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Title: TARGET COSTING OPERATIONALIZATION DURING PRODUCT DEVELOPMENT: MODEL AND APPLICATION

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Abstract: Target costing is a widely used technique for cost management during product development (PD). Despite target costing's strategic intuitiveness, its operationalization during PD requires careful decomposition of a product's constituent cost elements. The main objective of this paper is to describe an experience developing early-stage cost parameters for a specific PDP effort at a mid-sized Brazilian manufacturing company by proposing and applying a target costing model. One secondary objective is to provide a model to operationalize "target costing" by breaking down cost targets into product parts, features and common elements, focusing on creating parameters for cost control during product development. Using a detailed case study, target costing is explicitly decomposed in four different stages in a product development environment. All these are intended as a complement to the strategic use of "target costing".

October 20, 2008

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Dear Dr. Kelle,

We are resubmitting the paper: “Target costing operationalization during product development: model and application”. We are grateful for the reviewers’ comments and we believe we have addressed all points raised by them. Their comments helped improve this paper.

Below, we outline each point and what we have changed in the manuscript. In the new manuscript, we highlighted with the color grey all the changes that we have made. Below, it is an itemized list of reviewers’ comments and related changes.

FIRST REVIEWER:

Reviewer*: The authors present on this manuscript a very simple and efficient way of target-costing technique which adds value for others studies/investigations. minor revision is necessary as follow:*

Reviewer*: 1) revise the text since some typing error were identified as below:*
Sub-title 3.1: This stage is related to the decompsition->(decomposition)
Sub-title 3.4: If product is composed of parts A, B and C..., the target cost BIP->(IBP)
Authors: We corrected these errors and also revised all the text.

Reviewer*: 2) in figure 2, Project Target cost definition should be better described since it is a "total cost spent on yearly basis" different to the other target cost definition on unit cost basis. Proposal to use the definition "project budget or project funding requirement"*
Authors: We changed the definition from “project target cost” to “project budget target cost”. We also changed the definition to “The aggregate budget cost of the entire product development project for a product or family of products”.

***Reviewer**: 3) clarification of some phrases are necessary or should be deleted:*
Sub-title 3.4: "...However, when the price of the outsourced products is summed, it might not be equal to the target cost PRO..." please clarify why not if target cost PRO is on total unit cost, it means equal outsourced price in case all components/parts are outsourced.
Authors: We deleted this phrase.

***Reviewer**: last sentence: "...Cost data, in general, caries uncertainty, so the use of techniques of stochastic modeling, would help to improve it." what the author would like to mean with "stochastic modeling"?*
Authors: We changed this phrase to: “Another limitation was the use of simple deterministic point values. Cost data and market data, in general, caries uncertainty, so the use of techniques of risk modeling, for example, monte carlo simulation, would help to improve it”.

SECOND REVIEWER:
***Reviewer**: the topic of the article is interesting, although already discussed in literature.*
Authors: We believe that our study contributes to the literature and we tried to emphasize this point in the revised manuscript. Below, we point out our main reasons of why it should be published:

a) This paper presents an actual industry experience developing early-stage cost parameters for a specific PDP effort at a mid-sized Brazilian manufacturing company by proposing and applying a target costing model. A model accompanied by a detailed case study is developed. This gives some perspectives to the international academic community on the use of target costing in some emerging markets. For instance, in the extensive target costing review presented by Ansari et al. (2007), the great majority of the applications were focused in Japan, United States and Europe.

b) This study also provides a model to operationalize target costing by breaking down cost targets into product parts, features and common elements, focusing on creating parameters for cost control during product development. This was not just a semantics discussion. It was also a tentative approach to integrate the target and feature costing literature. This detailed decomposition also enables teams involved in product development to have more accurate cost control, in particular engineers and designers. Section 2 of the paper presents a discussion of other authors point of view and how we integrate this literature and contribute to it.
c) The separation of the target costing into four different stages and the definition of its inputs and outputs is another contribution to the target costing literature applied to product development. To briefly summarize the model: the model started with the definition of the product parts, feature and common elements. In stage two, the demand forecast, project budget target cost and target cost UDC were obtained. Stage three began with the product target price and profit definition and finished with the target cost PRO. Stage four began with the target cost INS, followed by the target cost IBP and target cost IBF. The way we separate the model, all the inputs and outputs definitions are contributions of the model to the literature. In section 3, 3.1, 3.2, 3.3 and 3.4, we try to clarify the importance and contributions of the model.

Reviewer*: However, in my opinion some important revisions should be made. In particular: - the section concerning the calculation of the Target Costo IBP/IBF is a little bit weak. Relying on the information coming from just one existing (similar) product might be very dangerous (some context variables might change, as, for instance, production technologies, performance features of the different components, etc). In other words, each step requires some justification, based on a deeper analysis*

Authors: To address this comment, we reformulated section 3.4 of the manuscript, and we also add some other explanations on section 4.4. We included more than two pages to make this part of the methodology clearer and deeper. We also included the concerns of the referee during the new section. All the changes are highlighted on sections 3.4 and 4.4.

***Reviewer**: it should be clarified if the flowscheme that leads from the Target Cost PRO to the target cost INS etc etc (Figure 3) has been elaborated by you, or if it has been drawn by literature (if so, please mention the reference/s). The fact of including the cost of the product development stage in the overall Target Cost PRO is not "automatic", for example;*

Authors: Yes, we elaborated the flow scheme, and this is *not* presented in previous literature. We included an explanation about the inputs and the outputs of the flow scheme in section 3. We believe this was important to clarify the model. We reformulated section "3", "3.1", "3.2", "3.3" and "3.4". All the changes are highlighted in these sections of the manuscript.

***Reviewer**: the market scenario and the demand forecast deserves a more thorough analysis;*

Authors: This comment has impact on section 3.2, 3.3, 4.2 and 4.3. First, to help clarify the market scenario we added a small literature review on section 3.3 and we also improved the explanation on section 4.3 (case study). We did the same in relation to the demand forecast, sections 3.2 and 4.2. All the changes can be verified in the manuscript (it is all highlighted).

***Reviewer**: it would have been interesting to know what happened next (i.e., from theory to reality: the matching between the target costs for the different parts identified through this model and the market prices/internal costs, as quantified by the purchasing/production managers/engineers, and the subsequent "fine tuning"/corrective actions). I know that this might be out of the scope of the paper, but it is by far the most interesting part of the process (also to understand if the proposed approach is "robust" or not).*

Authors: We agree with the reviewer that some other points could also be interesting. However, as pointed out by the reviewer it would also be out of scope. We cannot touch on all the interesting issues mentioned by the reviewer, but we added a paragraph right before the conclusion about the comparison about cost estimation and the parameters

created by the methodology that we proposed (last column Table 7 presents the new data). We are also preparing a paper about feature-based cost estimation, but we did not discuss it deeply because it is beyond the goal of this target costing paper. We believe that the suggestions of the reviewer were relevant, and we added them in the conclusion as future research opportunities. Again, this is all highlighted in the text.

***Reviewer**: literature on target cost application is lacking some important contributions (if I remember well).*

Authors: We included some other target costing studies that were not included in the first version:

AFONSO, P., NUNES, M., PAISANA, A., BRAGA, A., 2008. The influence of time-to-market and target costing in the new product development success. International Journal of Production Economics, 115, 559-568.

ANSARI, S., BELL, J., OKANO, H., 2007. Target costing: uncharted research territory. In *Handbook of management accounting research, Volume 2,* edited by CHAPMAN, C.S., HOPWOOD, A.G, SHIELDS, M.D., 507-530. Amsterdam: Elsevier.

ANSARI, S.L., BELL, J.E., CAM-I TARGET COST CORE GROUP, 1997. Target costing: the next frontier in strategic cost management. Chicago: Irwin.

AX, C., GREVE, J., NILSSON, U., 2008. The impact of competition and uncertainty on the adoption of target costing. International Journal of Production Economics, 115, 92-103.

COOPER, R., SLAGMULDER, R., 1997. Target costing and value engineering. Oregon: Productivity Press.

COOPER, R., YOSHIKAWA, T., 1994. Inter-organizational cost management systems: the case of the Tokyo-Yokohama-Kamakura supplier chain. International Journal of Production Economics, 37, 51-62.

DEKKER, H., SMIDT, P., 2003. A survey of the adoption and use of target costing in Dutch firms. International Journal of Production Economics, 84, 293-305.

KATO, Y., 1993. Target costing support systems: lessons from leading Japanese companies. Management Accounting Research, 4, 33-47.

OTTO, K., WOOD, K., 2001. Product design: techniques in reverse engineering and new product development. New Jersey: Prentice Hall.

TANI, T., 1995. Interactive control in target cost management. Management Accounting Research, 6, 399-414.

TANI, T., OKANO, H., SHIMIZU, N., IWABUCHI, Y., FUKUDA, J., COORAY, S., 1994.Target cost management in Japanese companies: current state of the art. Management Accounting Research, 5, 67-81.

YOSHIKAWA, T., INNES, J., MITCHELL, F., 1994. Applying functional cost analysis in a manufacturing environment. International Journal of Production Economics, 36, 53-64.

We also added some other studies, not directly related to target costing. They are also highlighted in the references.

***Reviewer**: I suggest you to include some more references to earlier publications on IJPE, if any (it is an evaluation element used by most editors)*

Authors: In the first version we had 3 studies from IJPE:

BEN-ARIEH, D., QIAN, L., 2003. Activity-based cost management for design and development stage. International Journal of Production Economics, 43, 169-183.

IBUSUKI, U., KAMINSKI, P.C., 2007. Product development process with focus on value engineering and target-costing: A case study in an automotive company. International Journal of Production Economics, 105, 459-74.

TORNBERG, K., JÄMSEN, M., PARANKO, J., 2002. Activity-based costing and process modeling for cost-conscious product design: A case study in a manufacturing company. International Journal of Production Economics, 79, 75-82.

In the new version we added more 6 studies (2 of them have just been published online):

AFONSO, P., NUNES, M., PAISANA, A., BRAGA, A., 2008. The influence of time-to-market and target costing in the new product development success. International Journal of Production Economics, 115, 559-568.
AX, C., GREVE, J., NILSSON, U., 2008. The impact of competition and uncertainty on the adoption of target costing. International Journal of Production Economics, 115, 92-103.
COOPER, R., YOSHIKAWA, T., 1994. Inter-organizational cost management systems: the case of the Tokyo-Yokohama-Kamakura supplier chain. International Journal of Production Economics, 37, 51-62.
DEKKER, H., SMIDT, P., 2003. A survey of the adoption and use of target costing in Dutch firms. International Journal of Production Economics, 84, 293-305.
LO, T., 1994. An expert system for choosing demand forecasting techniques. International Journal of Production Economics, 33, 5-15.
YOSHIKAWA, T., INNES, J., MITCHELL, F., 1994. Applying functional cost analysis in a manufacturing environment. International Journal of Production Economics, 36, 53-64.

***Reviewer**: and to translate references written in Portuguese or other languages into English (if available: it is the case of Horngren, Foster, Datar text, for example).*

Authors: All the references that were in portuguese and are available in english were changed.

***Reviewer**: Last: I have found some typo. Please check the names of the authors cited in references (I am afraid one or two of them have not been written correctly).*

Authors: Two of the authors' names were written incorrectly, we corrected that.

We believe we worked on all issues raised by the referees. We are sure that the IJPE is the most appropriate journal to publish this paper. Any other issue with the paper we will be happy to address.

Thanks for your attention and we look forward to hearing from you.

Tiago Filomena
Francisco Kliemann
Michael Duffey

TARGET COSTING OPERATIONALIZATION DURING PRODUCT DEVELOPMENT: MODEL AND APPLICATION

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Abstract

Target costing is a widely used technique for cost management during product development (PD). Despite target costing's strategic intuitiveness, its operationalization during PD requires careful decomposition of a product's constituent cost elements. The main objective of this paper is to describe an experience developing early-stage cost parameters for a specific PDP effort at a mid-sized Brazilian manufacturing company by proposing and applying a target costing model. One secondary objective is to provide a model to operationalize "target costing" by breaking down cost targets into product parts, features and common elements, focusing on creating parameters for cost control during product development. Using a detailed case study, target costing is explicitly decomposed in four different stages in a product development environment. All these are intended as a complement to the strategic use of "target costing".

Keywords: target costing; product development; operationalization; cost; feature costing.

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1. Introduction

Product development (PD) is a core factor in competitive advantage, and effective early-stage cost management techniques, during the product development process (PDP), are increasingly sought after by many industries. Horngren et al. (1997) and Tornberg et al. (2002) have established that most of the product costs are determined in the early stages of product's life-cycle. There is also an evolving literature to identify and manage the specific economic factors that are important during the PDP (Andreasen and Hein, 1987; Cooper, 1990; Crawford and Benedetto, 2006; Dickson, 1997; Kotler, 2003; Pahl and Beitz, 1995; Prasad, 1996).

Target costing is a technique for economic management, particularly cost management, during PD (Filomena et al. 2005). The use of the target costing during PD is supported by the surveys of Dekker and Smidt (2003) and Tani et al. (1994) which show that the product development and design departments are major users of target costing. Furthermore, Afonso et al. (2008) present a survey in which target costing has a positive impact in new product development.

Cooper and Slagmulder (1999) define target costing as a technique to manage future profits in the organization. The target costing begins with the target price, which is in general determined by market research or observation. A desired per unit profit is then simply subtracted from the target price to obtain the target cost (Cooper and Chew, 1996; Monden, 1995), as it is presented in Equation 1.

$$\text{Target Cost} = \text{Target Price} - \text{Profit} \quad (1)$$

The concept of target costing seems to be closely related to studies conducted in Japanese companies and/or by Japanese researchers (Cooper and Yoshikawa, 1994; Kato, 1993; Tani et al., 1994; Tani, 1995). The target costing apparently emerged as a cost management technique used by Japanese management accountants to enable better decision-making during the PDP and to stimulate employees to follow long-term strategic policies (Gagne and Discenza, 1995). Its evolution as a strategic concept has been described by Everaert and Bruggeman (2002).

However, practical applications of cost and profitability control during the PDP require detailed and available product cost information. Furthermore, despite the target costing strategic intuitiveness, its operationalization during early-stage product life-cycle decision making requires careful decomposition of a product's cost constituent elements. Terms such as "features," "characteristics," "parts," "functions," and "elements" can become inherently context-specific and overlapping depending on the type of product, the product family genealogy, geometric and functional complexity, and other factors. These issues are discussed in this study.

The main objective of this paper is to describe an experience developing early-stage cost parameters for a specific PDP effort at a mid-sized Brazilian manufacturing company by proposing and applying a target costing model. One secondary objective is to provide a model to operationalize "target costing" by breaking down cost targets into product parts, features and common elements, focusing on creating parameters for cost control during product development. Using a detailed case study, the target costing is explicitly decomposed in four different stages in a product development environment. All these are intended as a complement to the strategic use of "target costing".

This model is limited to the creation of product cost parameters, with a market to company point of view. As a complement to this model, the development team must estimate product costs during the evolution of PDP, and then the estimated product cost can be compared with the beforehand generated cost parameters (proposed in this model). As an example, at the end of the case study some estimated costs for the proposed features are presented. When the estimated costs excide the cost parameters, the development team knows that some action must be taken to decrease product's cost. Cooper and Slagmulder (1997), Ansari (1997) and Yoshikawa et al. (1994) point out the value engineering as a technique to reduce costs.

This paper is structured in three main sections. In the first one, concepts of product parts, features and common elements are standardized. In the second, a model that can be used to break down product target cost during product development is presented. Then the model is applied to the development of a new family of seats products in a Brazilian bus body automotive manufacturing company. Some other justifications for this study are presented on section 2 and 3.

2. Product Parts, Features and Common Elements Conceptualization

To provide some background and context, concepts of *product parts*, *features* and *common elements,* used during the target costing or product development, are examined, including the sometimes disparate terminologies deployed by various authors and practitioners. First, a brief review of how other authors have decomposed product costs during target costing and product development is presented. Then three important concepts for this study are defined: *products parts*, *features* and *common elements*.

Cooper and Slagmulder (1997; 2002a; 2002b) divide the target costing process into product-level target cost and component-level target cost. Between the product-level and the component-level, they define "functions", for which they provide the following definition: "*Major functions are the subassemblies that perform a critical function that supports the product in its ability to perform its primary function. For example, an engine cooling system is a major function of an automobile.*" Ansari et al. (1997) and Monden (1995) use taxonomies that are similar to Cooper and Slagmulder (1997; 2002a; 2002b). In a somewhat similar fashion, Ibusuki and Kaminski (2007), in a study of the automotive industry, decompose vehicles parts into their "functions" and "components".

Brimson (1998) does a different conceptualization. This author separates the product into "features" and "characteristics". For example, a pair of blue jeans has a watch pocket and a zipper fly as its "features", and fabric thickness and size as its "characteristics." In another study, Ou-Yang and Lin (1997) define "parts" as physically separable components of the product, and "feature" as the geometry of possible components.

Leibl et al. (1999) writes that a "*feature may consist of semantic facts of the case, of geometrical description, or of both. Semantics should be looked upon not simply as an accessory, but rather as a central component. For concrete application each feature obviously possesses a geometry*". Ben-Arieh and Qian (2003) use activity-based costing (ABC) to evaluate a rotational part development's cost, using during their paper the expression "part." Dixon, Duffey and colleagues (1988) developed a taxonomical classification system for decomposing mechanical systems that relates geometric "features" and other descriptors to the evolving stages of design. Dixon and Duffey

(1990) also present operational definitions of "features" for a variety of computer-aided mechanical design methodologies.

Weighting the relative merit and extensibility of theses definitions is not a goal for this paper. However, the semantics of *product parts*, *features* and *common elements* will be standardized because they are used to break down the product target cost during the product development. As an explanatory purpose, consider a bicycle.

Product parts are the main physically separable parts of the product. For example, without exhausting all the possibilities, consider 5 separable parts in a bicycle: frame, wheels, break, seat and suspension. The *features* are the characteristics that economically differentiate each part, not only for material but also for production. For instance, the material, the size and the design could be considered as *features* of the frame *part*. Figure 1 presents the deployment of the product in *parts* and *features*.

Figure 1. Deployment of the product in parts and features.

Common elements, the third concept, are just the components that are in the *product parts* independently of the product's *features*. They are independent of the configuration. *Product parts*, *features* and *common elements* can also have different hierarchical levels, as experienced in the bus body automotive manufacturing company case study.

Clarifying the semantics of *product parts*, *features* and *common elements* is

necessary for this study. The decomposition of the product and its costs in *parts*, *features* and *common elements* provides a tentative integration between target costing and feature costing literature which also contributes to the body of knowledge.

3. Target Costing during Product Development – Model

With some concepts standardized, the theoretical model is developed. Figure 2 presents some terms, acronyms and definitions to enable an easier read of the model and case study that follows.

Figure 2. Some terms, acronyms and definitions to be used along the text.

The model proposed in this paper is structured into four Stages: Stage 1 is the definition of the product parts, features and common elements, Stage 2 presents the unitary target product development costs (target cost UDC), Stage 3 is the product target cost (target cost PRO) calculation and Stage 4 is the definition of the insertion target cost (target cost INS) and the insertion target cost breakdown into parts (target cost IBP) and features (target cost IBF). The explicit separation into these four stages and the definition of inputs and outputs are contributions to the target costing literature applied to product development. The Figure 3 demonstrates a summary of the proposed model.

Figure 3. Summary of the proposed target costing operationalization model.

The details of each stage are discussed in the next 4 sections, but it is important to clarify the reasons for each stage and how they are interconnected. Stage 1 carries some main definitions proposed in this paper (as discussed in section 2). Product parts, features and common elements will be main drivers to break down the product and its costs during product development. Ansari et al. (2007) point out that cost targets must be decomposed in some way to be allocated to product development teams efforts.

Stage 2 is more related to the product development project itself (unitary target product development costs). It can be also viewed as the product development costs. The PDP phases can vary depending on each company and/or model. For instance, Baxter (1995), Cooper (1990) and Crawford and Benedetto (2006) have different approaches to the PDP phases. For the target costing operationalization model proposed in this paper, it is not necessary to define which kind of process is used during the PDP; this can be flexible. The real need is to define the target of how much the PDP can cost per product unit to guarantee desired profitability during the product life cycle. This is being captured by the output of this stage, target cost UDC.

In stage 3, there is no differentiation between the development costs (project budget target cost) and other costs associated with the product, for instance, raw material, labor and other production costs. The target cost PRO includes the overall target cost of each product. In this model, as presented in section 3.3, it is proposed to collect the target cost PRO considering the main features of the product. The features are obtained by using the information of stage 1.

Based on Figure 3, two relations between stage 2 and 3 are observed. The first

one is the interconnection between demand forecast and product target price. This is closely related to the concept of price elasticity of demand[1]. For a product that has elastic characteristics a price increase will be accompanied by a demand decrease. Thus, the product target price and demand definition are closely related.

The second is the relation between the target cost UDC and the target cost PRO which has as a result the target cost INS. The target cost INS includes the life cycle costs of the product excluding the development costs. This procedure is applied to the model, because it is operationally difficult to separate the target cost UDC in each *part, feature and common elements.* Furthermore, it becomes easier to understand different aspects of costs reduction, for example, in some industries the cost to develop a product might be very heavy in relation to the other costs. The way the target cost UDC is subtracted from the target cost PRO is also a contribution of this paper to the target costing literature, given that it clearly separates development and other costs.

Stage 4 is where the target cost is broken down into parts, features and common elements, using the information obtained on stages 2 and 3. This deployment of the product costs makes the target costing more operational for the members of the product development, for instance, designers and engineers. This breakdown is also an innovation to the literature presented by this paper, given its terms definition discussion and integration between the different methodologies of target and feature costing.

3.1. Stage 1: Product Parts, Features and Common Elements Definition

This stage is related to the decomposition of the product into parts, features and common elements, as described in section 2. Some studies, such as Ansari et al. (1997),

[1] Pindyck and Rubinfeld (2001) present an introductory discussion on price elasticity of demand.

Ben-Arieh and Qian (2003), Cooper and Slagmulder (1997; 2002a, 2002b), Ibusuki and Kaminski (2007), Leibl et al. (1999), Monden (1995) and Ou-Yang and Lin (1997) use the concept of "feature costing" (or some similar concept) during the target costing or product development. Filomena et al. (2005) also pointed out the importance of a feature based costing to enable designers and engineers to make a better decision during the product development.

3.2. Stage 2: Unitary Target Product Development Costs (Target Cost UDC)

The first input for this stage is the demand forecast for the product. Crawford and Benedetto (2006) point out that the demand forecast is one of the hardest challenges for financial analysis during new product development. Thus, demand forecast methods' classification and selection are briefly introduced in this session.

Armstrong (2001a) classifies the forecast methods in judgment and statistical. Judgmental methods include role playing, intentions and expert opinions. Statistical methods are the extrapolation, econometric and multivariate models. Kahn (2006) has a similar classification, but he also adds customer/market research methods as methods to forecast new product demand. Kahn (2002) also discusses a survey on new product forecast practices, where one of the findings is which forecast techniques companies are applying during product's development prelaunch and launch stage.

The best forecast technique to be used depends on a wide variety of circumstances. Armstrong (2001b) developed a methodology (flow chart) to help selecting the best demand forecast technique. Lo (1994) proposed an expert system to choose demand forecast technique. Other demand forecast techniques and selection

methodologies can be used to find the demand. The only constraint for the target costing operationalization model proposed in this paper is to have the forecast for the *family* of products as a whole; breaking down the forecast in each combination of features tends to become needlessly complex.

Another input is the project budget target cost. This cost can sometimes be forecasted by the historical data of previous projects developed by the company (as was practical for the case that follows). The company might not have made a project that is exactly the same project that is taking place at the moment, but some cost parameters of old projects will help to forecast current project cost, properly scaled for inflation and other factors. A database structured on activity-based costing system (ABC) is a good practice to store the data and forecast future project costs[2].

With the information about the demand forecast and the project budget target cost, the output for this stage is obtained: the target cost UDC. Equation 2 presents its calculation. This parameter avoids the amortization of this project cost in other products of the company.

$$Target\ Cost\ UDC = \frac{Project\ Budget\ Target\ Cost}{Demand\ Forecast} \qquad (2)$$

In this study, the time value of the money for the target cost UDC is not being considered. However, the actual project budget target cost could be annualized for future values, then the annualized value could be used to estimate the target cost UDC. This is

[2] Kinsella (2002) and Macarrone (1998) have discussions of ABC on projects.

not considered in this paper, but similar problems can be found on Sullivan et al. (2006) and Park (2007).

3.3. Stage 3: Product Target Cost (Target Cost PRO)

The product target price is the first input for this stage. Cooper and Slagmulder (1997) point out that there are three dimensions to define target price: the perceived value and loyalty of the customers; the relative offered functionality, quality and price; the considered strategic objectives including corporate image, market share and long-term profits. When the profit is subtracted from the target price, the target cost PRO is obtained. There are typically three ways to define the target price: pricing research with the customers, comparison with other products market price and exploring the experience of the company team[3].

Aaker et al. (2006) state that there are two main pricing research approaches with customers. On one hand, the same product with different prices is presented to participants, who state if they would buy the product for each of the prices. This method was developed by Gabor and Grainger[4]. On the other hand, the same product with different brands and prices are presented and the respondents answer which they would buy.

Defining the target price by comparison with other products market price can be very useful if there are similar products in the market. Monden (1995) point out that this can be used when there are not many differences between the product that will be offered by the company and the ones available in the market; when the life-cycle of the product is

[3] In this paper, it is not explored all possibilities to the target price definition. Aaker et al. (2006), Ansari et al. (1997), Cooper and Slagmulder (1997), Crawford and Benedetto (2006), Monden (1995) have more on this issue.
[4] See Gabor and Granger (1961, 1966).

short and new products will probably come at lower price; and when there is a matured buyer's market.

The experience of the company team with the product may help with the estimation of the target price. This is especially important when there is nothing similar to the new product in the market. Combinations of the pricing research with the customers, comparison with other players and exploration the team experience can be used to the target price definition.

One difficulty in analyzing the target price is that the combination of features for each variant can be wide. When this situation happens one might try to collect target prices based on the main features of the product, the other features might be determined during the process of target cost definition.

3.4 Stage 4: Insertion Target Costs (Target Cost INS) and Insertion Target Cost Breakdown into Parts (Target Cost IBP) and Features (Target Cost IBF)

The target cost INS is the first parameter to be obtained in stage 4. It is obtained by subtracting the target cost UDC from the target cost PRO, as it is presented in Equation 3. After the definition the target cost INS, this cost data must be decomposed into parts and features, becoming a set of target cost IBP's and then IBF's.

$$\text{Target Cost INS} = \text{Target Cost PRO} - \text{Target Cost UDC} \quad (3)$$

Three ways to break down the target cost INS into target cost IBP's are proposed: market price, previously produced similar products and experience of the company's

team. The market price approach is based on the fact that the product's parts can often be potentially outsourced to other companies, given that the parts are available in the market.

When a product (or part) was already produced by the company, previously produced similar products can be helpful to the transition from target cost INS to IBP. In this case, the physical and technological structure between the old and the new product (or part) have to be similar. The experience of the company's team is the option when no other source of information is available. This is the case for totally new products, for instance, new technology or physical structure.

The use of the market price and previously produced similar products techniques must be used with care given that the products (or parts) being compared might differ, for instance, in its materials performance, technology or components. A wrong benchmark can generate a distorted target cost IBP. Another problem that might occur is that when the target cost IBP is summed it might not be equal to the target cost PRO plus the target cost UDC. In this case, the target cost PRO, target cost UDC or the target cost IBP must be reviewed.

The decision of which technique to break down the target cost INS into target cost IBP will depend on a number of different factors: product and production technology, technology availability, materials and components performance, product degree of innovation and others. It is not the goal in this study to define all variables that might influence this choice, but a discussion, which can help in most cases for this model application, is offered. Two approaches to choose the best technique to break down the target cost INS into IBP are proposed: based (i) on product's degree of innovation in

relation to the company and to the market and (ii) on the design novelty.

The first method to choose the technique to break down the target cost INS into IBP would be to compare the product's degree of innovation to the company and to the market. The literature on innovation typology and innovativeness terminology does not present a standardized classification yet (Garcia and Calantone, 2002). The definitions of terms as "radical", "really-new", "incremental" and "discontinuous innovation" still vary among authors. For this target costing model, a simple framework is proposed to decide which the best technique is, as presented in Figure 4.

Figure 4: Proposed framework to choose the best technique to break down target cost INS into IBP.

Based on Figure 4, it is concluded that if the product's degree of innovation is high in relation to the company and to the market, then the experience of the company's team is the most appropriate technique. Previously produced similar products is reasonable if the product has a high degree of market innovation but low degree of company innovation. Market price is appropriate for conditions in which the technology of the product is new to the company but already exists in the market. The previously produced similar products or market price techniques are also adequate for products with low degree of market and company innovation. Also any mixture of the three methods could be used in this case.

The second technique would be based on the design novelty of the product. Otto

and Wood (2001) and Pahl and Beitz (1995) classify design novelty as “original”, “adaptive” and “variant”. Original design is to use original solutions to solve a given task or problem (Otto and Wood, 2001; Pahl and Beitz, 1995). The original design can involve whole product or just parts of it. Adaptive design is defined by Otto and Wood (2001) as “*adapting a known system to a changed task or evolving significant subsystem of a current product*”. Most of design effort is related to the adaptive one. The variant design is to vary already-existing parameters of the product to improve its performance (Otto and Wood, 2001; Pahl and Beitz, 1995).

The way the cost will be decomposed is in turn related to the type of design that is being done. Making a price comparison with products available in the market, means that the product already exists in the market, not being an original design. Thus, market price comparison would fit better for adaptive and variant design. Previously produced similar products would also fit better for adaptive and variant design if the company has already produced this kind of product. When the product is an original design, probably, the only way to break down the target cost INS into target cost IBP is to use the experience of the company’s team, given the internal and external lack of information to the company.

After the definition of each target cost IBP, the target cost IBF is obtained. It can be done in the same fashion as the target cost INS was decomposed into target cost IBP. Thus the cost object is not the product anymore but the features. This is defined by Brimson (1998) as Feature Costing. If the estimated cost for some feature or common element is greater than its target cost, some technique, such as value engineering, must be used to help decrease the estimated cost. The target costing, as it is presented in this paper, just provides the parameters to control the costs during the PDP; it is not used to

estimate and reduce costs. All the input and output for each of the four stages is summarized in Figure 3.

4. Target Costing during PD – a Case Study

This model was applied at a Brazilian bus body automotive manufacturer. This company was developing new seats for its buses. The case study follows the stages defined in Figure 3.

4.1. Product Parts, Features and Common Elements Definition

Initially the seat was separated in two parts: structural and finishing. The structural part has the alternative features of fixed or movable arms; these features are influenced by the existence or not of an ashtray. The finishing part has two main features: the anatomy of the seat and the existence of magazine holder. The anatomy of the seat is also influenced by the type of cover. Figure 5 presents the deployment of the seat in parts and features.[5]

Figure 5. Deployment of the seat in parts and features.

Some components and sub-assemblies are the same independently of the product's feature; these are the common elements. Some of these elements are defined for the structural and finishing part. Figure 6 presents the deployment of the product in parts,

[5] The magazine holder could have been considered as another part, but it was kept it in the finishing part given their highly connection. Also the magazine holder economic implication is not that high when compared to the structural and finishing part.

features and common elements. A combination of numbers and letters are used to code the last feature level and the common elements.

Figure 6. Deployment of the seat in parts, features and common elements.

4.2. Unitary Target Product Development Costs (Target Cost UDC)

To determine the target cost UDC it is necessary to define the demand forecast and the project budget target cost. Section 3.2 presented explanations and specific studies dedicated on how obtain these parameters. For the purpose of this study the demand forecast for the buses was already done, thus the demand forecast for the seats was a matter of multiplying the number of seats per bus by the forecasted buses. The total number of seats was estimated to be 91,000 and the total project budget target cost $145,000;

Table 1 presents the breakdown value for the project budget target cost. The project budget target cost would be more precise if the company already had an activity-based cost for the product development process implemented.

Table 1. Project budget target cost breakdown.

The target cost UDC is $1.59. This is obtained by dividing the project budget

target cost by the demand forecast, as proposed in Equation 2.

4.3. Product Target Cost (Target Cost PRO)

To determine the target cost PRO it is necessary to begin with the product target prices. The number of configurations in this case is wide, so it was defined some main features (Figure 7) and their prices (with these features it will be obtained all relevant cost decompositions for the product).

Figure 7. Main features to verify the seats prices.

Similar seats were available in the market. Thus, the product price definition was based on similar products produced by other companies. Four configurations were defined to find the prices of the main features:

a. Fixed arm without ashtray, conventional finishing, fabric cover and magazine holder – Configuration A;
b. Movable arm without ashtray, conventional finishing, fabric cover and magazine holder – Configuration B;
c. Fixed arm without ashtray, conventional finishing, vulcouro cover and magazine holder – Configuration C;
d. Fixed arm without ashtray, soft finishing, fabric cover and magazine holder – Configuration D;

The target prices for these configurations, obtained by similar products in the

market are presented in the second column of Table 2.

Table 2. Target price, target cost PRO and target cost INS for each configuration.

With the target prices of the products defined, the target cost PRO is obtained. The profit margin defined for this case is 10%. Equation 4 presents the calculation for Configuration A, and in the third column of Table 2 the other configurations' target costs PRO are defined.

Conf. A Target Cost Pro= \$250.50*(1-0.1) = \$225.45 (4)

4.4. Insertion Target Costs (Target Cost INS) and Insertion Target Cost Breakdown into Parts (Target Cost IBP) and Features (Target Cost IBF)

To begin this stage, the target cost UDC is subtracted from the target cost PRO to obtain the target cost INS for each of the four configurations. Equation 5 presents the calculation of the target cost INS for configuration A, and the fourth column of Table 2 summarizes the target costs INS for all four configurations.

Conf. A Target Cost INS = \$225.45 - \$1.59 = \$223.86 (5)

The framework proposed in Figure 4 was used to define the best technique to go from target cost INS to target cost IBP. The type of seat that was being developed was not very innovative either to the market or to the company. Thus, it was determined that

previously produced similar products was the technique with most information available. This is different than the decision made in section 4.3, where the option was to use market value for the product target price. This can be explained because the seats were available in the market, but their parts were not being offered separately. This drove the team's decision of using previously produced similar products[6].

First, it was verified that an old seat, which has similar features of configuration A, had 45% of its costs related to the structural parts and 55% related to finishing parts. The target cost IBP's of configuration A are obtained by multiplying these percentiles by the target cost INS of the configuration A. This is presented in the second column of Table 3.

Table 3. Target cost IBP of each configuration.

The values obtained for configuration A in Table 3 are fixed for any configuration that uses these parts. Given that the finishing part of configuration A is the same for configuration B, it is possible to obtain the target cost IBP for the structural part of B; this is presented in the third column of Table 3.

The structural part of configuration A is the same for configuration C, so it is possible to obtain the target cost IBP of configuration C; this is presented in the fourth column of Table 3. The structural part of configuration A is also the same for configuration D, so in the same fashion the target cost IBP of configuration D is obtained;

[6] To rely on the use of previously produced products, the company's team must assure that the product being developed is similar to the old product (or products). For instance, its materials performance, technology or components might differ. In this particular case the team evaluated that it was safe to use previously produced products as a comparison.

this is presented in fifth column of Table 3. Thus, in the last column of Table 3, it is summarized some of the target cost IBP's of some of the parts.

With the information about target cost IBP's, the target cost IBF's can be defined. To break down the target cost IBP into IBF were used estimates based on a mix of previously similar products manufactured by the company and the experience of the company's team. Again, the same carefulness that was discussed to transition from the target cost INS to IBP must be obeyed.

Similarly, as a percentage relation to calculate the cost of structural parts and finishing parts was obtained for configuration A, some relations were obtained to enable further deployment from target cost IBP to target cost IBF. Based on experience and old products, the team estimated that the ashtray would increase the cost of the structure (fixed and movable) by 1.5%. Table 4 presents target cost IBF's for the structures with and without ashtray.

Table 4. Target cost IBF for the structural parts with and without ashtray.

The team also verified that 85% of the costs related to structure of the fixed arm without ashtray are related to structural common elements. Equation 6 presents the target cost IBF for the structural common elements.

Target Cost IBF Structural Common Elements = 0.85*$100.74 = $85.63 (6)

The fixed common elements and movable common elements are also separated. The team found that the fixed common elements represent 7% of the cost of structural part with fixed arms and without ashtray. The movable common elements represent 8% of the cost of the structural part with movable arms and without ashtray. Equation 7 and Equation 8 demonstrate this calculation.

Target Cost IBF for Fixed Common Elements = 0.07*$100.74 = $7.05 (7)

Target Cost IBF for Movable Common Elements = 0.08*$112.98 = $9.04 (8)

With the values of Table 4 and Equations 6, 7 and 8, all the target cost IBF's for the structural parts are completed. Equation 9 presents the calculation for fixed arm without ashtray target cost IBF, and Table 5 shows all the target cost IBF's for the feature and common elements of the structural part.

Target Cost BIF Fixed arm without ashtray = $100.74 – 85.63 – 7.05 = $8.06 (9)

Table 5. Target costs IBF for features and common elements of the structure.

The same approach was used to define the target cost IBF of the finishing part. First, it was verified that the magazine holder is 11% of the cost of the finishing part with fabric cover cost. Equation 10 presents the target cost IBF's of the magazine holder.

Target Cost IBF Magazine Holder = 0.11*$123.12 = $13.54 (10)

It was also verified that the features without magazine holder represents 70% of the feature with magazine holder, totalizing $ 9.48. Using the values of Table 3 and Equation 10, it is obtained some results for the target cost IBF's related to the anatomy of the seat; this is presented on Table 6.

Table 6. Target cost IBF for the finishing features.

Now, the common elements for the finishing parts can be defined. It was verified that the conventional common elements are 50% of the fabric conventional finishing, and the soft common elements were 65% of the fabric soft finishing (the calculation of this term was not necessary, but it was done to facilitate the inclusion of other alternative covers to the soft finishing). Equation 11 presents the calculation for the conventional common elements, and Table 7 presents all the target cost IBF's for the structural and finishing part in the third column.

Target Cost IBF conventional common elements = 0.5*109.58 = $54,79 (11)

Table 7. Target cost IBF and estimated costs for the features and common elements of the seat.

Finally, Table 7 provides a detailed target cost, in other words "target cost IBF" (third column) for possible alternative configurations of the product. Thus, this methodology is a step by step fashion to define cost parameters to be controlled during the PDP. These parameters should be used as a product cost guide for the interdisciplinary developers. This enables the product develop team to take early actions if the target cost IBF's (or UDC) are not being achieved.

This methodology, when adequately integrated with the cost management system of the company, clarifies to the PD team where improvements can be made. Cost estimation and cost reduction techniques are complements to this methodology. The main goal of the company is to achieve the overall target cost PRO. This can be obtained by the achieving the target cost IBF and UDC.

Even though this model is just focused on the generating the cost parameters to be used as cost control, a brief discussion on the comparison of the target cost IBF and its estimates is also possible. The fourth column of Table 7 shows the estimates for each target cost IBF. When the estimated product cost exceeds the cost parameters (target cost IBF), some technique for cost reduction can be used to enable the product's profitability. This is true for the case of these seats. All estimated feature costs are above the target cost IBF's, which means the company has a lot of cost reduction work to do before launching this product.

5. Final Considerations

This paper presented an experience developing early-stage cost parameters for a

specific PDP effort at a mid-sized Brazilian manufacturing company by proposing and applying a target costing model. A model accompanied by a detailed case study was developed. This gives some perspectives to the international academic community on the use of target costing in some emerging markets. For instance, in the extensive target costing review presented by Ansari et al. (2007), the great majority of the applications were focused in Japan, United States and Europe.

It also provided a model to operationalize target costing by breaking down cost targets into product parts, features and common elements, focusing on creating parameters for cost control during product development. This was not just a semantics discussion. It was also a tentative approach to integrate the target and feature costing literature. This detailed decomposition also enables teams involved in product development to have more accurate cost control, in particular engineers and designers.

The separation of the target costing into four different stages and the definition of its inputs and outputs is another contribution to the target costing literature applied to product development. In summary, the model started with the definition of the product parts, feature and common elements. In stage two, the demand forecast, project budget target cost and target cost UDC were obtained. Stage three began with the product target price and profit definition and finished with the target cost PRO. Stage four began with the target cost INS, followed by the target cost IBP and target cost IBF.

A limitation of this study was lack of discussion of specific cost estimation and cost reduction techniques; it was just focused on the creation of cost parameters to be used as a control. Another limitation was the use of simple deterministic point values. Cost data and market data, in general, caries uncertainty, so the use of techniques of risk

modeling, for example, monte carlo simulation, would help to improve it. The model was tested in a not very innovative product. Thus it might need some changes in other environments.

As future research, other applications of this model to a larger variety of products could be done, for instance, products with higher degrees of innovation. The integration of the product development's cost management activities with the company's cost management system should also be accomplished. What the implications are to the product development team when differences between the target cost parameters and the estimated costs happen is another opportunity.

Ansari et al. (2007) points out that the decomposition of product-level price into customers' needs is another opportunity. This model might help to fulfill this gap. Ax et al. (2008) raised some questions about the relations between perceived environmental uncertainty and target costing adoption. Thus more extensive work on modeling uncertainty during target costing would probably make this model more appropriate for less predictable environments.

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Figure_1

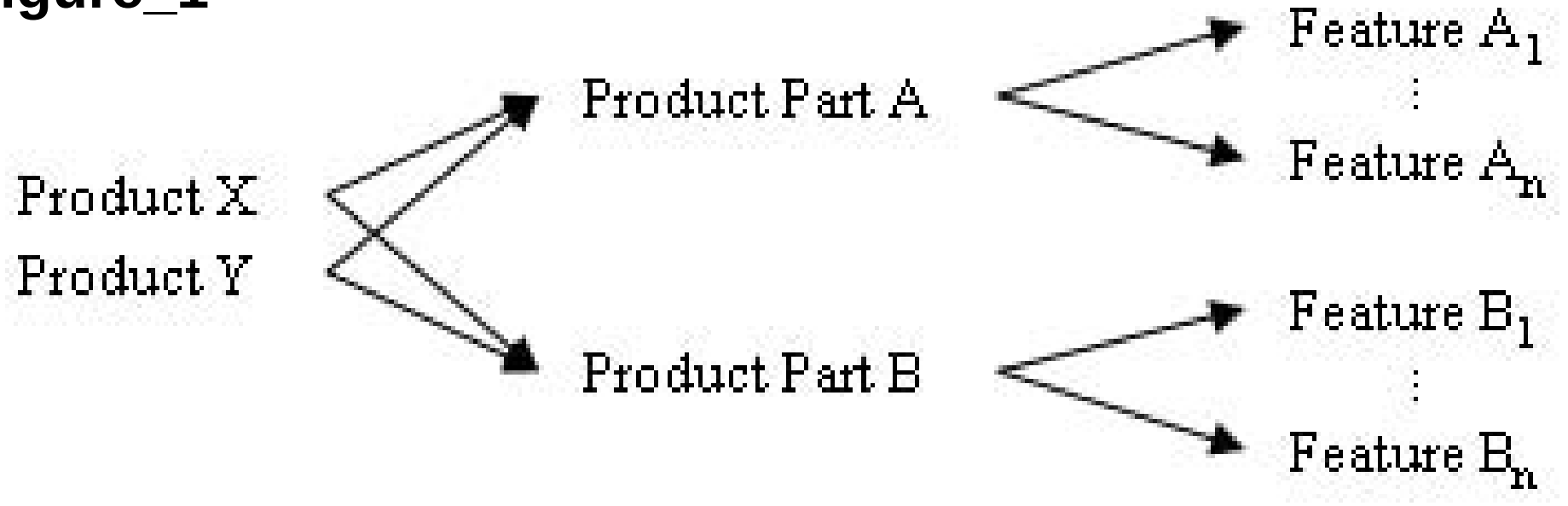
Product X
Product Y
Product Part A
Product Part B
Feature A_1
Feature A_n
Feature B_1
Feature B_n

Figure_2

Expression	Acronym	Definition
Target Costing	N/A	The general methodology of researching market prices and deploying into targets for costs of products and services
Target Cost	N/A	A specific goal for desired unit cost. The term can be further modified to indicate product cost, development cost, or other (see below)
Target Price	N/A	A specific goal for desired unit price
Project Budget Target Cost	N/A	The aggregate budget cost of the entire *product development* project for a product or family of products
Unitary Target Product Development Cost	Target Cost UDC	The target cost per unit product related to the costs incurred to *develop* a product
Product Target Cost	Target Cost PRO	The target cost per unit product related to all costs incurred to *produce* a product, including indirect and direct cost, raw material costs and development costs
Insertion Target Costs	Target Cost INS	The target cost PRO minus the target cost UDC
Insertion Target Cost Breakdown into Parts	Target Cost IBP	The breakdown of the target cost INS into subcategories (product "parts")
Insertion Target Cost Breakdown into Features	Target Cost IBF	The breakdown of the target cost INS into subcategories (product "features," including also common elements)

Figure 2. Some terms, acronyms and definitions to be used along the text.

Figure_3

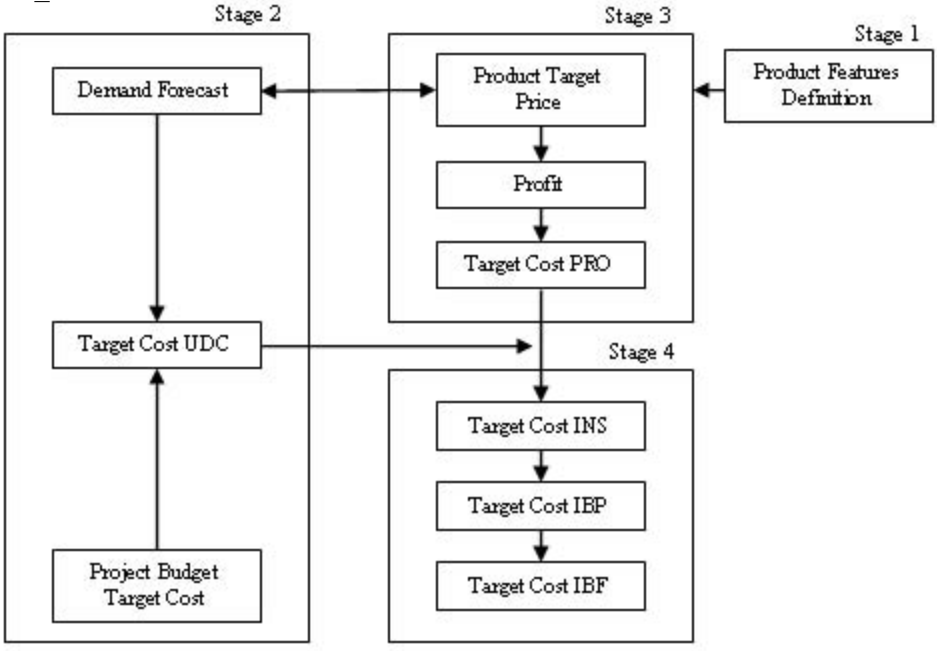
Stage 2
Stage 3
Stage 1
Demand Forecast
Product Target Price
Product Features Definition
Profit
Target Cost PRO
Target Cost UDC
Stage 4
Target Cost INS
Target Cost IBP
Target Cost IBF
Project Budget Target Cost

Figure_4

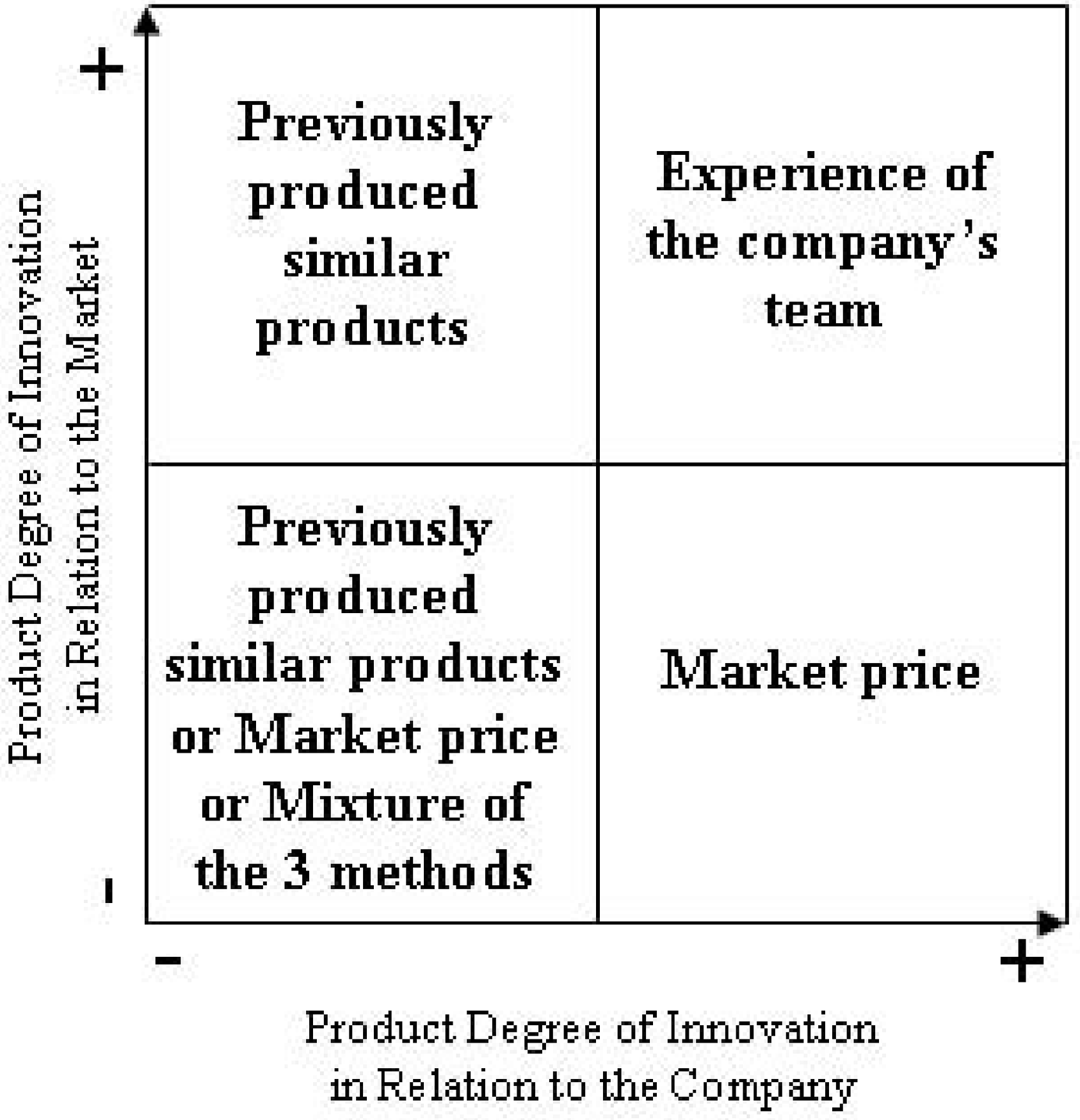
+
-
Previously produced similar products
Experience of the company's team
Previously produced similar products or Market price or Mixture of the 3 methods
Market price
-
+
Product Degree of Innovation in Relation to the Market
Product Degree of Innovation in Relation to the Company

Figure_5

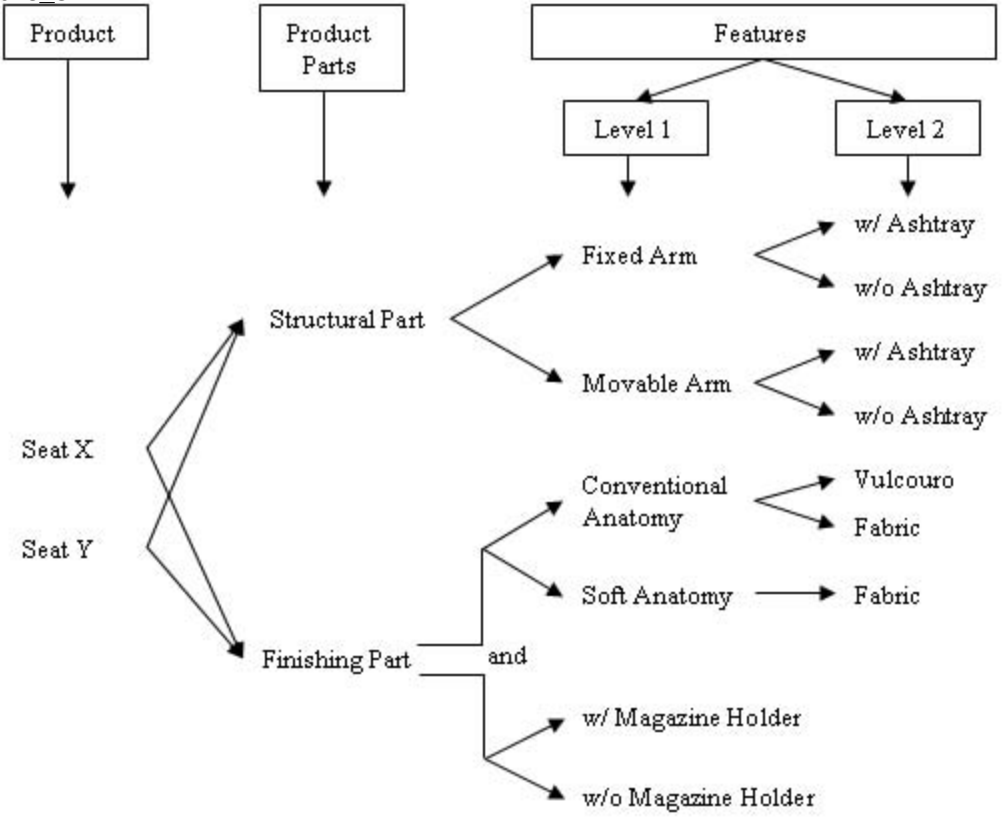
Product
Product Parts
Features
Level 1
Level 2
Structural Part
Fixed Arm
w/ Ashtray
w/o Ashtray
Movable Arm
w/ Ashtray
w/o Ashtray
Seat X
Seat Y
Conventional Anatomy
Vulcouro
Fabric
Soft Anatomy
Fabric
Finishing Part
and
w/ Magazine Holder
w/o Magazine Holder

Figure_6

Product Parts	**Features**		
Structural Part	(2) Common Structural elements		
	Fixed arm	(21) Common Fixed elements	
		Ashtray	(2ab1) w/ ashtray
			(2ab2) w/o ashtray
	Movable arm	(22) Common movable elements	
		Ashtray	(2bb1) w/ ashtray
			(2bb2) w/o ashtray
Finishing Part	Conventional	(31) Common conventional elements	
		Cover	(3a1) Vulcouro
			(3a2) Fabric
	Soft	(32) Common soft elements	
		Cover	(3b) Fabric
	Magazine holder	(4a) w/ magazine holder	
		(4b) w/o magazine holder	

Figure 6. Deployment of the seat in parts, features and common elements.

Figure_7

Product Parts	Features	
Struct. Part	Fixed arm with ashtray	
	Movable arm without ashtray	
Finishing Part.	Conventional	Vulcouro[1]
		Fabric
	Soft	Fabric
	With magazine holder	

Figure 7. Main features to verify the seats prices.

[1] Vulcouro is material made from scrap of letter.

Table_1

Table 1. Project budget target cost breakdown.

Stages of the Product Development	**Project Budget Target Cost**
FASE 0 – Opportunity Identification	$ 5.000
FASE 1 – Concept and Design Development	$ 20.000
FASE 2 – Tecnical Design	$ 30.000
FASE 3 – Manufacturing Design	$ 15.000
FASE 4 – Machinery Preparation	$ 70.000
FASE 5 – Manufacturing Release	$ 5.000
Total	$ 145.000

Table_2

Table 2 Target price, target cost PRO and target cost INS for each configuration.

Configuration **All without ashtray and with magazine holder**	**Target Price without Tax**	**Target Cost PRO**	**Target Cost INS**
A - Fix / Conv. / Fabric	$ 250.50	$ 225.45	$ 223.86
B - Movable / Conv. / Fabric	$ 264.10	$ 237.69	$ 236.10
C - Fix / Conv. / Vulcouro	$ 215.20	$ 193.68	$ 192.09
D - Fix / Soft / Fabric	$ 298.30	$ 268.47	$ 266.88

Table_3

Table 3. Target cost IBP of each configuration.

Seats Parts	Parts Target Cost IBP				IBP for each part
	Conf. A	Conf. B	Conf. C	Conf. D	
Structure of fixed arm without ashtray	$ 100.74		$ 100.74	$ 100.74	$ 100.74
Structure of movable arm without ashtray	--	112.98	--	--	$ 112.98
Conventional finishing, fabric cover and magazine holder	$ 123.12	$ 123.12	--	--	$ 123.12
Conventional finishing, vulcouro cover and magazine holder	--	--	$ 91.35	--	$ 91.35
Soft finishing, fabric cover and magazine holder	--	--	--	$166.14	$166.14
Total	$ 223.86	$ 236.10	$ 192.09	$ 266.88	--

Table_4

Table 4. Target cost IBF for the structural parts with and without ashtray.

Features of the Structural Part		Target Cost IBF
Structure with fixed arm	w/ ashtray	$ 102.25
	w/o ashtray	$ 100.74
Structure with movable arm	w/ ashtray	$ 114.67
	w/o ashtray	$ 112.98

Table_5

Table 5. Target costs IBF for features and common elements of the structure.

Features and Common Elements of the Structural Part		**Target Cost IBF**
Structural Common Elements		$ 85.63
Structure with fixed arm	Fixed Common Elements	$ 7.05
	w/ ashtray	$ 9.57
	w/o ashtray	$ 8.06
Structure with movable arm	Movable Common Elements	$ 9.04
	w/ ashtray	$ 20.01
	w/o ashtray	$ 18.31

Table_6

Table 6. Target cost IBF for the finishing features.

Features for the Finishing Part	**Target Cost IBF**
Conventional finishing and fabric cover	$ 109.58
Conventional finishing and vulcouro cover	$ 77.81
Soft finishing and fabric cover	$ 152.60

Table_7

Table 7. Target cost IBF and estimated costs for the features and common elements of the seat.

Product Parts	Features			Target Cost IBF	Estimated Costs
Structural Part	(2) Common Structural elements			$ 85.63	$ 100.40
	Fixed arm	(21) Common Fixed elements		$ 7.05	$12.17
		Ashtray	(2ab1) w/ ashtray	$ 9.57	$ 14.06
			(2ab2) w/o ashtray	$ 8.06	$ 11.65
	Movable arm	(22) Common movable elements		$ 9.04	$ 16.34
		Ashtray	(2bb1) w/ ashtray	$ 20.01	$ 21.09
			(2bb2) w/o ashtray	$ 18.31	$ 19.82
Finishing Part	Conventional	(31) Common conventional elements		$ 54.79	$ 70.59
		Cover	(3a1) Vulcouro	$ 23.02	$ 38.75
			(3a2) Fabric	$ 54.79	$ 76.47
	Soft	(32) Common soft elements		$ 99.19	$ 105.12
		Cover	(3b) Fabric	$ 53.41	$ 89.94
	Magazine holder	(4a) w/ magazine holder		$ 13.54	$ 15.27
		(4b) w/o magazine holder		$ 9.48	$ 11.91