced the notion of 'alps' (or tiered) supply chain structures in Japan and elaborated on the particular characteristics of Japanese supply chains and industry. He disputed the emerging assumption that Japanese manufacturers exploit their suppliers and identified the important support structures in Japanese industry. He also argued that cooperative attitudes toward suppliers could not purely be explained by Japanese culture, viewing industry characteristics and company priorities as much more important. Kamath and Liker (1994) echoed many of these findings, suggesting the need for different levels of supplier involvement using the typology: partner, mature, child, and contractual.

Towards the mid-1990s studies began to move away from the automotive industry. Bonaccorsi and Lipparini used a single Italian case study of a food processing and packaging company to distinguish three models of supplier involvement: traditional model, the Japanese model, and the advanced/partnership model. Their study was influenced by the Harvard study and the IMVP, but also by buyer–supplier interaction and network theory as developed by the Industrial Marketing and Purchasing (IMP) group (e.g. Håkansson, 1987). The final study included here is Eisenhardt and Tabrizi (1995), which was the first (non-automotive) study to indicate that *less* supplier involvement might be relevant under conditions of technological uncertainty. Grounding in organizational theory (e.g. Weick, 1993), their empirical survey of 72 NPD projects focused on what they termed 'adaptive processes' (including supplier involvement) in the computer industry. Distinguishing between 'compression' (predictable, mature products such as automobiles) and experiential (rapid and unpredictable projects) strategies, they found that technologically predictable projects showed positive effects of supplier involvement on development time due to certainty regarding suppliers; however, less predictable projects showed no significant effect of supplier involvement. Eisenhardt and Tabrizi (1995) consequently pointed to the problem of generalizing from compression to experiential situations.

2.3. A rapidly evolving field: the late 1990s

The late 1990s saw an upsurge in cross-industry US and European research, including large-scale surveys, which confirmed supplier involvement performance benefits but also pointed to a number of management challenges. Several studies (e.g. Bidault et al., 1998) focused on the timing of supplier involvement, having resulted in the concept of *early supplier involvement* (or ESI); supplier influence during early design efforts is now regarded as a critical factor in improved design for manufacture (Wasti and Liker, 1997; Swink, 1999). Other researchers highlighted the need for supplier selection and evaluation as a key success factor (Wasti and Liker, 1997; Hartley et al., 1997). Hartley et al. (1997) found that involving suppliers with strong technical capabilities reduces the risks of design-related delays, yet supplier selection and evaluation was not a priority in the firms that they examined. Indeed, in their study early supplier involvement, including increased supplier responsibility for design and greater communication were not confirmed as having positive influence on performance measured by reduction in project delays.

Studies also began to explore the need for supplier relationship development and adaptation, for instance, Ragatz et al. (1997) identified the critical role of shared training, trust, risk and reward sharing, agreed performance measurements, top management commitment, and supplier capability confidence. Research continued into the moderating role of technology uncertainty, but findings remained conflicting. Wasti and Liker (1997) found that technology uncertainty together with suppliers technical capabilities positively influence supplier involvement. In contrast, analyzing manufacturability and the effects of development team integration processes (of which supplier influence is one of several factors), Swink (1999) found supplier influence to be strongly associated with improved manufacturability, but the results diminished in cases of high product 'newness'. His results therefore provided more uncertainty regarding the positive effects of supplier involvement in products exhibiting a high degree of newness and thus uncertainty.

The studies that evolved during the late 1990s were grounded in a wider range of theories than previous research. Underpinning theories were more explicitly identified and included, for example, transaction cost economics (TCE) (Williamson, 1975), agency theory (Eisenhardt (1989), and resource dependence theory (Pfeffer and Salancik, 1978). Together with a greater mixture of both qualitative and quantitative research methods this helped to improve the validity and reliability of the empirical results. Table 3 provides an overview of the late 1990s research.

2.4. Increasing research sophistication: the early 2000s

Supplier involvement research at the beginning of the new millennium further investigated the need for relationship development and adaptation, begun by e.g. Ragatz et al. (1997), increasingly in combination with situations of technological uncertainty. Based on 17 cross-industry case studies and a survey of 84 American and European firms, Petersen et al. (2003) suggested that supplier representation on NPD development teams is critical, especially in situations of technology uncertainty; this finding is echoed in Ragatz et al. (2002). However, Primo and Amundson (2002) found the opposite that existing suppliers may be less important than new suppliers in conditions of technology uncertainty, i.e. radical innovation.

The focus on relationship adaptation, especially in terms of people-integration, was emphasized by Walter (2003), whose survey of 247 German firms highlighted the importance of what he termed 'relationship promoters' as a way to increase trust and commitment of suppliers. His study represents a very small number of studies that have investigated supplier involvement, from the perspective of suppliers, to identify how they perceive their involvement in customers' NPD projects, arguably important given the increasing number of studies that have identified the role of well-managed supplier relationships. In a similar vein, Takeishi (2001) studied nine large Japanese automotive suppliers and their customers (from the suppliers' perspective), thereby identifying the need for customers' internal capabilities to coordinate and capitalize on supplier involvement in vehicle component design; Hillebrand and Biemans (2004) broadly support these findings in a range of other industries. LaBahn

Table 3
Supplier involvement research: late 1990s.

Study	Method	Context	Focus	Theory	Performance measure	Key results and contributions	Journal/ discipline
Karlsson and Åhlström, (1996)	Case studies of 4 NPD projects in one firm	Mechanical and electronic office equipment manufacturer (European)	Lean NPD of which supplier involvement is seen as one element	Builds mainly on Harvard study, IMVP and related studies—empirically driven	–	Problems of early supplier involvement including risk sharing arrangements and cost estimates	JPIM
Ragatz et al. (1997)	Survey 60 companies	US companies	Identification of success factors for supplier integration based on range of management practices and environmental factors	Harvard study, more recent supplier involvement literature, and strategic alliance theory (Gulati, 1998)	Quality, speed, cost	Supplier involvement barriers require shared training, trust, risk & reward sharing, agreed performance measurements, top management commitment and supplier capability confidence	JPIM
Wasti and Liker (1997)	Survey of 122 component suppliers	Japan automotive suppliers	Factors leading Japanese buyers to involve certain suppliers in design, and performance impact of supplier involvement	Harvard study, IMVP and related studies plus TCE and agency theory	Supplier's role in NPD improvement, design for manufacturability	Design for manufacture benefits. Technology uncertainty & supplier technical capabilities positively influence supplier involvement, not supply market competition.	JPIM
Hartley et al. (1997)	Survey of 79 companies	Range of assembly industries e.g. industrial equipment, machine tools, pumps, computers, analytical instruments	Impact of management of buyer–supplier interface on NPD project delays.	Harvard study, IMVP and related studies	Speed	Involving suppliers with strong technical capabilities reduces risks of design-related delays, yet supplier selection and evaluation not priority. No positive influence of early involvement on project delays.	JOM
Karlsson et al. (1998)	Survey of 350 European auto suppliers and 3 case studies	European automobile industry	Supplier problems in black-box specification process	Builds mainly on Harvard study and related studies—empirically driven	–	Problematic implementation of black-box design: specification changes and ambiguities cause supplier frustrations	JPIM
Bidault et al. (1998)	25 case studies using multiple methods of data collection	Assembly industries e.g. electric appliances, electronics, office equipment. US, European & Japanese companies	Adoption of ESI in NPD. ESI adoption model and index		Speed (but not tested)	ESI practice evident in non-automotive industries, especially office equipment and US companies. Organizational choices more important driver than external drivers.	RP
Swink (1999)	Survey of 91 NPD projects	Cross-industry: supplier influence only analyzed using a single measure	Manufacturability and effects of development team integration processes (of which supplier influence is one of several factors)	Resource dependency theory (Pfeffer and Salancik, 1978)	New product manufacturability	Supplier influence strongly associated with improved manufacturability, but results diminished in cases of high product newness	JOM

Table 4
Supplier involvement research: early 2000s.

Study	Method	Context	Focus	Theory	Performance measure	Key results & contributions	Journal/ discipline
LaBahn and Krapfel (2000)	Survey of 422 component suppliers to OEMs	Supplier perspective on ESI. US automotive, aerospace and equipment industries	Supplier perspective on customer NPD. Problems of supplier dependency on powerful customers	Marketing and relational/network/ social exchange theory	Customer technical innovativeness; supplier technical capability	Customer innovativeness promotes suppliers ESI participation: contingent on customer trustworthiness. Power advantage decreases customer adherence to agreements.	JBR
Dröge et al. (2000)	Survey of 57 1st tier suppliers to 3 large US automakers	North American industry	Antecedents of time minimization factors in NPD, including supplier closeness	Harvard study, IMVP and more recent related studies	Speed	Significant relationship between 'supplier closeness' and development time ability	JPIM
Takeishi (2001)	Study of 9 large 1st tier suppliers and their customers. <100 interviews in total and questionnaire	Japanese auto industry	Internal capabilities to coordinate and capitalize on supplier involvement in vehicle component design	Harvard study, IMVP (of which this is part) and more recent related studies, including RBV	Component quality	Design quality related to automaker's early integrated problem-solving, frequent face-to-face communication, and level of architectural knowledge for component coordination	SMJ
Kaufman et al. (2000)	Survey of 200 US SMEs	US SMEs: fabricated metals, industrial equipment, electrical and electronic equipment, and instruments	Designs and tests a strategic supplier typology based on degree of collaboration and technology: commodity suppliers, collaboration specialists, technology specialists, and problem-solving suppliers	Strategic management and operations strategy (Harvard study, IMVP, TCE, RBV)	No. of employees, sales, profitability, proportion of export, and wages	Problem-solving (black box) suppliers have largest no. of employees, the most firms and highest export percentage of all supplier types, pay among highest wages, and the highest relative gross margins	SMJ
Primo and Amundson (2002)	Analysis of secondary survey data: 38 NPD projects in 5 companies	US Electronics industry	Supplier quality control indirectly affects NPD performance. Technical difficulty a moderating factor	Supplier involvement/ NPD literature and TQM	Speed, quality, cost (perceptual)	Supplier involvement benefits in terms of quality. Level of technical difficulty (degree of innovation) points to role of existing suppliers being less important than new suppliers.	JOM
Ragatz et al. (2002)	Survey of 103 NPD projects	Not stated	Benefits of supplier integration into NPD under conditions of technology uncertainty	Harvard study, more recent supplier involvement literature, NPD	Cycle time (speed, cost, quality	Cost, quality and cycle time benefits from supplier integration. Negative direct impact of technology uncertainty can be offset through supplier integration.	JBR
Petersen et al. (2003)	Case studies of 17 Japanese and American firms and a cross-industry survey of 84 North American (79%) and European (20%) firms	International cross-industry study with North American bias	Supplier integration in NPD model. Wide range of variables; including focus on technology uncertainty.	TCE, organizational design theory, relational theory, network theory	Cost, quality, speed, design, market share and volume, profit	Increased supplier knowledge causes greater information sharing and hence improved supplier involvement and performance. Supplier representation on NPD teams especially important in situations of technology uncertainty.	JPIM
Walter (2003)	Survey of 247 buyer–supplier relationships	German SME suppliers in e.g. engineering, electronics, metal-processing, and chemical industries	Relationship-specific factors affecting supplier contributions to customer NPD	IMP Interaction Model, and buyer–supplier relationship models, incl. commitment-trust theory	Supplier involvement in customer NPD	Adaptations towards suppliers (incl. use of 'relationship promoters') increases trust and commitment of suppliers	JBR
Hillebrand and Biemans (2004)	12 interviews plus 6 case studies of NPD projects (42 interviews and 61 questionnaire from 14 firms)	Machinery, electronics, automotive, metal, chemicals	Link between internal and external cooperation in NPD	Innovation, marketing, NPD, and relationship/network theory	–	Internal cooperation serves to coordinate external cooperation e.g. through use of cross-functional teams	JPIM

and Krapfel's (2000) large-scale study also specifically adopted the perspective of suppliers in customers' NPD projects, suggesting that suppliers look for customer innovativeness and trustworthiness, and that customers' power advantage may decrease their adherence to agreements and thus turn off suppliers. Their study suggests that the power dynamics within buyer–supplier relationships should not be underestimated and that powerful customers, who abuse their power advantage and behave opportunistically, may ruin the trust that is a critical ingredient in supplier involvement projects.

As shown in Table 4, the range of underpinning theories began to expand in this stage of research into supplier involvement in NPD. In addition to theories previously employed, studies were now grounded in theories as diverse as resource-based view (RBV), commitment-trust theory (Morgan and Hunt, 1994), and buyer–supplier interaction and relationship theory (e.g. Håkansson, 1987).

2.5. Latest research into supplier involvement in NPD: the early 2000s

The last few years have witnessed continued research on supplier selection process and adaptation (Petersen et al., 2005; Koufteros et al., 2007; Song and Benedetto, 2008). Analyzing a range of 'ESI strategies' of which supplier selection and assessment was one element, Petersen et al. (2005) recommended that supplier selection processes should emphasize complementarity of supplier capability and culture. They also highlighted the importance of supplier involvement in agreeing technical metrics and targets, especially in the case of grey-box suppliers. Koufteros et al. (2007) concur with many of these recommendations, pointing not only to the importance of supplier selection and qualification based on NPD capabilities, but also supply base rationalization and supplier embeddedness. Applying the transaction cost economics concept of asset specificity, Song and Benedetto (2008) likewise found a positive impact of supplier involvement on new product performance, strengthened by supplier-specific investments; as their study focused on radical innovation projects/ventures, it provides further support in favour of supplier involvement in radical innovation yet studies continue to find conflicting results on this issue.

In a study on a range of industries characterized by high degrees of modularity, Staudenmayer et al. (2005) suggest that firms are increasingly struggling with the quantity and variegated nature of external relationships, especially in what they term 'development web' contexts (e.g. digital camera and mobile phone industries). In these contexts they suggest that relationships are no longer in simple dyads but complex networks that include suppliers, customers, complementary producers, competitors, and institutions. There is a strong and long-established body of research on different forms of inter-organizational networks, which emphasizes the need to understand the embeddedness of dyadic relationships in wider networks (e.g. Granovetter, 1985; Uzzi, 1997; Anderson et al., 1994). Indeed, an increasing amount of research focuses on the role of networks in NPD and innovation (Håkansson, 1987; Freeman, 1991; Dhanaraj and Parkhe, 2006; Birkinshaw et al., 2007). Combining supplier involvement in NPD studies with network theory provides an opportunity to look beyond dyadic buyer–supplier relationships as the unit of analysis and consider the impacts of the wider network of relationships. This opportunity is discussed in more detail in the final section of the paper.

One of the latest studies to be published is by Van Echtelt et al. (2008) who have pointed to the need for understanding supplier involvement beyond specific NPD projects; they suggest that the conditions for successful supplier involvement is set prior to project participation and that projects may thus be a limiting unit of analysis (Table 5).

3. Discussion and conclusions: where are we and where are we going?

The review of approximately three decades of research into supplier involvement in NPD shows that the field has strong roots in Japanese automotive research, but that there is also an upsurge in cross-industry and cross-country research. Research methods include in-depth case studies and, increasingly, large-scale surveys. Although the majority of research is based on the responses from (and thus perceptions of) single customer companies, there have been some attempts to gather data from both customers and suppliers. The total picture is one of overwhelming evidence to support early and extensive supplier involvement as a key explanatory factor of superior new product performance in terms of cost, quality, and time to market benefits. Nevertheless, research also shows that major management challenges exist, including a need for internal coordination, advanced supplier selection processes, and long-term relationship adaptation to create supplier relationships with high levels of trust and commitment.

The extensive amount of rigorous research that has been conducted to date enables us to synthesize the research findings into a model of factors affecting the success of supplier involvement in NPD (see Fig. 1). This model integrates the findings from a range of contexts investigated through both in-depth qualitative and large-scale quantitative research methods. The extensive list of success factors are organized into three main groups: (1) supplier selection; (2) supplier relationship development and adaptation; and (3) internal customer capabilities. Divided into these three main groups, the model highlights the factors that have been identified as impacting on performance measured by shorter time to market, improved product quality, and reduced development and product costs.

The first factor concerns supplier selection processes. The need for early involvement is supported by much of the research discussed in this paper (e.g. Bidault et al., 1998; Takeishi, 2001), and this implies involvement at the concept stage or during early feasibility studies. However, it is not a question of involving all suppliers earlier—but the right suppliers. Suppliers to be involved early include suppliers of parts representing high value and complexity and these suppliers either take on a full black box or grey box responsibility (e.g. Clark and Fujimoto, 1991; Kamath and Liker, 1994). These in turn need to be selected and evaluated according to their innovative capability and complementarity (Hartley et al., 1997; Petersen et al., 2005).

The second factor is the need for supplier relationship development and adaptation. This includes a range of factors that concern the long-term process of integration between customers and suppliers, such as shared training (Ragatz et al., 1997), mutual trust, and commitment (LaBahn and Krapfel, 2000; Walter, 2003; Song and Benedetto, 2008), risk and reward sharing (Ragatz et al., 1997), agreed performance targets and measures (Petersen et al., 2005; Van Echtelt et al., 2008), and supplier representation on the customer's NPD team (Imai et al., 1985; Ragatz et al., 1997; Petersen et al., 2003). These relationship-specific factors are frequently underestimated by managers, but have been identified as critical across the range of studies examined in this paper.

The third factor involves the internal capabilities of the customer. Research has emphasized two internal factors in particular: top management commitment (Ragatz et al., 1997) and internal cross-functional coordination (Takeishi, 2001; Hillebrand and Biemans, 2004). The need to consider internal factors within the customer company suggests that the ability to manage supplier relationships begins by developing the ability to manage internal cross-functional relationships. Internal customer processes need to be developed to ensure that suppliers are

Table 5
Latest supplier involvement research.

Study	Method	Context	Focus	Theory	Performance measure	Key results and contributions	Journal/ discipline
Staudenmayer et al. (2005)	7 case studies of different modular industries: 19 interviews followed by another 11	Cross-industry (all high-tech and modular). Firms include: Red Hat, Lucent, The Gale group, Lexar Media, Interworld, Adobe Systems, and Motorola	Industries characterized by inter-firm modularity in terms of product definitions, inter-dependency management, and relationship management	Multidisciplinary: NPD, strategy, product design and development, innovation	–	Relationships no longer in dyads but complex networks (suppliers, customers, complementary producers, competitors, and institutions), especially in 'development web' contexts (e.g. digital camera, mobile phone). Divergent interests of partners controlling architecture.	JPIM
Petersen et al. (2005)	Survey of 134 firms	Cross-industry and international: 68% responses from North America	ESI strategies: supplier selection & assessment, supplier involvement in setting performance metrics & targets, project team effectiveness, timing of involvement	TCE, relational theory, organizational design theory, and network governance	Financial performance: sales, profit, return on investment; Design performance: ease and cost of design	Supplier selection process should emphasize complementarity of supplier capability and culture. Importance of supplier involvement in agreeing technical metrics & targets, especially grey box suppliers.	JOM
Koufteros et al. (2007)	Survey of 157 firms	US manufacturing firms, mainly under 500 employees	Black-box and gray-box supplier integration in NPD	Social network perspective (e.g. Uzzi, 1997; Levine and White, 1961)	Product innovation; external quality	Supplier embeddedness positively related to supply base rationalization and supplier selection based on NPD capabilities. Supply base rationalization positive impact on grey-box integration: positive impact on product innovation.	JOM
Song and Benedetto (2008)	Survey of 173 radical innovation projects (paired data from customer and suppliers)	New US ventures: small firms fewer than 500 employees	Supplier involvement in radical innovation projects/ventures. Role of supplier commitment, power, and qualification of supplier abilities	TCA (Williamson, 1975)	Gross margin; Sales growth	Positive impact of supplier involvement on new product performance, strengthened by supplier specific investments (asset specificity). Importance of supplier qualification & evaluation.	JOM
Van Echtelt et al. (2008)	8 embedded longitudinal case studies of manufacturer–supplier collaborations within one firm	One Dutch firm in copier and printer industry (Oce)	Distinguishes between short-term project-related operational processes and long-term strategic processes. Prioritizing, mobilizing and coordinating supplier resources.	Resource dependency theory (Pfeffer and Salancik, 1978) and Interaction approach (Håkansson, 1987; Axelsson and Easton, 1992)	Long-term (future collaboration, access to technology, roadmap alignment, project transfer of solutions) and short-term collaboration (technical performance, cost, development cost, lead time/speed)	Importance of long-term development of a willing and capable supplier base, learning routines, capability alignment and adaptation, and spin offs from individual projects, across individual NPD projects	JPIM

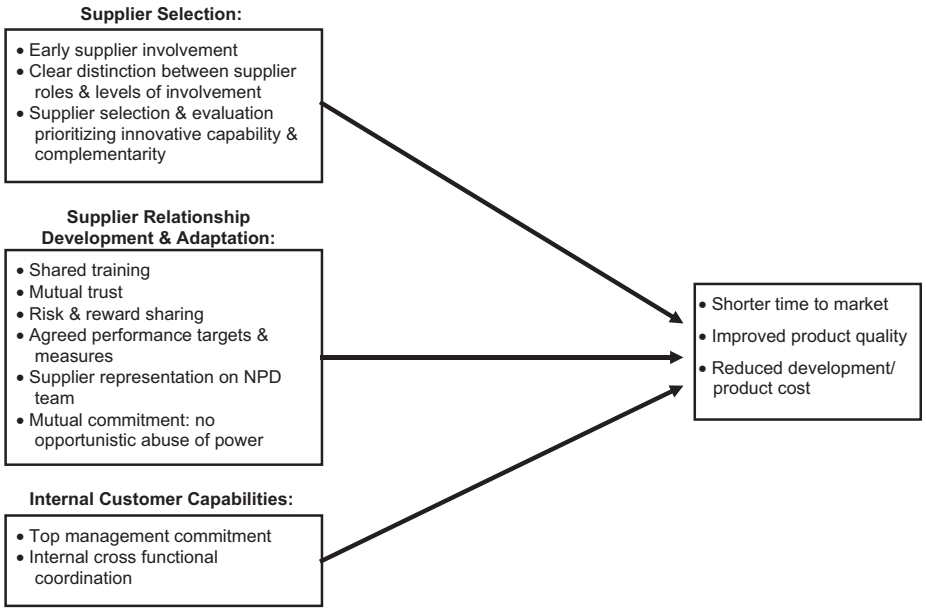

Fig. 1. Factors affecting supplier involvement success.

selected and evaluated on the right basis and ongoing trusting and committed supplier relationships are allowed to evolve.

3.1. Future research directions

Two themes seem likely to attract future research. The first theme is the need to develop a better understanding of the characteristics of supplier relationships and their industrial and cultural context. This theme arises partly as a consequence of the bias towards mature high-volume industries, especially the automotive industry. High profile research, i.e. studies that appear in the most highly ranked international journals, remains predominantly Japan and US-centric. The bias is partly due to the characteristics of these particular journals. However, many European-based journals, including the Journal of Purchasing & Supply Management, naturally publish a high proportion of non-US and Japanese studies. Globally, the fact is that the most influential studies (e.g. measured according to ISI impact), maintain many of the assumptions of high volume production. Thus, most research still focuses on large powerful customers and their less powerful suppliers. There is a need to develop a greater understanding of the characteristics and management of ongoing supplier relationships within and *between* supplier involvement projects (Van Echtelt et al., 2008). The second theme concerns the question of supplier involvement in radical innovation projects. A real question mark remains over the modifying effect of technological uncertainty. That is, some research suggests that a high degree of innovation in NPD projects may indicate that supplier involvement is particularly important, whereas other research indicates that supplier involvement becomes less important in comparison with other forms of inter-organizational relationships. In the following concluding sections these emerging research themes are discussed in more detail.

3.2. Supplier relationship development and management

As most research to date has adopted the perspective of large powerful manufacturers it tends to assume that suppliers are willing to invest in—and commit to—the customer's demanding NPD projects. A relatively small body of marketing-based research (e.g. LaBahn and Krapfel, 2000; Walter, 2003) has investigated supplier involvement from a supplier perspective, revealing a number of supplier concerns, such as customer exploitation of power, and supplier unwillingness to partner with customers during NPD. There is evidence to suggest that powerful customers, who abuse their power advantage and behave opportunistically, may ruin the trust that is a critical ingredient in supplier involvement projects. As much research points to the importance of developing and managing the buyer–supplier relationship as part of the ongoing supplier involvement process (Fig. 1), there is clearly a need to further explore supplier perspectives.

Research also suggests that successful supplier involvement requires customers to qualify and evaluate supplier capabilities, especially in terms of complementarity of capabilities and culture (e.g. Petersen et al., 2005). Moreover, suppliers need to agree technical metrics and targets in order to ensure long-term commitment (Petersen et al., 2005). Overall, supplier relationships need careful nurturing for supplier involvement benefits to materialize: trust takes a long time to develop but an instant to destroy through opportunistic behaviour.

3.3. Supply network involvement in product innovation

Early research into supplier involvement in NPD focused on incremental NPD. More recently, there has been a stream of research focusing on the role of technology uncertainty and projects characterized by radical innovation (Song and Parry, 1999; Ragatz et al., 2002; Song and Benedetto, 2008). Some research (e.g. Petersen et al., 2005) suggests that technological uncertainty may further necessitate the need for supplier participation on the customer's NPD team. Other research (e.g. Primo and Amundson, 2002), however, has found the opposite that existing suppliers may be less important than new suppliers under conditions of technological uncertainty, i.e. radical innovation.

Fig. 2 provides a synthesis of supplier involvement benefits in relation to levels of technological uncertainty. The horizontal dimension is usually measured by impacts on cost, quality and time to market, although some studies go further to analyze

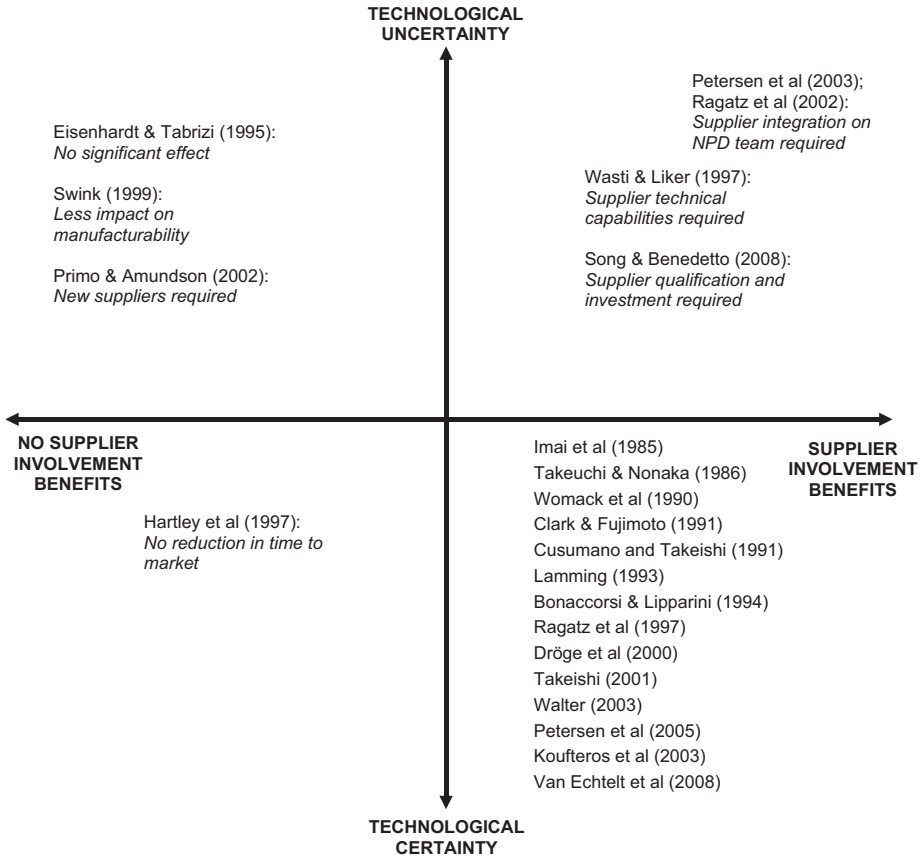

Fig. 2. Synthesis of supplier involvement benefits and level of technological uncertainty.

impacts on sales growth (Song and Benedetto, 2008) and return on investment (Petersen et al., 2005). The vertical dimension depicts the two extremes of technological uncertainty, or level of innovation. Much recent research in particular has concerned whether supplier involvement benefits can still be expected in situations of high technological uncertainty and the factors that can help to ensure that supplier involvement can also be beneficial in such difficult circumstances. The close occupation of the bottom right hand corner of Fig. 2 indicates the large bulk of research that has provided evidence in favour of supplier involvement under conditions of low technological uncertainty, i.e. typically incremental NPD projects. In comparison, there is little research showing no benefits from supplier involvement under conditions of low technological uncertainty (Hartley et al., 1997). One likely explanation may be that companies are simply improving their supplier involvement efforts and thus more likely to reap the benefits. Conditions of high technological uncertainty have caused concern for conflicting results and debate. Eisenhardt and Tabrizi originally raised the point and called for caution in extending the assumption of supplier involvement benefits from technological predictability to conditions of technological unpredictability. Swink (1999) and Primo and Amundson (2002) have later supported this concern. Nevertheless, contradictory results have been published, especially by Ragatz et al. (2002) and Petersen et al. (2003), suggesting that technological uncertainty calls for careful supplier integration of suppliers on customer NPD teams. Wasti and Liker (1997) and Song and Benedetto (2008) share some of these views, emphasizing the particular need for supplier technical capabilities and supplier qualification and investment (high asset specificity) when companies are dealing with radical innovation projects.

Focusing on the role of suppliers in *discontinuous* innovation (very high technological uncertainty), Phillips et al. (2006) take this one step further by suggesting that existing direct suppliers may be redundant, as new complementary capabilities and technologies from outside the existing supply chain are required. They suggest that long-term stable supplier partnerships, as commonly associated with world class Japanese manufacturers (e.g. Womack et al., 1990), may have limited innovative potential; supplier 'dalliances' rather than alliances are called for—evoking Wilkinson and Young's (1994) notion of dancing with several business partners rather than engaging in a stable marriage. This is supported by research by Primo and Amundson (2002), suggesting that existing suppliers may be less important under conditions of high technical difficulty, and also by Johnsen et al. (2006) who suggest that supplier relationships are mostly of relevance in mature industry contexts; in emerging new industries (fluid contexts) other forms of inter-organizational interaction (customers and horizontal relationships) seem to be more important.

Arguably, the majority of existing research on supplier involvement remains dyadic in focus. Although there has been an upsurge of research into different types of inter-organizational network, few studies have considered the role of wider supply networks on innovation. The thought-provoking study by Staudenmayer et al. (2005) suggests that modular products and industries require interaction with a web of partners, chiming with the idea of open innovation (Chesbrough, 2003) and extensive research into industrial networks (e.g. Håkansson, 1987; Axelsson and Easton, 1992). The network perspective gives rise to several interesting avenues of future research, including how companies can involve not only their direct existing suppliers

in NPD, but also their wider supply networks, in what circumstances entire supply networks need to be involved, and potential lack of ability to involve suppliers due to relationship interconnections. Studies by scholars linked to the Industrial Marketing and Purchasing group have long advocated the need to understand dyadic buyer–supplier relationships as parts of complex industrial networks (e.g. Håkansson, 1987; Anderson et al., 1994). However, the network perspective has yet to win over the mainstream supplier involvement literature, even though the (European) Journal of Purchasing and Supply Management has published a few studies that seek to bridge the two (Wynstra and ten Pierick, 2000; Wynstra et al., 2000). There is no sign that supplier involvement in NPD is becoming exhausted as an area of research, especially if it embraces these challenges.

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