

Part II

Supply Chain and Purchasing Strategy

Chapter 5

A Model of Codesign Relationships: Definitions and Contingencies. A Review and Outlook

Alberto De Toni and Guido Nassimbeni

Abstract The original paper investigated, with a case study method, the different forms of co-design, i.e. the joint development of products and processes by customer and supplier. Four types of co-design are identified, according to the type of knowledge transferred (product or process) and the degree of interaction between the parties (loose or tight). Results show that the success of co-design depends on the fit between the type of relationship adopted and two contextual factors: the uncertainty of the design endeavour and the relational capabilities. The commentary highlights the original contribution at the time, in terms of both theoretical and methodological approach: the paper proposes a situational approach, showing the need to adapt the type of co-design to the context, and adopts a qualitative method, investigating four co-design projects within the same buying company. Research in this field has been rich in the subsequent years and this paper can be seen as a precursor of the relevance of the relational environment and the eco-system concept, widely adopted today to analyse innovation and product development.

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5.1 Original Paper¹

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1 Introduction

Buyer-supplier relationships have grown in importance, since ever more firms tend to concentrate investments and resources on their 'core capabilities' and to outsource an increasing amount of product components and subsystems. As a consequence a firm's competitive performance increasingly relies on suppliers' performance in terms not only of cost/productivity, but also of quality, flexibility, timeliness and innovation. In many industries cooperation and partnership started from operating issues, concerning deliveries, inventory and capacity management, logistics and order management [1]. But, cooperation increasingly extends to new product development.

Indeed, in the ever more turbulent business environment, customers ask for higher customisation and innovativeness of products. Thus, the frequency of product innovation endeavours is increasing and the complexity of technologies calls for deep and advanced knowledge. Therefore there is a growing demand for resources and diversified competencies to carry on product development projects. Facing this challenge, firms often resort to suppliers as sources of customised innovation [2,3]. Hence, there is an increasing interest in co-design practice, that is early supplier involvement in the New Product Development process.

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A wide and heterogeneous literature has recognised the strategic relevance of codesign and has described its practice [4–6] and the related performance improvements regarding cost, quality and development time (see e.g., [7]). However, risks and drawbacks associated with co-design have also been highlighted and poor or even negative impact on product development process performance have been illustrated, thus questioning the general applicability and effectiveness of co-design [8,9]. Finally others have tried to highlight the conditions under which the potential benefits of co-design outweigh its costs [9–12,2]. Such contributions focused mainly on the relational conditions and suggested that mutual trust and frequent exchanges of information are needed to gain the potential benefits of co-design. However, most of them consider buyer-supplier collaboration in product development as a matter of ‘shades of grey’. Therefore, the ‘intensity’ of co-design is often related to performance improvements, disregarding the fact that different kinds of co-design activities can be developed according to different situations. Of course, most popular classifications of buyer supplier collaboration in product development implicitly consider various practices. For example, Kamath and Liker [13] in an evolutionary perspective of such relationships identified four stages of supplier role – contractual, child, mature, partner – characterized by different practices and an increasing level of collaboration. Almost the same early descriptions of co-design practice (e.g., [4,14]) focus on the level of autonomy of suppliers in accomplishing the design tasks up to the so-called ‘black box development’. According to such approaches, firms choose the proper degree of co-design depending on the objectives and environmental conditions they are facing (i.e., they choose the proper shade of grey according to the context they are working in). Indeed, Clark and Fujimoto [14] and Lamming [15] suggest that ‘grey-box’ parts can be distinguished as black-box parts where the auto manufacturer has more influence on the parts internal functioning.

On the whole there is lack of analysis and discussion about the different types of codesign relationships, that are not necessarily characterised by an increasing intensity of collaboration. Rather, it seems that co-design is a ‘matter of colours’, and not just a matter of shades of grey. Thus, a contingent model is needed to help practitioners to select the type of co-design that suits their situation best, i.e. to select the proper mix of colours.

In the light of the above considerations the aim of this paper is therefore twofold:

1. To provide a classification – a taxonomy – of different kinds of co-design relationships based on empirical in-depth analyses.
2. To discuss contingencies (when and what) under which certain types of co-design are successful, i.e., they produce high performance in the product development process.

In particular, to meet such aims this research assumes the perspective of the decision making process of the customer. Indeed literature often considers the new product development process as a series of inter-connected decision making processes and defines co-design as the involvement of suppliers in those processes. However, so far classifications have mainly focused on the phases of the new

product development processes during which the supplier is involved (e.g. [14]) and the kind of supplier involved in the co-design relationship [13]. In this paper, we will mainly focus on the roles of the suppliers and customers in the decision making processes performed when designing new products. Though it is clear that the decision making process is affected by several contingent factors, in our study we mainly focus on the uncertainty of the transaction which has been highlighted by both the transaction cost theory [16,17] and the theory of managerial decisions [18,19].

The remainder of the paper is organised as follows. Section 2 briefly discusses the methodology. Section 3 introduces a conceptual framework that guides the analysis of the empirical evidence from four in-depth case studies presented in Section 4. Section 5 introduces the different forms of co-design relationships, while Section 6 investigates the domain of applicability of different solutions, in the light of the model presented in Section 4. Finally, Section 7 draws some conclusions and discusses future developments.

2 The model of co-design

On the basis of the literature reviewed we provide a definition of co-design to identify the scope of analysis of this paper. Firstly, a co-design relationship involves the supply of customised innovation (see Figure 1). In this perspective, the transacted good shall be specific. That is, the innovation shall be performed in order to satisfy the specific needs of the customer. Moreover, in co-design relationships the supplier is a source of complementary knowledge. That is, customers look for the know-how needed to properly design the product and do not simply look for a supplier of components they do not want to design (since they are not relevant or they are available on the marketplace). Hence, the transacted good is the know-how and not just the manpower needed to perform relatively standard and non-specific tasks.

Given the above definition, to support the analysis of the rich information gained through case studies, we developed a conceptual framework that identifies co-design relationships in terms of inputs and outputs of a single co-design project.

Seminal works on partnership and co-design highlight that cooperation with suppliers can have many positive outputs [20]. Moreover, most of the previous work in this area identifies a wide set of managerial levers suitable for implementing partnership and codesign (e.g., trust, exchange of information, specific assets) [21,22]. However, the literature lacks a coherent classification of inputs (managerial levers) and outputs (objectives, results) of a co-design relationship.

We classified the levers of co-design into two clusters. A first cluster of levers characterises the technical and organisational situation of the relationship (e.g., prototyping policies, degree of involvement in the project, and innovativeness of the component). These levers can be easily deployed according to the needs of each single project and their effect is bound to the single project (hence they are

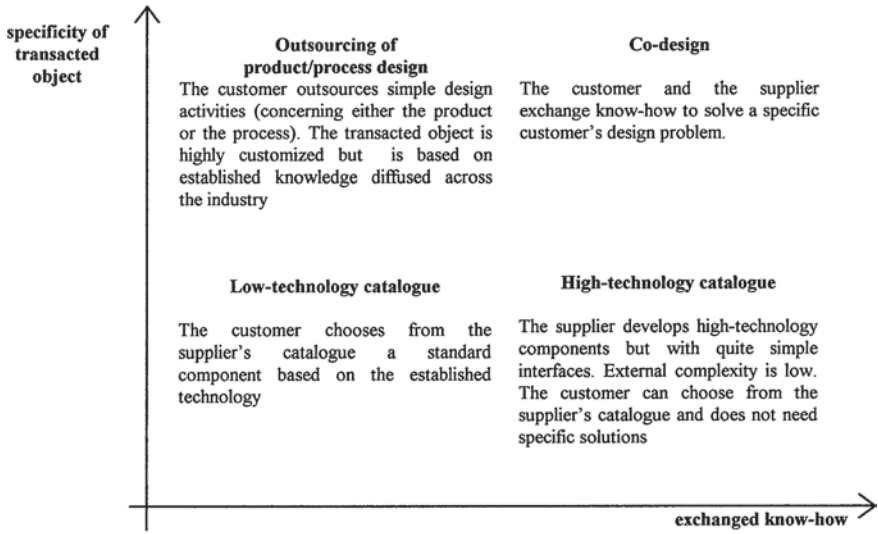


Figure 1 A definition of co-design relationships

named single-project levers). For example, an innovative project might require a close interaction between the customer and the supplier, while, for projects that require only minor improvements of the component a lower level of interaction might be required. Thus the extent to which the customer and the supplier jointly make decisions can be changed according to the needs of each single co-design project and can be considered a single-project lever.

On the other hand, a second cluster of levers has a wider impact on the relationship. These levers are set '*una tantum*' (once for many projects) since they have a longer-term orientation; hence, they tend not to be modified for each single project. For example, the customer typically chooses its vendor-rating criteria according to the general purchasing strategy rather than to a single co-design project. In other words, although the customer checks the quality of the transacted good (i.e., the output of the co-design relationship) at the end of each single project, the performance criteria of a co-design relationship are defined '*una tantum*'. Indeed, metrics shall be common in order to compare results of different projects and decide whether to undertake co-design projects with that supplier in the future or not. This second group of levers has a direct impact on many projects (therefore they are named multi-project levers). They also increase trust since they often give the partner important signals of commitment on the development of the relationship. For example, in one of the cases described later in the paper, the supplier increased its production capacity to respond to the actual and future demand for components from the customer. The capacity is not '*strictu sensu*' component-specific and can be used to manufacture various components from the same family. Obviously, this decision is not related to one single new component, rather it relates to the expectation of future contracts for the purchase of similar

components from the same customer. Although the supplier invests because he expects future purchases from the customer it is worth noticing that this investment is a signal of mutual commitment ‘*per se*’ which dramatically improves mutual trust and the relational environment.

Both single-project and multi-project levers are deployed according to the final goals of the company. In other words, they should depend on the strategy of the firm. In particular, the purchasing and the new product development strategies play a crucial role in defining a co-design relationship [23]. Indeed, in the customer firm, both the Engineering and the Procurement functions cooperate in co-design projects. This highlights a remarkable warning for co-design: an inconsistency between new product development practices (which often tend to involve suppliers to rely on their capabilities and to act in a win-win logic) and purchasing function (which often tends to play a zero sum game) can lead the co-design relationship to fail. In addition, given the strategic objectives the choice of the appropriate coordination levers clearly depends on some contingent variables such as, for example, the characteristics of the component (e.g., innovativeness) and the relational environment (e.g., level of trust).

As previously mentioned both multi-project and single-project levers influence the outputs of the co-design project. The outputs of the project are various and can be clustered according to the clusters of levers. The first, direct performance of the project is the new component. In more detail, the performance criteria are the time and cost spent in the project and the quality of the new component [14]. Both the customer and the supplier are interested in this output since, on the one hand, the competitiveness of the supplier depends on the performance of the component (which is the supplier’s product). On the other hand, the competitiveness of the customer depends on the performance of the final product that is influenced by the performance of the component (in terms of time, cost, product performance).

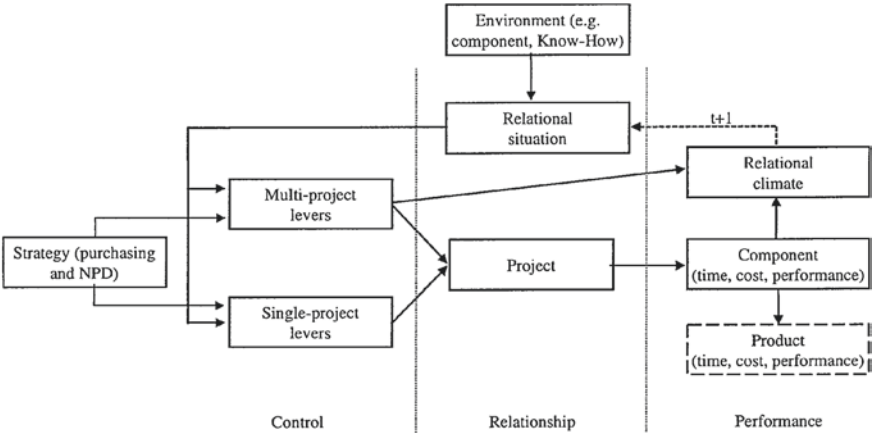


Figure 2 The model of co-design relationships

Furthermore, the output of the single project influences also the relational environment and, thus, contributes to the multi-project level of cooperation between the two firms. The ongoing results of the customer-supplier relationship influence relational variables such as trust, the expectation of relationship duration, organizational behaviours, and conflict resolution policies. For example, we might expect that a customer is not willing to cooperate in the future with a supplier that designed a poorly performing, expensive product and did not meet the deadline of the project. Neither the supplier nor the customer are interested in this relational output '*per se*', since the relational environment generated by the co-design project is not a direct performance improvement. However, this is a crucial output since it influences future projects. In this perspective, the outputs of a co-design project are the inputs for the successive decisions concerning multi- and single-project levers (they describe the status of the relationship before the new project starts). This loop clearly highlights the path dependencies of the relationship. Future developments depend on the actual performance of today's projects to a large extent. Hence, both the supplier and the customer shall consider the effects of their decisions on the relational environment when setting their strategies. Although a good relational environment is not an objective '*per se*', in the long run it can significantly improve the performance of both the customer (product performance) and the supplier (component performance).

3 Methodology

The research presented in this paper stems from a conceptual model presented in Section 2. Indeed this conceptual model introduces the variables at stake in a co-design relationship and represents the conceptual background for the empirical part of the study. In the model the variables are defined, clustered, and their dynamic interactions are discussed. Obviously this model is not the only contribution of the paper but it supports the empirical analyses discussed in the following paragraphs.

Given the exploratory objectives, this research adopts the case study methodology since it provides the great depth of information that is needed in the early phases of research on organisational issues. Indeed, though surveys can help to validate research hypotheses they can hardly provide the depth of information which is needed to identify and define research hypotheses. In addition, when studying customer-supplier relationships in general, and co-design in particular, the research focus should be on the relationship and not on a single firm (though often literature focuses on the customers' side). Thus in each case study, both the supplier and the customer of a given transacted good were investigated. In particular, the four case studies presented in this paper describe the relationships between a major international producer of white goods located in northern Italy and four of its first tier suppliers. For the sake of confidentiality hereinafter the producer of white goods will be named Customer. Customer is a large multi-brand manufacturer with several plants in Europe and the USA. Its European headquarters are located in northern Italy. Customer has several business units (including refrigerators, kitchens,

microwaves) characterised by significantly different products in terms of internal complexity (e.g., number of components and number of different technologies), market share of the firm, volumes. We chose to study four cases from a single business unit (Refrigeration – i.e., refrigerators, freezers, etc.). This makes the four case studies easily comparable. Indeed they belong to the same industry, and there are no differences in terms of the vertical integration and purchasing strategy of the customer. Thus, the differences between the cases are due either to the features of the transacted good, or to the characteristics of the supplier, or to the relational environment. Finally, the case studies were performed at the same time. Thus, time discrepancy of data is avoided (given the high rate of changes in multi-national organisations it might have made the projects hardly comparable).

4 Case studies

This section describes four cases thus providing the empirical data that support the empirical taxonomy discussed in the following sections. Since this paper focuses on codesign relationships, when performing case studies, we selected four cases that fit our definition of co-design (i.e., the supplier provides the customer with the know-how to respond to a specific customer need). Thus the relationships investigated in this paper are in the upper-right portion of Figure 1. Moreover, since this paper aims to identify different forms of co-design we looked for rather different relationships (e.g., in terms of success, innovativeness of the component and of the end-item). Cases A to C involve the development of components for a new chest freezer while case D concerns the development of a component for a one door free-standing refrigerator. This sampling procedure is not suitable for providing any evidence about success rates or average performance of co-design relationships. However, it enables the authors to study both successful and unsuccessful relationships and, thus, discuss which characteristics of the project (in terms of inherent features of the project, fit with the characteristics of the component, the relational and strategic environment) lead to performance improvements and strengthen the customer-supplier relationship. In addition, the authors selected four co-design relationships that were performed at about the same time in order to avoid time discrepancy. Finally, the authors studied four non-standard components that were customer-specific (according to the definition of co-design provided in Figure 1). However, different degrees of innovativeness were considered to investigate whether this feature of the single project has a relevant impact on the organisation of the co-design relationship.

4.1 Case A: lamp-holder

In case A, the supplier (hereinafter called Supplier A) provided Customer with the lamp holder. The lamp-holder is a part of a more complex sub-system consisting

of the lamp, the light switch, the thermostat and some electric connections. The lamp-holder is not very relevant in terms of costs (it accounts for about 1% of the overall cost of the chest freezer). However, it has a relevant impact on the reliability of the final product. Indeed, several electrical connections are co-stamped [24] in the plastic and can provoke reliability problems (for example because of the heat generated by electrical currents). In addition, the lamp-holder has very complex functional and geometrical relationships with the sub-system. Thus, there is a need for great integration between the development of the lamp-holder and other components of the sub-system. In the past, Customer and Supplier A jointly developed a new family of lamp-holders that exploits the potential benefits of the co-stamping technology. So, this relationship could benefit from previous developments both from a technical and a relational perspective. Indeed, on the one hand, only minor design improvements and customisations were needed. On the other hand, the cooperation between the customer and the supplier was relatively easily managed: the successes of past projects helped in building trust and, although the relationships between the component and the sub-system are quite complex, they were identified in previous projects. In other words, the two parties had in the past identified the technical specifications that are needed to describe the component and its interactions with the final product and were able to define them with relatively little organisational effort and within a limited time frame. This enabled the supplier to develop the component and the process with very little interaction with Customer whose role was just to deliver design specifications. In this case the relationship was very successful since it brought about some marginal improvements to the component that contributed to the design of a better final product. Moreover, the relational environment of the relationship was excellent and further improved by the successful development of this component.

4.2 Case B: hinge

In case B the supplier (hereinafter called Supplier B) tried to develop a new hinge for the external door of the chest freezer. In the past Supplier B had supplied hinges to other business units (e.g., the cooking business unit) of Customer. However, Supplier B had never supplied any hinge to the Refrigeration Business Unit. This unit used to buy standard hinges from the hinge-market leader. In this project, Customer was looking for a completely new hinge, since the strategic marketing function felt that customers were looking for a very thin chest freezer thus asking for a very thin door hinge (the hinge usually juts out from the chest freezer, so it exacerbates the problem). Supplier B and Customer signed a long-term contract and agreed to co-design the 'thin hinge'. However, several problems occurred in this relationship. First, some re-thinks took place since Supplier B proposed some new concepts for the component that were not consistent with the freezer door. Indeed, Customer took for granted some technical specifications, that Supplier B was not aware of, simply because they had never worked

with the Refrigeration Business Unit before. In other words, the two parties were simply not aware of the information their counterpart needed to perform their task and thus failed to provide it. This resulted in several re-thinks and extra costs. Finally, Customer and Supplier B agreed on a new concept. However, Supplier B failed to meet the technical specifications (in terms of reliability of the component) they had committed to. Indeed, Supplier B had not designed similar products (in terms of final product and environmental condition of usage) in the past and was not able to figure out whether the technical specifications were feasible or not. As a consequence, Customer decided to switch to another supplier both because the component did not match technical specifications and because the development of the hinge would have significantly delayed the launch of the freezer. Moreover, Refrigeration's Strategic Marketing came to consider the thinness of the chest freezer as a minor order winner and so a very specific and thin hinge was no longer needed. This project was a failure since component specifications were unstable, the supplier was not able to supply the component, and the product introduction was delayed. In addition, this project had negative effects on the customer-supplier relationship. Customer did not purchase any hinges from Supplier B. Consequently, the bad results of the project caused the final failure of the relationship.

4.3 Case C: packaging

In this case the supplier (hereinafter called Supplier C) provided Customer with the packaging for the chest freezer. The package has a relatively low impact on overall costs (3% of the overall cost) but significantly influences logistics costs. In addition, in the past the poor design of the packaging caused some damage to the final product which led to some product rejections and damage to the image of the firm. To reduce damage to the product, the engineering function decided to develop a new packaging concept that has very complex geometric relationships with the end-product, in effect tightening the end product to protect it from damage. The packaging was designed by Customer's engineering function. However, Customer decided to design the process for the production of the packaging with its suppliers since its engineering function was not very aware of the process technologies required. The plant that produces freezers is located in central Italy and, since the transportation cost of polystyrene packaging is very high, Customer selected Supplier C in central Italy as the producer for the packaging. Unfortunately, Supplier C had relatively low technical skills. So, Customer chose to develop the process for the packaging with a more skilled supplier located in northern Italy (near Customer's engineering function), while Supplier C was in charge of the production of the packaging. So the local supplier's and Customer's engineering functions, located in northern Italy, were co-designing the packaging that Supplier C (located in central Italy) was supposed to manufacture and Customer's plant (located in central Italy) was supposed to assemble. Customer

designed the new packaging and the local supplier developed the process on the basis of its technical capabilities. Unfortunately, though the component and process designs were consistent with the local supplier's machines, they were completely inconsistent with Supplier C's machines and Customer's assembly lines. It is interesting to note that in this case four organizations were involved and this provoked a weak link between the engineering functions (of Customer and the local supplier) and the production units (of Supplier C and Customer). This seems to be a major concern since on the one hand co-design aims to integrate different skills but, on the other hand, it aims to strengthen the relationships between Component specifications and the production process. Thus the packaging had to be completely re-designed to fit with the production plants at Supplier C and Customer in central Italy. In this case, the outputs of the co-design relationships were negative, indeed neither the component nor the products gained their initial goals (the defect rate was far higher than initial targets). In this case, though Customer kept a good relationship with both suppliers, Customer's managers recognised that the complex organizational structure of the relationship (four organisational units were involved – Customer's engineering function, Customer's plant, Supplier C, and the local supplier) caused significant problems. Thus, though the managers expect to develop partnership agreements with the two suppliers, they do not plan to adopt such a complex organization in the future.

4.4 Case D: freezer door

In case D the supplier (hereinafter called Supplier D) provided Customer with the internal freezer door which lies within the refrigerator. In this case the component is not very relevant in terms of costs (the freezer door accounts for about 2–3% of the overall cost of the refrigerator). However, it has a relevant impact on the technical performance of the final product. Indeed, it influences the insulation of the refrigerator and through that energy consumption, the temperature of the freezer, and ice generation. In addition, the design of the door is not independent from the design of the whole refrigerator. Not only does it influence several relevant performance criteria but it also has several geometrical relationships with the system (in terms of width, length, depth of the door, etc.). In this case the supplier provided the customer with the new process expertise (co-injection technology) that enabled them to change the concept of the freezer door and radically improve its performance. Once the new technological opportunity was identified, and process technology bounds were made explicit to Customer, the engineering function designed the new component. However, Supplier D technicians were often involved to verify the manufacturability of design features. In this case the Supplier was involved from the concept phase of the component, indeed the technological opportunity played a crucial role in defining the component concept.

The relationship was fruitful both for Supplier D and Customer. Customer was able to develop a new, cheaper, and better performing component. Moreover, the

new component development project was completed before the deadline. Thus the component contributed to the development of a good final product (the one door free-standing refrigerator). Consequently, Supplier D got a long-term contract. In addition both the supplier and the customer increased their mutual trust and relation-specific skills, so much so that they both think that they will be able to undertake better co-design projects in the future.

5 A taxonomy of co-design relationships

On the basis of the four case studies we found that co-design relationships can be quite heterogeneous. Although a wide array of variables characterise the co-design relationship, we focus our attention on two single-project levers that can have a significant impact on other features of the relationship (see Figure 3).

Know-how delivered in the relationship. The supplier might deliver either process know-how or product and process know-how. For example, while in the case of the ‘freezer door’ the supplier basically supplies process know-how (Customer’s technicians design the product), in case A the supplier designs and produces the lamp-holder on the basis of Customer’s functional specifications (thus providing both product and process know-how). This variable might be relevant since it influences the roles of the two parties and the time when the supplier is involved in the decision making process (e.g., see [14]). In addition, this variable is relevant since it determines the nature of the information exchanged between customer and supplier. In the case of process know-how, it relates to the component’s technical specifications and/or the process. In the case of product know-how, this relates instead to the functional specifications of the component. Finally different flows of information are supported by rather different exchange processes (in terms, for example, of frequency of the exchange of information, media, number and level of people involved) and different relationships (in terms, for example, of agreements, level of trust, ability to work together on partial information from the counterpart).

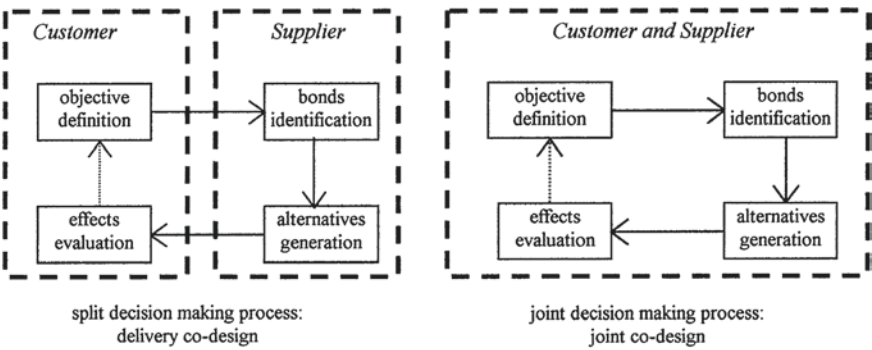


Figure 3 Different decision making processes in co-design relationships

Characteristics of the decision making process. The New Product Development process may be considered as a series of decision making processes. Nevertheless, as pointed out in the introduction, the literature has devoted little attention to the dynamics of decision making in co-design. In particular, co-design relationships may be classified according to the extent to which customers and suppliers jointly manage the different phases of the decision making process. In some cases, decision making is split and thus the supplier *delivers* the solution the customer has asked for. On the other hand, customers and suppliers may share all the phases of the decision making process (*joint* co-design). This variable can be very relevant when defining different kinds of co-design relationships [25]. Indeed, a joint decision making process asks for some pre-conditions about the relational situation such as mutual trust, and similar approaches to project management. In addition, a shared decision making process often requires a shared language, and a common knowledge (often built on previous experiences, see the model presented in Figure 2). For example, in case B the prototype for the new hinge was completely unsuccessful since Supplier B failed to identify the technical bonds that the customer had taken for granted. In this case, the lack of a shared language and knowledge instigated re-thinks in the project.

The *exchange of information* is very different in the two cases. In the *delivery relationships* the information tends to be codified. This often concerns technical specifications for the component and/or for the process, and the exchange of information tends to be relatively sporadic. In the case of *joint development relationships* there is a more continuous exchange of information that often is not completely codified. As a consequence, the method of communication changes accordingly. Indeed, a shared decision making process tends to require personal meetings to support a very comprehensive exchange of information (see case D and the first project for the development of a completely new lamp-holder platform). Delivery relationships, conversely, could rely on media such as telephone calls and e-mail (see the project for the marginal improvement and the customisation of the lamp-holder – case A).

The two previous single-project variables identify the following four different types of co-design relationships. Thus we suggest a classification that relies on the model presented in Section 3. As previously stated in our view these are all co-design relationships since in all of these cases the supplier provides the customer with customised know-how. However, we believe that recognising the differences in this relationship is a key point. On the one hand the deployment of managerial levers (especially single-project ones) can differ significantly. On the other hand, as discussed in the next section, different kinds of co-design relationships may suit different environmental and strategic conditions.

6 The role of uncertainty and of the relational environment: a contingent analysis

The previous section shows how co-design relationships may actually occur in different forms: four classes of co-design relationships have been proposed. One

might therefore investigate in which situation and context a given type of co-design relationship is most suitable. In particular, while the first dimension (characteristics of the know-how delivered) is an immediate consequence of the specific customer requirements (i.e., a new component or a new process technology), the second dimension (characteristics of the decision making process) calls for an explicit analysis of consistency. Indeed, choosing between a tight interaction (joint decision making) and a loose one (split decision making) is not simply a matter of intensity. Both types of relationships involve a co-design process and both of them may lead to success or failure depending on the design problem dealt with and on the implementation approach. As a matter of fact, in the case studies we observed both success (cases A and D) and failure (cases B and C). What is the reason behind these different outcomes of the co-design relationships? Our hypothesis is that failures are due to a mismatch between the type of co-design and the context of the relationship.

In this respect, the literature investigates the prerequisites and contextual factors that may support a tight or loose logistics integration (as opposed to new product development integration, i.e., co-design) within a partnership, including the degree of appropriability of the innovation, the complementary assets, the risk of imitation, etc. The four cases discussed in this paper shed light on the role played by two specific factors: the degree of uncertainty and the relational capabilities. The role of these factors is illustrated in Figure 5.

Uncertainty plays a major role in defining the intensity of interaction between the customer and the supplier. This uncertainty may be due to two major factors:

The novelty of the solution to be designed. This is related to the degree of innovation of the component (or the process technology) designed by the supplier and to the novelty of the end product in which the component has to be embedded. Uncertainty increases as new technological solutions are looked for and novel

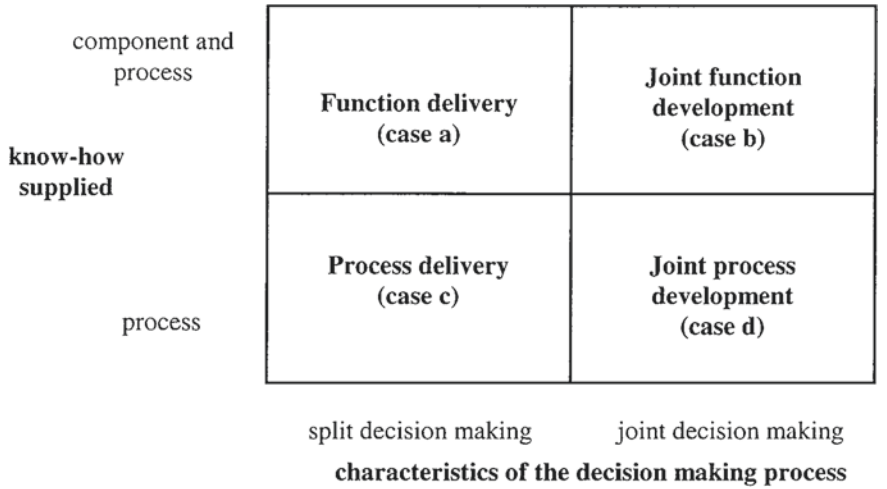


Figure 4 A taxonomy of co-design relationships

interfaces are developed between the component and the product architecture, thus requiring a tighter interaction between the partners.

Environmental turbulence. This is related to the dynamics of the project environment (the extent to which the requirements for the final customers are changed during the project; the chance that new technologies for the end product may emerge; requests for changes in the product architecture) and usually results in a significant instability in the technical specifications of the component. In highly turbulent environments therefore, the customer and the supplier must continuously adapt their design and have to continuously interact (see for example case B, where the concept evolved during the development of the hinge).

Our cases suggest that if partners enter into a co-design relationship in a highly uncertain context, a joint approach to co-design is required. Consider for example case B (hinge) and case D (freezer door). In both these cases the customer was looking for a major improvement in the component performance, on the basis of a fairly new design. Hence, complementary resources were jointly used and while setting the component specifications the customer considered the new opportunities that the supplier's technologies could offer. In other words, as already suggested in Figure 5, a joint decision making process was followed to deal with the high levels of uncertainty. In these cases, a delivery relationship would not have provided the necessary depth of interaction to master the turbulence of the environment and develop radically new solutions.

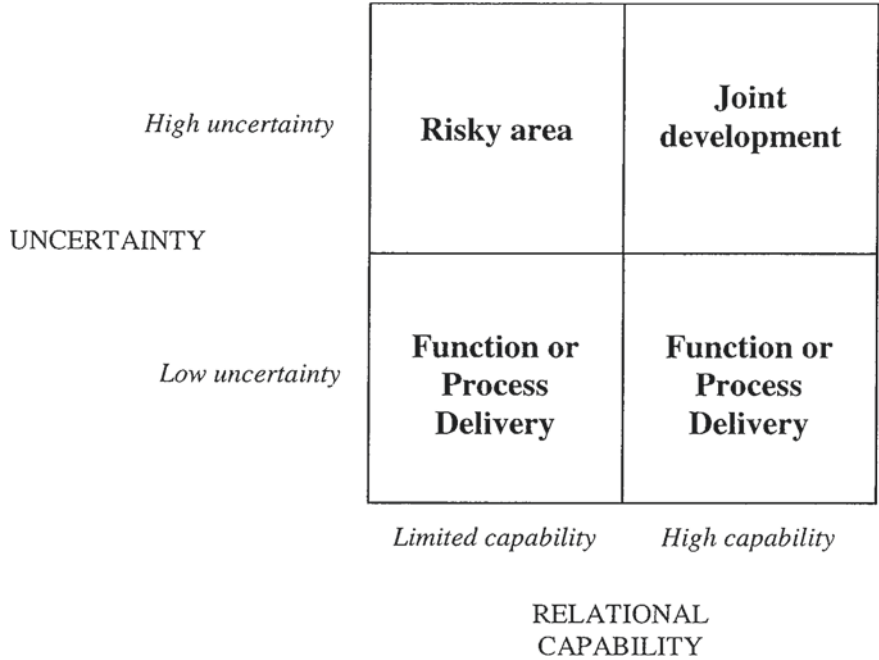


Figure 5 A contingent model of co-design relationships

The hypothesis that joint co-design is consistent with major innovations is further supported by case C, which was an unsuccessful undertaking. A major reason for design problems was that even though the customer was looking for a major re-definition of the packaging of the chest freezer, a split decision making process was undertaken. The local supplier from northern Italy was not able to anticipate the bonds of the process technologies of Supplier C, making the component design inconsistent both with the production process of the customer and with the assembly line of Supplier C.

On the other hand, case A (lamp-holder) shows that, when incremental improvements are sought, a split decision making process may be successful. In this case, the tight coordination and interaction of joint development is an unnecessary cost for achieving minor innovations or improvements. In addition, it would divert the project team and management support from more crucial and risky co-design undertakings.

Uncertainty is not the only contextual factor to be considered when choosing the co-design approach. Indeed, while both projects D and B followed a joint development approach, the former turned into a success and the latter failed.

The reason for the failure of project B has to be found in the second dimension of our model: the relational capability. As previously said, a joint decision making process asks for higher capabilities, in terms of relational knowledge, mutual trust, project management skills, teamwork and dedicated assets. These capabilities are a prerequisite for making a close interaction between customer and supplier successful. Project B lacked these prerequisites. Supplier B had never worked with the refrigeration business unit, and new behavioural patterns had to be developed, which did not happen quickly enough. Put simply, the customer and the supplier did not have the necessary basis to work closely together. In other words, case B is located in the upper left area of the matrix in Figure 4. This case suggests that though the joint approach might seem to be a more promising alternative, it does not always guarantee better performance than the delivery relationship. The former is much more complex and calls for careful implementation and for high relational capabilities.

Relational capabilities depend mainly on the relational environment and practices, which is often a consequence of previous co-design undertakings (see Figure 2). They are therefore generated through multi-project levers (such as dedicated technologies and investments, or the knowledge of the mutual patterns of communication). These capabilities evolve over time and are specific to a particular relationship (in other words, they vary as different pairs of customer-suppliers are considered). The dynamic growth (or atrophy) of the relational capabilities make the joint development approach a viable option in cases of radical improvements in the design.

However, it may happen that a novel design is needed, therefore requiring joint development even though relational capabilities are poor. This occurred for example in case D. This project is located in the upper left corner of our model as well (see Figure 5). The customer and the supplier had never cooperated before. Indeed, while the managers of both companies recognised the need for joint development (given the novelty of the solution to be developed) they also acknowledged the lack of relational capabilities required for this approach. This explicit understanding of the relational environment led the managers to invest

in coordination and integration not only to properly design the component, but also to build up a new relationship. In other words, they acted on single-project levers (such as dedicated supplier engineers, top management support, additional resources when needed) to compensate for the lack of relational capabilities at the project outset.

Cases B, C and D therefore show that high uncertainty calls for a joint approach, which is a viable option if outstanding relational capabilities have already been developed, or a risky option (i.e. it requires much more attention and effort) if these capabilities are initially weak. As a consequence, a joint approach may be adopted only in a limited number of situations, given the amount of resources and support from the top management it requires.

On the other hand, case A shows that once high relational capabilities are achieved (in a previous project the customer and Supplier A re-designed the overall family of lamp-holders for the Refrigeration Business Unit), a wider set of options are disclosed, ranging from split problem solving (when uncertainty is low) to joint problem solving (when uncertainty is high).

7 Conclusions

This paper shows that co-design relationships may occur in different forms and that the success of supplier involvement in product development mainly depends on the proper choice of the type of relationship according to the contingencies to be dealt with.

In particular, by adopting a decision making perspective to investigate design processes, we have identified four different approaches to co-design, depending on the type of knowledge transferred from the supplier to the customer (product knowledge or process knowledge) and the degree of interaction between the partners. In this latter regard, a co-design relationship may occur with a loose interaction (when the customer defines the component specifications and the supplier designs the solution that better fits those specifications) or a tight interaction (when the problem solving process is not split between the partners).

We have also shown how the choice between a joint or split co-design approach depends (among others) on two contextual factors: the uncertainty of the design endeavour (i.e., the novelty of the component to be developed and the turbulence of the environment) and the relational capabilities (i.e., the capabilities to manage the information flows occurring between the two patterns). High uncertainty calls for a joint co-design process, which, however, requires high relational capabilities (or, if these are lacking, a great deal of coordination effort being deployed). High relational capabilities, on the other side, allow a wider set of design approaches to be adopted, according to the design context to be dealt with.

Two major implications emerge from the findings and models discussed in this paper. The first one is a managerial implication, which concerns the choice and implementation of a co-design relationship. In this regard most product development management models (and most managerial practices) are mainly focused on

whether to implement a co-design relationship or not, assuming this relationship may take a unique form the major problem is how far to push the partnership. In other words, most models assume that there is an 'intensity' in a co-design relationship, and the more intense the relationship is the better. This paper, instead, shows that there are actually different forms of co-design relationships, and neither of them could be considered 'the best way'. All of these forms may be equally successful or unsuccessful depending on their fit with the project context and their implementation. For example, while apparently a joint relationship could seem a better choice, since it implies a closer interaction and exchange of information between the partners, it also involves a far larger amount of resources and effort, calls for dedicated and specific assets and, most of all, asks for higher relational capabilities. In several cases a split decision making process is more suitable, efficient and effective.

As far as implications for theory and research are concerned, this paper demonstrates that co-design relationships must be investigated (and managed) dynamically: the success of a given co-design project depends on previous experiences, which are an intrinsic characteristic of a relationship (i.e., they are not a characteristic of a single partner). There is therefore a feedback linkage between co-design performance and design management levers (especially at the multi-project level). Scholars have often overlooked these dynamics in co-design relationships since their models are mostly based on static observations (i.e., data on a co-design project at a given moment in time). Instead, this feedback effect calls for a deeper investigation and understanding of the factors of success in co-design relationships considering also the influence of previous relational experiences. This, however, requires a different approach to empirical investigation, one with more observations based on longitudinal studies.

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- 24 In the co-stamp technology the electrical connections are stamped in the plastic component. Thus there is no need to add wires while assembling the product.
- 25 It is worth noting that this variable is not completely overlapping at the time when the supplier is involved (which was suggested by prior literature on this topic). Indeed, both a split and a joint decision making process might take place even at the early phases of the project.

5.2 Review and Outlook

5.2.1 *The Context*

This work dates back to the early 2000s and is part of a debate that has involved academic scholars for over two decades. Within this debate on co-development we can recognize several investigative streams that have gradually converged.

The first stream relates to the studies on just-in-time purchasing (JIT-P) in the mid-80s, described mainly by Schonberger (1982, 1986), Hall (1983) and Ansari and Moddarres (1988). These studies focused on the logistics process: the JIT approach requires rigorous control and synchronization of entry flows and therefore reconfigures the customer–supplier connection. The “early involvement of the supplier in the design and product/process development” was mentioned amongst JIT-P practices, as well as some other related aspects (“information sharing”, “joint value analysis programmes” and “standardized packaging”). According to this perspective, however, co-development was considered to be little more than a specific management practice, which enabled cutting the time required to get goods to the market place and speeding up the flow of materials.

The second stream—mainly based on the works of Clark (1989), together with Fujimoto (1991) and Wheelwright (1992) in the late '80s—focused on the product development process. These authors regarded new product development as a set of problem-solving and information-processing scenario activities, within which the management challenge was to establish organizational structures and practices to ensure the adequate integration of diverse skills, including providing information and knowledge to—and between—suppliers and customers. Each supplier would be involved at different levels, based on the amount of design content, the complexity and technology of a specific item and the kind of the information shared.

These two streams of study, the first focused on the (synchronous) logistical links and the second focused on the (a-synchronous) collaboration in product development, converged in the '90s. During this decade, the Toyota model and “new” management systems dominated scientific debate in the field of operations. JIT, total quality management (TQM) and concurrent engineering (CE)—key pillars of the Toyota Production System—are all approaches that modified and extended traditional customer–supplier interactions (“lean supply”). In this context, co-development was framed as a set of management practices and tools not (only) related to a single process or to some functional interfaces, but forming part of an operations model extending beyond the plant boundaries.

In addition, the relevant relational implications of co-development began to be investigated in greater depth. The co-development process is bi-directional and interactive, at least partially tacit and intangible and cannot entirely be codified ex-ante and therefore measured ex-post. In addition, it involves a variety of specific assets. Thus, such kind of exchange requires relational forms and contractual arrangements quite different when compared to the traditional (antagonistic) ones.

Ultimately, this third line of enquiry examined co-development within that cluster of interdependent, cross-functional and inter-organizational methodologies and tools conventionally called *lean* management.

5.2.2 The Study

Notwithstanding the considerable amount of research on co-development emerging from studies on lean issues, a number of questions were still under discussion at the beginning of this millennium. The concept of co-development was still rather vague at that time and continued to be considered—as Gianluca Spina, Roberto Verganti and Giulio Zotteri wrote—as *shades of grey* rather than *a matter of colours*. Feasible forms of co-development were still unclear. In addition, the associated contingencies—that is, the contextual factors that signposted specific forms of co-development—were still largely unexplored. As a result, co-development tended to be described as a sort of “best practice”, independent of the context in which it was applied. Moreover, the most relevant experiences documented in the literature concerned the automotive industry, in which there was great need for experimentation and analysis, as was the case in other sectors.

As far as methodology is concerned, the instruments used for empirical investigation—in particular, surveys—reflected these conceptual weaknesses. The co-development construct was usually operationalized via few dimensions, which were in turn translated into perceptual and rather elementary items. The point of view of the supplier was often given little consideration due to the difficulty of defining consistent criteria for measurement. Taking into account this gap in the literature, the objectives of this study were precisely to provide a taxonomy of co-developmental relationships and to identify contingencies that would influence the implementation of specific forms of such relationships.

The theoretical and methodological framework of the study merits some remarks.

The conceptual background starts with the definition of co-development. The authors used two variables—the know-how exchanged and the specificity of the transacted good (Fig. 1)—to identify a first broad range of design solution exchanges. The co-development construct is thus delimited to the quadrant characterized by an innovative and specific exchange (“the supply of customised innovation”); here the authors wished to explore in greater depth possible forms of exchange. Then, the dimensions of analysis and the hypothesized relationships are pointed out (Fig. 2). The conceptual framework uses input variables (single and multi-project levers), output variables (product/component performance and relational climate) and contextual factors (strategy and environment). Compared to previous lever-performance models, this framework is characterized by the variety and nature of the levers considered (to characterize “the technical and organizational situation”) and the classification of these (“*una tantum*” and single project levers). In addition, the “relational climate” is considered here to be both the result

(output) and the premise (input) of subsequent projects. In this way, the relational context is analysed in a dynamic and at least partially longitudinal (retrospective) approach. To better identify and qualify some of these contextual variables, specifically those related to decision making in situations governed by uncertainty, the theories of transaction cost analysis and managerial decision making are used.

The exploratory nature and the complexity of the topic did not permit the application of “standard” investigation tools. The object of analysis was not merely practices, but also the non-material content (“the transacted good is the know-how and not just the manpower needed”), as well as the business and relational environment, which evolves over time and which cannot be codified a priori. Therefore, the study adopted a case study methodology. The unit of analysis was the single co-development project. The choice of the research population—companies in which such projects could be analysed—would have been quite challenging. The choice had to include an adequate variety of situations as compared to the number of research dimensions, but also needed to enable contrast between different situations. Four different projects belonging to a business unit of a (multinational) firm were selected. These projects differed in terms of transacted goods, the characteristics of suppliers and the relational environment, but their commonality in terms of the organization made it possible to control the results against a multiplicity of possible intervening factors (industry, level of vertical integration, purchasing strategy, etc.).

The industry was also carefully selected. The appliance industry is characterized by large-scale manufacturing and parts assembly, as in the automotive industry. Unlike the latter, however, the appliance industry exhibits a much wider variety of products and a shorter life cycle. It is therefore particularly suited to gaining insight into issues in co-development.

5.2.3 The Contribution

The cross-case analysis points to a taxonomy of co-design relationships structured in four types according to two variables: the know-how supplied and the characteristics of the decision-making process. The first variable, already used to define the co-development concept, is also useful for identifying specific additional forms. The second variable refers to the intensity (content) and kind of interaction (split or joint decision making). Based on the results of the projects analysed (two successes and two failures), the authors formulated a further hypothesis: failures are due to a mismatch between the type of co-design and the context of the relationship. The latter can in turn be characterized in terms of uncertainty and relational capability.

Because of its unconventional theoretical and methodological approach, this work has been able to make a significant contribution to the advancement of knowledge in various directions. First, the concept of co-design is defined and distinguished from similar forms. In addition, the authors have identified some

contextual variables either ignored or underestimated by previous research. Among these variables, the relational environment, its evolution and the resulting effects of path dependency play a key role.

Over the inter-temporal horizon of analysis, the most important decisions during the product development process are tracked and their consequences are evaluated. While previous research often provided static and stylized descriptions of the product development process, here a broad investigative perspective strongly anchored to the context and to the dynamics of the situation has been adopted.

Finally, on the basis of the contextual variables identified, the authors describe four approaches to co-design. There is therefore no longer “*a unique form*”, a best way, but rather a way that depends on the specific circumstances. Thus, the fit between the characteristics of the project and the relational modalities becomes even more important to achieve matches between all the relevant technological, organizational and managerial aspects. The theme of fit is central in almost every management ambit. It is due to the work of these authors that this theme was re-launched in the co-development field.

In conclusion, this study demonstrates that co-development relationships may take many forms and “that the success of supplier involvement in product development mainly depends on the proper choice of the type of relationships according to the contingencies to be dealt with”. In so doing, it opens up the way for extensive future research.

5.2.4 *The Heritage*

The work of Spina et al. has been adopted and cited by several other studies that have tested and expanded the contingencies and the typologies proposed here. In addition to the studies that explicitly cite this work, a more implicit but perhaps more relevant cultural heritage can be pointed out.

The work clearly shows the need for a situational understanding of the product development process, in other words, the need to explain the “phenomenon” from a situational point of view. Companies operate in different environments and exhibit peculiar organizational characteristics with unique histories. This is especially true in product development: each project has its own genesis and development, combining different knowledge and skills, which are variously distributed amongst internal and external organizational units. Each project constitutes a synthesis between market needs, technological opportunities and economic and constructive constraints. All these factors in turn depend on the specific inter-organizational context, as well as on time requirements. Thus, product development, a process that is structurally non-repetitive, exhibits strong idiosyncratic features.

This apparently obvious statement has important consequences, both for research methodology and management practice. On the methodological side, the study reinstated a qualitative, longitudinal, in-the-field research approach,

strongly oriented towards situational factors. On the managerial side, it follows that there is no one way to look at product development and collaboration processes. Companies need to adapt to the most relevant aspects of their environments to adopt those management approaches and organizational structures that better achieve this fit. This is the key message of the study.

If we look at the evolution that product development has undergone in recent years, we can better appreciate the great importance that the authors accorded the main situational feature: the relational environment. Today, the environment in which co-design takes place has dramatically expanded. It no longer merely involves suppliers, but also direct and indirect customers, complementary businesses, service providers, even communities of practice. All these groups are players and web-based interaction between them is the norm nowadays, with constant real-time connections provided by mobile communications technology enabling co-development from inception right through to the final consumption stage.

This open-to-innovation habitat co-evolves together with the businesses and the actors who inhabit it. A metaphor that recurs in current literature is “eco-system”. At a biological level, an eco-system is a community of different species in a given space, which in turn works as an active support for the community itself. In this space, companies co-evolve through a dense network of cooperative and competitive relationships, different technologies converge and product and service development is—to some extent—the combined effort of a varied population of professionals, users and service providers. The most direct example is probably that of the computing eco-system, which includes the software and significant segments of the hardware industries, but extends into many other industries.

It is within such a composite relational platform that product development processes take place today. The management of this platform is not just a matter of practices and technicalities, but rather a matter of construction and co-evolution of the social and technological environments.

In a nutshell, these aspects can be recognized in the work of Spina et al. The co-design context that the authors describe is a relational environment populated not only by suppliers and customers, but also manufacturers, distributors and final consumers, all operating in various industries. This environment is explored in its breadth, its complexity and in its evolution, precisely in order to gain a better understanding of the phenomenon under study. After 15 years, this work remains topical and continues to be a methodological reference.

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