

COLLABORATIVE PRODUCT DEVELOPMENT: HOW TO MAKE THE “BUY DESIGN” DECISION?

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ABSTRACT

This article focuses on the *design or buy design* decision process and aims at proposing a structured approach enabling to support the decision-making within a new product development (NPD) project team by using an action research approach. The tool associated to this approach mobilizes the *Supplier Involvement Matrix* in order to identify the different situations of supplier involvement and is based on two dimensions: (1) the supplier's autonomy level in product development and (2) the development risk linked to the outsourced item. In this matrix, five types of customer/supplier involvement in collaborative NPD projects are distinguished. The usefulness of our tool is illustrated on a detailed case study: the collaborative development of a shorting connector between a Schneider Electric NPD team and a supplier. Several managerial implications and lessons learnt have been identified following this case study. First, this tool provides an operational measure of the *development risk* associated to a *buy design* decision and a clear and formal identification of the project needs. Secondly, its use may facilitate the coordination between product design engineers and purchasing agents.

Keywords: New Product Development (NPD), Early Supplier Involvement (ESI), Design or Buy Design decision-making

1 INTRODUCTION

For a long time, “make-or-buy” decisions have received an important attention by both academics and practitioners. In most of existing literature, the decision is focused on the production activities [1]. However, in various industries, when firms contract out, they can also decide to let the suppliers handle the design and engineering activities. For example, in automotive sector an A.T. Kearney/University of Michigan study suggested that the transfer of direct task responsibilities began in 1985, and will continue to the end of 2009, with as much as 80% of the value added of the car being bought from the supplier [2]. Lamming [3] explained this trend by the fact that as assemblers operations become leaner, focus will necessarily shift earlier in the product development process, especially to the design relationships that a company forges with its suppliers. Consequently, the “make or buy” decision can not ignore design activities. In this respect, *design or buy design* decision is introduced to consider both design and production activities. Consistent with Ulrich and Ellison [1], we believe that design and production decision are often interdependent and can not be analyzed in isolation. Clark and Starkey [4] were the first to introduce the concept of “design chain” in order to describe the network of participants created throughout the product development process, from concept, detail engineering, process engineering, prototype manufacturing, through to post-launch activities. In their study of the American and Japanese automotive manufacturers, Fine and Whitney [5] distinguish different ranges of outsourcing choices. These choices depend from the “exit points” in the product development process at which a company can opt to buy rather than make. They introduce the *buy design* decision after the in-house customer's needs determination stage. At this point the buying company allows greater design responsibilities to supplier. These authors argue that a critical capability in product development is the ability to write competent specifications for components and systems and to be sure the specifications are realized. For previous research in automotive industry [6] [7], this *buy design* practice seems to be an important factor in the superior performance enjoyed by the Japanese automotive companies in product development activities in terms of both lead time and cost. However, existing economic theory based on Transaction Cost Economics (TCE) [8] predicts

that the design of complex parts will be performed in-house rather than being delegated to outside suppliers in order to minimize the coordination cost associated with developing that kind of systems. It is argued that both greater product complexity and technological uncertainty favor making a component in house, since both are likely to increase the cost of writing fully-specified contracts with a supplier [9]. In addition, some empirical studies in automotive sector point out negative effects of *buy design* decisions leading to increased product and development cost, worse product performance and mainly longer development times [10], [11]. We can therefore conclude as Monczka and Trent [12] that it's a touchy decision and for which the major obstacle is the lack of managerial expertise in *design or buy design* decision-making.

The issue addressed in this paper is how can the *buy design* decision-making be improved within a New Product Development (NPD) project's team? Consistent with the findings of the Novak and Eppinger's study on the automotive industry [13], we believe that the lack of efficiency in the decision-making process mainly results in the chronological and organizational separation between both product design and sourcing decisions. The goal of this paper is to propose a structured approach of the *design or buy design* decision-making process allowing the product design engineers and the purchasing agent to make decision jointly. The presented approach contributes to the "design chain management" introduced by Twigg [14, p.509] as "the management of the participants, both internal and external to the focal firm, that contribute the capabilities (knowledge and expertise) necessary for the design and development of a product". The objectives of the approach are twofold: (1) identifying the type of customer-supplier collaborations needed for each item that the team project wishes to contract out and, (2) hence, determining whether such collaboration would be acceptable relating to the supplier market and the available in-house skills.

The paper is structured as follows. First, the context in which the design or buy design decision must be made is presented. Section 3 describes the adopted research methodology as well as the Supplier Involvement Matrix mobilized in this study. In section 4, the four steps of our *design or buy design* decision-making approach are considered in more detail. Then, an application of the tool within a product project of Schneider Electric group is presented followed by a discussion of the managerial implications of its use. Finally, the last section draws conclusions and limitations of this work.

2 DESIGN OR BUY DESIGN DECISION CONTEXT

There is a spectrum of alternative design capabilities available to a firm. At one extreme, a firm has necessary design skills in house and hence decides to make design. In opposite, a firm may outsource design work in order to access pertinent knowledge that resides outside the boundaries of its own organization [15]. In this paper, we are interested in the supplier involvement in design by a focal firm. This case refers to one of the four basic modes of collaborative innovation identified by Pisano and Verganti [16]. Previous research presents different categorizations of supplier involvement. Asanuma [17] or Clark and Fujimoto [7] proposed one based on the degree of initiative of the supplier in the design of the product and process. Kamath and Liker [18] proposed four types of involvement based on the different roles played by the supplier. But most existing typologies do not address the issue of how to decide the appropriate level of design delegation nor when to involve the partner in the design process?

The outsourcing decision is a multidimensional one including the benefits of increased economies of scale, access to specialist expertise in the supply base, short and long term financial advantage and better focus on core operation [19]. In addition, Quinn [20] advocates the use of outsourcing for greater flexibility and decreased product design cycles especially where rapidly developing new technologies or highly complex systems are involved. However the consideration of product design activities requires attention to many other issues. For Elfring and Baven [21] a firm that is likely to outsource component design will need coordinating, strategic and interfacing skills as well as the capacity to manage contractual relationships. For operations management literature, the trade-off is highly influenced by the architecture of the product. The degree of modularization appears as a key element in the *buy design* decision [1]. For Ulrich [22], a product architecture is considered as modular if it induces a one-to-one mapping from functional elements to physical components and if the interfaces between components are sufficiently decoupled so that each functional element may be changed independently by changing only the corresponding component and if this change does not entail a redesign of the interface. The more modular the final product is the easier should be the *buy design* decision for the component because it may not require much coordination with suppliers during

the development [23]. However, all products can't be designed with a modular architecture. What happens when the product has an integral architecture [22] and if the customer would concentrate on its design core competencies inducing a down-sizing of their design resources? If the customer chooses to outsource, the TCE economic theory predicts an inefficient solution due to the increase of coordination cost. In this case, to avoid the theoretical pitfall, the customer must build up the design or buy design decision-making with a clear identification of the supplied risk and hence propose appropriate responses.

In order to tackle the whole complexity of *design or buy design* decision-making process, we advocate that this decision should stand at the early stages of a NPD project. In Figure 1, we position it between the open and go or no go stage-gates of the project according to the project needs in suppliers involvement in phase of concept design (phase 2) and product & process design (phase 3). The moment of the supplier involvement will depend both from the product architecture definition and the supplier ability and willingness to hold the design responsibility.

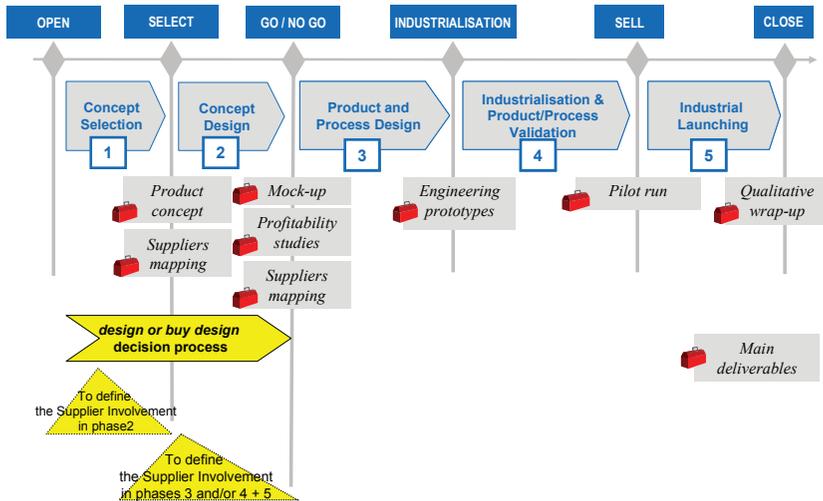


Figure 1. Design or buy design decision process within a NPD project

Based on the present overview, the question that our paper wants to deal with is: how to support the *buy design* decision process presented in Figure 1? In order to construct our response, we formulated two related research questions:

- What are the critical dimensions to identified prior to the *design or by design* decision-making?
- From the customer point of view, how to face to the specific risks associated to each type of supplier involvement?

3 RESEARCH METHODOLOGY

The objective of this exploratory study aims at developing ideas and derivate tools from induction of data and practices. The genesis of the study is the conjunction of conceptual material's generation about supplier involvement in NPD and the social need expressed by an industrial company.

This work is based on the Supplier Involvement Matrix (SIM) developed by Calvi and Le Dain [24]. The authors proposed a renewed Supplier Involvement Matrix (SIM) built from a literature review [25] [26] [27] and from an inductive approach based on 15 interviews representing a wide range of French Industries. The goal of this matrix was to provide an identification of the different situations of the suppliers' involvement in New Product Development projects. The suppliers considered in this matrix provide tangible objects (component, part, sub-system) and have manufacturing capabilities. The matrix is not applicable to suppliers providing only designs or technologies. This matrix defines five types of customer/supplier involvement in collaborative NPD projects (Figure 2), each of them being a combination of the following two dimensions: (1) the supplier's autonomy level in product development and (2) the development risk linked to the outsourced item. In section 4, this second

dimension is determined from seven combinatory types of product development risks. The metric to evaluate both these dimensions as well as the five identified collaborative situations will be described.

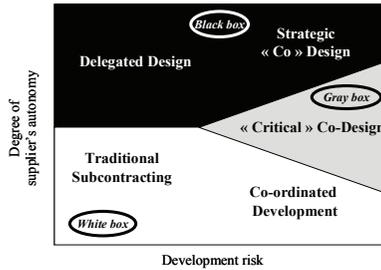


Figure 2. The Supplier Involvement Matrix (SIM) [24]

Schneider Electric, the world leader in electricity and automation management, was interviewed for this study and has taken a great interest in the use of this matrix within collaborative design with its suppliers. In January 2006, Schneider Electric launched the Tango project for a worldwide unification of methods and tools to facilitate and improve the supplier involvement in product development. A senior researcher joined this project team on a full-time basis to handle the development of a *design or buy design* approach using the SIM during the early phases of their NPD process.

We have adopted an action research approach [28] based on great interactions between researchers and practitioners for the co-construction of the approach and the associated tool. This was appropriate because an intervention was required to test the tool in a real-life setting and to obtain a feedback to improve it. A set of interviews were conducted with a *mirror group* including the representatives of all the skills involved in product development (Purchasing, Electro Mechanic Design, Electronic Design, Soft Design, Industrialization and Project Quality). Drawing from a literature review and from interviews findings, we have adjusted our previous SIM model to the industrial context of Schneider Electric and then devised a preliminary tool. This tool has been applied within product development projects and discussed during workshop sessions with the *mirror group* and project teams. Their remarks were taken into account to elaborate the tool supporting the *design or buy design* decision-making approach presented in this paper.

4 DESIGN OR BUY DESIGN DECISION-MAKING APPROACH

For the development of the *design or buy design* decision-making approach, we draw inspiration from the portfolio approach proposed by Wynstra and Ten Pierick [26]. We then enriched their approach in taking into account evidences from literature and Schneider Electric case. Our approach based on the use of the SIM consists of four steps:

- Determining the development risk relating to the outsourced item (horizontal axis of SIM)
- Determining the supplier's autonomy Level (vertical axis of SIM)
- Positioning in the Supplier Involvement Matrix and identification of the type of collaboration and the dominant development risks
- Making *design or buy design* decision

These different steps are detailed in the following sections.

4.1. Determining the Development Risk

Wynstra and Ten Pierick [25] [26] note that risk measurement used in traditional purchasing matrices (such as Kraljic, [29] for example) are not appropriate for describing the particular case of supplier involvement in NPD. These matrices aggregate various levels of risk (internal, external, commercial and technical risks) whereas the only relevant risk in our case is related to the impact of the outsourced item on the customer NPD project.

The development risk for each item is determined in adding together the score of the following seven types of risks. Five types of risk are the similar to the risks previously proposed by Wynstra and Ten Pierick [25] [26] in their portfolio approach, namely: *Systemic Link*, *Newness*, *Internal Complexity*, *Differentiation Produced*, and *Timeline*. In addition, we introduce the two following risks: *Cost Weight* and *Design Chain Complexity*. The score of each of seven risk's type is determined on the

basis of questions with an ordinal answering scale (from 1 to 5 point). Figure 3 describes the definition that we retained for each risk and the questions to evaluate it.

Concerning the *Internal Complexity* risk, we enriched the definition proposed by Wynstra and Ten Pierick [25] [26]. For these authors, the *Internal Complexity* only refers to the number of different technologies used in the item. According to the opinion of technical leaders of Schneider Electric, this definition doesn't take into account the difficulty to specify the performance required by some characteristics of a product and/or a process and to measure it. Novak and Eppinger [13] provide evidence of complementarities between product complexity and vertical integration. For these authors, a very complicated item due to its performance requirements may take more time to develop with a supplier because of coordination problems between firms. Clark et Fujimoto [7, p10] integrate both these dimensions in their definition of new product complexity in the following way: the dimension "product internal structure" refers to the number of distinct components and production steps, number of interfaces, and technological difficulty of and severity of the trade-offs among different components, and the dimension "product user-interface" is related to the number and specificity of performance criteria, importance of measurable versus subtle and equivocal dimensions, holistic versus narrow criteria.

Concerning to the two additional risks – *Cost Weight and Design Chain Complexity* – they refer to the purchasing point of view. Intensive contribution from the outsourced item to the cost of the final product poses potential risks for compliance with the target product cost and the development project's cost [30]. The *Design Chain Complexity* risk is related to the "design chain management" [14] of the item held by the supplier. If we adopt the customer point of view examining the design chain of its first-tier supplier, the more this design chain is complex, the more its management becomes crucial and presents a risk for the success of the collaboration. Thus, we propose two criteria to evaluate the complexity of this design chain: (1) the number of critical items in regard of the customer's NPD project developed by the first-tier supplier's network in order to estimate the iterations required for design and validation and (2) the time necessary for the first-tier supplier to deal with a problem occurring in its design chain, according to the design chain framework [31]. These criteria provide a measure of the coordination cost to design and execute production within this network [13].

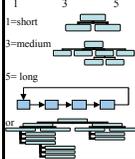
Type of risk	Risk Definiton	Questions	Quotation
Systemic Link	The outsourced item has tight interdependence links with the other items and consequently has a strong impact on the technical performance and the design of the final product	To what extent does the outsourced item determine the technical performance of the Schneider product?	1 5 low decisive
		To what extent does the outsourced item determine the design of the Schneider product?	1 5 low decisive
Newness	The technology(ies) used is/are new to Schneider Electric or the technology(ies) is/are known but the context of their use is new	To what extent are the technologies of the outsourced item new, or to what extent is the application of this technology new to Schneider Electric?	1 5 not at all entirely
Internal Complexity	This internal complexity refers to the number of distinct technologies or components used in the outsourced item, to the difficulty specifying the performance required by some product or process characteristics, measuring the performance criteria, the product/process	What is the internal complexity of the outsourced item?	1 5
			low high
Produced Differentiation	The outsourced item represents an essential new contribution to the functionalities of the overall system, in comparison to the previous system	To what extent does the outsourced item make an essential new contribution to the functionalities of the overall Schneider product, as compared to the previous Schneider product?	1 2 3 4 5 new value
Timeline	The outsourced item is or is not situated along the critical path of the Schneider Product Development project (PMP)	To what extent is the item on the critical path of the Schneider product development project ?	1 5 not very critical critical
Cost Weight	The outsourced item cost has/does not have a significant impact on the cost of Schneider's product	What is the impact of the outsourced item on the cost of Schneider's product?	1 5 low high
Design Chain Complexity	Design Chain complexity refers to the management of the tier suppliers involved in the development of the items outsourced to our first-tier supplier. Schneider's first-tier supplier is responsible for managing this tier-supplier development	How many of the items developed by the first-tier supplier's network of suppliers are considered as critical in regard to Schneider's product development project?	1 3 5 few medium many
		According to the design chain framework of the first-tier supplier, how long does it take for a problem occurring in a tier supplier of this design chain to reach Schneider's first-tier supplier and be dealt with?	1 3 5 1=short 3=medium 5= long 

Figure 3. Questions for the determination of the development risk relating to each risk's type

4.2. Determining the Supplier's Autonomy Level

The autonomy that a customer wish granted to the supplier for the development of the item – the vertical axis of the Supplier Involvement Matrix – is determined from a five-level scale (from 0 to 4). The distinction made between these five levels (Figure 4) is function of (a) the level of responsibility assumed by the supplier in the customer's NPD process [18] [25] [26] [32] [33], (b) the type of needs specified to the supplier (technical or functional specifications) [7] [25] [26] and (c) the rights of the intellectual property [27] [34] as well as the responsibility of the eventual changes made to the item during the mass production of the customer's product (i.e. Schneider Electric describes this activity as "continuous engineering"). These five levels are in line with the practices met in our case study.

4	On the basis of functional specifications, the supplier is responsible for the global design (concept, feasibility studies, design, supply chain organisation), the detailed design, the testing of global and detailed design and the setting up the production and assembly processes of a complex subsystem. The supplier holds the intellectual property rights of the subsystem and then he is in charge of its continuous engineering.
3	On the basis of functional specifications, the supplier has the full responsibility from concept design to manufacture of an entire part/component. The supplier holds the intellectual property rights of the part/component and then he is in charge of its continuous engineering.
2	On the basis of specifications, the supplier is fully or partly responsible for the detailed design, the testing and the setting up the production and assembly processes. 2a The customer keeps the intellectual property rights of the component and pays design fees to the supplier. The customer is in charge of its continuous engineering. 2b The supplier holds the intellectual property rights of the component and is held legally responsible. The supplier is in charge of its continuous engineering.
1	The supplier is responsible for the setting up the industrialization and production processes based on the drawings supplied by Schneider Electric. Supplier provides feedback on Schneider Electric's design including suggestions for cost or quality improvements.
0	The supplier is responsible for the setting up the production process. The supplier provides input in Schneider Electric's product design by sharing information about its equipment and process capabilities and production scheduling.

Figure 4. Five levels for determination of the supplier's autonomy in product development

4.3. Positioning in the Supplier Involvement Matrix

The position of each item in the Supplier Involvement Matrix is automatically calculated from the values on the horizontal and vertical axis. The position indicates the desired type of supplier involvement situation (Figure 5). Five types of supplier involvement in collaborative NPD projects are distinguished as follows [24].

When the level of autonomy of the supplier is low (levels 0 to 1 on the vertical axis), the relations are generally described as "white box" by Monczka and Trent [12]. In this case, Calvi and Le Dain [24] defined two types of relations according to the level of development risk: *traditional subcontracting* characterised by a low development risk and *co-ordinated development* characterised by a high *Systemic Link and Timeline Risk*. In both these situations, the outsourced items are mainly simple parts, whose design remains internalised. But with a *co-ordinated development*, due to the nature of the development risk, the product design activity performed by the customer and the process design activity realized by the supplier must be coordinated to obtain effective product/process integration in the building of the final product solution and to keep the supplier informed of modifications. The supplier plays the role of a "silent designer" [35] because he contributes to the customer's design activity by giving their tacit process knowledge.

If the autonomy of the supplier is high (*black box*), the results of the exploratory survey carried out by the authors invites us to distinguish two types of relationships, in accordance with the development risk: the *delegated development* (levels 2b to 4 on the vertical axis) and *strategic co-design* (mainly level 4 on the vertical axis). In both cases, the supplier is fully responsible for the design and development of the outsourced item. However, in *strategic co-design*, the high level of risk requires a great amount of communication with the supplier in order to clarify customer needs and to monitor the evolution occurring throughout the project.

Lastly, the authors qualify as *critical co-design* (levels 2a to 3 on the vertical axis and risk greater than 50% on the horizontal axis) the situation where neither the customer nor the supplier possesses the knowledge and the ability to completely execute the product design in house. The greater the development risks, the more the customer will try to promote and manage the collaboration between

its own project's team and the supplier's project team. This reasoning thereby explains the triangular nature of the conceptual Supplier Involvement Matrix.

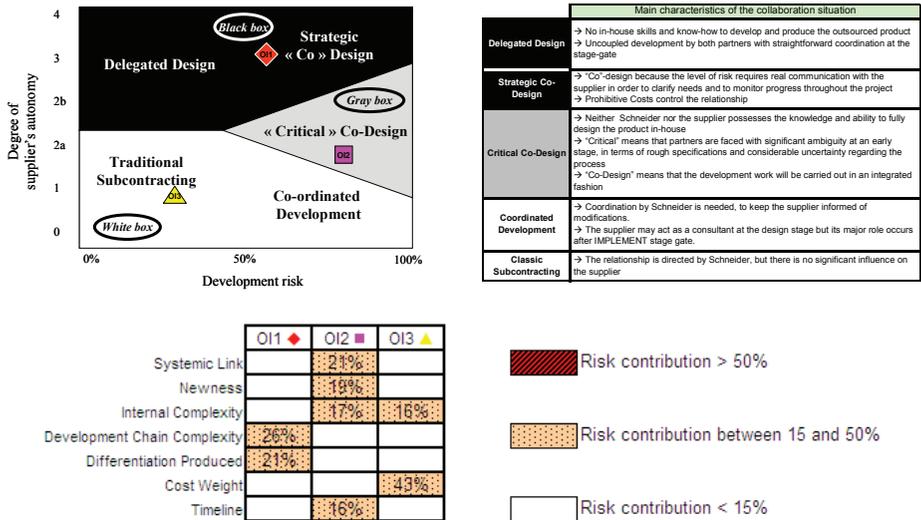


Figure 5. Position of outsourced items (OI) in the SIM and associated dominant risks

For each item, the dominant risks (Figure 5) are identified and some appropriated risk responses are proposed (Figure 6). Most products of Schneider Electric have an integral architecture rather than a modular architecture. Ulrich [22] describes this product architecture as not made up of off-the-shelf parts but rather comprising a set of components and sub-assemblies designed to fit with each other. In addition, functions typically are shared by components and components often display multiple functions. Consequently, the systemic link risk between items and a product with an integral architecture is often high. Thus each evolution and change in the definition and the validation of the Schneider Electric product must also be integrated into the item concerned and the coordination with suppliers will not be underestimated. We propose three main risk responses to face this systemic risk (Figure 6). Firstly, in order to facilitate the interface management the product must be developed as an engineering system defined by a top-down design process [5]. Indeed, this design process conceives of the system as decomposition into subsystems cleanly at points where their interfaces are simple and clearly defined. Secondly, the impact analysis stemming from this decomposition must be shared with the supplier in order the latter may "contribute to the design process by helping (the) customer meet functional requirements, without including excessive specification requirements that lead to unproductive additional costs" [36, p.44]. Finally, the supplier's regular participation in design reviews, including some co-location periods in the customer's development center [37] can help ensure an optimal product development process.

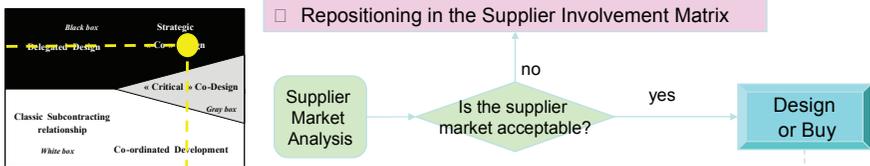
Risk	Impact on the Schneider Project	Risk Response
Systemic Link	* Management of modifications: All modifications to parts interfacing with the outsourced item must be reported to, even validated with, the supplier.	* Make sure that the item is specified with straightforward and well-defined interfaces * Intensive and reciprocal communication with supplier during the project
	* The greater the systemic link, the less the guarantee for Schneider that the outsourced item will turn out to be reliable during final testing within the environment of the Schneider Electric product's use	* Define with the supplier complementary verification tests on mock-up, simulation, correlation analysis * Share the impact analysis by clearly presenting the environment in which the outsourced item will be used in order that the supplier fully understands development and utilisation constraints and gets an overall picture of expected requirements
Newness	* Lack of expertise on Schneider's part.	* Analysis of competitors on purchasing
	* Uncertainty regarding the reliability of the outsourced item during final testing within the environment of Schneider Electric product's use	* Define with the supplier complementary verification tests on mock-up, simulation, correlation analysis.
Internal Complexity	Uncertainty regarding the reliability of the outsourced item during final testing within the environment of Schneider Electric product's use	FMEA Complementary verification tests on mock-up, simulation, correlation analysis.
Differentiation produced	Customer satisfaction	Make sure that the supplier has clearly understood our needs
Timeline	Impact on time to market	When analyzing the risks involved in the project, identify with the supplier the measures needed to control these risks
Cost Weight	The success of the project is jeopardized	Drive the project according to the target cost, standardize as much as possible
Design Chain Complexity	* Impact on the time to market	The first-tier supplier must be transparent in regard to the suppliers it involves in its own product development project
	* Possibility of delays due to the supplier's inefficient management of its design chain	

Figure 6. Impact of each type of risks and proposition of associated risk responses

4.4. Making Design or Buy Design Decision

As illustrated on Figure 7, the *design or buy design* decision-making is based on the following two questions: For each part, is there a known supplier capable to meet our requirements or can we find a suitable supplier within the supplier market to take on the desired position in the SIM? Is the desired distribution of all parts across the SIM acceptable in terms of management? If there is no suitable supplier and/or an unacceptable distribution, a repositioning in the SIM is necessary by adjusting either the supplier's autonomy level for the development and/or the development risk. A lower autonomy's level will be contracted out if the necessary skills and resources are available in house. In order to decrease the development risk, a redefinition of the item will be necessary. This redefinition may allow to the change of the used technology, the component and/or the design chain architecture.

1 Analysis for each outsourced item



2 Analysis for all potential outsourced items

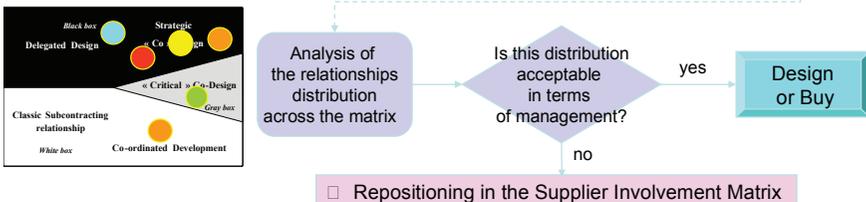


Figure 7. Making design or buy design Decision

5 ILLUSTRATION

In order to validate the usefulness of the tool, we conducted cases study within Schneider-Electric project teams. Those cases study were conducted in situ (i.e.: during a project, to support the project

team in the *design or buy design* decision) For confidentiality reason, only one case study within a product project actually commercialized by Schneider Electric is reported here. This study has been conducted with a triple purpose: First illustrating the usefulness of the approach and its associated tool, secondly creating a case study for the training program performed for new comers in NPD at Schneider Electric, and finally pointing out some managerial implications of this approach. In 2005, Schneider Electric launched the development of a protection relay of an entry range in order to complete its range of existing relays and to re-use it within other NPD projects. The main objectives of this project in relation to the current solution were twofold: first lowering to 30% the target cost and secondly proposing a solution more compact (without accessory).

The application of the tool has been carried out by a researcher with the project team in charge of this development during a workshop session. This team included the project manager and respectively the technical, purchasing and quality project leaders. The workshop went in the following way: After having selected the item for which the *design or buy design* decision-making approach will be tested; the cross-functional team jointly determined both axis of the SIM. Then, the positioning in the SIM and its feasibility are discussed. Finally, what the team has been learnt from this case is also discussed since at the beginning of the project the *design or buy design* decision has been make without the use of the tool.

5.1 Presentation of the co-development project

In order to appreciate the application of the *design or buy design* approach, it is necessary to give an overview of what a protection relay must do. A protection relay contributes to the safety of goods and people in detecting electrical failures and hence cutting the faulty part of network as well as securing the electrical distribution in the healthy part of network. In addition, it must be capable to work in severe environments in terms of temperature (from -40°C to +70°C) and for over fifteen years with a high level of reliability. Generally, the protection relay is connected with the current transformer and the circuit breaker. It provides a function of measure in analysing the electrical data given by the current transformer. If an electrical failure is detected, the protection relay sends an order to switch off the current to the circuit breaker.

The outsourced item selected by the participants is a shorting connector. It is a specific component that must handle the interface between the current transformer and the protection relay. It is considered as a key component because it has a considerable impact on the performance and the functionality of the protection relay.

5.2 Findings of the different steps of the Design or buy design approach

The development risk of the shorting connector has been evaluated to 57% by the participants. Figure 8 describes in detail the calculation of this risk from the score obtained for each type of risk and precise the main reasons of these different scores. We can note that the dominant risks are the *Systemic Link* and the *Differentiation Produced*.

Type of risk	Questions	Quotation	Score	Comment
Systemic Link	To what extent does the outsourced item determine the technical performance of the Schneider product?	5	5	The safety of goods and people depend on the quality of this interface. This connectic is composed of a socket and a male plug. The latter is integrated into the relay
	To what extent does the outsourced item determine the design of the Schneider product?	5		
Newness	To what extent are the technology of the outsourced item new, or to what extent is the application of this technology new to Schneider Electric?	2	2	The used technologies are standard with application conditions (temperature, ...) quite difficult but usual for a supplier from this industrial activity
Internal Complexity	What is the internal complexity of the outsourced item ?	3	3	Some difficulties to qualify the connector (what does a good connection means?) and hence to define the verification plan
Differentiation produced	To what extent does the outsourced item make an essential new contribution to the functionalities of the overall Schneider product, as compared to the previous Schneider product?	4	4	The connector is integrated to the relay that allows a more compact solution and hence the suppression of accessories existing in the previous solution Thus, it adds new value for the customer
Timeline	To what extent is the outsourced item on the critical path of the Schneider Product Development project ?	3	3	The connector is critical but does not block the development of the protector relay
Cost Weight	What is the impact of the outsourced item on the cost of Schneider's product?	2	2	Accounting for 10% of the relay cost
Development Chain Complexity	How many of the items developed by the first-tier supplier's network of suppliers are considered critical in regard to Schneider's product development project?	1	1	For the development of the connector, the first-tier supplier only must purchase raw materials
	According to the design chain framework of the first-tier supplier, how long does it take for a problem occurring in a tier supplier of this design chain to reach Schneider's first-tier supplier and be dealt with?	1		
		score / 35 = 20		
		value of the horizontal axis of SIM = 57%		

Figure 8. Determination of the development risk relating to the shorting connector

The project's team sets at level 3 the supplier's autonomy. The main reasons of this choice are twofold: (1) Design competencies exist in house but the resources are not available and as well the development of the connector is not a core-activity. Thus, it was relevant to take benefit of the experience of a specialist that can do the development work more efficiently than Schneider Electric and (2) Schneider-Electric team expressed the necessity to find production plants outside.

Finally, the type of relationship expected by Schneider Electric refers to a *strategic co design* collaboration. As there are suppliers from the Schneider Electric base known for their capability to develop this component, the decision of *buy design* has been made by the project team.

5.3 Managerial implications and lessons learnt

Several managerial implications and the lessons learnt have been identified following this case study. First, for the project manager in charge the project objectives achievement and the project management plan, the use of this tool provide in the early phases a clear and formalized identification of the project needs in terms of competencies and resources (internal or external) to bring in. Secondly, product design engineers typically determine product architecture and purchasing agents typically make sourcing decisions. Novak and Eppinger [13] highlight that while these two groups certainly interact but they do rarely make these decisions jointly. The authors suggest that "a great coordination of these functions within product development process could improve firm performance" (p.202). The use of our tool may facilitate this coordination by jointly defining the design or buy design decision-making.

For the team project, the tool provides an analysis of the development risk associated with the outsourced item by identifying main critical risks and their impacts of the final product and by defining the risk responses to set-up during the collaboration with the supplier. For the case study, three dominant risks have been identified by the project's team (*Systemic Link, Internal Complexity and Differentiation Produced*). In order to face the impacts due to these three risks, the following actions have been carried out at the beginning of the project with regard to the supplier. First, the environment in which the connector will be used has been clearly presented to the supplier. This presentation has allowed the supplier to well-identify the impacts of its component on the protection relay by fully understanding development and utilisation constraints and getting an overall picture of expected requirements. Secondly, the verification plan has been drew up with the supplier, clearly specifying the acceptance criteria and the verification tests as well as the respective roles and responsibilities regarding the actions and resources needed to implement the verification process.

6 CONCLUSION AND LIMITATIONS

A rich literature from economics and management science has addressed the make or buy decision. More recently, the systems engineering literature has established the importance of the architecture product and the product complexity. However, little research stressed the connection between these two important decisions and studied them jointly within NPD projects. Our research contributes to the creation of this link by offering a conclusive tool helping a project team to jointly make their *design or buy design* decision.

This research work is not without its limitations. First, our tool, co-constructed with Schneider Electric, is also the reflection of this contingency situation. A recommendation for future research would be to carry out investigations in other industrial contexts in order to test the generic property of our tool. Secondly, during the design or buy decision-making process, if a repositioning in the SIM is necessary for a given outsourced item, the latter may be impact the decision made for other items directly connected. This dimension of interrelation between items is not explicitly described and constitutes an improvement way.

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