Systems approach to make-or-buy decisions during 'product design and engineering': Three Indian case studies

Rob Dekkers [e-mail: rob.dekkers@glasgow.ac.uk]
Adam Smith Business School, Univ. of Glasgow, Glasgow G12 8QQ, U.K

Abstract

Make-or-buy decisions taken during 'product design and engineering' often happen based on incomplete and inaccurate information but have tremendous effects on the manufacturing function; however, this is an under-researched topic. Based on three case studies in India, the study examines the processes and decision-making for make-or-buy during new product development from a systems approach. Driven by both strategic intents and experiences with suppliers, these companies resorted to developing in-house capabilities rather than continuation of supply. That finding leads to reflection on the validity of current research but can be traced back to literature on outsourcing that dates back decades.

Keywords: Outsourcing, new product development, decision-making.

INTRODUCTION

Management of 'product design and engineering' itself is an under-researched domain, noted already a while back by Riedel and Pawar (1991, pp. 322-323) for the interaction with manufacturing. Recently, Dekkers et al. (2013, pp. 325-327) identify this weakness in literature, particularly with regard to the outsourcing decisions made during 'product design and engineering'; note that 'product design and engineering' has a wider scope than new product development, terms used interchangeably here. Others such as Kremic et al. (2006, p. 469) and Talluri and Naramsimhan (2004, pp. 236–237) note the gap with regard to the make-or-buy decision, too. However, the make-or-buy decision emerging during product design and engineering has a tremendous impact on manufacturing and, therefore, it is of paramount importance to ensure its effectiveness.

Research Objectives

Hence, how these decisions on outsourcing during product design and engineering are taken is an area of concern. Evidence for the interaction between new product development and manufacturing has been presented in previous studies (e.g. Adler, 1995; Swink and Calantone, 2004; Vandevelde and van Dierdonck, 2003). More particularly, the selection of suppliers (e.g. Petersen et al., 2003) and the make-or-buy decision (for instance, McIvor and Humphreys, 2000) are of paramount importance to the impact on the organisation. Moreover, the pecularities of the product design and engineering process – the incomplete and inaccurate information and iterative decision-making (for instance, Chao and Ishii, 2006, p. 492; Pahl et al., 2007, pp. 126, 410–38; Radhakrishnan and McAdams, 2005,

p. 378) – makes that the make-or-buy decision might differ from the traditional strategic outsourcing decision. That stance is the starting point of this paper; more particularly, how are make-or-buy decisions made by firms during new product development affecting the manufacturing strategy. Hence, the following research questions have been identified:

- What is the effectiveness of decision-making on outsourcing during product design and engineering?
- Does this particular decision-making process sufficiently account for the specific characteristics of product design and engineering?
- If not, what improvement should be made to the decision-making on outsourcing? How can such an improvement be underpinned by available methods and theories on decision-making?

Scope and Outline of Paper

The first step is a literature review leading up to a framework for the analysis of the outsourcing decision. The third section discusses the rationale for adopting the case study methodology. The fourth section provides the results of the empirical research. A discussion of findings and a concluding section complete the paper.

(Systematic) Literature Review

The first step of the study is looking at how existing studies into the make-or-buy decision during product design and engineering have accounted for the characteristics of new product development by means of a systematic literature review. For that review it should be noted that make-or-buy decisions, used here interchangeably with the term outsourcing decisions,. With that in mind, three questions have guided the systematic literature review (guidelines derived from Cronin et al. [2008] and Tranfield et al. [2003]):

- Which methods have been developed by researchers for the make-or-buy decisions during product design and engineering?
- Whether those works have taken into account the characteristics of product design and engineering?
- If no framework is available from literature, which framework can be derived that suits decision-making on outsourcing during product design and engineering?

Note that the onus of the paper is on those decisions during product design and engineering that affect manufacturing capabilities; that implies that outsourcing of new product development activities, for example prototyping (Liao et al., 2010), is not considered.

Process for Retrieval of Papers

From those review questions the Boolean expression for the keywords has been derived: {decision AND (“make-or-buy ” OR “outsourcing”) AND (“new product development” OR “product design and engineering”)}. During the search articles that focused on ‘supplier selection’ were retrieved, too; hence, this term was added to the keywords. In addition to the keywords, the keywords: {“incomplete (information OR data)” OR “inaccurate (information OR data)” OR “incorrect (information OR data)”} were used for searching Google Scholar and Scopus with articles up until 2013. The retrieved papers were inspected on title, abstract and if necessary content for inclusion, but some papers that this address outsourcing of new product development (e.g. Zhao and Calantone, 2003) were discarded. If the search in a specific search engine did not yield one relevant paper in 50 consecutive papers, the retrieval was halted. This search approach yielded only eight papers. Because the yield was lower than expected, the search was complemented with

Table 1: Evaluation of Retrieved Papers (no reference chaining included).

Source		Progressive Availability of Data		Iterative
		Incomplete	Inaccurate	
Anand & Kodali (2008)	Concept for NPD.	Mentioned only.	Mentioned only.	
Büyüközkan & Çifçi (2011)	Framework.	Fuzzy logic.		
Carrera & Mayorga (2008)	Propositional.	Fuzzy logic.	Fuzzy logic.	
Dulmin & Mininno (2003)	Decision method.	Statistical an.	Statistical an.	
Ibusuki & Kaminski (2007)	Value engineering.	Mentioned only.	Mentioned only.	
McIvor & Humphreys (2000)	Decision support syst.		Mentioned for cost.	
Shishank & Dekkers (2013)	Propositional.	Methods, processes.	Methods, processes.	Reference model.
Swan & Allred (2003)	Regression analysis.	Mentioned.		
Balakrishnan et al. (2008)*	Principal agent theory.	Integrated in model.		
Dekkers (2000)*	Case studies.			Embedded in model.
McCarthy et al. (2006)*	Comparative case stud.			Embedded in model.
Tayles & Drury (2001)*	Case study.	Ambiguity of information indicated.		

archival research (following the recommendation by Greenhalgh and Peacock [2005]). The combined search approaches resulted in 12 papers, see Table 1.

Results from Literature Review

Surprisingly, none of the studies fully addresses the characteristics of product design and engineering, except Shishank and Dekkers (2013) . This work presents a coherent framework that consists of strategic decision-making, processes and methods for decision-making related to product design and engineering and evaluation of processes towards achieving performance requirements; the framework is assessed by a a panel of academic and a panel of industrial experts through a Delphi study . However, the work is propositional and has not been tested.

Framework for Analysis of Decision-Making

Therefore, the only study that presents a complete framework for decision-making on outsourcing during product design and engineering is Shishank and Dekkers (2013). The framework consists of four interrelated quadrants, see Figure 1. By using these four quadrants for analysis

RESEARCH METHODOLOGY

With little precedence in literature about how actually decisions on outsourcing are taken during product design and engineering, the case study methodology is the most appropriate one, building on Shishank and Dekkers (2013). Decisions on outsourcing

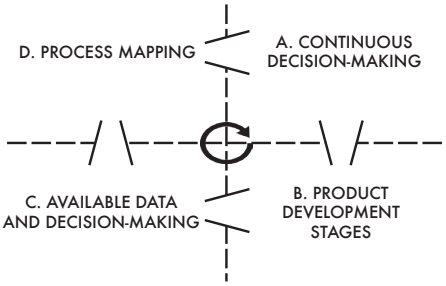


Figure 1: Framework for decision-making on outsourcing during product design and engineering.

are actually bound to specific orders or new product development projects; and they can be challenging in terms of product complexity, technological factors, implications for organisations and impact on strategy. Hence, both the decision on outsourcing during product design and engineering and the context of that decision needs be investigated.

Research Rationale

Since the decision on outsourcing is integrated in the product design and engineering process, it becomes necessary to conduct the empirical study from a holistic point of view, while at the same time looking in more details. In that respect, Arbnor & Bjerke (1997, pp. 49–53) position the systems approach inbetween the analytical and actors approach. For the current study, the framework by Shishank & Dekkers (2013) serves as the systems approach. Despite its heuristic character, all its components are interrelated and integrated, thus allowing analysis at the level of competitive strategy formation for companies as well as the actual engineering processes for designing and producing parts and components.

Particularly for this purpose, the case study methodology is the most appropriate method. This is following Yin (1994, p. 13), who suggests that the case study methodology 'benefits from the prior development of theoretical propositions to guide data collection and analysis', as is the case in this work. Moreover, the approach followed is one of embedded multi-case study design (Yin 1994). The dimension of embedded case studies appears because the unit of analysis is an outsourcing decision taken in a particular company for a specific project. To benefit from multiple cases, the individual cases should be either displaying 'maximum variation' or having common characteristics to be considered 'critical' (Flyvbjerg, 2006, p. 230). The latter is the case for the work presented here, see Table 1 for the three cases; the similarities between the cases in combination with the use of the framework will allow logical deductions.

Data Collection

The three Indian companies, see Table 1, that were willing to participate in this investigation, share a lot in common. All three are engineering-based but face similar challenges in terms of product design and engineering and processing of orders. That is to say, the design and engineering content plays a decisive role in their competitive positions, even though those are entirely different sectors.

Each of these cases represents an in-depth-study, comprising of both the analysis of the specific challenges for a company, the approach to product design and engineering and the way a decision on outsourcing was taken. Each of these case studies has been exclusively undertaken to analyse current practices and to issue guidelines and proposals for improvement, informed by a variety of sources, see Table 2; interviews have taken place with senior managers. The collection of data and the interviews aimed at obtaining a complete picture of (i) the organisational settings in relation to the specific markets and customers, (ii) the processes and structure of the product design and engineering processes, (iii) the criteria, processes and methods used for the outsourcing decision, and (iv) the impact of the outsourcing decision on both product design and engineering and production. After the latest study, the results have been classified and compared. The companies have chosen to remain anonymous due to the sensitive of the information.

Data Analysis

Addressing that variation only works with sufficient replication logic. Eisenhardt & Graebner (2007, p. 25) posit this as the central tenet of the case study methodology. In this case, the framework of Shishank and Dekkers (2013, p. 325) has served as starting point for the analysis, see Figure 1. It should be noted that the framework has been expanded; the four quadrants are each time an expansion of the previous one, except the connection between D and A (where D can be considered feedback about decisions made to start the cycle of analysis again). Also, we have taken the quadrants as starting points rather than the models of the original framework. Collected data and information obtained during interviews has been mapped against the components of the framework. While the approach of Shishank and Dekkers is wider the results and analysis have focused on the implications for manufacturing strategy, based on the second research question introduced in the beginning of this paper. To that purpose, the analysis addresses first each of these four components before drawing inferences and conclusions on an aggregate level with regard to the decision-making itself and the impact on manufacturing.

RESULTS

The cases in Table 2 are described briefly before the results are related to the individual quadrants; for each quadrant there is an introduction with respect to its contents.

Case I - Diesel Generators

Case I assembles final products and manufactures key components of the various products offered. The customer orders are initially processed as engineer-to-order and later delivered as make-to-order for recurrent orders. Furthermore, new product development at Case I is mostly initiated by bidding for tenders to provide power solutions to various industries. These tenders define technological capabilities and approximate estimations. The estimations are primarily based on previous cases and knowledge-acquired overtime and evaluated against the customers' requirements. The estimated lead-times for the diesel generators of 1 MW to 20 MW range from eight to twenty weeks, whereas it is six to twenty months for turnkey projects of capacity over 20 Mega Watts to 80 Mega Watts. The company uses a stage-gate approach for project management.

For the purpose of this research, the decision-making on outsourcing was analysed for a custom designed 20 MW diesel power generator unit. The company targets to design and install 20-25 units ranging from 1 MW to 25 MW per year. Outsourcing accounted for typically 40-50% of the value added to the projects.

Table 2: Overview of Cases

	Case I	Case II	Case III
Product range	• High-end silent diesel generator sets (7.5 kV - 2 MW) and control panels. • Turn-key captive power plants (1 - 25 MW).	• OEM earthmoving and construction equipment.	• Precision cooling units, industrial cooling, industrial power generation, embedded power and fire pump controllers.
Annual sales	US$ 550 mln.	US$ 1 bln. (subsidiary of UK firm)	US$ 7.5 bln. (US parent company)
Employees	about 2000, spread over five facilities in India.	approx. 3600, spread over four facilities in India.	ca. 9000
Orders	• Make-To-Order • Engineer-To-Order	• Make-To-Order • (Engineer-To-Order)	• Engineer-To-Order • (Make-To-Order)

Case II - Earthmoving and Construction Equipment

The second company's modus operandi is make-to-order and it mainly assembles and manufactures critical components. As part of new product development the company uses a modular product design platform to leverage product variations and improved models. The lead-times for new product development ranges from 18-24 months.

Case II is analysed for decision-making on outsourcing for a specific module of the new next generation green backhoe loader with an expected output of 2500-3000 units in the first year and then increasing the capacity to 5000 units in 2 years. The outsourcing decisions at Case II are similar to the outsourcing decisions in automotive industry and 70%-80% of the components are outsourced. The main criteria for decision-making outsourcing are reduction in costs and increased quality of the final assembled product.

Case III – Data centre cooling solutions

Case III adopts a 7-gate stage-gate approach to product development. The units are customised as engineer-to-order and later the orders are processed as make-to-order. Lead-times for project span from 16-18 weeks with a number of projects running simultaneously and in different stages.

At the time of the data collection, Case III was involved in a project for a precision cooling system to ensure smooth running of critical business processes at a research and development site of a customer. For the purpose of this research, the analysis was carried on a make-or-buy decision for a critical component of the unit. The project was in its early design stage and the decisions were being made on outsourcing as well as sourcing of various components. Due to the complex nature of the project, the firm was inclined to use a new technology for manufacturing the critical component. The decision was to make this component at the existing production site or to outsource and develop the capabilities of suppliers (internal or external) to manufacture the component. This would also entail transfer of knowledge and technology to the supplier. Note that his component could be used in different product ranges.

Quadrant A

Conform Shishank and Dekkers (2013, p. 324) this part of the data collection and analysis takes the Continuous Model for Decision-Making on Outsourcing as starting point. There seems to be no integral view seems present in literature other than this model covering strategic, tactical and operational decision-making. For the purpose of the current study, the results of the data collection for Quadrant B, as follows from Figure 1, will cover the tactical level. The results of the data collection based on the Continuous Model for Decision-Making on Outsourcing are found in Table 3 (Quadrant A).

Quadrant B

The data collection and analysis for Quadrant B uses the primary and secondary processes for product design and engineering from Dekkers et al. (2013, p. 6) as reference model. From Table 3 it is visible that new product development at the three case companies is initiated by internal research and development as well as by customer orders. This study restricts itself to project-driven decision-making on outsourcing due to data obtained during the case studies. Furthermore, some of the results are congruent with Quadrant A; the feedback from manufacturing as secondary process has been already covered, and, therefore, is not included in this quadrant. The presentation and discussion of the results

Table 3: Results for case studies.

Quadrant		Case I	Case II	Case III
A	Strategic decision-making on outsourcing	• Criteria: core competencies, cost, capacity management. • Mixed decisions for make and for buy (technological capability as determinant).	• Multi-disciplinary core group for outsourcing. • Aiming at reduction operat. costs with consideration of core competencies. • Acquiring high-end techn. capabilities. • Acquisition of tier-1 supplier.	• Main focus on cost and core competencies. • Expansion of existing production lines and acquiring techn. capabilities.
	Tactical decision-making on outsourcing	• Decisions during early stages of new product developm. • Outsourcing decisions by board (design, engineering, procurement, man.).	• Decisions during early stages of new product developm.	• Decisions during early stages of new product developm. • Decisions make-or-buy handled by core group (departments).
	Pre-selection of suppliers	• Database of suppliers (his. torical). • Supplier involvement. • Long-term relationships.	• Database of approved suppliers. • Supplier involvement. • Modular product design for reducing number of suppliers.	• Central (HQ) database for global suppliers (bargaining power). • Supplier rating underpinning selection. • Supplier involvement.
	Performance evaluation of suppliers	• Performance management of suppliers. • Audits of suppliers.	• Suppliers evaluated against multi-criteria. • Audits of suppliers.	• Suppliers evaluated against multi-criteria. • Continuous assessment of suppliers.
	Feedback from manufacturing	• Technological capabilities and capacity. • Previous cases of 'buy'.	• Previous cases of 'buy'.	• Previous cases of 'buy'.
B	Degree of novelty	• Project management based on production and assembly key components	• Redesign of products for improved efficiency. • Focus on existing products.	• Niche products with state-of-the-art technology. • Previous orders as cases.
	Feasibility of decisions on outsourcing	• Decisions on outsourcing during early stages of engineering. • Specifications based on previous cases.	• Outsourcing decisions during early stages of product design and engineering. • Modular platform design. • Process innovations for current product range (cost, quality).	• Outsourcing decisions during early stages of product design and engineering. • Outsourcing decision based on cases in previous projects. • Early decision-making results in close monitoring suppliers.
	Feedback, i.e. either iterative process or linear	• Decision-making on outsourcing based on internal standards, knowledge-based engineering, value engineering. • Case-based reasoning.	• Interlinking of stages but not accounting for characteristics. • Top management level makes decision with input from manufacturing.	• Decision-making on outsourcing based on internal standards, knowledge-based engineering, value engineering. • Case-based reasoning. • Evaluation of decisions during later stages.
C	Decision-making methods/process applied for outsourcing decisions	• Explicit: case-based reasoning. • Explicit: parameterisation. • Estimations based on previous cases. • Functional analysis.	• Multi-criteria group decision-making. • Explicit: case-based reasoning. • Explicit: estimation. • Explicit: parameterisation.	• Group decision-making (focus group style). • Explicit: case-based reasoning. • Explicit: estimation. • Explicit: parameterisation. • Explicit: cluster analysis.
	Availability of data at time of decision-making on outsourcing	• Limited information available • Make-Move-Buy analysis carried out based on internal standars, industry standards, specifications.	• New technologies: ill-defined and subject to change. • Collation of data from after-sales service and maintenance, based on previous version of product. • Knowledge-driven approach rather than case-based reasoning.	• Internal standards define information available. • Rough estimates based on previous cases. • Also business plan for acquisition.
	Effect of level of availability of data on decisions made about outsourcing	• Delay caused by uncertainty information (bi-directional). • Recurring costs (changes in specification). • Initially based on previous cases, but iterative processes caused changes (product and process.	• Modular design approach. • Close monitoring of suppliers.	• Delays in product development. • Changes in scope. • Close monitoring of suppliers for changes in specifications.

Quadrant		Case I	Case II	Case III
	Effects of outsourcing, risks associated			
D	Elicitation of customers' requirement and development of specifications	• Product design and engineering based on matching customers' requirements with technological capabilities. • Both functional analysis and previous cases.	• Internally defined by R&D and market demand. Iterative process, incremental changes. • Technological baseline ill-defined, based on assumptions from previous cases. • Leading innovations as industry standard.	• Weak starting point for product development. • Parametrisation as starting point. • Engineering parameters dominate. • Business plan.
	Process mapping stage of product structure, at what level of aggregation	• Mapping carried out based on previous cases and changed or redefined requirements. • Selection of suppliers against processes and technological and performance criteria collated from previous cases.	• Functional mapping of modules, components, etc. against processes and technological and performance criteria collated from previous cases. • Modular product architecture for managing suppliers and make-or-buy decisions. • Continuous monitoring of suppliers.	• Instable product specifications. • Repository of previous and current projects for decision-making. • Also inclusing entire product life-cycle • Intense process mapping with case-based approach. • Continuous monitoring of suppliers.
	Feedforward to Quadrant A	• Feedback about suppliers' performance. • Product design and engineering at order entry point.	• Evaluation data input for decision-making on outsourcing.	• Changes in specifications dominate. • Suppliers of critical component: exclusively linked to firm. • Suppliers share risks. • Matching of quality control standards with capabilities suppliers.

from the primary and secondary processes for product design and engineering will only concentrate on additional issues arising.

Quadrant C

Building on the progressive availability from data, the information gathered for Quadrant C shows more detail on how decisions are made. For the sake of avoiding a more technical discussion about the different sources, like in Shishank and Dekkers (2013, pp. 322–323), Table 3 lists how the companies used data available to them at the time of the decision-making.

Quadrant D

The consequences for manufacturing (strategy) should become visible when process mapping or any other appropriate is applied for evaluating the impact on manufacturing (Quadrant D). From the analysis it was apparent that defining product specifications and mapping processes against existing technological and performance criteria constituted the main aspects of the proposal definition phase (embedded in documents stating loosely-defined specifications, listing of pre-selected suppliers, technology readiness levels and production strategy). Initially, the requirements obtained by Case A were only approximate parameters for specifications from the OEM, calling for further development. These were translated to outline specifications utilising information from previous experiences. This was in line with various works presenting a method to reuse past cases to solve a new problem (e.g. Aamodt and Plaza, 1994, p. 40; Belecheanu et al., 2003, p. 36; McIvor and Humphreys, 2000, p. 297). From the evidence, so far, the cases were insufficiently capable of capturing the consequences of their decision-making due to their over-reliance on using previous cases while not accounting for dissimilarities.

DISCUSSION OF FINDINGS

First, it should be noted that for all three cases decision making on outsourcing did take place during the early stages of new product development. Furthermore, the companies did not delay decision-making either. If there were any delays, these were marginal (for example, postponement to a next meeting) and more a result of information not being made available rather than seeking a higher accuracy and completeness of information. That implies that decision-makers dealt with the information 'as-is'. Moreover, in none of the cases the nature of available information as being 'incomplete' or 'inaccurate' was considered to have an impact on the actual decision-making; information was taken at face-value. This starkly contrasts with the interviews with managers, where they acknowledged the tentative nature of information at early stages of product design and engineering. Hence, there is awareness of the impact of uncertainties in information but that has no practical effect on the decision-making itself.

Second, case-based reasoning dominates decision-making during both product design and engineering processes and outsourcing. However, in Case III the reliance of previous cases led to unstable cases, where potentially all decisions on allocation of resources were subject to revision. Due to agreements with suppliers selected during the early phases of product development, that was hardly the case and consequently led to intense communication about changes in design and deliveries. In two out of three cases, the companies practice close monitoring of suppliers to avoid problems with quality and deliveries. It seems from all three cases that the companies pay a lot of attention to monitoring of suppliers and they use supplier involvement as mechanims; how effective that is could be doubted since all three were engaged in vertical integration.

Third, it appears that the (poor) performance in conjunction with the assessment of business strategies leads to the insourcing decision in all three cases. That is an other indication that despite the efforts by the firm, suppliers are a major cause for concerns.

CONCLUDING REMARKS

Hence, the study demonstrates that at least for these three cases, the make-or-buy decision does not necessarily mean outsourcing to suppliers. That might be instigated by different reasons but is the performance of suppliers that seems to be the main driver.

Implications for Research

In addition, the cases show that decision-making during product design and engineering differs substantially from strategic decision-making on outsourcing. That difference has been mostly ignored by literature but plays a large role in practice. It could very well be that the uncertainty about the completeness and accuracy of information during strategic outsourcing is also marred and that academics have ignored this. Moreover, shunning to the nature of the information available might lead to sub-optimal decision-making.

Managerial Implications

Whereas wareness is a first step for managers, they can benefit most from better understanding how they actually take decisions on outsourcing during product design and engineering. That also implies that there should be less reliance on previous cases as point of departure. It is not that the organisational memory should be discarded but case-based reasoning should be exerted with caution.

Also, the study demonstrates that outsourcing is less beneficial than often assumed. Certainly, in two out of three cases, the decision for acquisition of first-tier suppliers was a results of decisions made in the past.

A Final Thought

The findings from this study seem to be antidote against the commonly hold contention that decision-making on outsourcing inevitably means only sourcing from suppliers!

REFERENCES

Adler, P. S. (1995). "Interdepartmental Interdependence and Coordination: The Case of the Design/Manufacturing Interface." Organization Science 6(2): 147–167.

Anand, G. and R. Kodali (2008). "Development of a Conceptual Framework for Lean New Product Development Process." International Journal of Product Development 6(2): 190–224.

Arbnor, I. and B. Bjerke (1997). Methodology for Creating Business Knowledge.

Balakrishnan, K., U. Mohan and S. Seshadri (2008). "Outsourcing of front-end business processes: Quality, information, and customer contact." Journal of Operations Management 26(2): 288–302.

Carrera, D. A. and R. V. Mayorga (2008). "Supply chain management: a modular Fuzzy Inference System approach in supplier selection for new product development." Journal of Intelligent Manufacturing 19(1): 1–12.

Chao, L. P. and K. Ishii (2006). "Design process error-proofing: Failure modes and effects analysis of the design process." 129(5): 491–501.

Cronin, P., F. Ryan and M. Coughlan (2008). "Undertaking a literature review: a step-by-step approach." British Journal of Nursing 17(1): 38–43.

Dekkers, R., C. M. Chang and J. Kreutzfeldt (2013). "The interface between "Product Design and Engineering" and manufacturing: A review of the literature and empirical evidence." International Journal of Production Economics 144(1): 316–333.

Dulmin, R. and V. Mininno (2003). "Supplier selection using a multi-criteria decision aid method." Journal of Purchasing and Supply Management 9(4): 177–187.

Eisenhardt, K. M. and M. E. Graebner (2007). "Theory Building from Cases: Opportunities and Challenges." Academy of Management Journal 50(1): 25–32.

Flyvbjerg, B. (2006). "Five Misunderstandings About Case-Study Research." Qualitative Inquiry 12(2): 219–245.

Greenhalgh, T. and R. Peacock (2005). "Effectiveness and efficiency of search methods in systematic reviews of complex evidence: audit of primary sources." British Medical Journal 331(7524): 1064–1065.

Ibusuki, U. and P. C. Kaminski (2007). "Product development process with focus on value engineering and target-costing: A case study in an automotive company." International Journal of Production Economics 105(2): 459–474.

Kremic, T., O. I. Tukel and W. O. Rom (2006). "Outsourcing decision support: a survey of benefits, risks, and decision factors." Supply Chain Management: An International Journal 11(6): 467-482.

Liao, Y., K. Liao and R. Hutchinson (2010). "A conceptual framework for prototyping outsourcing in new product development: A knowledge-based view." Journal of Manufacturing Technology Management 21(1): 122–138.

McCarthy, I. P., C. Tsinopoulos, P. Allen and C. Rose-Anderssen (2006). "New Product Development as a Complex Adaptive System of Decisions." Journal of Product Innovation Management 23(5): 437–456.

McIvor, R. T. and P. K. Humphreys (2000). "A case-based reasoning approach to the make or buy decision." Integrated Manufacturing Systems 11(5): 295–310.

Pahl, G., W. Beitz, J. Feldhusen and K.-H. Grote (2007). Engineering Design: A Systematic Approach. London, Springer Verlag.

Petersen, J. K., R. B. Handfield and G. L. Ragatz (2003). "A Model of Supplier Integration into New Product Development." Journal of Product Innovation Management 20(4): 284–299.

Radhakrishan, R. and D. A. McAdams (2005). "A methodology for model selection in engineering design." Journal of Mechanical Design 127(3): 378–387.

Riedel, J. and K. S. Pawar (1991). "The strategic choice of simultaneous versus sequential engineering for the introduction of new products." International Journal of Technology Management 6(3/4): 321–334.

Shishank, S. and R. Dekkers (2013). "Outsourcing: decision-making methods and criteria during design and engineering." Production Planning & Control: The Management of Operations 24(4–5): 318–336.

Swan, K. S. and B. B. Allred (2003). "A Product and Process Model of the Technology-Sourcing Decision." Journal of Product Innovation Management 20(6): 485–496.

Swink, M. L. and R. Calantone (2004). "Design-manufacturing integration as a mediator of antecedents to new product design quality." IEEE Transactions on Engineering Management 51(4): 472–482.

Talluri, S. and R. Narasimhan (2004). "A methodology for strategic sourcing." European Journal of Operations Research 154(1): 236–250.

Tayles, M. and C. Drury (2001). "Moving from Make/Buy to Strategic Sourcing: The Outsource Decision Process." Long Range Planning 34(5): 605–622.

Tranfield, D., D. Denyer and P. Smart (2003). "Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review." British Journal of Management 14(3): 207–222.

Vandevelde, A. and R. Van Dierdonck (2003). "Managing the design-manufacturing interface." International Journal of Operations & Production Management 23(11): 1326–1348.

Wu, F., H. Z. Li, L. K. Chu and D. Sculli (2005). "An outsourcing decision model for sustaining long-term performance." International Journal of Production Research 43(12): 2513–2535.

Yin, R. K. (1994). Case study research: design and methods. London, Sage.

Zhao, Y. and R. J. Calantone (2003). "The Trend Toward Outsourcing in New Product Development: Case Studies in Six Firms." International Journal of Innovation Management 7(1): 51–66.