Towards a Reliability Diagnosis for Servitization Decision-making Process

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Abstract

Servitization decision process is characterized by a high degree of complexity and uncertainty. We propose a diagnosis approach applied to servitization decision making process in industrial companies. We introduce a decision model to formalize the servitization process and a decision reliability assessment approach. This reliability assessment is interpreted from three viewpoints, to help decision-makers in managing

Keywords: servitization; decision process; reliability

Introduction

During recent decades, we have witnessed a development and an expansion of servitization and Product Service System (PSS) concepts in industrial and economic fields. Servitization involves the substitution of a product offering by a service offering. In many advanced economies, servitization is thought of as a development approach capable of providing opportunities for achieving sustainability, improving enterprise competitiveness, and better satisfying customer needs [1]. Nevertheless, turning to this new paradigm requires questioning business and organization roles and goals. In addition to technical and functional aspects, PSS are also based on organizational aspects, which introduce an additional difficulty in the implementation of this concept in businesses [2]. Consequently, transitioning from a product manufacturer into a service provider constitutes a risky managerial challenge [3]. It involves the company in a dynamic and complex decision-making process.
This research work focuses on the transition in industrial companies towards the integration of service strategies.
Previous state of the art and research developed in [4] have underlined the lack of methods or approaches to support the management of servitization from a decisional point of view. This paper intends to address this issue, with a contribution aiming at modeling, then diagnosing the way a servitization decision process is managed within a company.
To build this contribution we introduce below a formal method of describing the servitization decision process, and we introduce a decision reliability assessment procedure.
This decision reliability assessment will be further used to help decision-makers in managing the servitisation process. The diagnosis methodology will be illustrated through a case study of a French SME which is currently conducting a servitization transition.
This paper consists of three main parts. First, we introduce the basics of the servitization process and reliability notion. In the second part, we explain the decision modelling we propose, and introduce the illustrative case study. Finally, the aim of the third part is to illustrate our approach to reliability assessment and diagnosis in the servitization decision process though conceptual and practical analysis.

I. Preamble : servitisation decision-process and notions of reliability

1.1 Servitization decision process

Servitization can be understood and formalized as a complex decision process for enterprise transformation. On the basis of a bibliographic analysis [3][5][6] and experience feedbacks from different leaders of industrial companies trying to make the servitization transition, we decided to break the global servitization process down into 3 decisional issues which cover key dimensions of the business transformation [4]: **1.** The product service system (PSS) technical design; **2.** The PSS business model transformation; and **3.** The organizational changes required to support the PSS implementation.

Each of these decisional issues contributes to redesigning the positioning of the company in its ecosystem. Indeed, the first decision issue represented emphasizes the services' intangible nature; service delivery requires a delicate process of value proposition [5]. The second issue encountered in the servitization process is to predict market behavior vis-à-vis this new offering. Therefore, servitization leads consideration of a new form of competition outside the usual expected rivals [1]. In addition, the third issue considers the adaptation of organizational structures and processes necessary for ensuring congruence between their resources and capabilities implementing this new strategy [6].

We consider these decisional issues as decision macro-processes (MP): MP1: the product service system (PSS) technical design; MP2: the PSS business model transformation; MP3: the Organizational changes, required to support PSS implementation. Thus, the transformation of a manufacturing company to a product service organization confronts a set of challenges that we consider included within these three MP.

1.2 Notions of decision reliability

To define the concept of decision reliability, we refer to Simon's researches on procedural rationality. In this approach, Simon has identified procedural rationality as an important information processing and decision-making approach. Procedural rationality is *"problem solving by recognition, by heuristic search, and by pattern recognition and extrapolation [...]. They are not optimizing techniques, but methods for arriving at satisfactory solutions with modest amounts of computation"* [7]. Dean and Sharfman [8] later redefined procedural rationality as *"the extent to which the decision process involves the collection of information relevant to the decision, and the reliance upon analysis of this information in making the choice."* [9].

In the context of servitization decision process, we evaluate decision reliability according to the concept of procedural rationality. Our aim is to evaluate the procedural rationality of the decision maker through evaluating the reliability of the decisions made; our final purpose is to identify the least reliable areas of the decision process.

In order to evaluate the decision reliability we consider a theoretical reference model (i.e. a reference model providing a representation of the whole servitization decisional process) which reflects a "reference optimal procedural rationality", and which is complete in terms of:

- Presence of decision activities and their "state results" respectively ;
- Presence of the essential elements of the decision activity , "objective" and "decision variables";
- Presence of the Support elements of the decision activity "information", "necessary resources" and "constraints" ;
- And, presence of the trigger / origin status of the decision activity "input".

Thus, decision reliability is considered here as an estimator of the proximity between (i) a reference decision-making process known and modeled a priori and (ii) an effective decision-making process, followed by decision-makers according to a real case study.

II. Servitization decision process model

Before introducing the formalization of evaluation of decision reliability, it is necessary, first of all, to introduce the formalism used to represent the servitization decision process. This model has been fully explained in [4]: we simply provide here a short summary (section 2.1). In section 2.2 we introduce the industrial case study further used in the paper.

2.1 Decision process model

We propose a model that considers the complexity of the servitization decision process. This approach is inspired by the GRAI modeling formalism [10] and is represented through the servitization grid (in figure.1).

To build this model, we represent the decision making process along two axes. The vertical axis represents the decision horizons: long, medium and short terms. This aspect of the decision clarifies crossing from high strategic-decision levels to tactical and operational ones. The horizontal axis is related to three decision macro-processes described above: MP1, MP2, and MP3.

The intersection between a decision macro process and a decision horizon represents a decision center (DC). The model results in a matrix containing 12 decision centers (figure.1). Every decision center is composed of nets of decision activities, and every decision activity (DA) is represented through critical characteristics, which are differentiated according to the type of the decision activity considered. Two generic types of decision activities are distinguished: decisional activities (noted D-DA, with outputs constituted by decisions), or execution activity (noted E-DA with outputs constituted by simple information). This model enables understanding of the complexity of the overall transition process and identifying different interactions within the system. In addition, the servitization grid makes it possible to differentiate the granularity level of the decision process from strategic to operational level and from general to particular within each DC.

The reference model we propose has been built on the basis of an extensive literature study, then discussed and validated according to a qualitative approach of experiences feedback analysis with manufacturers and scientists from different fields. As part of a national consortium project (ServINNOV), we held regular workshops with scientists and business leaders, to revise and validate the reference model and to improve its flexibility.

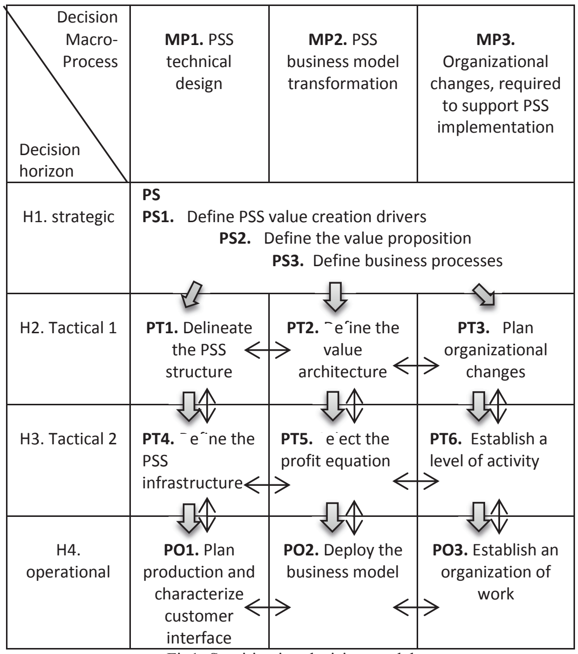

Fig1 Servitization decision model

2.2 Industrial case study General presentation

In order to illustrate our approach, we propose an application on a case study of a French SME named Ecobel. The company's main activity is the manufacturing, sale and installation of shower heads based on an innovative technique that allows water savings and protection from legionella. Its current market considers establishments receiving general public like hospitals, campsites clubs…etc. Ecobel is planning to propose a service oriented offer, so it has initiated a debate on the implementation of servitization. This case study has aroused our interest for its positioning in the transition process. Indeed, Ecobel currently offers two models simultaneously: the classic range selling only the showerhead product and the integrated PSS offer selling reliable showerheads over 5 years. The PSS offer includes service contracts for regular maintenance and periodic exchange of the showerhead product with a visual identification. Ecobel's leader highlights the difficulty of placing it on the market. The main barriers to the commercialization of the proposed PSS lie in the difficulty of measuring its value and in convincing potential customers of that value. Ecobel remains cautious about the development of the servitization model over its entire range.

III. Reliability diagnosis in servitization process

The decision model introduced in section 2.1 provides a formalized model of decisional activities. We use it to develop a reliability assessment method applied to the overall decision process.

3.1 Definition, formalization and evaluation of decision reliability

We have defined reliability as the proximity of the reference decision making process to the actual process. To estimate this proximity, the proposed approach consists in:

• Characterizing in detail the servitization processes through decision- activities of the reference model;

• Assessing qualitatively whether the different features of the reference model are present or not in the actual decision making process;

• Aggregating the first level of assessment to measure the decision-making reliability at the decision activities and decision centers of the grid.

As specified above, the servitization decision activities are formalized using GRAI modeling formalism [4] and include compounds of decision activities (D-DA and E-DA). In order to build the proximity measures mentioned, the decision-making activities are modeled in detail through a set of "decision-making characteristics" and "decision attributes", each attribute being associated with a "reliability coefficient". Thus the conceptual modeling of the reference decision-making activity is as follows:

D-DA_k, E-DA_k = $\{ C_i \}_{i=1 \text{ to } n}$ with C_i = decision making reference characteristics

C_i = {name, description, $\{A_j, Coef_j\}_{j=1 \text{ to } m)}$ with

A_j = decision attributes

$Coef_j$ = Reliability coefficient associated to A_j

Referring to the GRAI method, we describe the decision activities (D-DA) by seven reference characteristics and execution activities (E-DA) only by five characteristics. The specific attributes of each characteristic have been identified in the reference model by detailed analysis of each specific activity of the servitization model.

We construct descriptive detailed tables for every DA, this enables to determine the "reliability coefficients", which are fixed a priori for each attribute. These coefficients are determined in order to estimate an optimal reliability for each decision activity equal to 1, when effective decision activity has the same attributes as the reference decision activity (known by the servitization model). To determine these coefficients for each decision activity, the optimal reliability of 1 is equidistributed on the different characteristics C_i: this distribution provides a reliability coefficient of 1/7 for each C_i of D-DA and 1/5 for each C_i of E-DA. This coefficient is itself equidistributed among all the "attributes" components of the "decision-making characteristic", which represents the "reliability coefficient".

For example, within the D-DA_1 Є PT2 (BM, MT1) "Developing the internal value chain," there are 17 attributes, each characterized by its reliability coefficient:

- D-DA_1 = $\{C_1, C_2, C_3, C_4, C_5, C_6, C_7\}$
- C_1 = {input, description of incoming information from the decision-making activity, $\{(A_1$ = components of the internal value chain, $Coef_1 = 1/14)$, $(A_2$ = characteristics of the internal value chain, $Coef_2 = 1/14)\}$

Once the decision activities and the reliability coefficients are determined for the entire servitization reference model, they can be used to estimate the proximity between the

reference decision process and the actual one.
This assessment requires collecting information from the decision makers involved, and describing fairly precisely how they work: first identifying whether each of the decision activities of the servitization reference model was performed or not, then in more detail depending on whether each of the attributes characterizing these activities is present or not in the actual process followed by the decision maker. We represent this measure through a binary indicator of presence (1) or absence (0) for every "decision reference attribute" in the firm's effective decision making process: the proximity between the effective decision process and the reference one is estimated according to the absence or presence of these attributes that describe how to decide.
To formalize this notion, it is necessary to complete the conceptual model of the decision-making activity, first by adding an index of presence / absence for each decision attribute, and a reliability estimator F_i for the decision activity. For an effective decision-making process, the activity is described by:

D-DA_k, E-DA_k = {(C_i) = 1 to n, F_k} with F_k = reliability estimator of the DA_k ; C_i = {name, description, (A_j, $Coef_j$, Ind_j) j = 1 to k}, with Ind_j = presence / absence index for A_j; with Ind_j = 1 if A_j is present; 0 otherwise.

The decision-making reliability F_k for DA_k is obtained by aggregating a simple sum of the reliability coefficients, taking into account the index of presence / absence for each of them:

$$F_k = \sum_{i,j=1}^{k}\left(Ind_j \times Coef_i\right)$$

F_k =0 if no decision attribute is present; It is a lack of decision activity detected in advance normally.
F_k =1 if all decision reference attributes are present in the actual decision-making process; It refers to a situation when the decision maker proceeds by following closely the reference decision process.

3.2 The servitization decision process diagnosis approach

In the previous section, we proposed an approach by formalization and evaluation of the decision reliability concept. Systemic vision shows that the reliability of any system depends on the reliability of its components, and their relationships among others. Applied to the servitisation decision-making context, we call servitization process reliability "the probability of achieving a set of decision activities, within limits consistent with the goals of the servitization process". We also assume that an "unreliable" decision activity carries a failure potential for the whole process.
In our research context, we propose to carry out the reliability diagnosis of the servitization decision process, defining three stages corresponding to complementary perspectives for the diagnosis. These diagnosis stages are based on (table.1):

Table 1. Analysis levels

Level	Perspective of Analysis	Interest
1	Reliability assessment on decision activities	Submitting a macroscopic view of the process at t_1
2	Reliability assessment on decision horizons and decision macro processes	Highlighting priority axes for action
3	Aggregated reliability assessment on decision centers	Explaining the identified weaknesses through a detailed analysis of DA

<u>Reliability assessment and diagnosis of decision activities</u>

This analysis viewpoint aims to present a general state of the servitization process accomplished by the firm at time t_1. The evaluated reliability at each DA is represented using a radar diagram. It represents a general map for establishing reliabilities of DA, and then for reaching a conclusion about monitoring servitization process as instants (t_1, t_2, t_3).
The advantage of this analysis viewpoint is to provide a global understanding of the process advancement of servitization. The purpose is to establish a macroscopic mapping of the reliability of the process according to the reliabilities of all DA.

Table 2. Distribution of reliabilities among intervals

Reliability intervals	interpretations	Proportion of DA in the servitization process
0	DA unreliable	6.25%
] 0 ; 0 3]	DA with very low reliability	10.42%
] 0 3 ; 0.6]	DA with low reliability	14.58%
] 0.6 ; 0.9]	DA with average reliability	60.42%
] 0.9 ; 1]	reliable DA	8.33%

Additionally to the overall graphical map, we classify the DA of the process according to different reliability intervals (table 2). The reliability intervals are predetermined, making possible to identify the proportion of DA unreliable; with: very low reliability, low reliability, average reliability and the reliable DA.
We notice that for Ecobel, only 8% of the accomplished servitiazation process is considered reliable. More than 30% of the decision process is considered under the average of reliability.

<u>Reliability assessment and diagnosis of action priorities</u>

This analysis viewpoint aims at assessing the decision reliability at the grid's lines (figure 2) and columns (figure 3). This allows evaluation of the decision-making process according to servitization decision horizons (strategic, tactical and operational) and macro-processes. We construct a reliability graph analysis on decision horizons, counting on each decision horizon the proportion of decision activities with different levels of reliability (figure 2); and a graph of reliability for each MP, by counting the proportion of decision activities with different levels of reliability (figure 3). The decision horizons analysis allows taking into account the horizontal consistency of the servitization grid, which distinguishes horizontal information flows among distinct macro-processes. This helps to identify weaknesses in the decision process according to the defined horizons, and enable therefore to adopt different action measures. The purpose of the decision MP analysis is to highlight the vertical consistency of the servitization process. It reflects the relevance of the intra macro process exchanges in the grid. This will provide information on the internal consistency at each macro process and highlight the sources of internal failure of a specific MP.

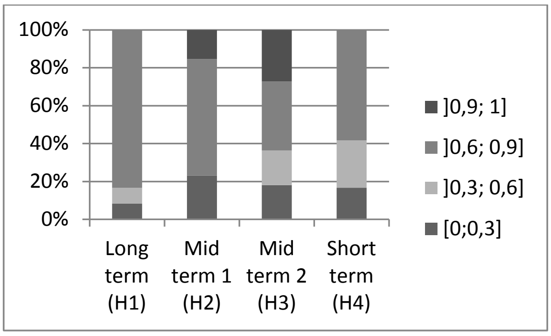

Fig 2 Reliability diagnosis on decision horizons

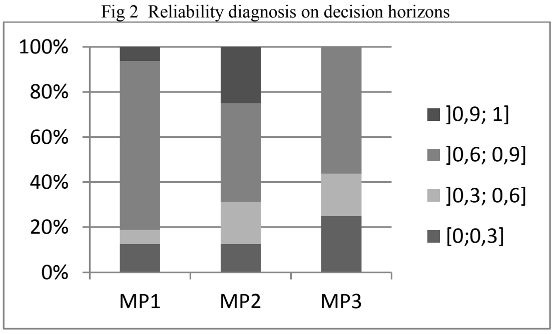

Fig 3 Reliability diagnosis on decision macro processes

Thus, the proposed diagrams are used to locate the weaknesses previously outlined in the first level of decision diagnosis.

The first diagram (figure 2) shows that Ecobel's servitization process is marked by a concentration of DA with low and very low reliabilities at the medium horizon. We deduce that Ecobel's servitization decision process would encounter significant weaknesses with tactical decisions.

The second graph (figure 3) shows that for Ecobel, MP3 is marked by a high proportion of DA with very low and low reliability compared to MP1 and MP2. We deduce that the weaknesses of the process are highly concentrated in the MP3 responsible for "organizational transformations specific to PSS".

The synthesis we conclude for Ecobel, from this second part of the diagnosis, is that process weaknesses are more concentrated in the medium term 1 horizon and in the MP3 "organizational transformations specific to PSS". These axes are then considered as carriers of the highest potential of failure. They represent the action priorities on which decision maker should concentrate.

Reliability assessment and diagnosis on decision centers:

This analysis perspective is about to provide the decision maker with a reliability estimation at each decision center of the grid. For that purpose, we provide the decision-maker with two useful indicators:

- F_{ij}^{DC} = Estimate the reliability of the decision center for the decision horizon i and Macro process j. This estimate is provided by the lowest reliability F_k for DA_k among all decision activities of a DC_{ij}.

$$DC_{\substack{ij \\ i=1\ to\ 3 \\ j=1\ to\ 4}} = \{(DA_{k_{k=1\ to\ n}};\ F_k);\ F_{DC}\}$$

$$F^{DC}_{\substack{ij \\ i=1à3 \\ j=1à4}} = Min\ F_{k,i,j}$$

- $N_{ij;\ F0}$= Number of decision activities not taken into account by the decision maker within a DC_{ij}.

Regarding the diagnosis of decision centers, we try to identify the decision centers that carry a potential risk of failure: by low reliability of one or more of the decision activities, or by not realizing some of the decision activities. The results interpretation in this analysis perspective is based on arbitration that takes into account simultaneously both of indicators (F_{ij}^{DC} and $N_{ij;\ F0}$), and thus prioritizes the DC on which we must act according to the importance of the potential failure revealed by the indicators.

We proceed to the classification of all DC according to the pre-established reliability intervals and also emphasizing the DC with $N_{ij;\ F0} > 0$.

This classification shows that half of DC in the decision-making process accomplished by Ecobel are divided between "very low reliability" and "unreliable". This locates the weaknesses previously identified in steps 1 and 2 more clearly.

DC with $N_{ij;\ F0} > 0$ are considered as unreliable. For Ecobel, PT3 responsible for planning the organizational changes includes this category. DC with "low" and "very low reliability" represent DC whose essential elements attributes are marked by a considerable absence. These DC are for the most part concentrated within the tactical and operational decision horizon, which confirms the tactical problems identified in the second level of analysis, and focuses especially on the MP3 and MP2. DC with "average reliability" represent DC whose decision support elements are very limited.

From this distribution, we proceed to prioritize the DC to deal with, and then to detail the analysis of each DC in terms of DA. Then we can draw three kinds of general conclusions / remediation according to the predefined reliability intervals for DC and to the importance given to each DA:

- First, for unreliable DC, which include ignored DA, remediation would be turned to awareness raising and training effort for the decision maker with respect to the issues ignored. This may have significant impact on the long-term performance of the firm.

- As for DC with “very low reliability” and “low reliability” , they show that DA were actually treated, but decision maker often referred to an intuitive decision-making process strongly influenced by the initial organizational model.
  Moreover, in order to improve the reliability of these DA, remediation would demand efforts to analyze, anticipate, and in particular to change dominant decision models in the business.
- Finally, DC with average reliability show that DA have been processed and analyzed, but the problem lies in the lack of resources for carrying out these decisions. The remediation effort will be directed more towards an allocation of resources in terms of competencies and investment for providing the additional information necessary for these decisions.

Conclusion

This diagnosis approach we propose aims at assisting decision makers to control the servitization process through recommendations. The diagnosis highlights areas of weakness in the accomplished decision process in order to make recommendations in terms of actions and improvements of the process. The decision-maker remains the only one who can take appropriate decisions: the method merely enables guidance for these choices and facilitates their prioritization. The main perspective of this work is to integrate the reliability assessment method and diagnosis within a risk analysis approach applied to servitization decision process. When the full risk analysis will be available, one of the perspectives is to develop a benchmark of the approach to compare it with the results of other decision supports provided in the literature, in the field of servitization.

Acknowledgements

The authors would like to thank all the members of the Servinnov ANR project for their support and insightful comments. We would also like to thank Mr. Bosles (Ecobel’s leader) for his time and for making his experience available to us in our research.

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