Cost targets and time pressure during new product development

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Abstract *Investigates the impact of using cost targets during new product development (NPD), in terms of design quality, product cost and development time. An NPD environment with cost targets is compared with an NPD environment where design engineers receive no specific cost targets, but are expected to "minimize" the cost level of future products. The impact of cost targets versus no-cost targets is investigated in combination with high/low time pressure. The 2 * 2 factorial design was tested in a laboratory experiment that simulated a real design process, with customers asking for the highest design quality. The results demonstrate that cost targets during NPD lead to lower-cost new products, while not impairing design quality or development time. However, under high time pressure, cost targets lead design engineers to work longer on the design, without a corresponding cost decrease.*

Introduction

Cost management is a key element for survival in a highly competitive environment (Kato, 1993; Cooper and Slagmulder, 1997). The active search for opportunities to decrease the total cost of a product has traditionally focused on reducing costs of existing products. Recently, the target costing approach has been described in management accounting literature as a way to reduce costs of future products, i.e. searching for cost reduction while the new product is still in the new product development (NPD) process. To Blanchard (1978), once the product is ready to launch, there are few opportunities left for cost reduction.

Current case study researchers (e.g., Kato, 1993; Cooper, 1995; Cooper and Slagmulder, 1997) have found that assigning a cost target (or target cost) to design engineers during NPD leads to future products with lower product costs than when design engineers have no specific cost target. This so-called favourable impact of cost targets on the level of product cost has only been

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supported by anecdotal evidence; however, this paper provides empirical evidence of the impact of cost targets on the cost of a future product.

While some researchers stress the strategic importance of cost management in highly competitive markets, others address the issue of time-based competition, and stress the importance of shortening development times (e.g. Stalk and Hout, 1990; Smith and Reinertsen, 1991; Wheelwright and Clark, 1992). Since much of the NPD activity is human-dependent, reduced development times create time pressures for design engineers (Kato, 1993). As far as we know current research on target costing has not studied whether high time pressure affects the target costing process. This paper also investigates whether cost targets can be combined with high time pressure during NPD.

During the development of a new product, design engineers face many goals other than just product cost. In this study, we also include objectives for design quality and development time. In the current target costing literature, there are hardly any studies that consider cost, quality and development time together. Nevertheless, Cooper (1995) and Rosenthal (1992) agree that the combination of cost and quality with development time determines the success of a future product. Consequently, we investigate in this study the differences created in new products between a "cost target" and a "no-cost target" environment, considering simultaneously the cost, the design quality and the development time of the new product.

This paper is structured as follows. First, the literature is reviewed and hypotheses are developed. Next, the assumptions about the NPD environment in this study are listed. In the methodology section, the laboratory experiment is described. The following sections analyse and discuss the results. The paper concludes with some discussion of the managerial implications and the limitations of this study.

Literature review and hypotheses

Lower-cost products

Based on the definitions of target costing, a favourable impact of cost targets during NPD on the cost of a future product could be expected (Sakurai, 1989; Horvath, 1993; Kato, 1993; Sakurai, 1995). For instance, Fisher (1995) defines target costing as "the systematic process for reducing product costs that begins in the product planning stage". Based on field studies, researchers conclude that target costing leads to products with lower costs than when design engineers are expected to minimize the cost of new products (Monden and Hamada, 1991; Cooper and Yoshikawa, 1994; Cooper, 1995; Kato *et al.*, 1995). However, very little is known about the combination of target costing and time pressure in relation to the cost level of future products. Several cost reduction techniques are described in target costing, ranging from value engineering, value analysis to teardown and checklist methods (Sakurai, 1989; Monden and Hamada, 1991; Horvath, 1993; Kato, 1993; Tanaka, 1993; Cooper, 1995; Fisher, 1995). Hence, we are led to assume that more cost reduction ideas will be generated when design engineers can take their time than when they have little time to try out cost reduction techniques. We hypothesize that the favourable impact of a cost target during NPD, compared with no cost target, will differ significantly across low and high time pressures. We predict that the impact on cost of cost targets will be more pronounced under low time pressure than under high time pressure. This leads us to the following hypothesis:

H1. The favourable impact of cost targets on the cost level will be more explicit when design engineers face low time pressure than when they face high time pressure.

Impairing design quality and increasing development time

Kato *et al.* (1995) provide anecdotal evidence that the use of cost targets leads to longer development times. They describe a new product introduction at a Japanese electronics manufacturer, where the NPD team was charged with reducing the cost of a new product to a level of 30 per cent below the cost of the existing product. The team succeeded in reaching this cost target, but did so by introducing the product late. Other field study researchers in target costing mention that sacrificing quality may be one easy way for engineers to attain the cost target (Kato, 1993; Cooper and Slagmulder, 1997).

Furthermore, Kato (1993) posits that, since much of the creativity involved in developing new products is human-dependent, too much pressure for reducing development time under target costing creates tension and results in poor performance and management fatigue. We expect that design engineers, receiving a cost target, will more easily sacrifice the design quality under high time pressure than under low time pressure. Similarly, we expect that design engineers, receiving a cost target, will sacrifice the development time objective more easily under high time pressure than under low time pressure. This leads us to the following hypotheses:

H2. Assigning a cost target to design engineers will harm design quality more under high time pressure than under low time pressure.

H3. Assigning a cost target to design engineers will increase development time more under high time pressure than under low time pressure.

Assumptions about the NPD environment in this study

The formulated assumptions will be tested in a particular NPD environment. They form the boundary conditions of this study.

- This study assumes an NPD environment with three conflicting objectives: i.e., for design quality, for cost and for development time (Rosenthal, 1992).
- Design quality receives the highest priority, followed by cost and development time. Prioritisation is necessary, because design engineers need to know what objective should be relaxed first, when events slip beyond the point of full recovery (Rosenthal, 1992; Cooper, 1995).

Quality is set as the primary characteristic here, because, in target costing, it is essential to avoid reducing costs without regard for the quality of the product from the customer's point of view (Kato, 1993).

- No target is set for development cost. A cost target is only defined for the product cost. These are the so-called downstream costs when the product is in the manufacturing stage. The development cost is not taken into account because the focus of this study is on "downstream" cost management of future products, i.e. on managing "the big dollars that come later" (Shields and Young, 1994).
- This study assumes that design engineers have immediate feedback, allowing them to track progress towards the achievement of the three objectives. To avoid the problem of feedback on quality always lagging feedback on cost performance because of the difficulty to notice a failure (Bassett, 1979), we define quality in this study as design quality, i.e. the fit between design specifications and customers' preferences.

Methodology

Experimental design

We used a laboratory experiment to test the hypotheses. The experiment had a completely randomised, two-by-two factorial design, with balanced cells ($n = 16$) and between-subjects effects, as shown in Table I.

Experimental task

The task was to design an attractive carpet for a given interior, while considering cost, time and quality instructions. The task was set up in such a way that variety and premium colours cost more. Eight judges rated the design quality of the submitted carpet designs. Examples of earlier carpet designs were provided to help participants in detecting the preferences of these judges. An incentive system (described later) made it clear that design quality should receive the highest priority in creating the carpets. Participants did not get any reward for meeting a cost target, unless they met the quality standard. Furthermore, the given interior fitted more with the expensive colours, requiring creativity in trading-off design quality and cost.

Table I.
Experimental design

	Cost target setting	
Time pressure	No cost target	Cost target
Low	Cell 1 ($n = 16$)	Cell 2 ($n = 16$)
High	Cell 3 ($n = 16$	Cell 4 ($n = 16$)

Manipulation of the independent variables

Participants receiving no cost target were instructed to design an attractive carpet, trying to minimize the cost of the carpet. Participants receiving a cost target were instructed to design an attractive carpet, taking into account a cost objective of €68.00. This cost target was determined by a pilot study (n = 22), identical to the no-cost target condition. We choose €68.00 as cost target, because 40 per cent of the participants in the pilot study attained this level, which accords with "attainable, but not without considerable effort" described in the target costing literature (Kato, 1993).

An easy-to-attain time objective (105 min.) represented the low time pressure condition. A difficult-to-attain time objective (75 min.) created the condition of high time pressure. Again, these limits were determined by the pilot study, where 40 per cent of the participants finished within 75 min. and all participants finished within 105 min.

Measurement of the dependent variables

The cost level of the new product was measured as the total cost of the carpet design that each participant handed in at the end of the session. Development time was measured as the time in minutes between starting and finishing the design task. The mean score from the judges, who were unaware of the treatment conditions, was used as a measurement tool for design quality. The eight judges scored the designs individually and independently from 1 to 5, considering the design within the given interior. The judges were faculty members of the university and were selected from a pool of 15 volunteers. We selected these eight, because they were most consistent in scoring 45 carpet designs created earlier (Cronbach's Alpha was 0.77 for 15 judges versus 0.82 for eight judges, and did not improve if the scores of one of the judges were deleted).

Feedback during the task

Participants received immediate feedback on the cost level of their creations by calculating the cost level themselves. The cost system (with direct and indirect cost differences) was fully explained in the instruction sheets. Immediate feedback was provided on the design quality of the carpets, because the eight judges scored on request during the laboratory session. A central clock provided feedback on the progression of the development time objective.

Participants

In total, 64 undergraduate students in business administration participated voluntarily as part of their official class time. Students reported together to the experimental session and were randomly assigned to one of the four treatment conditions. The session took no one longer than three hour (instructions, task itself and post-experimental questionnaire). Students worked quietly and were relaxed; 94 per cent found the task "interesting" and "fun".

Incentive system

As mentioned above, we assumed a product environment where design quality was considered as the primary characteristic, before cost and development time. The reward structure was set up to make this priority clear. Creators of the five most attractive carpets in each cell received a bonus of €7.50, with a first extra bonus of €7.50 if they did not exceed the cost target, and a second extra bonus of €2.50 if they finished within the time limit. For those in the no-cost target conditions, a first extra bonus of €7.50 was provided for the five lowest cost designers in each cell and a second extra bonus of €2.50 if they finished within the given time limit.

Results

Manipulation checks

Manipulation checks for target costing (cost target versus no cost target) and time pressure (low versus high) were conducted by self-reported measures in the post-experimental questionnaire. All manipulation checks were significant and in the right direction ($p < 0.001$; $p = 0.020$). Furthermore, participants perceived the priority among the NPD objectives (design quality, cost and development time) as intended.

Testing hypotheses

First, we look for differences on the three dependent variables together, since the outcomes of the NPD are not totally independent. Participants faced trade-offs between design quality, cost and development time; in addition, Bartlett's test of sphericity asks for a multivariate analysis ($\chi^2 = 235.153$, df = 5, $p < 0.001$). The data reveal that the multivariate interaction effect is indeed significant (Hotelling's T^2, $F_{(3,58)} = 3.427$; $p = 0.023$). To analyse the nature of this multivariate interaction effect further, we will test the earlier formulated hypotheses.

H1 in this study predicts that the favourable impact of cost targets on cost will be more pronounced for low time pressure than for high time pressure. The F-test in Table II shows that the interaction effect on cost is significant ($F_{(1,60)} = 3.992$, $p = 0.050$), which supports *H1*. The group means show that the differences in cost are larger under low time pressure than under high time pressure. For low time pressure, the t-test detects a significantly lower cost level ($t = 3.652$, one-tailed $p = 0.001$) when participants received a cost target (mean = €62.5) than when they did not receive a cost target (mean = €73.4). Under high time pressure, the t-test does not detect a significantly lower cost for participants receiving a cost target ($t = 0.840$, one-tailed $p = 0.203$). The group means are in the expected direction (€65.2 for cost target versus €67.7 for no cost target, see Table III), although the improvement in cost is not significant. Thus, assigning a cost target had a favourable impact on cost, but only under low time pressure.

H2 in this study expects that giving a cost target to design engineers will harm design quality to a larger extent under high time pressure than under low

Source	Sum of squares	Df	Mean square	F	Sig.
ANOVA on cost level					
Cost targets	716.767	1	716.767	10.128	0.002
Time pressure	36.736	1	36.736	0.519	0.474
Cost targets * time pressure	282.481	1	282.481	3.992	*0.050*
Error	4,246.101	60	70.768		
ANOVA on design quality					
Cost targets	0.220	1	0.220	0.314	0.577
Time pressure	1.978	1	1.978	2.828	0.098
Cost targets * time pressure	0.250	1	0.250	0.358	*0.552*
Error	41.955	60	0.699		
ANOVA on development time					
Cost targets	240.250	1	240.250	1.725	0.194
Time pressure	3,025.000	1	3,025.000	21.719	0.000
Cost targets * time pressure	1,024.000	1	1,024.000	7.352	*0.009*
Error	8,356.750	60	139.279		

Table II. Univariate interaction effects on cost, design qulaity and development time

	Cost level in euro		Design quality mean on 5		Development time in min	
	Mean	SD	Mean	SD	Mean	SD
Low time pressure						
No cost target	73.4	6.5	2.5	0.8	80.4	15.2
Cost target	62.5	10.0	2.8	0.9	76.3	12.6
High time pressure						
No cost target	67.7	9.7	3.0	0.9	58.7	7.4
Cost target	65.2	8.3	3.0	0.8	70.6	10.9

Table III. Group means and standard deviations) for all four cells

time pressure. This hypothesis is not supported by the data, because the interaction effect on design quality is not significant ($F_{(1.60)} = 0.358$, $p = 0.552$), as shown in Table II. Contrary to what was expected, cost targets do not have an impact on the design quality; even the main effect of cost targets on design quality is not significant ($F_{(1.60)} = 0.314$, $p = 0.577$), as shown in Table II. Thus, assigning a cost target did not impair design quality.

H3 in this study hypothesizes that giving a cost target to design engineers will increase development time to a larger extent under high time pressure than under low time pressure. The data support this hypothesis. Table I shows a significant univariate interaction effect on development time ($F_{(1.60)} = 7.352$, $p = 0.009$). The group means in Table III reveal that the differences in development time are much larger under high time pressure than under low time pressure. Under high time pressure, the t-test detects a significantly higher development time ($t = 3.652$, one-tailed $p = 0.001$) for cost targets (group mean

= 70.6) than for no-cost targets (group mean = 58.7). For low time pressure, the t-test does not detect a significantly higher development time (t = 0.838, one-tailed p = 0.205). Thus, the use of a cost target had an unfavourable impact on development time, but only under high time pressure.

Discussion

Combining all our results (see Figure 1), we can conclude that:

- Providing a cost target to design engineers during NPD has no detrimental impact on design quality.
- Providing a cost target leads to lower-cost new products, though only when design engineers face low time pressure.
- Providing a cost target does not lead to lower-cost new products when design engineers face high time pressure, but it does increase development time.

Interpretation of the first conclusion should only be made within the context of this study. Design quality was communicated (and also perceived) as the most important objective. Feedback during the task prevented participants from overlooking this characteristic of the new product. Hence, participants did not skip over design quality in order to attain the cost target, because they knew that top quality was absolutely essential for new products to be successful.

The second conclusion of this study supports what has been found so far by field study researchers in target costing (Kato, 1993; Cooper and Slagmulder, 1997); namely, that assigning a cost target during NPD results in new products with a lower cost than when asking design engineers to "minimize the cost of future products". However, this favourable impact was only significant when design engineers faced low time pressure. Indeed, participants receiving a cost target focused extensively on reducing the cost of their design, though they only succeeded in cost improvements when they had plenty of time in the low time pressure condition. This was probably because the design task in this study required creativity, and the participants needed to develop effective design strategies. In general, imposing a sharp time restriction does not lead to breakthroughs (Abernathy and Utterback, 1978; Quinn, 1985). The combination of cost targets with high time pressure does not lead to lower-cost new products, because the time constraint imposes a restriction on people's creative behaviour in generating cost reduction ideas. In contrast, combining cost targets with low time pressure leads to lower-cost new products because design engineers found the appropriate strategy to create a high quality, but low cost design.

The third conclusion of this study supports the anecdotes of field study researchers in target costing (Kato *et al.*, 1995) that cost targets lead to longer development times, but only when design engineers face high time pressure (i.e. receive a severe development time objective). We communicated development time as the least important characteristic of the NPD process (compared with

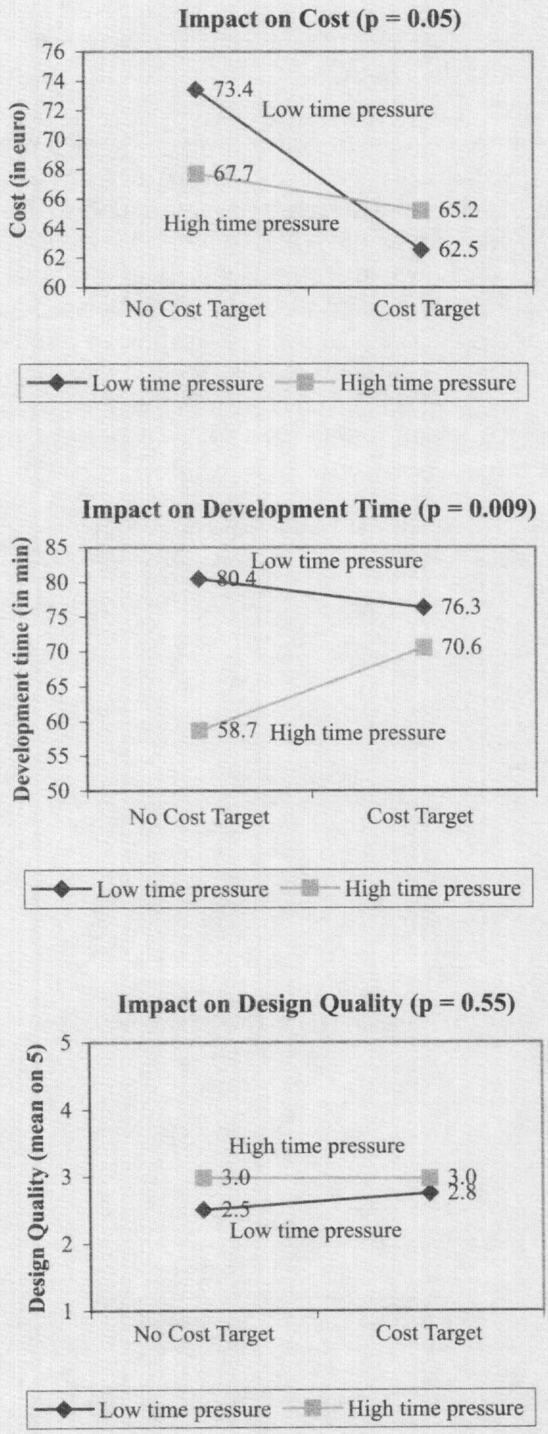

Figure 1.
Interaction between cost targets and time pressure

design quality and cost). Hence, designers skipped over the development time objective, when all three objectives (design quality, cost and development time) were difficult to realize at the same time.

The design strategy used by participants (see Figure 2) can help us in further exploring the reasons for the differences in development time. In the post-experimental questionnaire we asked to what degree participants found the given examples of successful designs relevant (scale 1 to 5) and how many trial designs they made during the NPD. On both variables, the interaction effect is significant, as shown in Table IV. In the conditions of high time pressure, participants not receiving a cost target performed a very efficient design strategy. They extensively considered the previous successful designs (group mean of 4.6 for no cost target versus 3.9 for cost target), and made fewer trial designs (group mean of 6.1 for no cost target versus 7.8 for cost target). This strategy resulted in a significantly shorter development time (group mean of 58.7 for no cost target versus 70.6 for cost target). The cost target forced

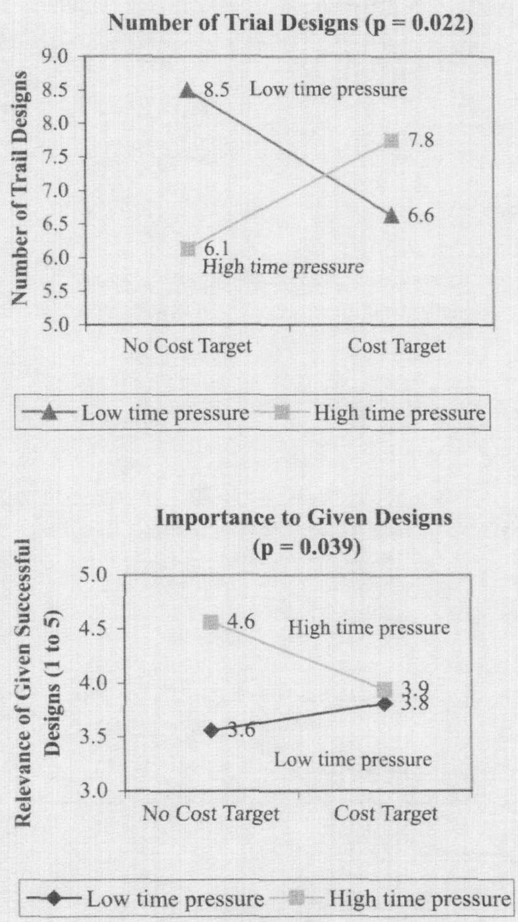

Figure 2.
Design strategy

Source	Sum of squares	Df	Mean square	*F*	Sig.
ANOVA on number of trial designs					
Cost targets	0.250	1	0.250	0.028	0.868
Time pressure	6.250	1	6.250	0.702	0.406
Cost targets * time pressure	49.000	1	49.000	5.500	*0.022*
Error	534.500	60	8.908		
ANOVA on relevance of given successful designs					
Cost targets	0.563	1	0.563	0.818	0.369
Time pressure	5.063	1	5.063	7.364	0.009
Cost targets * time pressure	3.063	1	3.063	4.455	*0.039*
Error	41.250	60	0.688		

Table IV. Univariate interaction effects on design strategy

designers to consider the cost implications of their creations, taking their attention away from the previous versions of the product, which also resulted in a higher number of trial designs. In the conditions of low time pressure, participants receiving a cost target did not experiment as much as participants in the no-cost target group. This last group created at random trial designs without considering extensively the existing products (group mean of 3.6 for no cost target versus 3.8 for cost target). They also created a higher number of trial designs (group mean of 8.5 for no cost target versus 6.6 for cost target). By randomly experimenting and creating a high number of trial designs, they actually adjusted their work speed to the available time (known as Parkinson's Law in psychology literature (Bryan and Locke, 1967)). The cost level of these no-cost-target creations was much higher under low time pressure than under high time pressure, because of this experimenting behaviour. Looking now again at the cost target condition under low time pressure, we find a relatively low number of trial designs, though this did not result in significantly shorter development times, because these participants worked longer on each trial design, thinking extensively about cost reductions. This last strategy resulted in designs with a significantly lower cost.

In conclusion, the cost target prevented designers from experimenting at random under low time pressure and focused their attention on the cost implications, resulting in a lower-cost design, while not increasing development time. In contrast, the high time pressure forced designers with no-cost target to speed up, resulting in shorter development times. Designers with a cost target had to worry about the maximum cost as well, and spent extra development time.

Managerial implications

The general recommendation to use a cost target during NPD (also called target costing), as a way to survive in a competitive environment, should be used with caution. Our study shows that target costing only has a favourable impact on the new product when design engineers can afford to work relaxed. In that situation, imposing a cost target to design engineers leads to lower-cost new products, without an unfavourable impact on design quality or a delay in development time. Setting a no cost target in that situation leads to random experimentation by design engineers, resulting in a new product with a higher cost level than that achieved when receiving a specific cost target during NPD. This is what Cooper (1995) meant by: "If we just add this feature, the product will be so much better and only cost a little more". Thus, when the cost level is the key issue for success, the use of target costing is recommended during NPD.

However, if design engineers perceive high time pressure, because of a sharp development time objective, the application of a cost target is not recommended during new product development. Assigning a cost target to design engineers does not lead to a cost advantage for the new product, and they spend much more time in developing the new product. Thus, in a situation where short development time is important, management should have confidence in the creative power of the design team and should not expend efforts on assigning cost targets. The high time pressure will focus designers on the product to be developed. Thus, when development time is the key issue for success in the market, the use of target costing is not recommended.

This study provides a first understanding of the paradox between the literature and practitioners as to whether to impose cost restrictions to the behaviour of design engineers. On the one hand, researchers in target costing assert that cost targets are necessary to manage aggressively the cost of future products in order to survive in highly competitive markets (Kato, 1993; Cooper and Slagmulder, 1997). On the other hand there is the general belief among many western design engineers that their creativity should not be constrained by cost targets during NPD, because they know best on how far to go with cost reductions (Shields and Young, 1994; Hertenstein and Platt, 1998). Our study shows that, when design engineers do not face high time pressure, the practice of using cost targets is beneficial, which has been found in many (Japanese) cases of target costing (Cooper, 1995). However, when design engineers face high time pressure, the best products are found when no cost targets are set.

Limitations

The purpose of this study was to test the relationships under "pure" and "uncontaminated" conditions, to enrich the current case study findings by empirical evidence. The artificial environment of the laboratory forms its main strength in terms of internal validity, but it is also its major weakness in terms of generalizing the results. Opponents of laboratory experiments would argue: "You can't generalize from a 120-minute task performed by undergraduates in a laboratory to design engineers in the real NPD world". Indeed, this study had no ambition to reproduce the total field situation of an NPD environment in the laboratory. Instead, we tried to replicate the essential features, which allow us to generalize from the laboratory to the field (Zelditch, 1969; Swieringa and

Weick, 1982; Locke, 1986). The design task was set up in such a way that trying to obtain one goal hindered the attainment of the other goal. There was no single best outcome of the task, which required creativity and strategy search from participants (Ulrich and Eppinger, 1995). Prioritisation of the goals was included (Rosenthal, 1992).

Furthermore, with respect to undergraduate students as surrogates for real "business people", there has been some discussion in the literature as to whether the results found by students can be generalized to real employees (Locke, 1986; Ashton and Kramer 1980). A key consideration is whether students possess the knowledge, motivation and other characteristics to effectively make the decisions required (Birnberg *et al.*, 1990). In this study, the task was explained in detail by written instructions (14 pages), participation was voluntary and the answers on the post-experimental questionnaire convinced us that students understood the task, that they took it seriously and were eager to achieve the different objectives. By including feedback possibilities during the task and by providing examples of earlier successful designs, we tried to facilitate a learning process on what the market (judges) really liked. By random assignment to treatment, we ruled out possible differences between participants in terms of design capabilities. Nevertheless, we admit that these students (business administration) were not used to artistic tasks. Future research is needed to determine whether the settings of this laboratory experiment interact with target costing and time pressure and, hence, whether other settings will lead to different results.

A second limitation applies to the operationalization of target costing. Target costing is understood here to be positioned at the individual level of the designer. A cost target is assigned to the individual design engineer, using the top-down approach (Kato, 1993). By providing detailed cost information during NPD, by comparing the estimated cost with the cost target at different points during NPD and by aiming "not to exceed the cost target", we included the main characteristics of the target costing process (Sakurai, 1989; Kato, 1993). However, the dynamics of teamwork and cooperation with suppliers to perform cost reductions were not included in this study. Future research needs to show whether teamwork and suppliers would change the results of this study.

A third limitation is the measurement scale for design quality. The eight judges were blind to the conditions, their scores were highly consistent (Cronbach's Alpha = 0.92) and this measure comes as close as possible to reality. Nevertheless, the resulting quality measure might be noisy.

Finally, the conclusions of this study only apply to the specific type of NPD environment formulated earlier (three NPD goals, quality as main characteristic, and immediate feedback). It would be interesting to test the hypotheses in other NPD environments (e.g., cost as main characteristic, four NPD objectives, and other dimensions of quality). This study is only a start in the determination of the effectiveness of target costing as a cost management tool.

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