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THE MANUFACTURER'S SERVITIZATION PROCESS: A PROPOSAL FOR A DECISION-MAKING MODELING FRAMEWORK AND DIAGNOSIS

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AB STRACT

Servitization can provide significant economic opportunities, but its implementation in the industry remains surrounded by much uncertainty. This is due to the complexity of its decision making process. This research work focuses on decision making process followed by one industry during a servitization transition. The paper aims to introduce a framework of risk occurrence anticipation and analysis within servitization decision process. This is based on an innovative approach of decision reliability diagnosis. For this, we adopt a methodology typical of enterprise modeling and diagnosis domain, illustrated by a case study.

KEYWORDS: Servitization, decision process, reliability, risk occurrence

INTRODUCTION

Servitization and product service systems (PSS) concepts and applications have spread during the last decades in the academic and practitioner communities (Hou and al, 2013). In many advanced economies, servitization is thought as a development approach able to provide opportunities to achieve sustainability, improve enterprise competitiveness, and better satisfy customer needs (Vandermer and Rada, 1998). Nevertheless, this paradigm shift requires questioning the business objectives and overall functioning. PSS are not based only on technical aspects, organizational aspects are also involved, which make the implementation of this concept in businesses more difficult (Cook and al., 2006). Thereby, transition from product manufacturer into service provider constitutes a risky managerial challenge (Oliva and al, 2003; Nudurupati and al, 2013). It involves the company in a dynamic and complex decision-making process. Therefore, it becomes necessary to provide decision makers with tools to manage the process, and to anticipate associated risks.

This research work introduces a modeling framework of servitization decision making process, and decision reliability diagnosis. The purpose of the paper is to propose a method for risk occurrence anticipation in a servitization transition, to help decision-maker controlling the process.

This paper consists of three main parts. First, we introduce the basics of the servitization process, risk analysis, and reliability notion. In the second part, we explain the decision modelling and the reliability assessment approach we propose. Finally, the aim of the third part is to illustrate the diagnosis approach and risk interpretation according to a case study of a French firm.

1 SERVITIZATION PROCESS, RISK ANALYSIS AND DECISION RELIABILITY

1.1 Servitization decision process

Servitization can be understood and formalized as a complex process to make enterprise transformation (Oliva and al, 2003). Servitization leads to rethink the enterprise strategy, internal processes and competencies as well as its external networks. On the basis of a bibliographic analysis (Oliva and al, 2003; Baines and al, 2009; Gebauer and al,2012) and experience feedbacks from different leaders of industrial companies in a servitization transition, the global servitization process can be decomposed in 3 decisional issues which cover key dimensions of the business transformation (Dahmani and al, 2013): **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 redesign the positioning of the firm in its ecosystem. Indeed, the first decision issue emphasizes services' intangible nature (Baines and al, 2009). The second issue focuses on the importance of predicting the market behavior vis-à-vis this new offering (Vandermerwe and al, 1988). And, the third issue considers the importance of adapting organizational structures and processes to ensure congruence between the firm's resources and objectives (Gebauer and al, 2012).

We define servitization as a transition decision-making process, which generates information and knowledge progressively through temporal sequences according to each specific context. This is the system adopted by an organization to move from a current economic model (product-oriented offer) towards a servitized economic model (integrated product and service offer). This decision-making process is decomposed in three decision Macro-processes (MP) according to servitization decisional issues underlined: MP1: the product service system (PSS) technical design; MP2: the PSS business model transformation; MP3: the Organizational changes, required to support PSS implementation.

Coordinating these three decisional issues simultaneously can be problematic for the decision-maker; he has to take into account the complexity of the process and its dynamic evolution over time. This transition is then considered risky and full of uncertainties for the decision-maker.

Then, preparing a servitization process may be compared to a project planning for the manufacturer. He will need a planning tool in order to control the process and to minimize uncertainties and attached risks.

1.2 Risk analysis in servitization process

The term risk is used in a wide range of meanings. According to literature, risk in business can mean either a feared event, or the probability of occurrence of the event, or its harmful consequences (Courtot, 1998). Project risk often refers to any departure from the planned objectives related to performance expectations (Girard, 1991). According to a quantitative approach, risk refers to the exposure to loss/gain, or the probability of occurrence of loss/gain multiplied by its respective magnitude (Jaafari, 200). Risk therefore can be defined as "an uncertain event which, occurrence would have an effect on achieving the objectives" (Schmitt and al, 2013). Risks can be classified in several ways. It depends on the specificities of the project, the company and the ecosystem (Schmitt and al, 2013).

Generally in risk analysis modeling, it's important to differentiate risk factors from risk impacts. According to a reference model we adopt (Gourc, 2006), every risky situation is due to a combination of causes (origins) brought together in an occurrence area, and generates a set of impacts (consequences) brought together in an impact area. The risk event represents the intersection between both of the distinct areas.

For a manufacturing company, servitization represents a transforming project which affects all strategic pillars of the business. Literature often emphasizes internal and external barriers faced by a firm in servitization process (Mont, 2004; Hou and al, 2013). Servitization barriers can be related to value creation issues (Baines and al, 2009). Risk related to service is mainly due to coordinating issues between business ability and market expectations on one hand and organizational strategy, design and development on the other hand (Sawhney and al , 2004), service types can also affect considerably a servitization performance (Benedettini, 2013). Studies oriented towards risk assessment for service innovations attempt to quantify risk occurrence probability and extent of losses in risk matrices, in order to propose risk management plans (schmitt and al, 2013).

We consider risk in servitization decision process as the possibility for a decision-maker to fall in a risky decision-making position, which occurrence can lead to negative consequences for conducting the process as well as for the planned objectives.

In this paper we introduce a risk analysis approach for servitization decision process focused on risk occurrence domain. We propose a diagnosis method for the decision process of a pivot firm to deduce decision areas carrying potential occurrence of risk. For this, we need to evaluate the decision process accomplished by the firm. We proceed then to evaluate the decision reliability of servitization process.

1.3 Notion 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"* (Simon, 1990). Dean and Sharfman (1996) redefined later 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"* (Riedl and al, 2013).

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.

To evaluate the reliability of decisions 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 and consistent.

Thus, the 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.

2 SERVITIZATION DECISION PROCESS MODELING AND RELIABILITY ASSESSMENT

In this section we introduce the formalism used to represent servitization decision process. The diagnosis approach we propose is based on this formalism. This model has been fully explained in (Dahmani and al, 2013) we just provide here a short synthesis.

2.1 Decision process modeling

We propose a model that considers the complexity of servitization decision process. This approach is inspired by the GRAI modeling formalism (Doumeingts and al, 2000) and is represented through servitization grid (in figure1).

Decision Macro-Process / Decision horizon	MP1. PSS technical design	MP2. PSS business model transformation	MP3. Organizational changes, required to support PSS implementation
H1. strategic	**PS** **PS1.** Define PSS value creation drivers **PS2.** Define the value proposition **PS3.** Define business processes		
H2. Tactical 1	**PT1.** Delineate the PSS structure	**PT2.** Define the value architecture	**PT3.** Plan organizational changes
H3. Tactical 2	**PT4.** Define the PSS infrastructure	**PT5.** Select the profit equation	**PT6.** Establish a level of activity
H4. operational	**PO1.** Plan production and characterize customer interface	**PO2.** Deploy the business model	**PO3.** Establish an organization of work

Figure 1: Servitization reference decision model

To build this model, we represent decision making process through two axes. The vertical axis represents the decision's horizons: long, medium and short terms. This aspect of the decision clarifies crossing from high strategic-decision level 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 (figure1). Every DC consists of decision activities (DA) nets, and every 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 decision choices), or execution activity (noted E-DA with outputs constituted by simple informations). This model allows understanding the complexity of the overall transition process and identifying different interaction 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.

2.2   Definition, formalization and evaluation of decision reliability

We have defined reliability as the proximity between reference decision making process and effective one. To estimate this proximity, the proposed approach consists in:
• Characterizing in detail the actual servitization process followed by the firm according to decision-activities (DA) 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 decision activities and decision centers of the grid.
As specified above, servitization decision activities are formalized using GRAI modeling formalism and include compounds of decision activities (D-DA and E-DA). In order to build the proximity measures mentioned, DA are modeled in detail through a set of "decision-making characteristics" and "decision attributes", each attribute is associated with a "reliability coefficient". Thus the conceptual modeling of the reference DA is as follows:

$$\text{D-DA}_k, \text{E-DA}_k = \{ C_i \}_{i=1 \text{ to } n} \text{ with } C_i = \text{decision making reference characteristics}$$
$$C_i = \{\text{name, description, } \{A_j, \text{Coef}_j\}_{j=1 \text{ to } m)} \text{ with}$$
$$A_j = \text{decision attributes}$$
$$\text{Coef}_j = \text{Reliability coefficient associated to } A_j$$

Referring to GRAI method, we describe decision activities (D-DA) by seven reference characteristics (Table 1) 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. Table.1 provides example of characteristics and attributes for one D-DA Є PT2 (BM, MT) *"Developing the internal value chain"*.

Table 1: D-DA 1 Є PT2 (BM, MT) "Developing the internal value chain" (reference model)

Characteristics (C_i)	Input	Detailed output	Information's	Constraints	Resources	Decision variables (DV)	Objective
Attributes (A_j)	Components of internal value chain	New links created	Product Service Mix	Human resources	Competencies available	Create links	Develop the value chain to better meet the needs of the new business while respecting the available resources
	Characteristics of internal value chain	Links removed	Physical structure of the defined PSS (defined physical system)	Technical resources		Delete links	
		Links modified	Immaterial structure of the defined PSS (defined management system)	Commitment of the business	Duration / time required	Edit links	

The construction of these descriptive detailed tables allows determining "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 satisfies correctly all attributes of the reference decision activity. To determine these coefficients for each decision activity, the optimal reliability of 1 is equidistributed on

the different characteristics Ci: 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 (A_j) components of the "decision-making characteristic", which represents the "reliability coefficient".

In this paper, we choose an equidistribution for coefficients among different characteristics, and attributes within one characteristic in order to simplify the analysis process. We attribute similar importance to all components of the decision making process to illustrate the overall approach, before adding a specific part to explain the weightings.

Thus, for D-DA$_1$ Є PT2 (BM, MT) "Developing the internal value chain", there is 17 attributes, each is 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)}

We use then the theoretical modeling of decision activities and reliability coefficients to estimate the proximity between the reference decision process and the actual one. This assessment requires collecting information from the involved decision makers, to describe quite precisely how they decide: first identify whether each of the decision activities of the servitization reference model was performed or not, then in more details if 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 attributes" in the effective decision making process of the firm: the proximity between the effective decision process and the reference one is estimated according to the absence or presence of these attributes.

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 reliability F_k for D-DA$_k$ activity is obtained by aggregating a sum of the reliabilities 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 that should be detected in advance.
F_k =1 if all decision reference attributes are present in the actual decision-making process; It corresponds to an optimal situation when the decision maker proceeds by following fairly the reference decision process.

3   SERVITIZATION DECISION PROCESS DIAGNOSIS APPROACH: ILLUSTRATION ON A CASE STUDY

3.1   Industrial case study: General presentation

To illustrate our approach, we propose an application on a case study of a French SME named Ecobel. The main activity of the firm is 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. 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 commercializing it. He remains cautious about the development of the servitization model over the entire range

3.2   The servitization decision process diagnosis approach according to a case study

In the previous section, we proposed an approach of 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. We suppose that an "unreliable" decision activity carries a potential occurrence of risk to the whole process which can cause negative losses for the firm.

We propose to carry out the reliability diagnosis for servitization decision process according to two complementary points:

- Reliability assessment on decision activities with the interest of submitting a macroscopic view of the process;
- Aggregated reliability assessment on decision centers with the interest of explaining weaknesses through a detailed analysis of DA.

Reliability assessment and diagnosis on decision activities

This analysis viewpoint aims to present a general state of servitization process accomplished by Ecobel at one moment. All decision activities are presented in the radar axes through a numbering from 1 to 48 (Figure 2). The advantage of this analysis viewpoint is to provide a macroscopic mapping of the reliability of the process according to the reliabilities of all DA. The contribution is to deduce a global mapping of potential occurrence of risk.

Table 3: Distribution of reliabilities among intervals
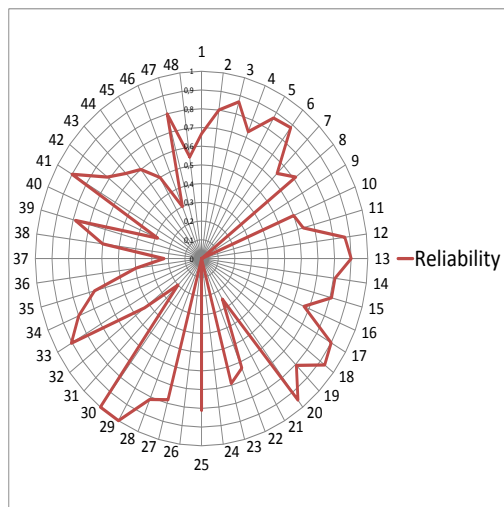
Reliability intervals	interpretations	Proportion of DA in the servitization process	Potential occurrence of risk interpretation
0	DA unreliable	6.25%	
] 0 ; 0.3]	DA with very low reliability	10.42%	DA carrying very high potential occurrence of risk
] 0.3 ; 0.6]	DA with low reliability	14.58%	DA carrying high potential occurrence of risk
] 0.6 ; 0.9]	DA with average reliability	60.42%	DA carrying average potential occurrence of risk
] 0.9 ; 1]	reliable DA	8.33%	DA carrying very low potential occurrence of risk

Figure 2: Reliability assessment on decision activities

Then, we proceed to classify the DA of the process at different reliability intervals as shown in the three first columns of Table 3. The intervals are predetermined.

Since we focus on the planning phase of an innovative process, we can only evaluate a potential occurrence of a risk, instead of the classic probability of occurrence. Then we consider potential occurrence of risk inversely proportional to decision reliability. We interpret the reliability intervals according to a qualitative scale to evaluate the potential occurrence of risk which varies from "very high" to "low" as shown in the fourth column of Table 3.

We can see that 31% of the process is caring a considerably high potential occurrence of risk which will impact the process advancement and the firm objectives negatively.

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 two useful indicators:

- F_{ij}^{DC} = Estimates 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}.

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

$$F^{DC}_{ij}_{\substack{i=1\,to\,3 \\ j=1\,to\,4}} = Min\ F_{k,i,j}$$

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

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 DC on which decision-maker must act according to the importance of the potential occurrence of risk revealed by the indicators.

Table 4: Reliability and risk diagnosis on DC

Indicators	Meaning of the evaluated reliability	number of DC / total number of DC of the grid	Potential occurrence of risk interpretation	DC titles
$N_{ij;\,F0} > 0$	DC Holding ignored DA	2/12		-PS1 « Define PSS value creation drivers » -PT3 « Plan organizational changes»
$F_{ij}^{CD} \in]\,0\,;\,0.3]$	DC with very low reliability	5/12	DC carrying very high potential occurrence of risk	-PT2 « Define the value architecture» -PT5 « Select the profit equation» -PT6 « Establish a level of activity» -PO1 « Plan production and characterize customer interface» -PO3 « Establish an organization for work»
$F_{ij}^{CD} \in]\,0.3\,;\,0.6]$	DC with low reliability	2/12	DC carrying high potential occurrence of risk	-PS2 «Define the value proposition » -PO2 « Deploy the business model »
$F_{ij}^{CD} \in]\,0.6\,;\,0.9]$	DC with average reliability	5/12	DC carrying average potential occurrence of risk	-PS1 « Define PSS value creation drivers » -PS3 « Define business processes » -PT1 « Delineate the PSS structure » -PT3 « Define resources» -PT4 « Define the PSS infrastructure»
$F_{ij}^{CD} \in]\,0.9\,;\,1]$	Reliable DC	0/12	DC carrying very low potential occurrence of risk	0

We proceed to the classification of all DC according to the pre-established reliability intervals and potential risk occurrence interpretations, 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 carrying a significantly high potential occurrence of risk.
DC with $N_{ij;\,F0} > 0$ are considered as unreliable. We consider these DC as the most prioritized DC for the remediation plan.
From this distribution, we proceed to prioritize the DC to deal with (in descending order of potential occurrence of risk), 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 for the ignored issues. This may have significant impact on the long-term performance of the firm.
- Then, for unreliable and very unreliable DC, they show that DA were actually treated, but decision maker referred often to an intuitive decision-making process strongly influenced by the initial organizational model.
Then, in order to improve the reliability of these DA, remediation would demand efforts of analysis, anticipation and especially of changing dominant decision models in the business.
- Finally, for DC with average reliability, they show that their belonging DA have been processed and analyzed, but the problem lies in the lack of resources to carry out these decisions. The remediation effort will be directed more towards an allocation of resources in terms of competencies and investment to provide additional information necessary for these decisions.
It's also important to consider the positioning of the prioritized DC on the grid. Actions plans should take into account the concerned decision horizon and MP in order to keep a global consistency of the process.

CONCLUSION

The purpose of this study is to introduce a diagnosis approach for servitization process planning, which is based on risk occurrence anticipation. The diagnosis allows highlighting weaknesses of decision areas in the accomplished decision process. We consider these weaknesses as carrying a potential occurrence of risk. The main perspective of the study is to establish a global model that considers simultaneously potential risk occurrence and risk impacts, in order to prioritize the decision centers to deal with for the decision maker. This would facilitate controlling the servitization transition, and limiting time and effort losses. We recognize the limits of the study focusing only on the reliability of the decision process, the intuitive side of the decision making process is not taken into account in this work.

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