Lecture Quality Management

04 Quality and Economics

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  Quality Controlling
  Data Preparation (1): Assessment of Nonconformities
  Data Preparation (2): Quality Cost Accounting
  Evaluation and Provision of Quality- and Cost-Related Information
  Quality and Costs in Product Development: Target Costing

Bibliography:
Horváth, P.: Target Costing. Stuttgart: Schäfer-Poeschel Verlag, 1993
Nonconformities and Their Economic Effects

Change of market conditions has significant influence on the managerial policy within all areas of industry. Particularly in the last decades, rapid developments have taken place in the field of quality assurance. More and more effort is required to meet the rising quality demands from customers and legislators that companies are faced with.

Due to fierce competition among companies, failures or nonconformities (lacking quality) have significant influence on their economic situation. Most of the time, rising quality costs are the result. In addition to the monetary effect of nonconformities, companies have to consider potential losses of image.
The Triangle of Effects

In the traditional view, quality, costs and time have always been thought of as being in a tension triangle. They were considered to be business objectives of equal importance. The factor quality was exclusively associated with the quality of products and services. Depending on the situation of the company and its competitive environment, one of the three factors, e.g. costs, was often optimized at the expense of another factor, e.g. quality.

In the modern view, quality is no longer only considered to include the quality of products but of business processes as well. Another part are continuous improvement programs. This understanding of quality as the most important business objective assists in saving time and decreasing costs as well as in improving product quality.
Increase of Process Quality through Avoidance of Waste

7 kinds of waste caused by:

- Production
- Stocks
- Transport
- Holding time
- Production space
- Rework (nonconformity)
- Transit time

Waste also includes *not* to use talents, skills and knowledge of all employees!

Companies should not save on necessary but instead on unnecessary things.

In the focus of interest:

- Work that doesn't produce additional value (if it can be avoided)
- Faulty work which decreases the value of a product

Increase of Process Quality through Avoidance of Waste

Failures/nonconformities occur while planning and performing production processes. The consequences of these failures can be subsumed under the term *waste*. It must be the company’s objective to avoid waste as far as possible.
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Tasks of Quality Controlling

The tasks of quality controlling can be depicted as shown above. To carry out a continuous improvement process, the following steps have to be carried out:

- To evaluate the actual state, relevant information has to be gathered and provided.
- In a next step, deviations from the quality objectives have to be identified.
- To create a basis of decision-making concerning possible improvement projects, data is prepared in the form of compressed and clear reports. Data is carefully prepared to support the identification of action priorities that need to be established in order to choose among all potential improvement projects.
- The processes that are carried out during improvement projects are evaluated based on the established approach (steps 1-3). This is done in order to find out by how much costs were reduced and by how much quality was improved. The costs of these projects are compared to the accomplished reduction in costs.
- That way, quality controlling supports the assessment of improvement projects.
Quality Controlling and Cost Accounting

Quality-based costs are identified and calculated with the help of managerial accounting. It makes sense to adapt the existing processes in managerial accounting to the requirements of quality-based cost analysis. This is the case because data on costs that can be classified as quality-based costs is already being collected by managerial accounting.

Cost accounting is carried out in three steps:
- Cost category accounting classifies the production factors, which are used in the company, according to their origin (e.g. personnel costs or material costs).
- Cost centre accounting distributes the overhead costs, that are not directly attributable to the products, to the different areas of the company, according to the costs’ actual origin and reason.
- Cost unit accounting assigns costs to the different kinds of output generated, namely the manufactured products or the services provided. The objective is to calculate the manufacturing costs of individual products.

Managerial accounting also includes investment appraisals and the compilation of cash-flow statements. Their results are aligned with quality controlling.
**Arithmetic mean: Will-Rogers-Phenomenon**

Will-Rogers Phenomenon, named after the American burlesque actor and comedian Will Rogers (1879 – 1935). Some of his jokes were derived from the fact that shifting selected elements from one group to another, the mean value of both groups can be altered in the same direction. Citation: „If an Okie moves from Oklahoma to California, the intelligence in both states is increased."

Nowadays, combined with the fact that by better diagnosis the survival time of ill people can be observed to be prolonged without improving the cure. So, root cause and effect are often misinterpreted. In the given examples of „reorganizing“ different cost centers, the same effect appears. Be careful: The example is satirical.
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Causation and Detection of Nonconformities

Between 75% and 80% of all nonconformities/failures that occur in a company are caused during the planning stages. The consequences of these failures do not become apparent until the production stages. This causes significant amounts of costs and inconvenience for the customer. It is reasonable to assume that failure costs are higher the later the failures are detected.

This insight has led to the development and improvement of numerous failure prevention methods and techniques in the field of quality management. They are especially relevant for the stages preceding the manufacturing stage.

In practice however, most of these tools are not yet used or only used in an insufficient manner. One reason for this is that it has not yet been shown that if these methods are employed, objectives of time, costs and quality will be met more easily.
Classification of Nonconformities/Failures

- Critical failure
  - Failures that cause dangerous or unsafe situations for persons while they use the product
- Major failure A
  - Total impairment of serviceability (breakdown, loss)
- Major failure B
  - Partial impairment of serviceability
- Minor failure A
  - Impairment of serviceability to a minor degree
- Minor failure B
  - No impairment of serviceability

100 % error-free products do not exist in our reality. They cannot be realized under economic aspects.
The objective is to consistently ensure the serviceability of the products.

Classification of Nonconformities/Failures
According to DIN EN ISO 9001 (1994), nonconformity (failure) means the non-fulfillment of a required feature. In this chart, quality-based costs are depicted subject to the freedom from defects or the quality level. Due to the different consequences of failures, it is difficult to quantify the quality level. Consequently, it has to be interpreted in terms of a general tendency.
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Traditional Quality Cost Accounting

The definition and approach of quality costs was defined by JURAN in 1932. Since then, it has not changed significantly.

- Costs for product inspections within the scope of quality assurance are called inspection costs. They are mainly incurred by test personnel, costs of inspection equipment and occupancy costs.
- Failure costs are costs that are caused by the fact that products do not fulfil their specified requirements. Failure costs also include costs that are caused by faulty products within the scope of manufacturer's liability.
- Failure prevention costs are those costs caused by measures carried out to prevent failures within the scope of quality management.
Critique of Traditional Quality Cost Accounting

- Quality costs are interpreted as a surcharge on manufacturing costs.

- It is misleading to present the connection between costs and quality as a causal link. The costs are not caused by quality, but rather by nonconformity with quality standards during production.

- Quality costs in the traditional view deflect attention from real savings potentials.

Critique of Traditional Quality Cost Accounting

Points of criticism:

- The prevention of failures is an integral part of every activity. It cannot be isolated how much of any given activity is caused by failure prevention. Usually, identified failure prevention costs are those costs that are caused by additional measures such as trainings and the implementation of specific methods. Therefore, it is difficult to assign a target value for failure prevention costs.

- On the one hand, screening inspections are used to stop failures from being forwarded through the production chain. On the other hand, they generate control variables needed for statistical process control. Therefore, they cannot be reduced, it is difficult to comprehensively gather them and to assign a target value.

- Failure costs are mostly identified during the production process. But the costs are not attributed to the stages of product development during which they were caused.

- A direct causality between an increase of failure prevention costs and a decrease of failure costs does not exist. Because measures taken to prevent future mistakes do not impact the current cost-incurring failures, longitudinal analyses need to be carried out.
Opportunity Costs

**Opportunity costs:** Profit or benefit of the next best alternative forgone as the result of making a decision.

**Opportunity costs in quality control:** Opportunity costs are caused by the behavior of the customer due to low quality, which may lead to dissatisfaction, migration to competitors and decrease of the potential customers' willingness to purchase.

Opportunity Costs
- Faulty products can lead to loss in sales, e.g. as a result of loss of image. Therefore, quality-based costs must also include opportunity costs which can be interpreted as costs of lost sales. They accrue because some customers will not purchase the company’s products in the future because they experienced or expect low product quality.
- The costs of lost sales should be considered as an independent cost category in cost accounting since they indicate the degree of the satisfaction of the customer as well as his opinion on product quality.
Including Opportunity Costs (Costs of Lost Sales)

If opportunity costs are considered in addition to traditional quality-based costs, the quality level at optimal costs is higher.

For given courses of the functions of conformity and non-conformity costs, the quality cost optimum is located in point A. If opportunity costs are included in the model, a higher level of total quality costs emerges (difference between points C and D).

A real cost-cutting potential (between D and E) can be realized, if more means are invested in failure prevention measures. The new quality optimum is in point B, in which a higher quality-level can be realized.

Advantages of the consideration of costs of lost sales:
- The customer's opinion of the product quality can be considered by management accounting.
- The consideration leads to a higher quality level.

Criticism:
- Costs of lost sales are hard to define.
Structure und Classification of Quality Costs

The optimisation of the total costs of the product creation process with 100% compliance of customer demands is the fundamental idea of the quality-based costs. This requires an adjustment of the product- and process quality.

An appropriate definition and classification of the quality costs is being discussed controversially. A prevailing definition is not found within DIN ISO 9000:2005. In literature a segregation of conformity-costs and non-conformity-costs (Cosby and Wildemann) has been established.

The aim is a clear cut between:
- Costs, which are necessary to produce products according to their specifications.
- Costs, which are caused by the deviation of the results from the value added chain and the customer demands.

The costs of lost sales can be assigned to the non-conformity-costs, as far as they can be acquired. The remaining costs of a product or the deviation costs have to be assigned to the conformity-costs, in the sense of the fundamental idea and the definition of conformity-costs (controversial discussed in literature).
Ascertainment of Costs Based on Activity Types of Processes

The processes are classified into 4 output categories in order to illustrate the value-added processes in a clear and differentiated way:

- **Useful output**: Planned processes, which increase the value of a product or intermediate product, and therefore the benefit for the customers.

- **Supporting output**: Processes which support the useful output in the value adding-chain so that the planned results of the process are achievable. Therefore, supporting performance is planned as well, however, it only has a limited impact on the increase of the product-value.

- **Ineffective output**: Inefficiencies in the planned value-adding-chain, which result in unplanned processes or activities. Although the processes incur costs, they have no positive effect on the value of the product and according to this they must be minimized or eliminated.

- **Counter-productive output**: Results of incapable or uncontrolled processes. They reduce the value of the product.
**Cost-Oriented Quality Management**

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<tbody>
<tr>
<td>Value-adding activities</td>
<td>Sales, service</td>
<td>Research &amp; development</td>
<td>Work scheduling</td>
<td>Procurement</td>
</tr>
<tr>
<td>Flanking activities</td>
<td>Logistics/Documentation</td>
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</tbody>
</table>

**Value Creation**

- Value creation is the difference between an output value in terms of created goods/services and an input value at two given points in time.
- Processes only create value if they increase the benefit for the customer.
- Profit can only be made if the value that is created by the needed processes exceeds their costs.

Cost-Oriented Quality Management

Problems of the classification of quality-based-costs:

- At an optimum of the total costs, the dichotomy of quality based costs theoretically leads to 100% failure-free products. Because of numerous influences a “100% failure prevention” is not possible.
- Since wasting of resources does not necessarily lead to failures or to a deviation of requirements, it is not completely considered. Real potentials to reduce costs, however, are partly not being discovered.
- Similarly to the traditional trisection of quality costs, the quality-based expenses are considered as costs and not as investments.

A more differentiated consideration of the *cost-oriented quality management (QM)* allows the approach of Kamiske und Tomy:

- This approach analyses the results of different processes within the value added chain, which are applied for the production of goods.
- The aims are to uncover the wasting of resources and to optimize the production of goods. Therefore the value added chain will be split up in single processes.
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Indicators to Analyze Quality-Based Costs

Example: quality-based costs $\times$ (5 %)

Quality-based costs

Indicator of quality costs =

Reference parameter

Cost-oriented

Profit-oriented

Example:

\[ \text{Quality-based costs} \div \text{Number of produced units} \times (6 \%) \]

(lower manufacturing costs)

- Manufacturing costs
- Value creation

Example:

\[ \text{Quality-based costs} \div \text{Market price} \times (3 \%) \]

(lower demand)

- Market price
- Sales

Quality-based cost indicators must not be considered as an absolute standard for the measurement of economic efficiency!

Indicators to Analyse Quality-Based Costs

The absolute level of the quality-based costs is influenced by different factors. In order to compensate this influence for economic analyses, quality based costs are compared by using indicators.

- The market price as a success-oriented indicator allows the consideration of annual price increases.
- Cost-oriented indicators are useful when output-quantities vary.
- Quality-based cost indicators should be evaluated critically regarding several parameters. They must not be considered as absolute standards for the measurement of economic efficiency but as indicators of economic trends.
Cost-Oriented Indicators of QM: Process Efficiency Factors

The use of the efficiency factor of processes offers the opportunity to appraise the effectiveness of the production process and to recognise weaknesses. It is applied for target-actual-comparisons of quality-based costs.

The efficiency factor of processes is calculated by the ratio of
- useful output which is rewarded on the market by customers purchasing the product and
- the total used output of processes, which consists of useful, supporting, reactive and counter-productive performance.

The efficiency factor of processes strives to reach the theoretically ideal value 1. If the supporting output is minimised and the reactive and counter-productive performance is eliminated the process efficiency of the corresponding process increases.

<table>
<thead>
<tr>
<th>Process Efficiency factor</th>
<th>Specific efficiency factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\eta = \frac{\text{Value-creating output}}{\text{Total output expended for processes}}$</td>
<td>$\eta_{\text{supporting}} = \frac{\text{Useful output}}{\text{(Useful + supporting) output}}$</td>
</tr>
<tr>
<td>$= \frac{\text{Useful output}}{(\text{Useful + supporting + ineffective + counter-productive) output}}$</td>
<td>$\eta_{\text{ineffective}} = \frac{\text{Useful output}}{\text{(Useful + ineffective) output}}$</td>
</tr>
<tr>
<td>$\eta_{\text{counter-productive}} = \frac{\text{Useful output}}{\text{(Useful + counter-productive) output}}$</td>
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</tbody>
</table>
Cost-oriented Indicators of QM: Overall Equipment Effectiveness (1)

<table>
<thead>
<tr>
<th>Description</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Operating Time</td>
<td>POT</td>
</tr>
<tr>
<td>Planned Production Time</td>
<td>PPT</td>
</tr>
<tr>
<td>Operating Time</td>
<td>OT</td>
</tr>
<tr>
<td>Net Operating Time</td>
<td>NOT</td>
</tr>
<tr>
<td>Productive Time</td>
<td>PT</td>
</tr>
</tbody>
</table>

Sources of losses are breaks in operation and setting-time, and losses of output and quality. A reduction of these losses leads to higher efficiency and, therefore, to a reduction of costs.

The identification of the Overall Equipment Effectiveness supports the continual analysis of weak points. Further it is the basis for transferring responsibilities and, therefore, it supports preventive and autonomous maintenance.
Cost-Oriented Indicators of QM: Overall Equipment Effectiveness (2)

Overall Equipment Effectiveness = Availability \times Performance \times Quality

**Availability** = \frac{Operating Time}{Plant Operating Time}

**Performance** = \frac{Net Operating Time}{Operating Time} \times \frac{Output \times Cycle Time}{Operating Time}

**Quality** = \frac{Productive Time}{Net Operating Time} \times \frac{Output - Scrap}{Output}

**Causes of Losses**
- Tool life (dependent on order situation, shifts)
- Set-up time
- Plant shutdown
- Idle time
- Small stops (component jams, cleaning/checking)
- Reduced speed (rough running, operator inefficiency)
- Faults in the process (scrap)

Availability = Planned Availability \times Real Availability
Planned Availability = \frac{Planned Production Time}{Plant Operating Time}
Real Availability = \frac{Operating Time}{Planned Production Time}
Net Operating Time = Output \times Cycle Time
Examples of Other Quality-Based Indicators

**Complaint quotient (CQ)**

Is calculated as the quotient of the number of complaints received and the quantity delivered.

Formula: \( CQ = \frac{\text{Number of complaints}}{\text{Delivered products}} \times 100 \)

**Customer satisfaction index (CSI)**

- Important indicator for the customer perspective regarding the perceived product quality
- Quantitative output of an oral or written interview carried out to measure customer satisfaction

Formula: \( CSI = 100 \sum_{i=1}^{n} g_i \cdot Z_i \)

- \( Z_i \): Attribute-specific rating of the satisfaction with the \( i \)-th characteristic
- \( g_i \): Attribute-specific weighting of the \( i \)-th characteristic
- \( i \): Performance characteristic, \( i = 1,2,\ldots,n \)
- \( n \): Number of characteristics

More essential quality-based indicators are the complaint-quota and the customer satisfaction index. Customer satisfaction indices are usually detected by market studies, which are created by external market research institutions with the help of customer questionnaires and then sold to different target groups. The complaint quota is also detected by market studies but predominantly by analysing guarantee cases, e.g. with the help of authorized dealers.
Management Performance Measurement Systems

Performance measurement systems are used to determine performance trends using financial indicators. The profitability as well as the solvency of a company are used to describe the economic success. Starting out from the return on investment the indices are separated by the level of cost- and profit-categories. On the next level non-monetary quality indicators are to be regarded, which have to be compared with trends from former periods. They are used to determine the impact of quality management measures on the economic success. Following assumptions can be made:

- A successful orientation concerning customer- and society-requirements leads to increasing sales.
- A successful orientation concerning process-management- and employee-requirements leads to decreasing costs for the creation of goods and services.

The quality indicators evaluate so-called quality drivers, which are understood as QM-oriented tools and measures. The quality drivers are applied as enablers within the scope of the Business Excellence.

### Financial indicators

- **ROI** (return on investment)
  - Profit resulting from an investment
  - Amount invested

### Quality indicators

#### Sales-oriented
- Customer perspective
  - Customer satisfaction index
  - Target price index
  - Number of new customers
  - Complaint quotient
- Society perspective
  - Image-index
  - Environment quality index

#### Cost-oriented
- Employee perspective
  - Employee satisfaction index
  - Staff efficiency
- Process perspective
  - Process capability
  - Efficiency factor

#### Quality drivers (management-and organization-methods)
- Target Costing
- Simultaneous Engineering
- Complaint management
- Public relations
- Environment protection
- Employee qualification
- Introduce teamwork
- Restructuring processes
- Process management
- Process optimization
- Lean production
- Process management
- Process optimization
- Lean production

![Diagram](image-url)
Balanced Scorecard - Structure

**Strategic objectives:**
- How should we act towards our partners in order to reach the financial objectives?
- In which processes do we have to lead the field in order to satisfy our partners and customers?
- How should we support potential changes and growth in order to realize our visions?
- How should we act towards our customers in order to realize our visions?

**Finance**

**Customer**

**Internal processes**

**Development/innovation, learning (knowledge)**

**Vision and Strategy**


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**Balanced Scorecard - Structure**

The Balanced Scorecard (BSC) is a well structured measuring system for the determination of success-relevant indicators. A key characteristic is the balance of the illustration and reporting of indicators.

Within the scope of company-specific applications, an individual adaptation of indicators is necessary. Starting out from a “Basis-Scorecard” as an index-system for the top management, scorecards with a smaller focus and a higher level of detail work as an information system for company departments.

Applications in the scope of quality controlling:
- Communication instrument in order to define objectives
- Evaluation of aim achievement
- Measure definition, assignment and prioritisation

Advantages:
- Stakeholder-approach (Consideration of the business success from the perspectives of all relevant interested parties)
- Structured translation of the company’s strategy into functional characteristics
- Reasonable extension of financial and non-financial keys
Balanced Scorecard – Cause and Effect Chain

The vision and the strategic objectives have to be translated into indicators for the four sub-objectives. Thereby, objectives and indicators are set in relation to each other using cause- and impact-chains. Therefore, the objectives, measures and indicators are chosen with regard to the realisation of the company's strategy. Both the success of strategic and quantifiable objectives are closely related.
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Target Costing

Which price will be accepted on the market?

- Market situation
- Behavior of the competition
- Customer behavior

Target Costing

Target Price - Target Profit = Allowable Costs

How much would the product cost under current conditions?

- Factors of engineering
- Production-relevant factors
- Existing production facilities

Drifting Costs

Consequences:
- Costs-optimized implementation of customer demands
- Early identification of possible potentials to reduce costs
- Cost control
- Price- leadership in competition
- Ensure a customer-oriented price-performance ratio
- Increase of innovation-intensity

Target Costing

Target costing is a concept for extensive cost planning, management and control, which is basically applied to the early phases in the product development process in order to influence the structure of the product cost regarding actual market demands.

The key question to be asked in order to determine the target costs is “How much may the product cost?”. The answer to this question is given by a detailed market survey (e.g. conjoint analysis), which determines the customer demands in terms of price (Target Price).

- The allowable costs are given by the difference between the target price and the target profit of the company.

- Further, the realizable costs (Drifting Costs) are predicted on the basis of the company’s capability according to technology and process.

- The difference (target gap) between these two variables indicates the need for cost reduction.

- Defining the target costs, is now the job of the management. The more the target costs approach the allowable costs, the higher is the need for the development to react.
Target Costing - Determination of Target Cost Indices

The target costs are broken down to product functions and components.

- The *function*-cost-determination processes the information acquired from market studies (Conjoint-Analysis) or the results of a Quality Function Deployment (QFD).

- The *component* method is the easier way. It involves deriving the target costs by updating the product structure.

By using target cost diagrams a “call for action” can be clearly illustrated for individual components.