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and long-term Cost Structure

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STRATEGIC MANAGEMENT ACCOUNTING; COORDINATION AND LONG-TERM COST STRUCTURE

Abstract

During the last years issues of strategic management accounting have received widespread attention in the accounting literature. Yet the conceptual foundation of most proposals is not clear. This paper presents a theoretical analysis of one of the most prominent approaches of strategic management accounting, i.e., Target Costing. First, the relationship between Target Costing and Life-Cycle-Costing is shown. Secondly, a model based on a mechanism-design-approach is used to answer the question of whether the „Market-into-Company“-method of Target Costing can somehow be endogenized. The model captures problems of asymmetric information, price policy and cost structures (i.e. learning effects etc.). The analysis shows that the more „strategic“ is the firm’s cost function, the less valid is „strategic“ management accounting in terms of the usual way Target Costing is employed.

JEL classification: M41, D82, D83

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Asymmetric Information

1. Introduction

For the past decade, new methods and systems of Managerial Accounting have received widespread attention in the literature. A general feature of these methods is their emphasis on intermediate or long-term cost management. They want to accomplish this by explicitly taking the firm's market position into account. From these two features result many modern catchwords such as „customer-oriented“, „supplier oriented“ or „competitor-oriented“, which abound in today's literature. Most eminent among these new methods are Activity Based Costing (ABC)¹, Target Costing (TC)² and Life Cycle Accounting (LCA)³. Taken together, they can be seen as distinctive representatives of the line of research known as Strategic Management Accounting (SMA).

Though often analyzed and discussed separately, there exists a general consent in the literature that these systems or methods must not be seen as independent entities. On the contrary, these authors claim that a firm can only achieve the goal of a successful long-term and market-oriented cost management, if it integrates these various new instruments into one coherent concept. An obvious and often-cited example is the link between Target Costing and ABC⁴. In this context, the purpose of ABC would be to put a „price tag“ on the various design alternatives for a new product. The design engineers in their turn can use these „prices“ to assess whether their specific designs are in compliance with the market-oriented target costs. However, except for this rather general statement about the necessity to integrate the various components of SMA into one coherent concept (sometimes accompanied by simple examples for illustration pur-

1. see Horváth, P.; Mayer, P.: Prozeßkostenrechnung - Der neue Weg zu mehr Kostentransparenz und wirkungsvolleren Unternehmensstrategien, in: Controlling 1989, p. 214-219.

2. Sakurai, M: Target Costing and How to Use it, in: Journal of Cost Management, Summer 1989, p. 39-50.

3. Berliner, C.; Brimson, J. A. (Hrsg.): Cost Management for today's Advanced Manufacturing - the CAM-I Conceptual Design, Boston, MA, 1988.

4. see Freidank, C. C.: Unterstützung des Target Costing mit Hilfe der Prozeßkostenrechnung, in: Horváth, P. (Hrsg.): Effektives und schlankes Controlling, Stuttgart 1992, p. 221-243.

poses), there is an almost total lack of literature explicitly dealing with this integration problem.

Apart from the objective to integrate SMA's different instruments (TC, ABC, LCA), these methods are often seen as important tools to coordinate the firms' cost (and revenue) management efforts on all levels of hierarchy. This view coincides with the so-called coordination-oriented definition of **management accounting**/ Controlling, suggested by some eminent European authors ¹. Here, a further subdivision of the coordination-concept has proven quite helpful. The older and more traditional approach is justified by the fact that the „typical“ firm faces numerous interdependencies due to risk, market structure, externalities and intertemporal relationships such as learning processes. A typical result in this line of research is the finding that the presence of learning processes in production will generally result in higher output due to the fact that the firm wants to „invest in experience“, i.e. capture the advantage of unit costs decreasing in output. For the purpose of this paper, we will call this approach „non-personal coordination“ ².

A more recent concept of coordination analyzes problems of asymmetric information and conflict of interest between the firms' numerous participants ^{3 4}. We will call this concept „personal coordination“. Research into this later concept has yielded many important results. The most important one for our analysis lies in the fact that problems of non-personal coordination can only be addressed **after** a satisfactory solution to the problems of personal coordination has been found. This is so because the latter determines a firm's organization and incentive structure and these two in turn determine how a firm deals with the numerous interdependencies in the field of non-personal coordination.

1. see Küpper, H. U.: Controlling - Konzepte, Stuttgart 1995.

2. for a detailed discussion of non-personal coordination problems, see Ewert, R.; Wagenhofer, A.: Interne Unternehmensrechnung, 2. Aufl., Springer, Heidelberg u.a. 1995, p. 404 ff..

3. these problems are present on all levels of hierarchy, typical examples include CEO/Boards' objectives/information (o./i.) vp. Division Mangers' o/i., Division Mangers' o/i and regional Sales Staffs' o/i, foremen's o/i and assembly-line workers' (o/i) etc.

4. for such an approach see Ewert, R.: Controlling, Interessenkonflikte und asymmetrische Information, in: Betriebswirtschaftliche Forschung und Praxis 1992, p. 277-303.

If we apply these two concepts to SMA's various methods, we find that their main focus is on questions in the domain of „non-personal coordination“. Target Costing's strict market-orientation is an obvious example. Though problems of human resource management (worker motivation) or proper incentives are always deemed important in this literature ¹, there has never been a closer analysis of this problem up to now.

The purpose of this paper is to link the two problems of integration and personal coordination with the aim of gaining some further insights into the applicability of some of SMA's most eminent instruments. Using the tools of economic theory, we try to answer the question whether procedures can be endogenously arrived at that show some proximity to results in the SMA literature. Naturally, we can only deal with some of the many aspects involved. We start with the question usually analyzed in the Target Costing literature: How is a firm to coordinate today's product design efforts in such a way that the unit cost resulting from these design efforts assures the product's economic success in its future market? At first inspection, this approach seems quite puzzling, because a firm in a competitive environment will always benefit from cost reductions. In particular, it begs the question why cost reduction efforts should cease at the point prescribed by Target Costing's „Market into Company“ approach. Using this so-called „subtraction method“, a target profit $T\pi$ is subtracted from the (exogenously-determined) market price p to arrive at a target (unit) cost k , i.e. $k = p - T\pi$.

This procedure only makes sense, if one takes into consideration that the cost savings due to an efficient product design, themselves, are not costless. On the one hand, the firm incurs a cost for a modern and efficient product design department such as CAD software, testing facilities, prototypes, etc. On the other hand, it must pay qualified design engineers (considerable) salaries or they will not work for the firm. Furthermore, these design engineers will generally have better information about a product's cost saving potential than corporate headquarters. If one makes the additional assumption that design engineers, like most workers, prefer less work to more work at the same remuneration, it becomes obvious that conflict of interest and asymmetric information should also be included in the analysis.

1. see Seidenschwarz, W.: Target Costing, München 1993, p. 158 and Horváth, P.; Niemand, P.; Wolbold, M.: Target Costing - State of the Art, in: Horváth, P.: Target Costing - Marktorientierte Zielkosten in der deutschen Praxis, Stuttgart 1993, p. 4.

Based on this line of reasoning, there exists a trade-off between costly product design efforts today, which have to be compared with future benefits from low unit costs when the product is actually manufactured and sold. These cost substitution effects play a central role in Life Cycle Accounting¹ Systems. Thus, there exists an obvious link between Target Costing and Life Cycle Accounting, if the firm pursues the goal of an efficient and coordinated cost management. Furthermore, the firm's long term cost structure exerts an important influence on this trade-off by way of potential learning processes in the manufacturing phase. These learning processes constitute an integral part of almost all modern management theories², including strategic cost management. The following discussion will show that the structure and intensity of these learning effects will have a decisive impact on the usability of Target Costing's methodology as a coordination instrument.

Our main result is that any analysis has to distinguish between learning effects that are **independent** of the „personal coordination“ objective and those that are not. Given this independence, learning effects can be dealt with in the traditional way as a problem of „non-personal coordination“. If there are interdependencies between personal and non-personal coordination, however, the traditional view of „always beneficial“ learning processes has to be modified in a number of ways. We analyze a case where a certain type of learning effect leads to a trade-off between reduced marginal total cost and higher expected compensation for the design-engineer. We show that in this scenario an optimal policy may consist of reducing design-efforts and increasing the product price if learning is taken into account ! In another learning environment, the firm can use a different type of learning process to reduce problems arising from conflict of interest and asymmetric information. Compared to the traditional SMA-literature, these results are quite provocative. They suggest that the more „strategically- oriented“ a cost system becomes, the less reliable become our commonly held beliefs about the interaction between learning and output decisions.

Therefore our analysis addresses important questions in the field of Target Costing and Life

1. see Ewert, R.; Wagenhofer, A.: Interne Unternehmensrechnung, p. 292-298.

2. see Porter, M. E.: Wettbewerbsvorteile, 3. Aufl., Deutsch von Angelika Jäger, Frankfurt 1992, p. 102f..

Cycle Accounting as well as aspects of non-personal versus personal coordination and problems of long-term cost structure. We attempt no explicit analysis of Activity-Based-Costing in our paper. We do assume, however, that the firm has access to relevant cost information that it can use in such a way as to assess the cost of today's design alternatives and measure its impact on future manufacturing costs. To address the questions mentioned above, we use a „mechanism-design“¹ model, applying results obtained by Laffont/Tirole² in the context of optimal regulation to the issue of strategic cost management.

Section 2 of our paper introduces the general model and shows what questions it can address. In section 2.1., we first solve the model for an unspecified cost structure under the additional assumption that corporate headquarters and the design engineer share the same information about the firm's technology. Based on these results, we analyze four specific cost functions, one without any learning effect, the other three with a learning effect to assess the impact of these effects in a first best world. We use these results as a point of reference for the more complex case of asymmetric information about the technology in sections 2.2. and 2.3. Section 3 consists of a detailed example to illustrate our theoretical findings. In Section 4 we discuss the findings and show possibilities for future research. To focus on the economic implications, the formal analysis is kept to a minimum in the paper itself. Readers interested in the formal analysis can obtain proofs and formal details from the authors upon request.

2. The general model

A firm faces the problem of implementing an optimal pricing-, sales-, cost - and investment

1. the first paper is Mirrlees, J.: An exploration in the theory of optimum income taxation, *Review of Economic Studies* 1971, p. 175-208. For an overview, see Fudenberg, D.; Tirole, J.: *Game Theory*, Cambridge, MA, Chapter 7. Further applications include questions relating to budgeting and organizational structure, see Kirby et. al.: Participation, Slack, and Budget Based Performance Evaluation, in: *Journal of Accounting Research* 1991, p. 109-128, and Kanodia, C.: Participative Budgets as Coordination and Motivational Devices, in: *Journal of Accounting Research* 1993, p. 172-189, or questions of transfer pricing, see Stoughton, N. M.; Talmor, E.: A Mechanism Design Approach to Transfer Pricing by the Multinational Firm, in: *European Economic Review* 1994, p. 143-170.

2. Laffont, J.-J., Tirole, J.: *A Theory of Incentives in Procurement and Regulation*, Cambridge MA, 1993, Chapter 3. What is new to our paper is the analysis of the interaction between unit-cost-decreasing learning effects and informational rents leading to an additional tradeoff for the principal.

strategy for a new product. Following the basic idea of Life Cycle Accounting, our model includes all phases of the product's life cycle, that is product design and development, building the manufacturing capacities, manufacturing phase and eventual withdrawal of the product from the market. There is constant investment expenditure I per unit of the product. The production costs K depend on the available technology $\theta \in [\theta^u \ \theta^o]$, $\theta > 0$, total output x and cost reduction efforts by the design engineer denoted a , so $K = K(\theta, x, a)$. We assume that for any two $\theta_1 < \theta_2$, θ_2 depicts the better technology. This technology is the basis for cost-reducing efforts by the design-engineer. For instance, a may be interpreted as efforts by the engineer to replace special components in the product's design with standardized components to reduce product unit cost (an interpretation consistent with ideas often put forward in the literature on Activity-Based Costing). We further assume that θ is the only possible stochastic component of the cost function¹.

It is often stated in the SMA literature that a large percentage of a product's cost is already determined when it is actually launched in its respective market². The same authors stress the importance of cost-reducing efforts in the product design and development phase. We have argued above that such activities in these earlier phases require expenditures on the part of the firm. We depict these costs as a linear function $Z(a) = z \cdot a$, strictly increasing in the engineer's design efforts. These costs determine the trade-off between today's costly efforts a and reduced unit costs in the future. In the context of this paper, we interpret $z \cdot a$ as an expected value of this cost category over a probability distribution with constant support. This implies that the firm cannot determine actual effort expended by the engineer from observing $Z(a)$. The firm's total cost TK

1. Stochastic demand or an error term in the cost function will complicate the analysis but offer few additional insights for the purpose of this paper, for a model that uses a somewhat simpler cost function but stochastic demand and stochastic cost, see Ewert, R.: Target Costing und Verhaltenssteuerung, in: Kostenmanagement - Neue Konzepte und Anwendungen, C.C. Freidank, U. Götze, B. Huch, J. Weber (eds.), forthcoming 1997.

2. see Berliner, C.; Brimson, J.A.(eds.): Cost Management for Today's advanced manufacturing - The CAM-I Conceptual Design, Boston, MA 1988.

is:

$$TK(\theta, a, x, I) = K(\theta, a, x) + I \cdot x + z \cdot a$$

K is assumed continuous and differentiable to the required degree. With respect to its first order partial derivatives, we assume $K_\theta < 0$ (better technology reduces cost), $K_a < 0$ (higher design efforts reduce cost) and $K_x > 0$ (cost is strictly increasing in output)¹.

The market side is depicted by a deterministic demand function $x = x(p)$, $x' < 0$ and $x'' \geq 0$. For the most part of the detailed formal analysis of the paper this demand function is assumed to be linear.

Design engineers will not supply effort for free. It is quite realistic to assume that effort causes the product designer a feeling of disutility of work. She has deadlines to meet, must work long hours, many of her suggestions will be rejected, she has to acquire new skills etc. We model this disutility of work as a function $V(a)$, with $V' > 0$ and $V'' > 0$, i.e. higher efforts cause a higher disutility at an increasing rate.

For her cost-reducing efforts the engineer receives a salary s . In order to induce the engineer to work for the firm, this salary must ensure that the engineer receives at least her so-called reservation utility \bar{U} , which is often interpreted as the expected utility from the engineer's alternative employment opportunities. Without altering the results, we normalize it to 0.

The engineer and headquarters are both assumed risk-neutral. The engineer's utility thus depends on her monetary reward and her disutility of effort. In accordance with most principal-agent models, we assume utility to be additively separable in these two components. Thus, the engineer's utility function is $U^E = s - V(a)$ and the individual rationality (IR) constraint is given by $U^E \geq 0$.

Note, that effort a affects two components of total cost. It is directly responsible for the cost category $z \cdot a$, increasing in a . In addition, it affects the disutility of effort $V(a)$ the engineer has to be compensated for, if the firm is interested in her cooperation.

1. for a learning effect present in the cost function, this assumption states that the learning effect's impact is never so great that a higher output can be produced at a lower cost.

Headquarters delegates no pricing, output or investment decisions, but determines the final values for these variables by itself ¹. The model assumes the following sequence of events. Headquarters is offering the engineer a compensation contract. The engineer accepts the contract if her IR-constraint is satisfied and exerts effort. With the unit or ²marginal total cost determined by θ , a and possibly x , headquarters chooses price p , corresponding output x and total investment $I \cdot x$. Output x is produced and sold and the firm collects its sales revenues. Headquarters is residual claimant to all payments after obligations have been met, i.e.

$$\pi = p \cdot x - K(\theta, a, x) - I \cdot x - z \cdot a - s.$$

2.1 Symmetric information between headquarters and engineer about technology θ (1st best)

Without asymmetric information about θ , all aspects of personal coordination become irrelevant. In particular, a is implicitly observable by headquarters since production costs K , the quantity x and the technology θ are observable. Headquarters can thus „force“ the engineer to exert any effort a considered desirable. One way to accomplish this would be a so-called „forcing contract“. Under such a contract, the engineer will only receive salary s , if she supplies the effort preferred by headquarters. In all other cases she gets nothing. If the compensation s depends on K , headquarters effectively controls the effort a due to the observability of all other variables.

For each θ the risk-neutral firm maximizes its profits:

$$\text{Max } \pi(\theta) = p(\theta) \cdot x(p(\theta)) - K(\theta, a(\theta), x(p(\theta))) - I \cdot x(p(\theta)) - s(K) - z \cdot a$$

$$s. t. U^E = s(K) - V(a(\theta)) \geq 0; \rightarrow s(K) = U^E + V(a(\theta)) \text{ (engineer's utility)}$$

Note, that U^E is a cost factor from headquarters' point of view. Positive values of this variable

1. for a mechanism design approach that addresses related questions see Melumad, N. et. al.: A theory of Responsibility Centers, in: Journal of Accounting and Economics 1992, p. 445 - 484.

2. Unless otherwise stated, marginal total cost denotes the derivative of total cost w. r. t. x , i.e. K_x

will lead to lower profits. If headquarters knows θ , it can never be optimal to pay the design engineer more than her reservation utility! Headquarters thus compensates the engineer for her disutility of effort only. She will work for the firm because her IR-constraint is satisfied. The first order conditions with respect to a and p are:

$$\frac{\partial \pi}{\partial a} = -K_a - V'(a) - z = 0 \Rightarrow V'(a) + z = -K_a \quad (1) \quad \text{with} \quad K_a < 0$$

$$\frac{\partial \pi}{\partial p} = x + p \cdot x' - K_x \cdot x' - I \cdot x' = 0 \Rightarrow p - \left(\frac{x}{-x'}\right) = K_x + I \quad (2)$$

Condition (1) states that today's marginal expenditure on cost-reducing design-efforts ($V'+z$) must equal future cost savings (K_a) at the time the product is actually produced. Note, that any increase in x will necessarily lead to an increase in design-effort, if $K_{ax} < 0$, i.e. the marginal total cost savings due to increased effort rise at larger production volumes. This assumption is rather intuitive, for if better design efforts induce lower unit costs the total advantage increases with larger quantities x .

Condition (2) is the well-known result from standard pricing theory, whereby marginal revenue must equal marginal total cost. Since our main interest is on Target Costing in combination with learning processes, we subsequently analyze four different cost functions that take TC's focus on unit cost into account. The same functions will later be used in the case of asymmetric information, thus offering an excellent opportunity for meaningful comparisons. These functions are:

$$K^1 = \left(\frac{c}{\theta} - a\right) \cdot x$$

$$K^2 = \left(\frac{c \cdot f(x)}{\theta} - a\right) \cdot x$$

$$K^3 = \left(\frac{c}{\theta} - g(x) \cdot \theta - a\right) \cdot x$$

$$K^4 = \left(\frac{c}{\theta} - m(x) - a\right) \cdot x$$

$$f(x) \leq 1, f(0) = 1, f(x) < 1 \text{ for } x > 0, f'(x) < 0; \quad g(x) > 0, g'(x) > 0; m(x) > 0, m'(x) > 0, \\ c > 0$$

These cost functions differ only in the unit cost term, which will subsequently be denoted by k . For K^1 , this unit cost depends on effort and technology only. The unit costs in the other functions additionally depend on total output. Using the assumptions regarding $f(x)$, $g(x)$ and $m(x)$, these

unit costs will decrease in x . This is what we mean by learning effects in the context of our model. Observe, that for K^2 and K^3 there is a non-trivial relationship between technology and output. This will prove quite important in the case of asymmetric information about θ .

For the present scenario of symmetric information, condition (1) is the same for all four cost functions and is now given by:

$$V'(a) + z = x \quad (1)$$

The respective first order conditions (2) for the four functions are:

$$p - \left(\frac{x}{-x'}\right) = \left(\frac{c}{\theta} - a\right) + I = k + I \quad (2)^1$$

$$p - \left(\frac{x}{-x'}\right) = \left(\frac{c \cdot f(x)}{\theta} - a\right) + \left(\frac{c \cdot f'(x)}{\theta}\right) \cdot x + I = k(x) + I + \left(\frac{c \cdot f'(x)}{\theta}\right) \cdot x \quad (2)^2$$

$$p - \left(\frac{x}{-x'}\right) = \left(\frac{c}{\theta} - g(x)\theta - a\right) - g'(x) \cdot \theta \cdot x + I = k(x) + I - g'(x) \cdot \theta \cdot x \quad (2)^3$$

$$p - \left(\frac{x}{-x'}\right) = \left(\frac{c}{\theta} - m(x) - a\right) - m'(x) \cdot x + I = k(x) + I - m(x) \cdot x \quad (2)^4$$

The notation $k(x)$ is used to remind the reader that unit cost depends on x in the case of K^2 , K^3 and K^4 . Comparative-statics of the four cost environments with respect to technology θ yield the following results for a linear demand-curve:

$$\frac{dp}{d\theta} < 0; \frac{da}{d\theta} > 0; \frac{dk}{d\theta} < 0 \quad (\text{Appendix 1})$$

We can draw the following conclusions with respect to the learning effects in K^2 , K^3 and K^4 . On the right hand side (RHS) of (2)² to (2)⁴, marginal total costs depend on x . For K^4 the marginal learning effect depends on x only, for K^2 and K^3 , there are interdependencies with technology. Cost function K^3 assumes the marginal learning effect proportional to the firm's technology, i.e. firms with a better technology will benefit more from learning processes than those in a less favorable technological environment. For cost function K^2 , the marginal learning effect is higher for lower θ , if x is held constant. This means that firms in an unfavorable technological environment tend to benefit more from learning effects than firms with a better technology given a quantity x .

Cost environments K^2 , K^3 and K^4 lead to lower prices, higher quantities and higher design-

efforts than cost environment K^1 for all θ (Appendix 2). Intuitively this becomes clear, if one observes the first order conditions for each cost environment. Condition (1) would imply the same optimal effort a^* in all four cost environments, if output were the same. Likewise, the LHSs of (2)¹ to (2)⁴ would be identical in this case. The RHSs of (2)¹ to (2)⁴, however, are strictly smaller than the RHS of (2)¹ for a given x , violating the assumption of identical quantities. The two sides of (2)² to (2)⁴ can only be „balanced out“ by lower prices and higher quantities because $LHS_x > RHS_x$.¹ This in turn requires higher effort levels from (1).

Thus we have the classic „learning effect“, long recognized in the literature². Firms with cost functions K^2 , K^3 or K^4 „invest in experience“, i.e. produce higher quantities at lower prices over the product life cycle than a firm with cost function K^1 . Lower marginal total costs are due to both , learning effects and higher design efforts. The cost category $Z = z \cdot a$ leads to lower design efforts relative to the case that this cost driver is ignored since $V' = x - z$ determines a^* from (1). This implies higher marginal total costs and lower quantities produced. Furthermore, we can address the question of cost substitution between today's costly efforts a and lower future cost in the manufacturing phase of the product's life cycle. We see that the firm should expand design-effort to the point where today's marginal total cost of a (consisting of z and the marginal disutility of work) equal the future marginal total cost savings x from these efforts.

To answer some questions related to Target Costing, we should focus on the four first order conditions with respect to price. We may interpret the LHS $(p - x / -x')$ in (2)¹ to (2)⁴ as price minus target profit. At first glance, we can seemingly identify a target profit function $T\pi = x / -x'$, solely determined by conditions in the product's market, which must be subtracted from price in order to arrive at a cost that will assure an overall optimal policy. In the case of K^1 (2¹), the RHS is independent of x and marginal total costs equal variable unit costs. For this cost environment,

1. LHS_x and RHS_x denote partial derivatives of the two sides with respect to x .

2. to our best knowledge, the first source is Wright, T.: Factors affecting cost of airplanes, in: Journal of Aeronautical Sciences 3, 1936, p. 122-128.

one might draw the conclusion that the subtraction method of the „market into company approach“ can indeed be endogenously derived from the model. In the other cases, however, the RHS depends on x as well because learning effects affect marginal total cost via total output. Since the extent of these learning effects is determined within the firm, aspects of „Into and out of Company“ become relevant in these cases.

However, even for cost environment K^1 , there is a fundamental flaw in this line of argument, because conditions (2)¹ to (2)⁴ beg the question what optimal price the firm should choose. This question does not arise in „standard“ problems of optimal pricing policy since costs are given in such a problem. However, in the current scenario this is not the case. Costs crucially depend on design-efforts a , which the firm must purchase at price $V(a) + z \cdot a$! What price the firm is willing to pay depends on the expected cost savings caused by these design efforts a . These expected cost savings in their turn are determined by total output x which depends on price p . Price p , however, has to be coordinated with cost, taking potential learning processes into account ! Thus many interdependencies have to be considered simultaneously by the firm in order to implement an optimal strategy. This is at odds with many papers on Target Costing. They generally favor a more sequential approach, e.g.: Step 1: determine market price, Step 2: subtract target profit and get target cost, Step 3: contrast target cost with drifting cost, etc.¹.

The problem becomes also formally clear if we rewrite (2)¹ using (1). This yields:

$$p - \left(\frac{V'(a(\theta, k)) + z}{-x'} \right) = \left(\frac{c}{\theta} - a \right) + I = k + I \quad (2)^1$$

This expression shows that the firm can only determine the optimal price after the optimal solution of the entire system is known. Without knowledge of the optimal design efforts a^* , the optimal price cannot be found. The same is true for K^2 , K^3 and K^4 . The formula „ $p - T\pi =$ target unit cost “ is thus little more than an „empty shell“. Substance can only be added after the various interdependencies have been explicitly taken into account. In particular, this structural relationship contributes nothing towards finding the optimal solution.

1. for this procedure, see Horváth, P.; Seidenschwarz, W.: Zielkostenmanagement, in: Controlling 1992, p. 142-150.

Since we assumed away problems related to personal coordination in this first best world, it is not very surprising that the problem can be solved fairly easily. Knowing θ , headquarters can solve for p^* , K^* and a^* for the relevant θ , while heeding potential learning effects. It then implements the desired policy by making the design engineer exert effort a^* on product design. In the remainder of the paper the additional problems caused by asymmetric information are analyzed.

2.2 Asymmetric information about θ between headquarters and design engineer

In this section two assumptions of the previous model are altered. We now assume that the design engineer knows θ , whereas headquarters has only a probability distribution of θ , $H(\theta)$, with strictly positive density $h(\theta)$ on support $[\theta^u, \theta^o]$. This implies that effort a is no longer implicitly observable as it was the case in first best¹. Headquarters is aware of the fact that the design engineer knows the exact value of θ . Taking this into consideration, headquarters could ask her to submit a report θ^r about θ . This report would determine the engineer's salary $s(\theta^r)$ and headquarters would compute $K(\theta^r)^*$, $p(\theta^r)^*$ and $a(\theta^r)^*$ based on this report. In order for this procedure to yield the same results as the first best solution above, it must be in the design engineer's best interest to report θ truthfully. However, a design engineer who knows θ_2 to be the true parameter will find it advantageous to incorporate slack by reporting a worse technology $\theta_1 < \theta_2$, if headquarters sticks to the first best policy of $s = V(a)$. To see this, consider an engineer in $\theta_2 = \theta_1 + d\theta$, $d\theta > 0$. If she reports θ_1 , headquarters will pay her $V(a(\theta_1))$ and set the corresponding cost target for technological environment θ_1 . But if θ_2 is the true parameter, the engineer can meet this cost target by expending **less effort on product design than would have**

1. technically, we have a model that combines adverse selection (θ) with aspects of moral hazard (a).

been necessary if θ_1 had been the true technological environment. This is so because her effort reduces a lower initial cost ($K_\theta < 0$). In economic terms, she obtains a rent due to asymmetric information, i.e. she receives more money than is necessary for compensating her for her disutility of work.

Thus, headquarters faces a trade-off between limiting the informational rents and providing incentives for the engineer to undertake design efforts a . This trade-off between rent extraction and proper incentives has been called the key thought of modern information economics ¹. It is quite possible to implement the first best solution, but it is generally not optimal because the new cost category „informational rents“ renders design efforts more costly for headquarters.

2.2.1 The General solution of the model

We assume the following sequence of events for the asymmetric information case:

- 1) Headquarters offers the design engineer a salary $s(\theta^r)$ based on her report θ^r . Furthermore, θ^r is used to determine cost target $\bar{K}(\theta^r, x(p(\theta^r)))$. This is in fact a flexible budget that specifies the admissible production cost, depending on the design engineer's report and the production quantity, which in turn depends on the optimal pricing policy of headquarters. Thus given the cost function $K(\theta, x, a)$, this cost target implies a certain effort level on the part of the design engineer, since the salary $s(\theta^r)$ will be paid if and only if the flexible cost target is met.
- 2) The engineer chooses θ^r to maximize her utility, taking into account the way headquarters transforms her reports into compensation payments and cost budgets..
- 3) The engineer exerts cost-reducing efforts $a(\theta, \bar{K}(\theta^r, x(p(\theta^r))))$ on product design to meet cost target \bar{K} .

1. see Laffont, J.-J.: The new economics of regulation - 10 years after, in: *Econometrica*, 62 (1994), p. 507-537.

Headquarters sets price p , total output x and total investment $I \cdot x$ ¹.

- 5) The product is manufactured and sold, costs are incurred and the engineer receives salary s . Any profits accrue to headquarters after all obligations have been met.

In accordance with the mechanism-design literature, we additionally assume $V''(a) \geq 0$ ² and the Inverse Hazard Rate (IHR), $(1-H(\theta))/h(\theta)$ ³ strictly decreasing in θ .

Let $A(\theta, x, K)$ be the effort an engineer in technology environment θ must exert on design, so that quantity x can be manufactured at cost K . Regarding partial derivatives we assume $A_K < 0$ (less effort is necessary, if the allowable cost is higher) and $A_x > 0$ (if a higher quantity is to be produced for a given cost, efforts must increase). Of crucial importance is the relationship between A and θ . In the case of the general cost function we can obtain it by totally differentiating this cost function for a given quantity x :⁴

$$0 = K_a \cdot A_\theta + K_\theta, \text{ thus } A_\theta = -K_\theta / K_a < 0 \text{ because } K_\theta < 0, K_a < 0 \text{ by assumption.}$$

Using this relationship, we can formally support the argument that an engineer with a better technology $\theta_2 = \theta_1 + d\theta$ will find it advantageous to report only θ_1 . If headquarters sets some cost budget $K(\theta_1)$, the engineer with technology θ_2 can reduce her efforts to attain $K(\theta_1)$ by $da = A_\theta \cdot d\theta$. An incentive-compatible payment scheme must therefore compensate the engineer for this advantage, if she is to report truthfully. Furthermore, this advantage is increasing in $d\theta$. The higher $d\theta$, the smaller the design effort a an engineer with technology θ_2 must exert to meet a given cost $K(\theta_1)$. This means that an engineer's marginal informational rent is strictly increasing

1. Observe, that cost is deterministic after θ has been reported. Therefore, total investment must equal $I \cdot x^*$, if the firm wants to produce the desired quantity x^* . This would only change, if demand were stochastic, see Ewert, R.: „Target Costing und...“, 1997.

2. this assumption renders stochastic incentive schemes infeasible.

3. most standard distributions (normal, Chi-Square, Uniform, Exponential, Laplace) used in economic modeling satisfy this requirement, discrete distributions however, pose a problem, see Laffont/Tirole: A Theory..., p. 66.

4. see Laffont/Tirole: A Theory of..., p. 178.

in θ , i.e. $dU^E/d\theta = -V' \cdot A_\theta > 0$ ¹. For our four cost environments A_θ is given by:

Cost Function	$A_\theta = (-K_\theta/K_a) < 0$
$K^1 = (c/\theta - a) \cdot x$	$-c/\theta^2 < 0$
$K^2 = (c \cdot f(x)/\theta - a) \cdot x$	$-c \cdot f(x)/\theta^2 < 0$
$K^3 = (c/\theta - g(x)\theta - a) \cdot x$	$-c/\theta^2 - g(x) < 0$
$K^4 = (c/\theta - m(x) - a) \cdot x$	$-c/\theta^2 < 0$

Table 1

Observe that in cost environment K^1 and K^4 this advantage depends on θ only. For K^2 and K^3 , it depends on θ and total output x . K^4 is thus a benchmark to compare technology-dependent learning processes with technology-independent learning processes.

In order to avoid notational complexity the cost target will be denoted by $\bar{K}(\theta^r)$. Formally, the design engineer now solves the following problem:

$$\text{Max}_{\theta^r} U^E = U^E(\theta^r | \theta) = s(\theta^r) - V\left(A\left(\theta, x(p(\theta^r)), \bar{K}(\theta^r)\right)\right)$$

She chooses θ^r to maximize her utility, conditional on θ being the true parameter. Using the „Revelation Principle“, we can restrict our attention to those contracts where the engineer will report truthfully². The necessary condition for truthful reporting $\theta^r = \theta$ is:

$$\frac{\partial U^E}{\partial \theta^r} \Big|_{\theta^r = \theta} = 0$$

Let $U^E(\theta | \theta) = U^E(\theta)$. Using the envelope theorem, we get:

$$\frac{dU^E}{d\theta} = \frac{\partial U^E}{\partial \theta^r} \cdot \frac{d\theta^r}{d\theta} + \frac{\partial U^E}{\partial \theta} = -V' \cdot A_\theta > 0$$

Thus informational rents have to increase in θ in order to induce the engineer to tell the truth about θ . It can be shown that truthful reporting of θ is indeed the engineer's global optimum,

1. see Laffont/Tirole: A Theory of..., p. 169.

2. the result is due to Myerson, R. B.: Incentive Compatibility and the Bargaining Problem, in: Econometrica 1979, p. 61-73. This „Revelation Principle“ must not be confused with some miracle technique to induce truthful reporting of information. His applicability in the present model is based on an implicit assumption about the firm's reaction to truthful reporting. If the engineer discloses $\theta^r = \theta$, headquarters knows the true technology θ , but has implicitly agreed not to act strategically on this report, i.e. paying the engineer the rent corresponding to technology θ .

provided the cross partial $U_{\theta\theta'}^E$ is positive. $U_{\theta\theta'}^E$ positive requires, among other things, that cost K be strictly decreasing in θ , $K_\theta < 0$. Based on this result, we can later check whether some of our cost environments may lead to problems with truthful reporting (Appendix 3).

To operationalize headquarters' optimization problem, we now derive an expression for the cost category „expected informational rents“ over the technology interval $[\theta^u, \theta^o]$. An engineer's utility (informational rent) ,net of disutility of work, in technological environment θ may be expressed as:

$$U^E(\theta) = \int_{\theta^u}^{\theta} -V' A_w dw + U^E(\theta^u)$$

For a payment scheme based on the „Revelation Principle“, we may write:

$$s(\theta) = U^E(\theta) + V(a) = \int_{\theta^u}^{\theta} -V' A_w dw + U^E(\theta^u) + V(a)$$

If the firm produces positive quantities for any realization of technology θ , including the worst θ^u , we can eliminate the IR constraints based on the following argument. Since rents are costly to the firm, headquarters will set $U^E(\theta^r) = 0$. For $\theta > \theta^u$, incentive compatibility requires higher payments, thus the constraint $U^E \geq 0$ is automatically met for all technologies $\theta > \theta^u$. Expected utility for the design engineer is:

$$E(U^E(\theta)) = \int_{\theta^u}^{\theta^o} \left(\int_{\theta^u}^{\theta} -V' A_w dw \right) \cdot h(\theta) d\theta$$

After some manipulations, we may write: (Appendix 4):

$$E(U^E(\theta)) = - \int_{\theta^u}^{\theta^o} (1 - H(\theta)) \cdot V' \cdot A_\theta \cdot \frac{1}{h(\theta)} \cdot h(\theta) d\theta$$

Risk neutral headquarters maximizes expected profits:

1. It is possible to include cut-off values in the present model, i.e. for some $\theta < \theta^{cri}$, the firm will not produce, see Laffont/Tirole: A Theory..., p. 73 ff.. Likewise, the target costing literature assumes that production is feasible only after efforts have been undertaken. At the same time, this literature is very vague on what should happen if the target costs cannot be attained at all.

$$\begin{aligned} \text{Max}_{a(\theta), p(\theta)} E(\pi(\theta)) = \\ \int_{\theta^u}^{\theta^o} \left(p(\theta) \cdot x(p(\theta)) - K(\theta, a(\theta), x(p(\theta))) - I \cdot x(p(\theta)) - z \cdot a(\theta) - U^E(\theta) - V(a(\theta)) \right) \cdot h(\theta) d\theta \end{aligned}$$

Since the boundaries of the two integrals are the same, we can substitute the expected rents and obtain (dropping the argument θ in the expressions for p and a to ease notation):

$$E(\pi) = \int_{\theta^u}^{\theta^o} \left(p \cdot x(p) - K(\theta, a, x(p)) - I \cdot x(p) - z \cdot a - \frac{(1-H(\theta))}{h(\theta)} \cdot (-V'(a) \cdot A_\theta) - V(a) \right) \cdot h(\theta) d\theta$$

Pointwise optimization and some algebraic manipulations lead to the following general first order conditions with respect to a and p : (Appendix 5)

$$V'(a) + z = -K_a - \frac{(1-H(\theta))}{h(\theta)} \cdot (-V''(a) \cdot A_\theta) - \frac{(1-H(\theta))}{h(\theta)} \cdot (-V'(a) \cdot A_{\theta K} K_a) \quad (3)$$

$$p - \left(\frac{x}{-x'} \right) = K_x + I + \frac{(1-H(\theta))}{h(\theta)} \cdot (-V'(a) \cdot \left(\frac{\partial A_\theta}{\partial x} + \frac{\partial A_\theta}{\partial K} \cdot \frac{\partial K}{\partial x} \right)) \quad (4)$$

Comparing these first order conditions to the corresponding expressions for the first best scenario shows changes in both equations. With regard to the first order condition for design effort two additional terms emerge on the RHS of (3). The first one is strictly negative. If the second new term were also negative, induced design effort a would be strictly lower (given quantity x) for any technology $\theta < \theta^o$. Only for the very best technology will effort be the same in both scenarios because $IHR(\theta^o) = 0$. The cross partial $A_{\theta K}^1$ measures the impact on the engineer's rent, if total cost increases. But without specifying the sign of this cross partial, no more conclusions about the design effort are possible.

A more precise statement is possible with respect to (4), the first order condition for the optimal pricing policy. Questions of personal coordination will have no direct impact on the structure of optimal pricing², if and only if the engineer's informational rents are independent of total output, i.e. $A_{\theta x} = 0$. In this case, the target costing „shell“ remains unaltered. In the subsequent sec-

1. $-V' < 0$ and $K_a < 0$ by assumption.

2. Of course, the indirect relationship between optimal effort and optimal price from 1st best is still relevant.

tion we analyze how these dependencies between technology θ , output x and rents U^E affect optimal effort and pricing for the four cost environments.

2.2.2 Specific solutions for the four cost environments

Table 1 shows immediately that $A_{\theta K} = 0$ for all four cost functions. The four first order conditions with respect to effort are therefore given by:

$$\text{for } K^1: V'(a) + z = x - \frac{(1 - H(\theta))}{h(\theta)} \cdot V''(a) \cdot \left(\frac{c}{\theta^2}\right) \quad (3)^1$$

$$\text{for } K^2: V'(a) + z = x - \frac{(1 - H(\theta))}{h(\theta)} \cdot V''(a) \cdot \left(\frac{c \cdot f(x)}{\theta^2}\right) \quad (3)^2$$

$$\text{for } K^3: V'(a) + z = x - \frac{(1 - H(\theta))}{h(\theta)} \cdot V''(a) \cdot \left(\frac{c}{\theta^2} + g(x)\right) \quad (3)^3$$

$$\text{for } K^4: V'(a) + z = x - \frac{(1 - H(\theta))}{h(\theta)} \cdot V''(a) \cdot \left(\frac{c}{\theta^2}\right) \quad (3)^4$$

Compared to the first best-case, induced effort a is smaller for all $\theta < \theta^o$. This is so because headquarters can limit informational rents for better technologies by reducing the incentives for design effort for worse technologies. Since we have the more ambitious goal of comparing different second best scenarios, we assume $V(a)$ to be quadratic in a . In this case V'' is constant and meaningful comparisons between the four cost environments are possible.

Given constant V'' , conditions (3)¹ and (3)⁴ are structurally identical. The reason is that the price increase for design efforts due to informational rents is the same for both cost functions because total output has no impact on informational rents. Differences in optimal price and output are solely due to the learning effect in K^4 , as we shall see below.

Extending the analysis to environments K^2 and K^3 is more complex. For a given technology $\theta < \theta^o$ and a given positive quantity x , the second term on the RHS of (3)² is smaller than the corresponding term of (3)¹ because $f(x) < 1$ for $x > 0$ by assumption. For K^3 , the opposite is true, because $c/\theta^2 + g(x) > c/\theta^2$ for the same θ and $x > 0$. Because V is convex, this implies that higher design efforts would be induced for a given quantity x in K^2 relative to K^1 but lower design efforts are optimal in the case of K^3 relative to K^1 . This is due to the fact that both learning effects $f(x)$ and $g(x)$ reduce marginal total cost as x gets larger but affect informational rents dif-

ferently.

Using the general first order condition with respect to price yields further insights regarding this point:

$$p - \left(\frac{x}{-x'}\right) = K_x + I + \frac{(1 - H(\theta))}{h(\theta)} \cdot (-V'(a)) \cdot \left(\frac{\partial A_\theta}{\partial x} + \frac{\partial A_\theta}{\partial K} \cdot \frac{\partial K}{\partial x}\right), \frac{\partial A_\theta}{\partial x} = A_{\theta x} \quad (4)$$

For the four cost functions $A_{\theta K} = 0$. So, if $A_{\theta x} \neq 0$, the pricing relationship obviously changes structurally vis a vis the first best-case. The optimal price is used by headquarters for personal coordination because price has an impact on informational rents by way of the quantity effect ¹.

How this affects the optimal price depends on the influence of higher output on informational

rents. For cost function K^2 we have $A_{\theta x} = \frac{-cf'(x)}{\theta^2} > 0$ because $f'(x) < 0$ and for cost function

K^3 , $A_{\theta x} = -g'(x) < 0$. The complete expression $-V' \cdot A_{\theta x}$ thus measures the change in marginal

rents as output increases. For K^2 , this effect is negative, for K^3 it is positive. Higher output in the case of K^2 has the twofold effect of decreasing marginal total cost because of learning processes

while limiting informational rents at the same time. In the case of K^3 , there exists a tradeoff between decreasing marginal total costs due to learning effects and simultaneously rising informational rents.

The results up to now can be summarized as follows: Informational asymmetries about θ have the unambiguous effect of making design efforts more costly for headquarters because informational rents accrue to the design engineer for all technologies $\theta > \theta^u$. Taking K^1 as a point of reference and assuming V'' constant, this cost increase is lower for the learning effects depicted in K^2 than for cost function K^1 because rents can be limited by higher output. Therefore, design efforts given any identical quantity x will be higher in environment K^2 than in environment K^1 . In the case of K^3 , the price increase for design efforts is higher for K^3 than for K^1 , since rents for K^3 are increasing in x . Thus, design efforts, given any identical quantity x , will be lower for

1. in a regulation context, $A_{\theta x} = 0$ is called the incentive pricing dichotomy, see Laffont/Tirole: a theory..., p. 169.

K^3 than for K^1 .

Based on these findings and the four cost environments, we will now enter into a more comprehensive discussion of several implications of our analysis with special attention placed on problems of Target Costing.

2.3 Discussion of formal results

It has been shown above that asymmetric information increases headquarters' cost for design efforts because of informational rents. Taking this into account, headquarters reduces the use of costly design efforts for all $\theta < \theta^o$. If rents are independent of x , these lower design efforts only have an indirect effect on pricing decisions. Compared to a first best world, lower design efforts lead to higher marginal total cost for all $\theta < \theta^o$. This in turn implies higher optimal prices and therefore lower output x . The role of technology-independent learning processes (K^4) is not much different from the analysis in a first best scenario. The first order conditions with respect to a are structurally identical for K^1 and K^4 , given output x . For the same x , however, the RHS of (4) for K^4 would be strictly smaller than the corresponding RHS for K^1 , implying that quantities cannot be the same. The two sides can only be „balanced out“ by lower prices and higher quantities in the case of K^4 . This in turn requires higher design efforts from (3)⁴ (Appendix 5). We may conclude that technology-independent learning processes remain a matter of non-personal coordination, since they play only an indirect role in determining optimal price.

If learning processes are technology-dependent (K^2 and K^3), the analysis is more complex. K^3 is the more demanding case because of the additional trade-off between decreasing marginal total cost and increasing informational rents as quantity x gets larger. Regarding the Target Costing-aspect of our research, several interesting questions emerge. The literature on Target Costing is mostly silent with respect to aspects of personal coordination and implicitly assumes that the proposed procedure („market into company“, subtraction method etc.) is optimal in this regard also. But taking a look at the subtraction method reveals obvious differences to the results obtained here, which are represented by equations (3)³ and (4) for cost environment K^3 . Thus, it might be interesting to investigate the consequences for the firm, if optimal pricing is set accord-

ing to the standard subtraction method (i.e., without explicitly considering quantity-induced rent effects in the pricing equation) while the optimal design effort is still determined from (3)³. Writing $R(\theta)$ for the IHR, our results for environment K^3 are:

$$V'(a) + z = x - R(\theta) \cdot (V''(a)) \cdot \left(\frac{c}{\theta} + g(x)\right) \quad (3)^3$$

$$p - \left(\frac{x}{-x'}\right) = \left(\frac{c}{\theta} - g(x) \cdot \theta - a\right) - g'(x) \cdot \theta \cdot x + I + R(\theta) \cdot (V'(a)) \cdot (g'(x)) \quad (4a)$$

But ignoring the rent effects in the pricing equation („classical“ subtraction method) would yield:

$$p - \left(\frac{x}{-x'}\right) = \left(\frac{c}{\theta} - g(x) \cdot \theta - a\right) - g'(x) \cdot \theta \cdot x + I \quad (4b)$$

Since $R(\theta) \cdot V''(a) \cdot g'(x)$ is strictly positive, optimal incentives determined by (3)³ in combination with the simple subtraction method (4b) would ignore a marginal-cost-increasing factor. The firm would therefore charge too low a price for the product. Differentiating the RHS of (3)³ with respect to x leads to $1 - R(\theta) \cdot (V'' \cdot g'(x))$. This is the cross-partial of expected profit $E(\pi)_{ax}$ with respect to a and x . To obtain standard comparative statics¹, this expression must be positive. If this holds, the simple subtraction method of (4b) will lead to too low a price and design efforts which are too high. This misses the optimum given by (3)³ and (4a) because informational rents are too high on average. This is due to the fact that the firm only takes the beneficial effects of higher x (i.e. the learning effect) into consideration and ignores the detrimental effect of increased rents.

A comparison between K^1 (no learning) and K^3 is also of interest. As we have seen, the purely beneficial effect of learning processes in the first best-scenario is now superseded by a trade-off, because higher output increases rents. In first best, learning processes lowered marginal total cost and therefore price and led to higher design efforts. The second best trade-off in cost environment K^3 offers a potential for results that are quite at odds with the traditional view of these

1. complete comparative statics for the second best solution can be found in appendix 7 for all four cost functions.

effects. If rent considerations dominate cost savings induced by learning, the theoretical possibility of $p_{K^3}^* > p_{K^1}^*$ for some $\theta \in [\theta^u, \theta^o[$ emerges, i.e. rent considerations lead a firm with learning effects in its cost function to charge a higher price and to induce lower design efforts than a firm without learning effects. That such a case can really occur is shown in the example section of this paper. In the current section we are interested in more general insights. In order for the inequality $p_{K^3}^* > p_{K^1}^*$ to hold, the following argument has to be considered: For $\theta = \theta^o$, this relationship is impossible because the symmetric and asymmetric information case have the same solution. If it is to hold at all, there must exist a point of intersection between $p_{K^1}^*(\theta)$ and $p_{K^3}^*(\theta)$ to the left of θ^o . Based on this reasoning, the possibility of its existence can be explored from the first order conditions of cost environments K^1 and K^3 . For simplicity, the constant V'' of the quadratic disutility function V is denoted by v and we assume (without loss of generality) $z = I = 0$. The four first order conditions of cost environment K^1 and K^3 are:

$$\text{for } K^1: v \cdot a_1 = x - R(\theta) \cdot v \cdot \left(\frac{c}{\theta^2} \right) \quad (3)^1$$

$$p - \left(\frac{x}{-x'} \right) = \left(\frac{c}{\theta} - a_1 \right) \quad (4)^1$$

$$\text{for } K^3: v \cdot a_3 = x - R(\theta) \cdot v \cdot \left(\frac{c}{\theta^2} + g(x) \right) \quad (3)^3$$

$$p - \left(\frac{x}{-x'} \right) = \left(\frac{c}{\theta} - g(x) \cdot \theta - a_3 \right) - g'(x) \cdot \theta \cdot x + R(\theta) \cdot V'(a) \cdot g'(x) \quad (4)^3$$

If the price is to be the same, the LHS of (4)¹ must equal the LHS of (4)³ because the firms face the same demand curves. Since price is the same, marginal total cost on the RHS must be the same also. From (3)¹ and (3)³, we know that $a_1 > a_3$ must hold at this point. Thus, by using (4)¹ and (4)³ as well as (3)¹ and (3)³ we get two explicit expressions for $a_3 - a_1 < 0$:

$$a_3 - a_1 = -R(\theta) \cdot g(x) \quad (\text{from } (3)^1 / (3)^3)$$

$$a_3 - a_1 = R(\theta) \cdot V'(a_3) \cdot g'(x) - g(x) \cdot \theta - g'(x) \cdot x \cdot \theta \quad (\text{from } (4)^1 / (4)^3)$$

These two equations imply:

$$R(\theta) \cdot V'(a_3) \cdot g'(x) - g(x) \cdot \theta - g'(x) \cdot x \cdot \theta + R(\theta) \cdot g(x) = 0$$

Rearranging terms yields:

$$g'(x) \cdot [R(\theta) \cdot V'(a_3) - \theta \cdot x] + g(x) \cdot [R(\theta) - \theta] = 0 \quad (g(x), g'(x) > 0)$$

Observe that the existence of a point of intersection depends mainly on the values of $R(\theta)$ and technology θ . For instance, if $R(\theta) < \theta$ holds, prices can never be equal because the above expression is negative ¹. If there are some values of θ for which $R(\theta)$ is high relative to θ , then the chances for the existence of a point of intersection rise. A possibility for such a situation is a probability distribution with very low densities for bad technologies, for in this case the inverse hazard rate is high for low values of θ . But high inverse hazard rates imply generally that the distortion of the solution due to asymmetric information is quite severe, so it is not surprising that exactly in these cases the possibility of $P_{K^3}^* > P_{K^1}^*$ arises.

For cost environment K^2 we can similarly ask what consequences will result for a firm that disregards the impact of technology-dependent learning effects on optimal price. This can be done briefly, however, because the effect is just the opposite of the one discussed in cost environment K^3 . From table 1 it follows that $A_{\theta x} = -c \cdot f''(x) / \theta^2 > 0$. This leads to the overall expression $-R(\theta) \cdot V'(a) \cdot A_{\theta x}$ being negative and this, in turn, decreases the RHS of condition (4) for any given quantity x . Using the simple subtraction method will therefore lead the firm to charge too high a price. It does not take into account that higher output does not only lower marginal total cost but limits the engineer's informational rents at the same time. Therefore, the firm overestimates the cost of inducing second best design efforts. The firm's decision, based on the simple subtraction method, will be characterized by design efforts which are too low. Low design efforts, however, lead to higher marginal total cost, implying a higher price and lower quantities than would be

1. this follows from the fact that $[R \cdot V' - \theta \cdot x]$ will be strictly negative in this case because $x > V'$ from the first order condition for effort. Solving for a critical R, it can be shown that $R = \theta \cdot Z$, $Z > 1$ must hold if prices are to be the same.

optimal. The trouble with this is that this mistake is large, if the firm faces an unfavorable technological environment. It is for low θ that the greatest distortion between the first best and second best solution occur (for $\theta = \theta^o$, the optimal values are the same). If we interpret θ^o as a „benchmark“, i.e. the best available technology in the market, the disadvantage of the subtraction method becomes obvious. In particular, if the firm’s own technology is quite unfavorable compared to the best available technology in the market, it would engage in overpricing, undertake design efforts which are too low and make inefficient use of its learning potential. This is hardly an optimal long-term strategy.

Comparing cost environments K^2 and K^3 , we have already seen that optimal design efforts in K^2 will be higher than in K^1 for a given output x . This is due to the fact that the possibility of limiting informational rents by increasing output leads to a lower cost increase for design efforts, when we change from a first best to a second best situation. Thus, we have no trade-off between limiting rents and making optimal use of learning effects as was the case in K^3 . In the Appendix we show that for a linear demand curve, $P_{K^1}^* > P_{K^2}^*$ and $a_1^* < a_2^*$ will hold for all θ . This kind of learning effect implies that problems of asymmetric information tend to be less severe in cost environment K^2 because headquarters can limit informational rents by choosing a higher quantity. Under cost structure K^1 , it lacks this very possibility. A premature conclusion at this point could lead us to downplay the role of informational asymmetries, thus leading to a justification for much of the SMA literature’s exclusive focus on problems of non-personal coordination. Premature this would be for at least three reasons. First, it would only apply to cost environment K^2 , second, this result can only be shown if asymmetric information is explicitly analyzed and third, problems of asymmetric information are only reduced and not eliminated. To see this, consider the problem of truthful reporting. Asymmetric information puts the better-informed design engineer in a position where she can extract a positive rent from headquarters if $\theta > \theta^o$ holds. Our usage of the Revelation Principle was based on the implicit assumption that headquarters has agreed to pay the rent corresponding to technology θ , if the engineer reports truthfully. If the

disadvantageous effect of rent limitation by higher output were to dominate the advantages to be had by better information, it would decidedly not be in the engineer's best interest to report θ truthfully ¹.

We can attach a certain meaning to the premature conclusion mentioned above, however, if we conceive of real world systems (such as Target Costing) as instruments to obtain good rather than optimal results. Our analysis of K^2 would suggest that there may be scenarios where informational rents are quite small due to the output effect. In this case, acceptable or even good results can be obtained even though problems of personal coordination are not explicitly dealt with in such a system. This is particularly true, if we consider the fact that elaborate incentive schemes are costly to implement.

Turning back to our original question of Target Costing in the framework of our analysis, we have seen that the subtraction method, based on the market into company approach, is at best an empty shell (K^1, K^4), at worst a procedure that can cause the firm to make grave mistakes with respect to pricing and optimal design-efforts (K^2, K^3). For no learning effects and technology-independent learning effects, incentive problems within the company had to be solved first before any meaning could be attached to the shell. This lends support to the claim that some kind of „into and out of company“ approach is actually preferable to the market into company method. The issues of incentives and rents (personal coordination) are dealt with on a firm-level. If the firm uses an incentive-compatible payment system, it obtains $a^*(\theta, p)$, that is, proper design-efforts for any combination of price and (truthfully-reported) technology. Based on this information, the firm would then determine an optimal price p^* . We may interpret this as belonging to the field of non-personal coordination because this is where learning effects and market structure are considered. In such a firm (K^1 or K^4), there is a kind of separation between aspects of personal and non-personal coordination. If the non-personal coordination department knows the incentive-system, it can determine an optimal policy solely taking aspects of non-personal coordination into account. This was the indirect effect, where optimal pricing in the second best world was affected only by the increased cost of design efforts due to informational rents.

The problem with technology-dependent learning (K^2 and K^3) is that it affects personal as well

1. some further details on this issue can be found in appendix 3.

as non-personal coordination. Questions of non-personal coordination, such as learning, have a direct impact on personal coordination because they alter informational rents. These rents, in turn, determine optimal design-efforts. Design efforts, however, determine marginal total cost and therefore price and quantity. Quantity in its turn determines the informational rents that accrue to the engineer and the line of argument starts all over again. In addition, no general conclusions can be drawn concerning the impact of these learning effects on optimal design efforts and optimal price. How they affect these decisions depends crucially on whether higher output increases or limits informational rents.

This is also one of the main conclusions of the present paper. If a firm wants to integrate the various aspects of personal (incentives) and non-personal coordination (learning effects, market structure) into one coherent strategic concept (the integration problem), the results are a lot less clear than conventional wisdom would lead us to believe. A slight re-interpretation of the four cost environments proves helpful with this question in mind. Suppose, a firm has been working under the assumption that K^1 is its true cost function. For K^1 , unit cost equals marginal total cost, an assumption often made in reality. The firm knows, however, that learning effects are potentially relevant for its long term cost structure, but does not know whether K^2 , K^3 or K^4 is the true cost function. If it tries to make use of this knowledge for decisions on price and optimal design-efforts but ignores issues of personal coordination, an easy rule of thumb can be derived from the first best results. Lower prices, increased production and higher design-efforts should improve the firm's performance in the first best world. This is in line with the standard SMA view of learning effects.

The picture changes dramatically, if we explicitly include aspects of personal coordination. First, there is a general second best effect of more costly design efforts due to informational rents for the engineer. Second, some learning effects (K^3) can lead to the seemingly paradoxical result that - for some values of the technology parameter - prices should be higher and design efforts even lower than for the original cost structure, though learning effects are present. Thus, the more „strategically-oriented“ a cost management system becomes, (here modelled as the interaction between learning and Target Costing), the less applicable are traditional relationships like the „investment in experience“ effect due to learning put forward in more traditional

approaches. On the other hand, with a learning effect of type K^2 headquarters could use higher output as a means to limit informational rents. Only technology-independent learning processes (K^4) have no such impact. We believe K^2 and K^3 are the more realistic cases because links between available technology and learning are likely to exist. This is quite important because it shows that coordination of SMA's various instruments will by no means lead to uniform solutions for all industries. Thus, the numerous contributions to the literature, exploring the applicability of these instruments to different industries seem quite justified¹. But surely some empirical investigation is needed to support this view.

For some assumptions about the parameters of our model, we can obtain explicit solutions. In the following section, we have compiled a detailed example to illustrate our main findings.

3. Example

We obtained solutions for our example using the mathematical software „*Derive*®“. In a first step, we determine optimal a^* and p^* in a first best world for all four cost functions. Next, we develop the second best solution for K^1 and K^4 . This is used to demonstrate the distortions between first and second best that are due to informational rents. A comparison between K^1 and K^4 shows that technology-independent learning effects pose no special problems because they leave pricing unaffected. Subsequently, an example of technology-dependent learning is presented (K^2, K^3). Illustrating our analysis in the text, we show the mistake a firm would make, if it only used the simple subtraction method. For K^3 we present an example where the optimal price with learning effect actually exceeds the optimal price without learning effects.

In a final example, we compare technology-dependent learning effects K^3 with technology-independent learning effects K^4 .

1. see, for instance, Gleich, R.: Target Costing für die montierende Industrie, Diss., Vahlen, München 1996. [Target costing for manufacturing industries, Ph.D. thesis, Vahlen, Munich 1996, transl. are by the authors] or Niemand, p.: Target Costing für industrielle Dienstleistungen, Diss., Vahlen, München 1996 [Target Costing for industrial services, Ph.D. thesis, Munich 1996], Finkler, S.: Cost Accounting for Health Care Organizations, Aspen, CO, 1995, Chapters 17, 18, 19.

Data for the example:

$$x = 10.500 - p, Z(a) = z \cdot a, z = 200, c = 100.000, V(a) = a^2, V'(a) = 2 \cdot a, V''(a) = 2.$$

$$f(x) = 1 - (x/30.000), g(x) = 1/200 \cdot x, m(x) = 1/10 x.$$

$I = 0$, $\theta \in [20, 25]$ and uniformly distributed. The IHR for this uniform distribution is:

$$\frac{1 - H(\theta)}{h(\theta)} = \frac{1 - \int_{20}^{\theta} \frac{1}{5} d\theta}{\frac{1}{5}} = (25 - \theta)$$

With this data, the respective first order conditions of the four cost environments are linear in a and p . Solving these four systems of equations leads to solutions for p^* and a^* for the first best scenario. With this knowledge we can compute unit cost and marginal total cost. Optimal values for all four variables are presented in table 2 for $\theta = 20$ and $\theta = 25$. The explicit formulae for optimal a^* and p^* as functions of θ can be found in the appendix .

	K^1	K^2	K^3	K^4
$p^*(\theta)$	[6900; 6233,3]	[5871,42 ; 5310,8]	[6346,16, 5380]	[6346,16 ; 5577]
	s.d. in θ	s.d. in θ	s.d. in θ	s.d. in θ
$a^*(\theta)$	[1700; 2033,3]	[2214,28; 2494,6]	[1976,92; 2460] u.	[1976,92 ; 2361,54]
	s.i. in θ	s.i. in θ	s.i. in θ	s.i. in θ
$k^*(\theta)$	[3300; 1966,67]	[2014,28, 813,51]	[2607,69; 900] u.	[2607,69 ; 1146,15].
	s.d. in θ	s.d. in θ	s.d. in θ	s.d. in θ
$K_x^*(\theta)$	[3300; 1966,67]	[1242,85; 121,62]	[2192,33 ; 260]	[2192,33 ; 653,87]
	s.d. in θ	s.d. in θ	s.d. in θ	s.d. in θ

Table 2 (1st best), s.i. = strictly increasing, s.d.=strictly decreasing

Chart 1 shows p^* and k^* for K^1 , K^2 and K^3 . Since the optimal values for K^4 are very close to those for K^3 , they are omitted from the chart to keep it tractable.

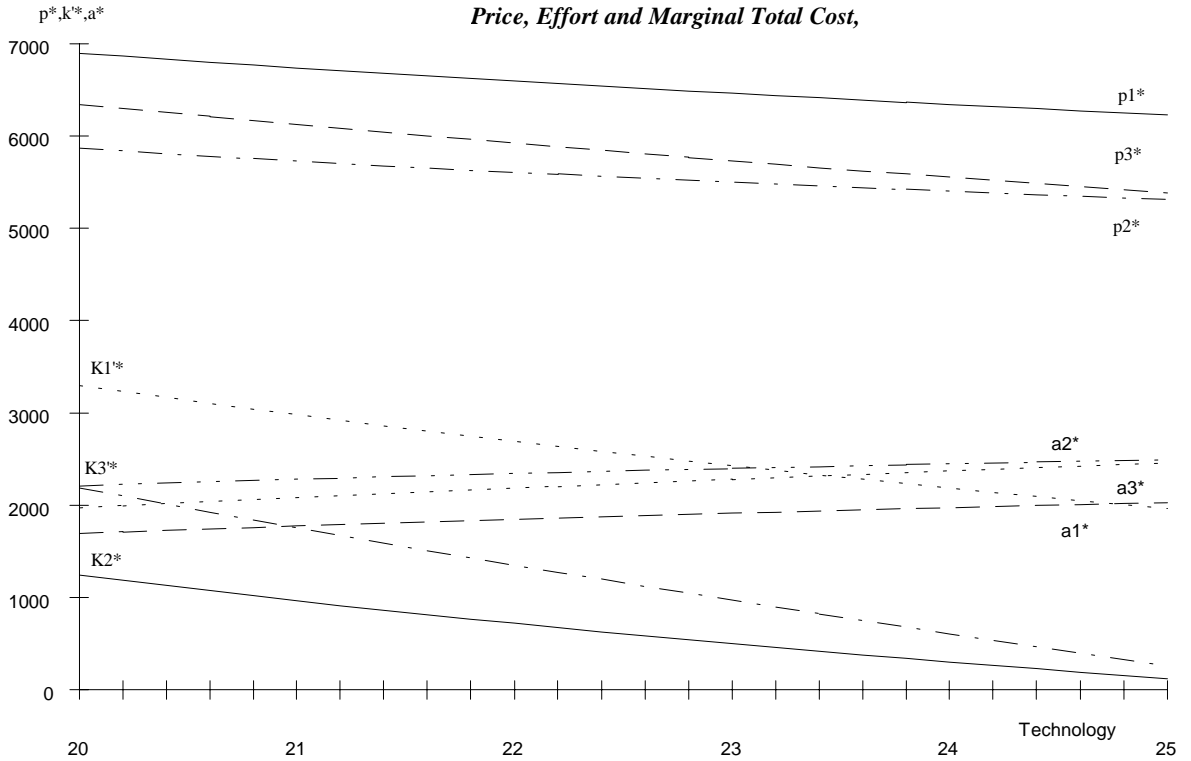


Chart 1

We see that learning effects in the cost function have the unambiguous effect of lower prices and lower marginal total cost for all θ . These lower prices are accompanied by higher design efforts, strictly increasing in θ . The firm „invests in experience“, i.e. produces a higher quantity x to make efficient use of these learning processes.

The next example solves for the optimal a^* and p^* for K^1 and K^4 in second best. The results are presented in table 3.

	K^1	$K^1 a (x = 10.400-p)$	K^4
$p^*(\theta)_{II}$	$\in [7733,34, 6233,34]$	$\in [7700, 6200]$	$\in [7307,6 ; 5577]$
	s.d. in θ	s.d. in θ	s.d. in θ
$a^*(\theta)_{II}$	$\in [33,34; 2033,34]$	$\in [0(!); 2000]$.	$\in [246,15 ; 2361,53]$
	s.i. in θ	s.i. in θ	s.i. in θ
$k^*(\theta)_{II}$	$\in [4966,67,1966,67]$	$\in [5000 ; 2000]$	$\in [4434,34 ; 1146,67]$
$K_x^*(\theta)_I$	$\in [4966,67,1966,67]$	$\in [5000; 2000]$	$\in [4115,2; 653,87]$
I	s.d. in θ	s.d. in θ	s.d. in θ

Table 3: K^1 sand K^4 , second best, s.i. = strictly increasing, s.d.: strictly decreasing

The following chart compares the first best and second best optimal values for K^1 for all θ :

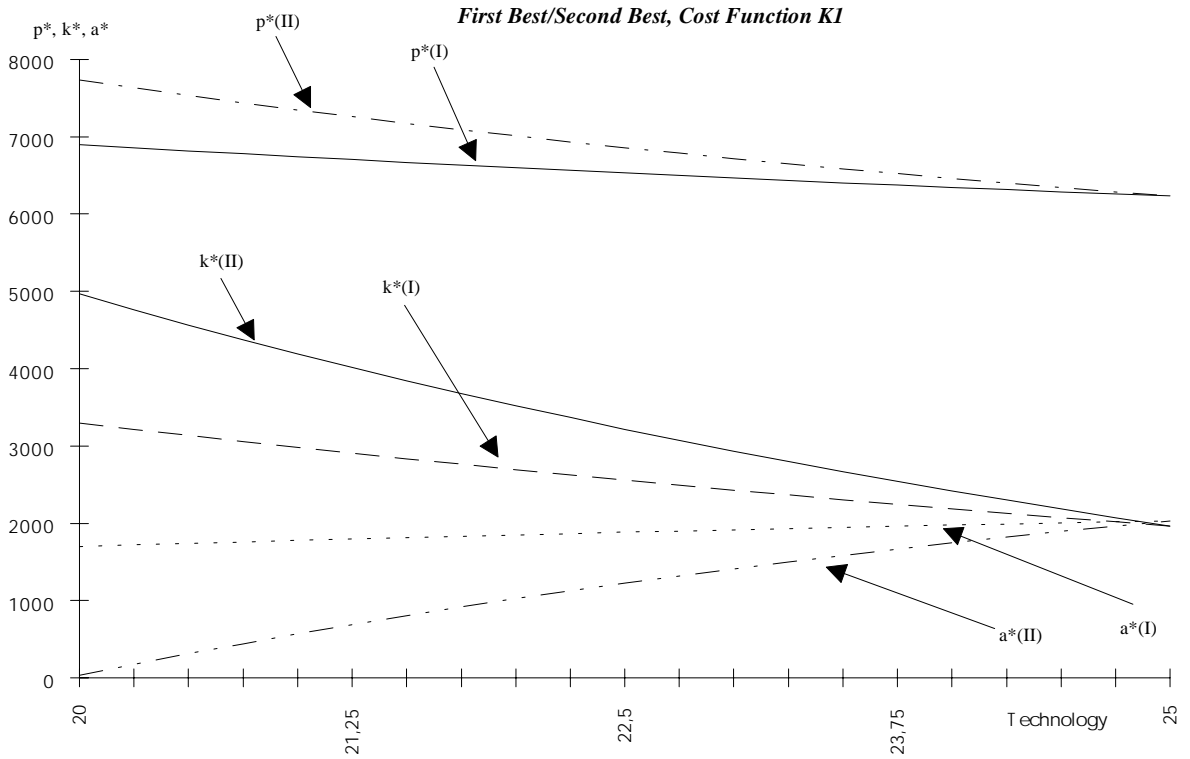


Chart 2: I = first best, II = second best.

Observe, that the greatest distortions occur for unfavorable technologies θ . This is so because headquarters can reduce expected rents for more favorable technologies by reducing incentives for design effort in the case of worse technologies. Induced effort is very small for $\theta = 20$ in second best. For

$K^1 a$ we have reduced the intercept of the demand curve from 10.500 to 10.400. If the firm operates in the worst technological environment, no design effort at all is induced when the engineer reports $\theta = 20$. This is a hint that usage of new cost management techniques such as Target Costing is not necessarily accompanied by advantages for the firm. Positive design efforts for $\theta = 20$ would lead to higher expected rents for $\theta > 20$ and higher cost $z \cdot a$, therefore it is better to do without any design efforts. If production is feasible, even with no design-efforts and the worst possible technology, the firm can be better off, if it enters the market directly with a unit cost of 5000 determined by technology only.

Table 3 confirms what we said about technology-independent learning processes. The price

increase for design-effort is the same for K^1 and K^4 , if we move from first to second best. This has only an indirect effect on the optimal price, however. Prices will therefore be lower in K^4 and design-efforts higher for all θ .

The following example shows what would occur if the firm ignored the incentive effect for determining optimal price in the case of K^2 and only applied the simple subtraction method. From table 4 we see that price would be too high and design-effort too low for all but the best technology $\theta = 25$. The disadvantages of such a policy have already been analyzed in the text.

K^2 , 2nd best	K^2 , using simple target costing shell
	$p-(x/-x')=K_x$
$p^* \in [6761 ; 5310,8]$ s.d. in θ	$\in [\underline{6811,11(!)} ; 5310,8]$ s.d. in θ
$a^* \in [675,241 ; 2494,6]$ s.i. in θ	$\in [\underline{648,15(!)} ; 2494,6]$ s.i. in θ
$k^* \in [3701,6 ; 813,51]$ s.d. in θ	$\in [3737; 813,51]$ s.d. in θ
$K_x^* \in [3022; 121,62]$ s.d. in θ	$\in [\underline{3122 (!)} ; 121,62]$ s.d. in θ

Table 4: Second best K^2

For K^3 , we have the opposite effect. The firm would underestimate the price increase for design-efforts due to informational rents. It ignores the fact that higher output not only lowers marginal total cost but increases rents at the same time. The results are presented in table 5.

K^3 , 2nd best	K^3 , using simple target costing shell
	$p-(x/-x')=K_x$
$p^* \in [7373 ; 5380]$,s.d. in θ	$\in [\underline{7368(!)};5380]$, s.d. in θ
$a^* \in [135,31; 2460]$,s.i. in θ	$\in [\underline{137,5(!)};2460]$,s.i. in θ
$k^* \in [4552; 900]$,s.d. in θ	$\in [\underline{4549(!)}; 900]$, s.d. in θ
$K_x^* \in [4246; 260]$,s.d. in θ	$\in [\underline{4236(!)}; 260]$, s.d. in θ

Table 5: second best K^3

The following example shows a case where $P_{K^1}^* < P_{K^3}^*$ and $a_1^* > a_3^*$ holds in a second best scenario. We continue to use the original data except for $z = 0$ and $g(x) = L \cdot x = 1/5000 \cdot x$. We also change the probability distribution. The technology parameter θ is now assumed normally distributed with mean 25 and standard deviation 200, i.e. $\theta \sim N(25,200)$. The true technology is θ

= 100. If the firm uses an incentive compatible mechanism, the design engineer will reveal this true value of θ^1 . The IHR, $R(\theta)$ of this distribution at $\theta = 100$ is given by:

$$(1-N(100,25,200))/n(25,100,200) = 190,305.$$

The following table summarizes the example:

Optimal Solution for $\theta = 100$	K^1	K^3
p^*	5435,37	5450,63,-
a^*	629,25	429,45
k^*	370,75	469,55
K_x^*	370,75	401,25

Table 6

Despite the good technology and the presence of learning effects in K^3 , it will be optimal for headquarters to charge a higher price and induce lower design-efforts ! This is largely a result of the large value of $R(100)$. If higher output results in higher rents for the engineer, we have an additional marginal-cost-increasing term. The absolute value of this term mainly depends on the relationship between $R(\theta)$ and θ . If $R(\theta)$ is very large, this effect may lead to higher prices and lower design efforts. In the following chart we plot L against p for $\theta = 100$:

1. The example is incomplete because for some values of the technology parameter solutions occur that make no economic sense. This is, however, a general problem with the normal distribution, since its support is the entire real line.

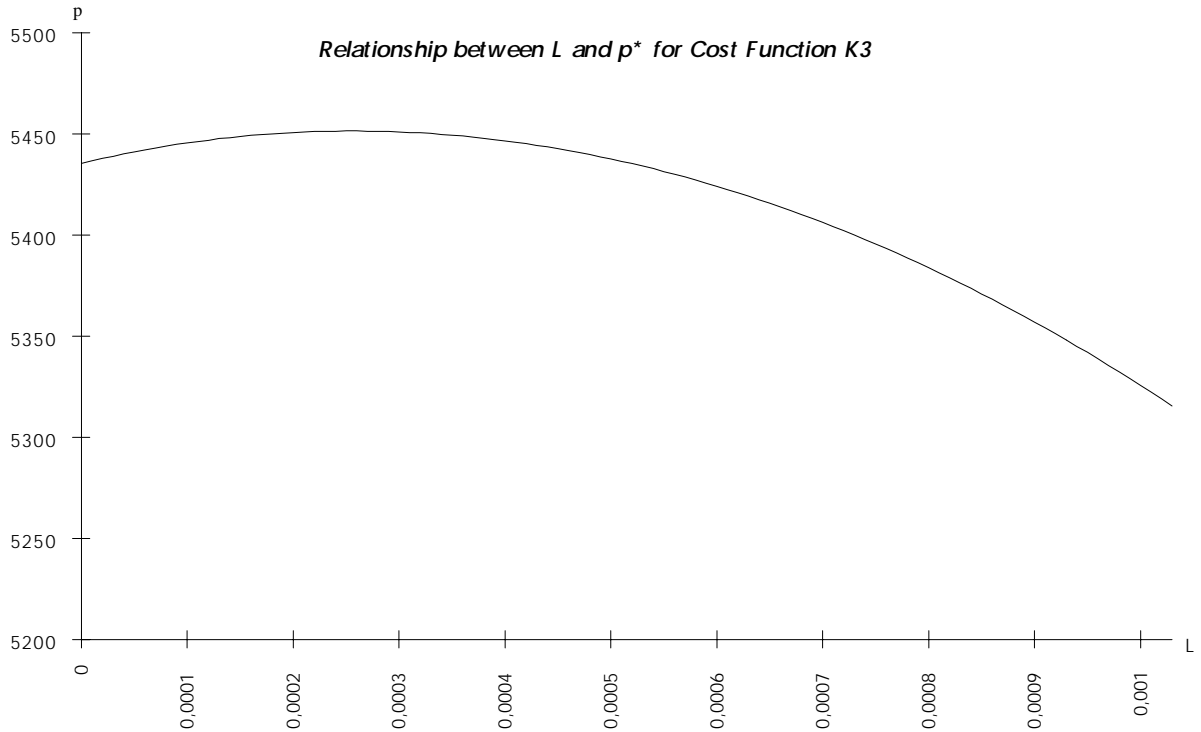


Chart 3.

As L increases from the maximum, optimal price will fall. This is the usual way learning effects operate. If L decreases however, optimal price will fall too. It reaches the second best price for K^1 at $L = 0$. It is necessary to add a word of caution to this analysis. We may **not** conclude from this example that a firm with cost structure K^3 may actually be worse off than a firm lacking learning effects in its cost function. This is due to the fact that marginal total cost, unlike in the classical Cournot Model, is telling us only half the story here. An explicit analysis of revenues and cost for $\theta = 100$ in the appendix 9 shows that firm K^1 has higher revenues and lower cost $k^1 \cdot x$, but since design-efforts a_1 are larger, its incentive term $R(\theta) \cdot V'(a_1) \cdot A_{\theta x}$ is also larger and it has to compensate its engineer for a higher disutility of effort. These two effects dominate the higher revenues and other cost savings, so that profits for K^3 are actually higher than for K^1 . Thus, the true meaning of the effect has less to do with overall profits but with the finding that the first best relationship between unambiguously lower prices and unambiguously higher design efforts, if learning effects of any kind are considered, does not hold any more in second best.

The final example compares technology-dependent learning effects of type K^3 with technology

independent ones of type K^4 . We have chosen $m(x) = M \cdot x$ in a way to make the marginal learning effect identical for the point where distortions are largest, $\theta = 20$. We can thus filter out the impact of learning and study the differences of design-efforts in the two cost environments. $M \cdot x$ is then $\approx 0,0982 \cdot x$. The results are presented in table 7.

Variable	K^3 (2nd best)	K^4 (2nd best)
p^*	7373	7316,4
a^*	135,31	241,8
k^*/K_x^*	4552/4246	4445,5/4132,8
marginal learning effect	625,4	625,4
$(2 L x \theta) \cdot (2 M x)$		
$V' \cdot A_{\theta x}$	$V'(a) \cdot g'(x) =$	0
	$a^*/100 = 1,3531$	

Table 7: Comparison K^3 , K^4 second best

We find that price is lower and design-effort is higher for K^4 . Though the marginal learning effect is the same¹, a firm with cost structure K^3 would induce considerably less design-efforts because its second best efforts are more expensive than the same activities for K^4 . This is due to informational rents increasing in x in the case of K^3 .

4. Discussion and future research

The current paper has offered some structural insights into the related problems of integration of SMA instruments and questions of personal and non-personal coordination. Most of these instruments such as Target Costing or Life Cycle Accounting can be interpreted as methods to cope with problems of non-personal coordination. Target costing accomplishes this by an explicit analysis of the future market for a new product. The question „what will a product cost?“, is replaced by the question „what may a product cost in order to make it an economic success?“. If this approach takes learning effects into account, i.e. seeks to integrate the concept

1. Note that the difference in unit cost $k^3 - k^4$ is the same as the difference in effort levels $a^4 - a^3$. The more important marginal total cost differ by the difference in incentives and the incentive term in the case of K^3 .

of market-orientation and learning processes, we found that results differ sharply, depending on whether problems of personal coordination are also included into the analysis or not. If we ignore these latter problems, it is not surprising that our analysis largely confirms the assumed positive interaction between learning and market-orientation. A firm that tries to coordinate learning with market orientation (K^2 , K^3 , K^4) will do better than a firm that only observes the market but ignores marginal total cost decreasing in output as a result of learning processes. This view can be challenged on the ground that it solves a problem that is incomplete. One crucial parameter (technology) is not readily available, if the engineer has superior knowledge about the technology and stands to profit from understating it.

If this is taken into account, some results may change dramatically. Asymmetric information leads to a considerable price increase for the factor „design-efforts“ because rents accrue to the better-informed engineer. In order to limit these rents, headquarters uses this factor more sparingly. In particular, headquarters induces lower design-efforts for unfavorable technologies in order to limit rents in cases of better technologies. Another finding was that technology-independent learning effects (K^4) pose no special problems since they have only an indirect effect on price, while the price increase for design-efforts remains the same. Prices for K^4 in second best will still be lower and design-efforts higher for K^4 relative to K^1 for any θ .

For technology-dependent learning effects we distinguished between two scenarios. For cost function K^2 , higher output negatively affects informational rents. If the firm applied the simple subtraction method (the target costing shell), it would overprice its product and induce too little design efforts. It ignores the fact that higher quantities can be used as a coordination instrument to reduce informational rents. If headquarters uses this instrument efficiently, this has the effect of making the price increase for design-efforts from first best to second best less severe. Problems from asymmetric information can only be reduced in this case, however, because headquarters can only limit rents but never completely eliminate them. Otherwise, truthful reporting of private information will not be in the engineer's best interest.

If informational rents are increasing in output (K^3), headquarters faces a tradeoff. On the one hand, higher output reduces marginal total cost. On the other hand, it increases informational rents. If the firm ignores this incentive effect on optimal pricing, it will set price too low and induce too much design-effort. The firm thus underestimates the price increase for design-efforts relative to a first best world. We presented an example where the second-best-price for a cost

structure with learning effects was actually higher than for a cost function without learning effects. Though overall profitability was still higher for the firm with learning effects, this result is quite important. It shows that the unambiguous relationship between learning effects (lower prices and increased design-efforts) from a first best world no longer holds in second best. If the firm wants to include learning processes into an overall concept of strategic cost management that already takes market-orientation and aspects of personal coordination into account, the optimal strategy may actually involve a reduction of costly design-efforts. More pointedly, the more strategically oriented a cost system becomes, the less applicable may concepts like the learning curve become. Thus, overall strategy depends crucially on the type of learning processes (technology-dependent, rent-increasing/rent-decreasing) within a company or industry. This may be seen as a justification for the vast literature that explores the applicability of SMA-concepts to specific industries. This literature only rarely addresses the issue of interaction between personal and non-personal coordination, however. Thus, our results may serve as a basis for future research design with respect to specific industries.

We know that our model is only a highly stylized representation of reality. Our parties are risk-neutral, we have only one design-engineer and asymmetric information is limited to one parameter. In addition, we did not include competitors, except for the benchmarking interpretation. Furthermore, design-effort is a simple one-dimensional variable. Nevertheless, we were able to obtain some results that improved our understanding of the various interdependencies that need to be considered, if we want to achieve the aim of an integrated strategic cost management. The main point, relevant to all our findings, is the fact that meaningful statements on how a firm should deal with issues of non-personal coordination can only be made after problems of personal coordination have been included into the analysis.

Moreover, we may relax all our simplifying assumptions within other approaches of the line of research known as (new) information economics. Thus, we could analyze the role of many design-engineers within the framework of a multi-agent model. This approach would be in a position to address important questions that we ignore in our model such as competing design-teams or relative performance evaluation¹. With the aid of a multi-task principal agent model,²

1. Holmström, B.: Moral Hazard in Teams, in: *Bell Journal of Economics*, 13 (1982), p. 324-340, and Shleifer, A.: A Theory of Yardstick Competition, in: *Rand Journal of Economics*, 16 (1985), p. 319-327.

2. Holmström, B.; Milgrom P.: Multitask Principal-Agent analysis: Incentive contracts, asset ownership and job-design, in: *Journal of Law, Economics and Organization*, 7 (1991), p. 26-52.

the role of various dimensions of design-efforts such as (unobservable) quality versus (observable) number of prototypes could be explored. Models developed in the field of new industrial economics could be used to incorporate competition¹. Other approaches, using methods that combine capital budgeting techniques with option pricing theory also yield interesting insights into questions relating to SMA. We may conclude that our understanding of integrated concepts of SMA is still far from complete. Still, we believe that an application of the theories mentioned above offers a very promising approach for future research into this exciting subject.

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