Evaluating the Effects of Poorly Performed Product Development Phases on Customer Satisfaction

Y. Borgianni[1], G. Cascini[2], F. Rotini[1]
[1] Dip. di Meccanica e Tecnologie Industriali, Università di Firenze,
via di Santa Marta, 3, 50139, Florence, Italy
yuri.borgianni@unifi.it, federico.rotini@unifi.it
[2] Dip. di Meccanica, Politecnico di Milano
via La Masa, 1, 20156, Milan, Italy
gaetano.cascini@polimi.it

Abstract
The research of the authors within product development is addressed at developing a tool for innovation in industry, namely Integrated Product and Process Re-engineering (IPPR), whose overall objective is enhancing and harmonizing ideation, design and manufacturing with a product lifecycle approach. The module of IPPR indicated as Process Value Analysis (PVA) is aimed at ranking the phases of a business process according to their contribution to customer satisfaction with respect to the employed resources. The original contribution of the present paper is complementing the method with information concerning drops in customer satisfaction as a result of poorly performed process phases. By accepting the non-linear relationship between satisfaction and attributes' quality level and the different roles played by customer requirements according to Kano categories, the authors propose a preliminary method to provide quantitative evaluations of the effects of process phases that do not thoroughly fulfil the intended objectives. An exemplary application here presented refers to the cosmetic industry, by investigating the production process of lipsticks, to which PVA was previously applied with encouraging outcomes.

Keywords:
Process phases performance, customer satisfaction, Kano categories, Process Value Analysis, lipstick production

1 INTRODUCTION

Several works in the literature demonstrate that Business Process Reengineering (BPR) tasks have failed to pursue the objective of generating value for companies' customers. Among others, Holland and Kumar [1] assessed that 60–80% of BPR initiatives haven't fulfilled the declared objectives. More specifically, the analysis performed by Hall et al. [2] remarks that, in order to carry out successful BPR initiatives, redesign efforts should be focused not only on cost and time reduction, but mainly on the areas of the business process which have the most direct impact on customer value. These results show that managers must reengineer their core processes starting from the customer perspective.

The focus on customers and on their perception of products and services has consequently played a relevant role within companies by affecting industrial practices, policies [3] and product development cycles, leading moreover to a great impact on the required managerial skills [4].

In this context the authors have developed a methodological approach namely Process Value Analysis (PVA), aimed at analyzing business and manufacturing processes and identifying the contribution of each phase in determining customer satisfaction through quantitative metrics [5]. The overall objective of this research is the enhancement of BPR practices by providing information about the phases which generate consistent value for the customers and into which improvement efforts should be channeled. In this way, re-engineering actions can focus on the industrial activities which may be substantially improved through the adoption of novel or emerging manufacturing activities in terms of expected performance and employed resources by aligning them with the whole production process [6].

The first version of the methodology has been applied to several case studies, obtaining positive feedback that have highlighted its potential. However, in order to enhance the robustness of the approach and widen the applicability of the methodology, some development guidelines have been identified. Among them are the need to make the methodology more systematic with a particular emphasis on the partial subjectivity of certain steps and to improve the models that are used to evaluate the extent of customer satisfaction by taking into account their performance and reliability. This is particularly important because PVA [5] assumes that each phase works at its maximum potential, thus neglecting the effects on customer satisfaction played by limited robustness and/or malfunctions of the process.

The link between process performance and expected customer appreciation (and consequently the market success) of products and services is relevant not only for anticipating the drawbacks of mistakes and negligence, but also for supervising ongoing activities. In the industrial world, increasing interest is addressed by predictive metrics for anticipating the outcomes of a business activity and by monitoring its related processes [7].

With the aim of widening the set of indications provided by the PVA method, this paper presents a preliminary investigation of models for assessing the impact of process performance on customer satisfaction.

Section 2 summarizes the logic of PVA, then overviews the state of the art about the models providing quantitative evaluations of customer satisfaction. In section 3 the integration of the most acknowledged models within the PVA module for customer satisfaction analysis is presented. Section 4 reports the application of the proposed models to a case study in the cosmetics industry, with the aim of showing their functionality. The outcomes of the case study are discussed in Section 5, while the considerations about the preliminary model are drawn in Section 6. Section 6 also outlines expected future activities.

2 STATE OF THE ART

2.1 Brief outline of the PVA methodology

The PVA methodology follows a step by step procedure, aimed at supporting business process re-engineering activities based on the evaluation of the impact of each process phase on the perceived value of products and/or services and taking into account the employed resources. The results of this assessment are used to identify suitable guidelines for process evolution strategies which will preserve and improve the market competitiveness of products and services.

The first stage concerns the gathering of the information related to the business process under investigation. IDEF0 models are suitable to represent the flows of information and materials along the process phases, as well as the employed technology, machinery, human skills. Complementary data are collected to map the expenditures and the timing of each process phase.

The next step of the methodology regards the investigation of the customer requirements that are intended to be delivered during the business process. Each of these product/service attributes are characterized in terms of Kano categories (One-dimensional, Attractive, Must-be) [8] and relevance *R* [9], meant as the relative importance of the customer requirements within the bundle of benefits provided by the business process (on a scale ranging from 1 to 5). Both the Kano category and the attribute relevance are established through customers interviews or stated by business experts.

Then, on the basis of business experts' evaluation, the coefficients k_{ij} ($0<=k_{ij}<=1$) that relate each phase *i* to each attribute *j* are identified, in terms of the accounted contribution of the process stages to fulfil the customer requirements when delivered at their maximum achievable offering level. Such parameters allow a quantitative link to be established among the process steps and the arisen benefits. The subsequent result is the evaluation of the role played by each phase contribution in both providing unexpected benefits perceived in the marketplace (Customer Satisfaction, *CS*) and avoiding user discontent (Customer Dissatisfaction, *CD*), according to mathematical expressions dealing with the implications of Kano model fundamentals. Thus, at the current step, the PVA evaluates the contribution of each process phase in determining customer satisfaction under the hypothesis of achieving the greatest potential, without taking into account the effects of poor repeatability of the outputs and underperformances.

According to Value Engineering, employed resources, costs and time necessary to carry out the process activities are measured and compared with the terms expressing the extents of customer satisfaction. Thus the phases are estimated in terms of their capability to provide both basic quality and unexpected features.

However, such a step is not relevant for the scope of the present paper, since the purpose of this contribution concerns a deeper investigation of the value offered to the customer by each process phase. More in detail, in order to evaluate the effects of process underperformances on the delivered value, the objective is to establish a relationship among the phases' performance and customer satisfaction. Therefore, while k_{ij} coefficients represent the connection between the process stages and the customer requirements, it is necessary to quantitatively link the attributes quality with customer satisfaction parameters.

2.2 Models for quantitative evaluation of customer satisfaction

The task of a quantitative evaluation of customer satisfaction according to the level at which the attributes are fulfilled has been already investigated in the literature. However, an acknowledged well validated model has not been identified yet. By recognizing the non-linear relationship between satisfaction and quality, as well as the different relevance shares of the attributes, the Kano curves remain the reference model for this research.

Thus, a sort of mathematical extrapolation of the curves standing out for must-be, one-dimensional and attractive features, has represented the starting point for building such models. By taking into account the shape of the curves, Tan and Shen [10] relate the ratio between two degrees of satisfaction to the ratio between the corresponding performance levels, according to attributes' Kano categories. With respect to their formulation:

$$s_1/s_0 = (p_1/p_0)^k \quad (1)$$

where s_1 and s_0 are the extents of satisfaction matching the performance levels p_1 and p_0, respectively, and the coefficient *k* depends on the attribute category according to the Kano classification: for attractive attributes, $k>1$; for one-dimensional attributes, $k=1$; and for must-be attributes, $0<k<1$. However *k* commonly assumes the values $k=2$ and $k=1/2$ for attractive and must-be customer requirements, respectively. The ratio between the satisfaction levels is commonly indicated as adjusted Improving Ratio (IR_{adj}), while the ratio between the performances is generally indicated with Improving Ratio (*IR*), as depicted in Figure 1(a). It is worth noting that prior to the publication of models for the quantitative evaluation of customer satisfaction investigating the non-linear relationships between achieved performances and originated benefits, only the *IR* was commonly used.

The expression (1), developed to support Quality Function Deployment (QFD) tasks, was first applied to an exemplary case in the Internet field and has been further employed in different domains, such as catering [11], mobile communication [12], education [13].

A modification of the recalled formula has been recently proposed by Chadua et al. [14], who introduced a corrective coefficient *m* in the relationship between the improving ratios:

$$IR_{adj} = IR \times (1+m)^k \quad (2).$$

The *m* coefficient, with $0<m<1$, depends on the distribution of the attributes within the Kano categories, as well as on their relevance. The authors of the model describe an application of the proposed model by surveying the field of webpage design.

The models proposed in [10] and [14] aim to perform a comparison among different product profiles or to evaluate the effects of improvement scenarios by using a QFD approach, but they have never been used for other tasks.

In the literature there are also other models to evaluate customer satisfaction that are supposed to overcome the rigid distinction among Kano categories. However such approaches haven't yet found an appreciable consensus, nor a wide application.

"A-Kano" [15] considers two different importance scores for each attribute, by separately taking into account their supposed relevance in being triggers for customer satisfaction and means for avoiding discontentment. Subsequently, the product profile is summarized in a bi-dimensional graph, where the two different relevance scores represent the coordinates. By placing the attributes in the graph, depicted in Figure 1(b), their categorization depends on the inclination of the segment connecting the representative point with the origin, while their overall importance is evaluated through the length of the same segment. Falls in the attribute performances determine proportional drops in the capability to generate satisfaction and avoid dissatisfaction. The new representative point thus stands on the same segment, but at a minor distance from the origin. A demonstrative application regards the automotive field.

With respect to [10], [14] and [15], Xi et al. [16] propose a different model to represent the satisfaction curves on the basis of attribute quality. Their characterization first considers the supposed maximum dissatisfaction (minimum attribute quality) and the greatest satisfaction (maximum attribute quality). Subsequently, the two representative points are connected by a 3-segment broken line, whose inclination in the three portions depends on the local rates of satisfaction growth, as in Figure 1(c). The curves shown in the manuscript refer to attribute investigations within the financial field. The model depicts then very different shapes of the curves, whose end segments of the broken lines are however frequently flat, recovering therefore the concept of satisfaction thresholds expressed in [17].

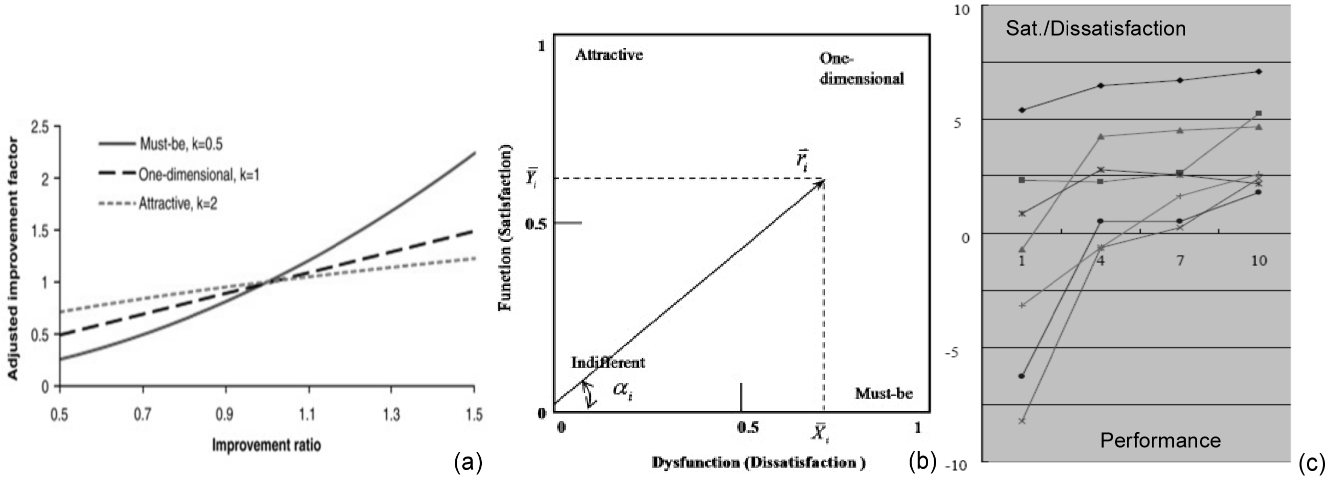

Figure 1: Models for quantitative evaluation of customer satisfaction as a function of attributes performance [13, 15, 16].

2.3 Critical review of the existing models

On the basis of the previously performed analysis of existing approaches for the quantitative estimation of customer satisfaction, the purpose is to choose a reference model to be embedded in the PVA. In order to fulfil this task it is necessary to make further considerations about the reliability and the applicability of the recalled models.

None of the models foresee markedly different patterns for customer satisfaction and dissatisfaction, neglecting the dissimilar effect they give rise to. Just as in "A-Kano", the two indexes follow different functions; however the simultaneous modification of customer satisfaction and dissatisfaction doesn't comply with the trajectories of Kano curves.

Furthermore, in [10] and conversely in [14], the employed approach is tailored for incremental levels of attributes' quality modifications and, in such a context it can be advantageously applied just by considering positive values of satisfaction.

On the contrary the model depicted in [16] envisages both negative and positive values, allowing a graphical representation for the whole range of potential attributes' performance.

However, beyond their more limited scientific evidence, the main limitation of the models represented in [15] and [16] relates to the need of introducing further coefficients, mostly consisting of personal estimations of the attributes' roles. Such issues can potentially increase the degree of subjectivity impacting the outcomes of the PVA, hindering the pursued goal of enhancing the systematic level of the whole methodology.

3 EVALUATING THE IMPACT OF PRODUCT DEVELOPMENT PHASES ON CUSTOMER SATISFACTION

This Section describes the criteria leading to the choice of the reference model, according to the literature review and the PVA requirements. Then the integration of such a model within the evaluation module of PVA is described. The readers who don't know the details of PVA proposed in [5-6] can better comprehend the contribution of the current paper through the exemplary application reported in Section 4.

3.1 Adapting the reference model for its implementation within PVA

A suitable model for satisfaction estimation within the PVA should:

- express mathematical formulas for both customer satisfaction (*CS*) and dissatisfaction (*CD*) indexes, according to the various categories of Kano model;
- consider the minimum and the maximum extents of both coefficients with respect of the criteria established within Kano framework;
- relate both coefficients with attributes quality ranging from 0 to 100%.

According to the performed survey and the limitations of the reviewed models, the authors have chosen a reference framework and adapted it according to the intended purposes. The choice of employing the model described in [10] as a starting point for developing a novel framework to measure customer satisfaction indexes lies on the following observations:

- it can be considered the only contribution facing significant scientific evidence;
- it is based on a mathematical interpretation of the trajectories of the original Kano curves;
- under certain circumstances and objectives, resumed further on, no additional parameters must be defined in order to make it suitable for the implementation within PVA.

Indeed, although it is not possible to adopt the model "as is", the criteria involving linear, quadratic and square root like progress of the improvement ratios can be maintained. With reference to concepts and equations belonging to the original Kano formulation or to acknowledged scientific contributions aimed at developing its model [18-22], the authors have taken into consideration the following hypotheses in order to build the novel framework:

- Customer Dissatisfaction *CD*, that is neglected in the reference model [10], has to be considered as the extent of avoided discontentment when delivering a certain attribute at a proper level (with the minus sign); hence, it makes reference to the maximum dissatisfaction that a poor attribute quality can deliver.
- Customer Satisfaction *CS* will be considered as the extent of generated unexpected benefits, thus considering the satisfaction curves above the zero-level.
- Attractive attributes play no role within *CD*. Their maximum amount of generated *CS* equals to their relevance *R*. In case of minimum quality the *CS* turns to 0.
- For must-be attributes, the progress of the satisfaction related to (1), stands for the avoidance of potential dissatisfaction when the performance of the customer requirement grows. The same concept can be employed even for one-dimensional features when considering the negative part of the Kano curve.
- Must-be attributes play no role within *CS*. Their maximum amount of *CD* is equals to the absolute value of their relevance *R*. In the event of their lowest quality, the *CD* turns to 0.
- One-dimensional attributes influence both *CD* and *CS*. The relevance *R* characterizes the extent of both the generated benefits and the avoided dissatisfaction. Hence, due to such symmetry:
  - They generate *CS* when their performance overcomes 50% of the range; the maximum *CS* equals to *R*.
  - The related *CD* equal to *- R* when the performance is greater than 50%; *CD* turns to 0 in event of the minimal performance.
- Both *CD* and *CS* are proportional with the attribute relevance *R*.

According to the above hypotheses about Kano categories, Table 1 summarizes the equations for calculating the extents CS_j and CD_j with reference to the *j*th customer requirement when varying its degree of fulfilment q_j (alike the performance *p* in the model represented in [10]).

Kano category	Quality range	CS_j	CD_j
Must-be	$0<=q_j<=1$	0	$-R\sqrt{q_j}$
One-dimensional	$0<=q_j<0,5$	0	$-2Rq_j$
One-dimensional	$0,5<=q_j<1$	$R(2q_j-1)$	$-R$
Attractive	$0<=q_j<=1$	Rq_j^2	0

Table 1: Equations of the satisfaction indexes.

3.2 Implementation of the presented metrics within the PVA methodology

The PVA methodology evaluates the process phases according to their contribution to customer satisfaction through the determination of proper indexes.

The novel evaluation module requires the input data related to the business process that are introduced throughout the PVA previously to the calculation of satisfaction indexes. This includes:

- the process phases;
- the customer requirements, their relevance and classification according to Kano model;
- the extent of each phase in fulfilling each product and service attribute (k_{ij} coefficients);
- the performance of each phase in determining product or service attributes (p_i coefficients). This is assessed through a score ranging from 0 to 1, in accordance with the specific productivity of the phase, or other metrics related to the compliance of its outcomes to the expected characteristics. If these data are not available, the score is assigned by the experts according to their knowledge of the process performances through a discrete evaluation, e.g. with 5 discrete performance levels.

Given this starting point, the evaluation module consists of a procedure that includes the following calculation stages:

1) the determination of the attributes' quality q_j through the expression (3);
2) the estimation of modified CD_j and CS_j coefficients through the formulas summarized in Table 1;
3) the calculation of the sums of current CS_j and CD_j values, indicated as modified Global Customer Satisfaction/Dissatisfaction (GCS_{mod} and GCD_{mod}), representing therefore the overall amount of generated satisfaction;
4) the calculation of the sums of maximum CS_j and CD_j values, indicated as hypothetical Global Customer Satisfaction/Dissatisfaction (GCS_0 and GCD_0), representing therefore the achievable amount of generated satisfaction in event of best phases performances (p_i=1 $\forall i$);
5) the evaluation through the expressions (4) and (5) of not-exploited margins of satisfaction, due to limited performances, both in terms of supplied benefits ΔCS and avoided dissatisfaction ΔCD:

$$q_j = \sum_i p_j \times k_{ij} \quad (3);$$

$$\Delta \mathrm{CS} = \frac{GCS_0 - GCS_{\mathrm{mod}}}{GCS_0} \quad (4);$$

$$\Delta \mathrm{CD} = \frac{GCD_0 - GCD_{\mathrm{mod}}}{GCD_0} \quad (5).$$

Equation (3), determined as a modification of the model employed within PVA, stands for a preliminary evaluation of the effects of poorly performed phases on the attributes' degree of fulfilment. At this stage of the research, the authors aim to take into account just the linear impacts of phases performances, without considering second order interrelations among the phases in the effective determination of the attributes quality values. The performed module is viable to evaluate the effects of a single phase showing non-optimal performance, as well as the impact of a set of p_i scores attributed to various process tasks and operations.

4 EXEMPLARY APPLICATION

This Section illustrates the application of the Process Value Analysis for an industrial case with a particular reference to the module for investigating the effects of poorly performed phases.

4.1 Outline of the case study and of the application of Process Value Analysis

The cosmetics industry in Italy has undergone relevant transformations in the last years from the viewpoint of the firms operating in such sector. Although activities which were once predominantly craftsmanship tasks have been turned into massive industrial productions regulated by policies which are common for big companies, the manufacturing technology hasn't been subjected to radical modifications. With reference to lipstick design and manufacturing, the case study under investigation deals with the business process of a medium-sized firm, whose main customers are global players in the field of women's make-up products and fashion in general.

Attributes \ Phases (k_{ij})		A11	A121	A122	A123	A13	A21	A22	A23	A31	A32	A33	A34	A35	A36	A41	Attribute quality (q_j)
		Marketing Briefing	Stick technical design	Packaging technical design	Prototyping	Industrial engineering operations	Laboratory research	Laboratory analysis	Development of the formulation	Quality Control and warehousing of raw materials	Additional manufacturing operations	Bulk manufacturing	Liquid bulk casting	Assembly	Quality Control of end product	Warehousing of end product	
CR1	Stick colour	0	0	0	0	0	0,2	0	0,45	0	0	0,25	0,05	0	0,05	0	0,50
CR2	Stick colour precision	0	0	0	0	0	0	0	0	0	0,5	0,45	0	0	0,05	0	0,91
CR3	Stick taste	0	0	0	0	0	0	0	0	0,1	0	0,35	0,4	0	0,05	0,1	0,73
CR4	Stick scent	0	0	0	0	0	0	0	0	0,1	0	0,35	0,4	0	0,05	0,1	0,73
CR5	Absence of foreign bodies in the stick	0	0	0	0	0	0	0	0	0	0	0,65	0,3	0	0,05	0	0,72
CR6	Stick surface porosity	0	0	0	0	0	0	0	0	0	0	0,45	0,5	0	0,05	0	0,66
CR7	Lipstick applicability	0,2	0,2	0	0	0	0,5	0	0	0	0	0	0,1	0	0	0	0,55
CR8	Presence of active principles in the lipstick	0	0	0	0	0	0,45	0	0	0	0	0,2	0,3	0	0,05	0	0,45
CR9	Lipstick resistance on the lips	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0,20
CR10	Avoiding irritation phenomena	0	0	0	0	0	0,5	0,2	0	0,05	0	0,1	0,1	0	0	0,05	0,53
CR11	Quantity of product in the lipstick	0	0	0	0	0	0	0	0	0	0	0	0,65	0,3	0,05	0	0,68
CR12	Duration of lipstick properties	0	0	0	0	0	0,5	0	0	0	0	0,1	0,3	0	0,1	0	0,43
CR13	Customizable stick shape	0,1	0,3	0	0,4	0	0	0	0	0	0	0	0,2	0	0	0	0,74
CR14	Special effects providing	0,1	0	0	0,5	0	0	0	0	0	0	0	0	0,4	0	0	0,80
CR15	Customizable chemical formulation	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0,20
CR16	Compatibility of the primary packaging with the stick	0	0	0,2	0,2	0,3	0,3	0	0	0	0	0	0	0	0	0	0,64
CR17	Colour of the primary packaging	0,2	0	0,75	0	0	0	0	0	0	0	0	0	0	0,05	0	0,85
CR18	Customizable primary packaging	0,2	0	0,8	0	0	0	0	0	0	0	0	0	0	0	0	0,84
CR19	Shapes variety	0,2	0	0,4	0,4	0	0	0	0	0	0	0	0	0	0	0	0,76
CR20	Resistance of primary packaging	0	0	0,2	0,2	0,4	0	0	0	0	0	0	0	0,2	0	0	0,88
CR21	Functionalities of primary packaging	0	0	0,2	0,2	0,6	0	0	0	0	0	0	0	0	0	0	0,88
CR22	Technical dossier	0	0	0	0	0	0,6	0,3	0,1	0	0	0	0	0	0	0	0,46
CR23	Product labelling	0,1	0	0	0	0,3	0,4	0	0,1	0	0	0	0	0,1	0	0	0,62
Phase performance (p_i)		1,0	1,0	**0,8**	**0,6**	1,0	**0,2**	1,0	**0,4**	1,0	1,0	**0,8**	**0,5**	1,0	1,0	1,0	

Table 2: Calculation of attributes quality according to phases performances.

	Attribute quality (q_j)	Kano category	Relevance (R)	CS_i	CD_i	Maximum CS_i	Maximum CD_i
CR1	0,50	MB	5	0,0	-3,5	0	-5
CR2	0,91	MB	4	0,0	-3,8	0	-4
CR3	0,73	MB	3	0,0	-2,6	0	-3
CR4	0,73	MB	4	0,0	-3,4	0	-4
CR5	0,72	MB	5	0,0	-4,2	0	-5
CR6	0,66	MB	3	0,0	-2,4	0	-3
CR7	0,55	MB	4	0,0	-3,0	0	-4
CR8	0,45	MB	3	0,0	-2,0	0	-3
CR9	0,20	OD	3	0,0	-1,2	3	-3
CR10	0,53	MB	5	0,0	-3,6	0	-5
CR11	0,68	MB	3	0,0	-2,5	0	-3
CR12	0,43	MB	3	0,0	-2,0	0	-3
CR13	0,74	AT	4	2,2	0,0	4	0
CR14	0,80	AT	4	2,6	0,0	4	0
CR15	0,20	AT	3	0,1	0,0	3	0
CR16	0,64	MB	4	0,0	-3,2	0	-4
CR17	0,85	MB	4	0,0	-3,7	0	-4
CR18	0,84	AT	5	3,5	0,0	5	0
CR19	0,76	OD	4	2,1	-4,0	4	-4
CR20	0,88	MB	1	0,0	-0,9	0	-1
CR21	0,88	MB	4	0,0	-3,8	0	-4
CR22	0,46	MB	4	0,0	-2,7	0	-4
CR23	0,62	MB	4	0,0	-3,1	0	-4
				10,5	-55,7	23,0	-70,0
				GCS_{mod}	***GCD_{mod}***	***GCS_0***	***GCD_0***

Table 3: Calculation of satisfaction coefficients according to attributes quality.

The goal of the firm was to evaluate value bottlenecks and phases reliability within the process (schematized with an IDEF0 framework in compliance with PVA and here omitted due to space reasons) for producing lipstick batches (as summarized Table 2) and to consequently support the ideas of technological enhancement that had been previously undertaken.

The business process under investigation ranges from marketing studies intended to determine the characteristics of new trendy lipsticks to warehousing and distribution activities, throughout the phases concerning laboratory testing, prototyping, raw materials supplying, manufacturing and quality control. A set of 15 phases is deemed to fulfil 23 customer requirements that include functional and emotional features regarding the bulk and the primary packaging, the make-up quality and characteristics, the compliance with the regulations concerning the presence of foreign bodies and the skin irritation, up to the technical documentation for the clients. Table 2 summarizes the phases (listed in the first row) and the recalled attributes (reported in the first column), as well as their mutual influence along the process through the k_{ij} coefficients. Attributes' Kano category and relevance are indicated in Table 3.

For space reasons, this paper omits indications about the employed resources in terms of consumption materials, machinery, structures, energy, human skills, labour and time, that have led to the end results about value estimations. Such final outcomes are briefly summarized in the following:

- certain routine tasks, such as bulk manufacturing, laboratory analysis and raw materials warehousing provide a low amount of value for the business process;
- the technical design of the primary packaging has resulted in the most valuable phase, by consistently contributing to the fulfilment of both basic and unexpected requirements with a limited resources consumption. Analogous conclusions can be drawn also for the outputs of laboratory research;
- several phases concerning product detailed design and manufacturing belong to the basic performance area, whereas the activities ranked in the industrial engineering phase (such as the definition of product specifications, manufacturing planning, determination of materials to be purchased, etc.) show the best value in avoiding dissatisfaction;
- creative tasks give rise to exciting performance, with a particular emphasis on prototyping operations.

The indications issued from the analysis have provided general support for the reengineering directions that the firm was intending to undertake. Indeed, while a technological development was envisaged for the creative phases and the fundamental manufacturing activities, the outsourcing of routine tasks with perceived low value for the customers was debated within the enterprise management.

4.2 Application of the integrative module

According to the business process described in Section 3 and with reference to Table 2, the bottom row, labelled as “Phase performance”, allows the introduction of p_i coefficients into the worksheet. This set of values represents the input according to which the impact in terms of reduced attribute quality, and consequently unexploited benefits, are evaluated. As a result of phases that partially fulfil the intended purpose (p_i<1, highlighted with grey cells background), q_j values are calculated according to (3) and summarized in the right column, labelled as “Attribute quality”.

In Table 3, on the basis of the quality (as calculated in Table 2), the Kano category and the relevance *R* of each attribute, the columns labelled as CS_i and CD_i, indicate the modified contributions to customer satisfaction according to the equations summarized in Table 1. Their sums reported in the bottom row stand for the GCS_{mod} and GCD_{mod} indexes. Conversely, according to the greatest extent of customer satisfaction and dissatisfaction that each attribute can give rise to, the GCS_0 and GCD_0 indexes are calculated; such coefficients are reported at the bottom right of the Table. It is therefore possible to subsequently calculate ΔCS and ΔCD through (4) and (5). The exemplary distribution of phases performances reported in Table 2 would thus lead to not exploited margins of about 54% and 20% in terms of customer satisfaction and avoided dissatisfaction respectively.

With the integrative module it is possible to investigate the effects of reduced outcomes regarding each phase singularly and thus the amount of not exploited margins due uniquely to its underperformances. Figure 2 illustrates the effects of the limited performance of various phases, with p_i indexes ranging from 0 to 1, under the condition that all the other process activities are undertaken at an optimal level. The depicted curves refer to process phases with meaningful value indexes according to the outputs of PVA analysis summarized in the Subsection 4.1. The abscissas refer to the phase performance quality, while the ordinates indicated the ΔCS and ΔCD coefficients, which are represented with dotted grey and continuous black lines respectively.

5 DISCUSSION OF THE RESULTS

Through the diagrams of Figure 2 it is possible to appreciate the different paths for the fall of customer satisfaction and dissatisfaction, as well as dissimilar maximum extents of unexploited margins. The curves' trajectories depend consistently on the kind of attributes that are primarily fulfilled along the process phases. On the other side, the peaks of unexploited satisfaction are related with the relevance of the customer requirements and the degree of influence played (k_{ij} coefficients). It is worth to notice that, while some diagrams follow gradual trajectories along the whole abscissas range, in some cases the slope of the curves is significantly different according to the performance level. Thus, with reference to Figure 1b an intermediate level of Laboratory Research performance would result in a consistent drop of unexpected benefits, while it doesn’t meaningfully affect the avoidance of customer dissatisfaction.

Thanks to the introduced model, the firm dealing with the process underpinning lipsticks production can better evaluate the consequences of underperformance and effects of further limited reliability of the phases. A more detailed survey of the business process can also highlight the risks arising from outsourcing, in the event that the accounted activities aren’t undertaken at the current performance, thus providing additional insights for the firm within the strategic decisions regarding the business process. As a whole, the integrative module allows a more careful investigation of the *as-is* state of the process and of the results of hypothetical *to-be* situations.

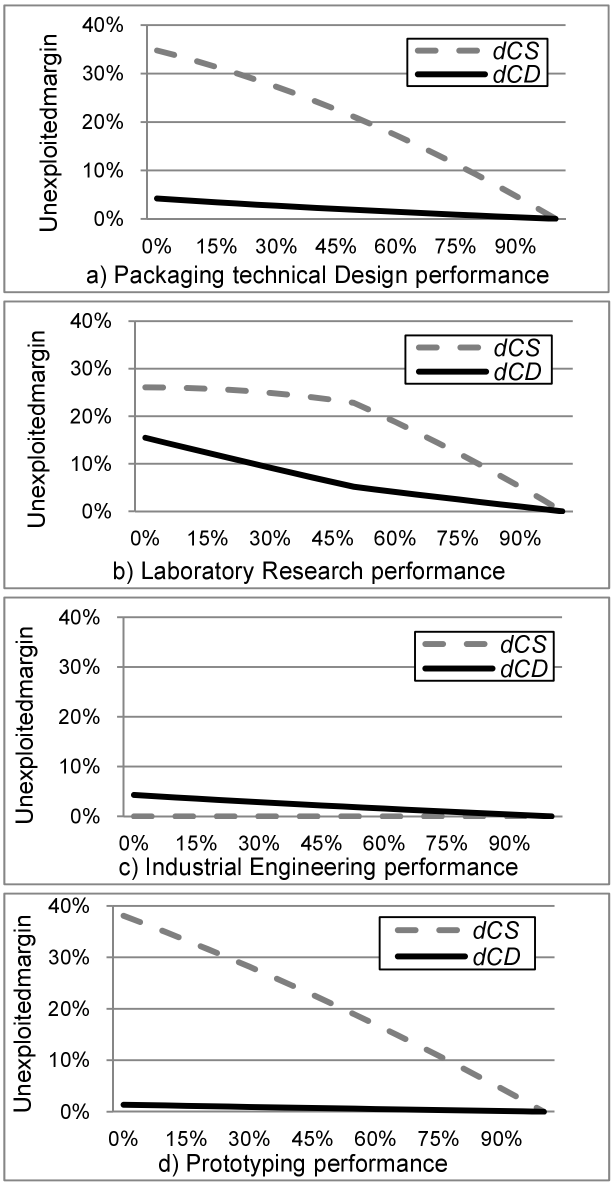

Figure 2: Not exploited margins of satisfaction according to phases performance.

6 CONCLUSIONS AND FUTURE ACTIVITIES

The original contribution of the paper is the investigation of a preliminary model for estimating the harm provoked by process underperformances in terms of perceived customer satisfaction. The information that the model provides represents a considerable amount of insight concerning the business process, complementing the indications about value bottlenecks emerging from the PVA application. Such further insights overcome the limitations of the PVA in terms of representing the current situation rather than ideal circumstances. However, the preliminary integrative module requires wide confirmation, notwithstanding the acknowledged scientific findings it is based on.

Indeed, the planned future activities include an all-encompassing evaluation by the cosmetic firm of the briefly summarized outputs, assessing whether the outcomes have been judged reliable and if the consequent decisions will be supported by positive confirmations. Furthermore, the experimentation of the proposed approach, aimed at assessing not only its effectiveness but also robustness and usability, represents an ongoing activity.

Another thread of research will involve the implementation of different models for the evaluation of customer satisfaction extents according to attributes quality. The survey will include the models mentioned in Section 2 that weren't firstly chosen for the recalled task and the results will be critically compared. Also the link (3) between phases' performance and customer requirements quality has to be further investigated. More specifically the interplay of the phases in determining the provided level of the attributes requires a more detailed examination, taking into account diversified patterns to affect the quality, depending on the nature of the product features.

Once the above mentioned open issues will be surveyed and the employed tools regarding the integrative module will be validated, analogous evaluations upon the phases value can be carried out with respect to those currently concerning their contribution to customer satisfaction. Further extensions will regard also the capabilities of the PVA methodology to interpret further negative outcomes of the ongoing business process (such as limited market appeal, non-conformities, unpredicted drawbacks) by revealing the inadequate phases and pointing out the measures to be attained and the proper resources to be channelled.

ACKNOWLEDGMENTS

The authors would like to thank Luca Lazzarini for the efforts spent in scrupulously analyzing the business process object of the exemplary application.

REFERENCES

[1] Holland, D., Kumar, S., 1995, Getting past the obstacles to successful reengineering, Business Horizons, 38:79–85.

[2] Hall, G., Rosenthal, J., Wade, J., 1993, How to make reengineering really work, Harvard Business Review, 71:119–131.

[3] Choi, T.Y., Eboch, K., 1998, The TQM Paradox: Relations among TQM practices, plant performance, and customer satisfaction, Journal of Operations Management, 17: 59-75.

[4] Joshi, A.W., Sharma, S., 2004, Customer Knowledge Development: Antecedents and Impact on New Product Performance, The Journal of Marketing, 68: 47-59.

[5] Borgianni, Y., Cascini, G., Rotini, F., 2010, Process Value Analysis for Business process Re-engineering, Proceedings of IMeche Part B: Journal of Engineering Manufacture, 224: 305-327.

[6] Borgianni, Y., Cascini, G., Rotini, F., 2010, Product-driven Process Value Analysis, in 20th CIRP Design Conference, Nantes, France, April 19-21, 2010.

[7] Neely, A., Gregory, M., Platts, K., 2005, Performance measurement system design: A literature review and research agenda, International Journal of Operations & Production Management, 25: 1228-1263.

[8] Kano, N., Seraku, N., Takahashi, F., Tsuji, S., 1984, Attractive quality and must-be quality, The Journal of the Japanese Society for Quality Control, 14: 39-48.

[9] Hauser, J.R., Clausing, D., 1988, The House of Quality, Harvard Business Review, 66: 63-73.

[10] Tan, K.C., Shen, X.X., 2000, Integrating Kano's model in the planning matrix of quality function deployment, Total Quality Management, 11: 1141-1151.

[11] Tontini, G., Silveira, A., 2007, Identification of satisfaction attributes using competitive analysis of the improvement gap, International Journal of Operations & Production Management, 27: 482-500.

[12] Hsu, C.H., Chang, T.M., Wang, S.Y., Lin, P.Y., 2007, Integrating Kano's Model into Quality Function Deployment to Facilitate Decision Analysis for Service Quality, in 8th WSEAS Int. Conference on Mathematics and Computers in Business and Economics, Vancouver, Canada, June 19-21, 2007.

[13] Garibay, C., Gutiérrez, H., Figueroa, A., 2010, Evaluation of a Digital Library by Means of Quality Function Deployment (QFD) and the Kano Model, The Journal of Academic Librarianship, 36: 125–132.

[14] Chaudha, A., Jain, R., Singh, A.R., Mishra, P.K., 2010, Integration of Kano's Model into quality function deployment (QFD), International Journal of Advanced Manufacturing Technology, in press.

[15] Xu, Q., Jiao, R.J., Yang, X., Helander, M., Halimahtun, M.K., Opperud, A., 2009, An analytical Kano model for customer need analysis, Design Studies, 30: 87-110.

[16] Xi, J.Y., Lee, C.L., Teng, H.L., Lin, S.B., 2010, Piecewise Regression: A Tool for Understanding The Relationship between the Attribute-Level Performance and Customer Satisfaction, in Conference on Information Management, Cheng Yun, Taiwan, January 26, 2010.

[17] Tripsas, M., 2007, Customer Preference Discontinuities: A Trigger for Radical Technological Change, Managerial and Decision Economics, 2-3: 79-97.

[18] Berger, C., 1993, Kano's methods for understanding customer-defined quality, Center for Quality Management Journal, 2: 3-36.

[19] Sauerwein, E., Bailom, F., Matzler, K., Hinterhuber, H.H., 1996, The Kano model: how to delight your customers, in IX International Working Seminar on Production Economics, Innsbruck, Austria, February 19-23, 1996.

[20] Tontini, G., 2003, Deployment of customer needs in the QFD using a modified Kano Model, Journal of the Academy of Business and Economics, 2: 103-113.

[21] Sireli, Y., Kauffman, P., Ozan, E., 2007, Integration of Kano's Model Into QFD for Multiple Product Design, IEEE Transactions on Engineering Management, 54: 380-390.

[22] Zhu, D.S., Lin, C.T., Tsai, C.H., Wu, J.F., 2010, A Study on the Evaluation of Customers' Satisfaction - The perspective of Quality, in 4th International Quality Conference, Kragujevac, Serbia, May 19, 2010.