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Decision support model for the optimization of quality systems in the agri-food industry

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Decision support model or the optimization of quality systems in the agri-food industry

Abstract

Quality management is of paramount importance in all stages of the Agri-Food production and process chain. The approach of quality management has been changed in the past years due to the effects of globalization, numerous deficits in food safety and the legislative such as the new European regulation 178/2002 concerning food safeties. A trend, which can be shown, is the development of several quality systems and norms in response to this challenge. Therefore programmes will be developed and improved in the Agri-Food-industry further on.

There are general quality systems, which are applied in different countries and sectors, country and product specific standards and programmes, which were developed by retail initiatives.
This paper will give an insight into the variety of quality standards in the agribusiness and food industry in Europe and beyond. The main aspect will be a cost/benefit analysis for the implementation of different quality systems in firms and supply chains.

Keywords: quality management systems, cost, benefit, transaction costs, economic of scales

1 Introduction

Thinking on quality management started in the fifties and till now many different quality management systems have been developed. The most dramatic modification during this time was the change from product-oriented to process-oriented concepts. In the last ten years more and more country and product specific quality systems were developed. Deficits in food safety and the globalisation were some reasons for the development of quality systems in the agribusiness and food industry.

In some cases several quality systems are relevant for firms. However, it is more efficient for firms to analyse different requirements of quality management standards to eliminate double requirements. The result would be an integrated quality management system.
The aim of the QUALINT project is the development of an integrated description model to simplify the management of different quality systems in the agri-food industry. The model utilizes a databank, which automatically generates operational system descriptions.

This paper characterise the changes in the legislation, which are relevant for quality management and the development of quality systems. The next part analyses existing literature on the impact of costs and benefits of quality systems in an enterprise (section 3). The description of the decision support model: QUALINT is the content of section 4. Methodologies to analyse cost-benefits of quality systems is the next part of this paper (section 5).

Finally, the report finishes with a conclusion.

2 Changes and developments in the agri-food industry with the focus on quality management

2.1 Changes in the food safety legislation

Food legislation has changed during the last years, which has also influences on quality management. In the year 1990 the product liability law was published. A key element of this law is that the producers have to fulfil the due diligence of the product, what simply means that firms must

taken all relevant steps to assure the safety of its products. In the year 2000 the law redefined the legal meaning of due diligence (Krieger, 2002).

Another development was the publishing of the white book in the year 2000. One result was the new EU regulation 178/2002 with paragraph 18 concerning traceability of food. This regulation started in the year 2005 like the new subsidy payments. Till now the farmers get their payments in due to the agricultural land size, since January 2005 farm subsidy payments have been linked to compliance with basic standards relating to environmental management, animal health and welfare. From January 2006, Regulation 852/2004 aims to harmonize food hygienic legislation across Europe. This regulation lays down general requirements relating to food hygiene, clarifying the existing responsibilities of food businesses. In a true ´farm to fork´approach, primary producers are now subject to the hygiene requirements.

An important development is that, in line with the principles established in the Codex Alimentarius, food safety mangement systems based on Hazard Analysis and critical control point (HACCP) principles, which will be mandatory for all food businesses. This will not apply to primary producers for the time being.

2.2 History of quality management systems

At the beginning of the sixties the FAO and WHO developed the Codex Alimentarius regulation because of the expansion of the food trade. And till now this regulation has influences on the quality and safety in the global food supply chain and is a basis for a ´fair´ international trade.
In the eighties the development of systems with regard to processing management (´Good practice´) started.

Good practice (especially the good agricultural (GAP), good hygienic (GHP), good manufacturing (GMP) and good trade practice (GTP)) is the basis of quality management.
GAP is a guideline for the reducing of chemical, physical and biological hazards. GHP is obligatory for the preventive hygienic arrangements in the firm and GMP is a basis for ensuring that products are consistently produced and controlled according to quality standards. GTP is a guideline for the adequate transport of animals, raw materials and food (Krieger, 2002).

Since the nineties the international standard ISO 9000ff has been popular. ISO (International Organisation for Standardisation) norms are international standards in order to achieve uniformity and to prevent technical barriers to trade throughout the world.

The reason of the development of ISO 9000 was the publication of a consistent norm, which formulates the framework for quality management.

The DIN EN ISO 9000:2000 norm includes basics and definitions of quality management (ISO 9000), makes demands on quality management (ISO 9001) and formulates a guideline for the improvement of the quality system (ISO 9004). It is a sector independent standard.

Since the middle of the nineties more and more systems with reference to the HACCP system are implemented in the agri-food sector.

The main point of the HACCP-concept is the identification of health hazards during the production. It includes the seven HACCP principles. Conduct hazard analysis and identify control measures, identify critical control points (CCP), establish critical limits, monitor each CCP, establish corrective action to be taken when a critical limit deviation occurs, establish verification procedures and establish a record-keeping system (Luning et al., 2002)

On account of increasing different national certification standards for HACCP (e.g. the DS 3027 in Denmark, an HACCP standard in the Netherlands, an Australian norm) the international norm DIN EN ISO 22000 is directed for the standardization of these different systems. The system´s main point is the control of the hazards with specific measures (SSM). The definition of the SSM is: “Supportive safety measures: specified activities, other than critical control points, which affect food safety by preventing, eliminating or reducing the probability of hazards occurance.”

Furthermore quality systems have been developed with specific demands for the agri-food industry and with a view on supply chains.

Examples for systems of the agri-food industry are the “quality and safety system” (Q+S) and the “quality management milk” in Germany and the integrated chain control system (IKB) of the Netherlands, these are vertically oriented quality systems. Horizontally quality systems are for example the International Food Standard, which was developed by retailers, the ISO 9000 standard and the HACCP.

3 Measuring the costs and benefits of these systems

3.1 Costs of quality systems

In the past years firms have implemented quality management systems in order to manage food and process quality. Nevertheless, the implementation didn’t accommodate in every case the expected result. Companies have to search the best combination of quality systems for their specific situation. To make the right selection of quality management activities costs and benefits have to be investigated.

In April 2003 a survey with the 300 biggest companies of the German food industry was accomplished and 85 responses were received. The aim was to determine and analyse cost and benefit of quality management systems.

Documentation and the high cost of entry checking and process analysis got the most criticism by the firms. Fault analysis causes 14%, quality checking 11% and training 10% of quality costs (Beyer & Krieger, 2004).

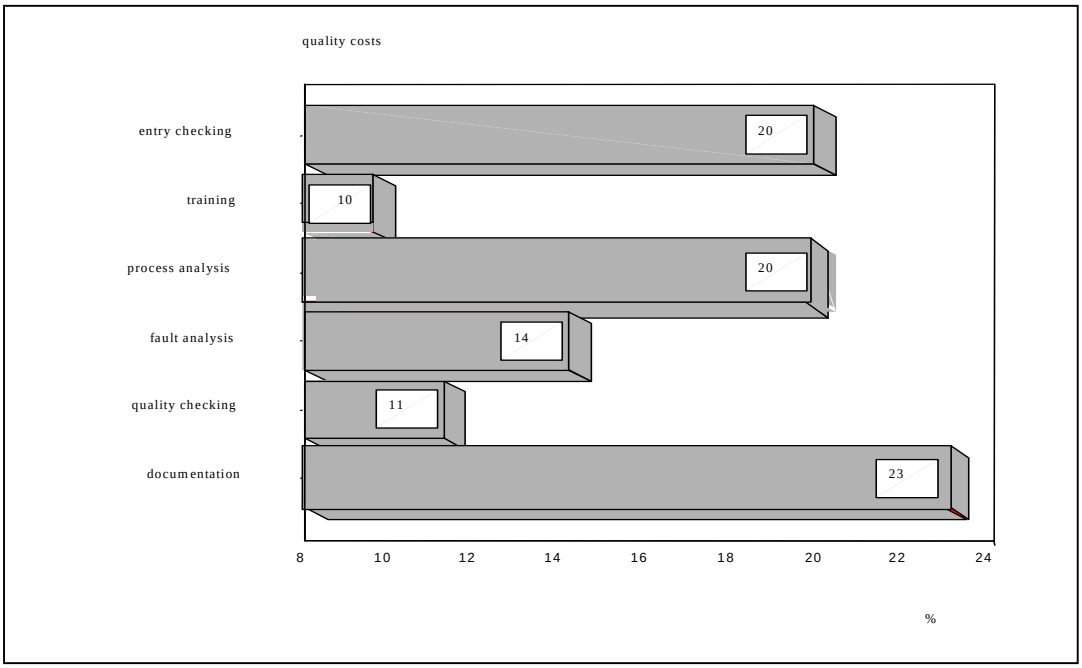

Figure 1: Internal costs of a quality system in firms: results of an questionnaire

3.2 Benefits of quality systems

Benefits of quality management have very different dimensions. Results from expert interviews and literature reviews present that some benefit aspects are more important and actual than others. Therefore, the following aspects of benefit have been selected to evaluate the quality concepts:

1. Market entry

In some cases, a quality system certification is an entry to markets. The reason is that without a certification it is not possible to sell on special markets. Standards can also be a barrier to trade for poorer developing countries because the cost of meeting them is assumed prohibitively high.

2. Product liability

Since the year 2000, product liability has been a catchword not only in the agri and food industry. A key example is the legal standard to meet the due diligence requirements of the product liability law. The requirements that firms practice due diligence simply means that a firm must have taken all necessary steps to assure the safety of the products.

3. Cross Compliance

Cross Compliance has been relevant for farmers since this year. The subsidy payments will now be paid according to the fulfilment of 19 EU-Regulations. In addition, in some cases the demands of those regulations have intersections with demands of quality management systems.

4. Process quality

Process quality is the organisation of the internal process and transactions between firms. An optimal organisation of a process means lower costs. Moreover, the requirements of different quality systems have a special focus on the optimal organisation of the processes in firms.

5. Product quality

Product quality concerns on the one hand physical product attributes (taste, shelf life, etc.) and on the other hand safety of a product with regard to health aspects.

6. Traceability

The EU regulation 178/2002 contains general provisions for traceability (applicable from 1. January 2005), which cover all food and feed business operators, without prejudice to existing legislation on specific sectors such as beef, fish, GMOs etc. (EU Commission, 2002). Importers are similarly affected, as they will be required to identify from whom the product was exported in the country of origin. Traceability has to be done one step back and one step forward.

The evaluation of quality concepts is based in this study on the six above-mentioned benefit dimensions. The focus of different quality system categories is not the same like the following figures (2-5) due to benefits of quality management presents. The four figures also show the historical development of quality systems with the focus on their main benefits for the agri-food industry on the European market.

In the eighties started the population of the HACCP-Concept in the USA and later on also in Europe. HACCP is widely recognised in the food industry as an effective approach to establishing good production, sanitation, and manufacturing practices that produce safe foods (Pierson and Corlett, 1992). It establishes process control through identifying points in the production process that are most critical to monitor and control. HACCPs preventive focus is seen as more cost-

effective than testing a product and then destroying or reworking it. The system can be applied to control any stage in the food system, and is designed to provide enough feedback to direct corrective activities (Unnevehr & Jensen, 1998)

The main focus of HACCP is product quality of food like figure 2 presents. Studies shows that since the integration of HACCP a reducing of food borne illness is increased.

Adoption of HACCP as a regulatory standard has been motivated first by food safety concerns, and only second by a desire to facilitate trade (Caswell & Hooker, 1996). The process of facilitating trade required mutual recognition of HACCP regulations across national boundaries, which shows that HACCP is international necessary for the market entry (Unnevehr & Jensen, 1998).

In addition to greater food industry concentration, HACCP regulations may also create incentives for greater vertical coordination to control food safety throughout the production process. There is no necessary control if the product deliver and it is less expensive to contract or control production processes upstream (Mazzocco, 1996).

Another benefit is seen in due to product liability. Cross Compliance was not important in the eighties (Figure 2).

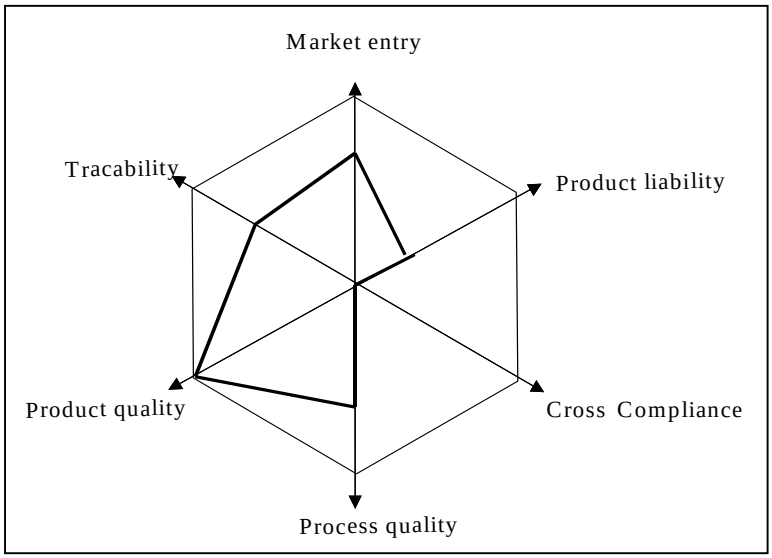

Figure 2: Benefits of HACCP

In the nineties the ISO 9000 norm was developed. ISO 9000 is a set of international, voluntary quality management standards that ensure a consistent production process. The result is an improving in the efficiency (Böcker et al., 2004). The ISO 9000 is a framework for a quality management system and the integration in a firm is very flexible. Therefore, the accomplishment of the ISO 9000 is not a guarantee of good product quality.

This standard has an international acceptance and it can be relevant for the market entry. A survey presents that international marketing aspects of the ISO 9000 certification and access to other markets have been regarded as one of the most important reasons to seek certification (Capmany et al., 2000). A vertical traceability is not the main focus of the ISO 9000 like the product liability. The ISO 9000 has also no special requirements which are important to fulfil Cross Compliance demands. However, it is possible to create the ISO 9000 on the farm with focus on their fulfilment (Figure 3).

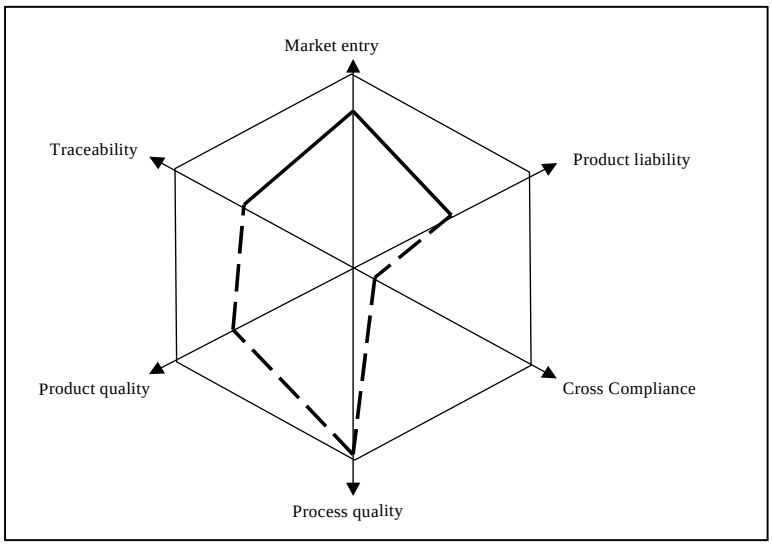

Figure 3: Benefits of ISO 9000

Retailer initiatives developed quality systems for the food industry in the past years. On the one side there are quality systems like the International Food Standard (IFS), the British Retailer Consortium (BRC) and the European Food Safety Inspection Service (EFSIS) for the supplier and on the other hand, there is EurepGAP, a system for the farmers (Krieger, 2004). These quality systems are often important for the market entry. Retailers ask for this system also in due to product liability. Interventions exist between the requirements of the EurepGAP System and Cross Compliance.

The requirements of horizontally quality systems are mainly recording process quality (Krieger, 2002). Product quality is also in focus of these quality systems. An interaction between different QS systems over the stages of the agri-food supply chain would raise traceability. For example a combination of EurepGAP for farmers and of IFS for the supplier could increase a higher tracking and tracing between the stages of the agri food industry (Figure 4).

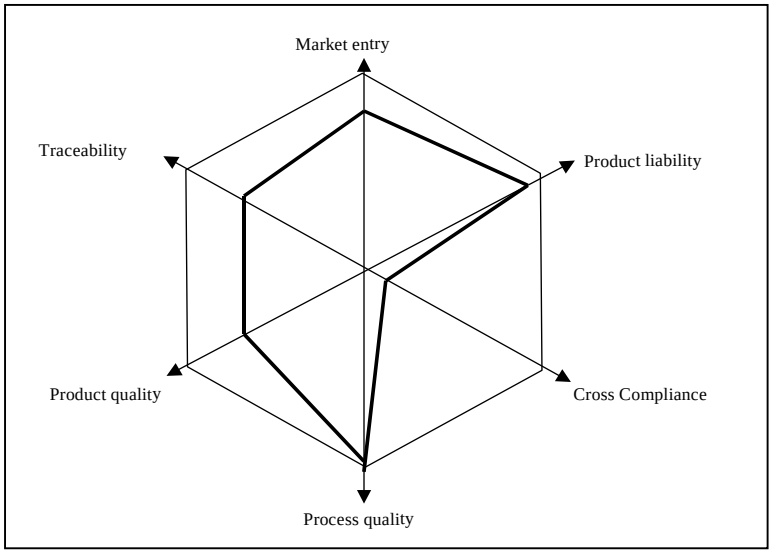

Figure 4: Benefits of horizontally oriented quality systems

The main focus of vertically oriented quality systems is traceability. The intensity of the cooperation between the different stages of the supply chain can be different. The supply chain can have an open character (e.g. Q+S), a semi closed character (e.g. IKB) and a closed character (e.g. regional quality systems). The result is that cooperation and traceability have a different intensity. Vertically oriented quality systems have problems to be accepted by the retail, because the retail stage has designed their "own" quality systems. The result was that only a few retailers ask for vertical oriented quality systems because they also have to fulfil special requirements. Product liability plays also a rule like Cross Compliance. The directives, included in the Cross Compliance demands, are often addressed by farm assurance schemes.

Process quality is characterized by management routines that support the organisation and control of processes to assure desired process output (Schiefer, 2004). Points with this focus are also implemented in vertically oriented quality systems, but more important is the preservation of product quality and safety (Figure 5). But it is also individual in specific quality systems.

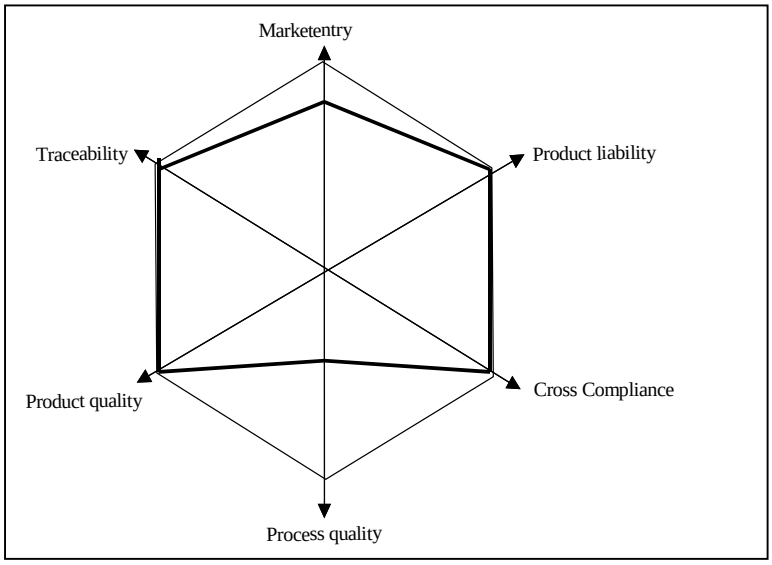

Figure 5: Benefits of vertically oriented quality systems

These figures presents only a general overview about benefits of quality systems. Special systems have different views and the requirements in these different systems have high varieties.

4 Decision support model: QUALINT

The aim of the project "QUALINT" is the development of an integrated description model to simplify the management of different quality systems in the agri-food industry. The model utilizes a databank, which automatically generates operational system descriptions. The model is a decision support model for the minimization of costs in different quality management scenarios.

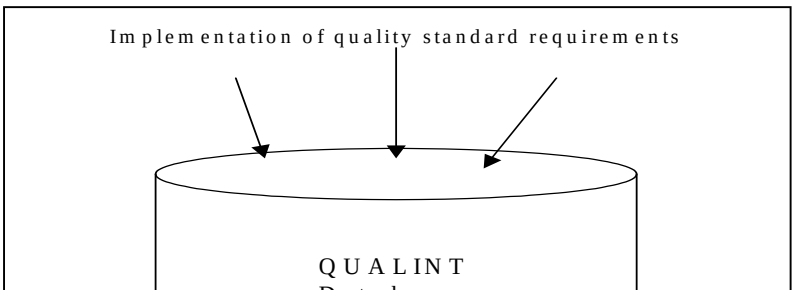

Figure 6: Construction of the Decision support model: QUALINT

But how does Qualint exactly works?

User could enter existing and new quality management systems into the description model.

The additive requirements are the result of the procedure.

The presentation of these requirements act on different scenarios:

1. integrated into the ISO 9000
2. hinge on department
3. unstructured or in
4. combination of 1. and 2.

5 Range of methodologies

This chapter gives an inside in different analyses methods and theories in due to the implementation and integrated application of quality systems.

5.1 Marginal Costs Analysis

Marginal cost is the additional cost from increasing an activity. In production, marginal cost is the additional cost of producing one more unit of output (Varian, 1995). The calculation of marginal costs can be a supporting measure, if a firm would like to implement a new quality standard and to find the optimal combination of different standards.

The firms' optimisation calculus can be represented as follows:

The firm's marginal costs (MC) arise from the marginal costs of fulfilling the demands of the new quality system (MC_N) minus the marginal costs of requirements, which are in the intersection of the existence and new quality systems (MC_{EN}). Another relevant parameter for the integration of a quality management system is the certification costs (MC_C).

$$(1) \qquad MC = MC_N - MC_{EN} + MC_C$$

Where MC = marginal costs
MC_N = marginal costs of the requirements of new quality systems
MC_{EN} = marginal costs of the requirements of the existence and also new quality system
MC_C = marginal costs for certification

The marginal benefit (MB) of a new quality system is the marginal sum of the advantages, which arise from an implementation for a firm like a new market entry (MB_M), more product liability (MB_P), fulfil of demands for Cross Compliance (MB_C), improving in the process quality (MB_C), better product quality (MB_{PR}), enhance changes in the traceability (MB_T) and other special benefits for a firm (MB_F).

(2) $MB = MB_M + MB_P + MB_C + MB_{PQ} + MB_{PR} + MB_T + MB_F$

Where MB = marginal benefit
MB_M = benefits for market entry
MB_P = benefits for product liability
MB_C = benefits for Cross Compliance
MB_{PQ} = benefits for process quality
MB_{PR} = benefits for product quality
MB_T = benefits for traceability
MB_F = additional benefits for firms

From this initial situation an optimal combination of quality systems ($q_{opt.}/c_{opt.}$) can be developed (see figure 6).

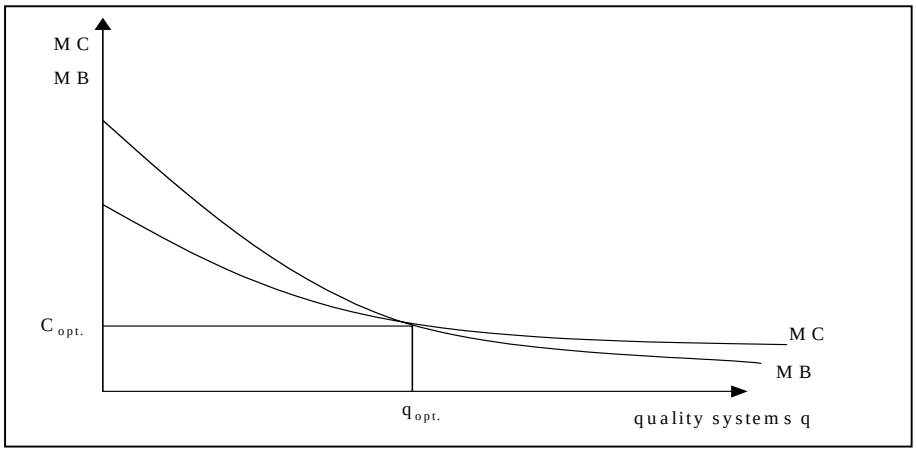

Figure 6: Relationship between the number of quality systems and cost/benefit

But to analysis the relation between costs and benefits the Analytic hierarchic process can be a supporting measure.

5.2 Analytic Hierarchic Process

Saaty (1995) has developed the Analytical Hierarchic Process to structure and solve complex decision situation. This decision support system can increase firm profit and other measures of performance" (Wierenga et al. 1999).

Aspects for the use of the Analytic Hierarchy Process (AHP) are:
1. AHP is one of the few methods where hard (e.g. costs) and soft (e.g. market entry) facts can be combined. The combination and analyses of hard (quantitative) and soft (qualitative) aspects is often required (Mingers 2000).
2. AHP is also very easy and flexible to use. This is also on of the main requirements for the application in this project.

Basic of the AHP is that specific foundations and Axioms will be accepted:
Axiom 1: The decision maker can compromise two different elements, which will be done in a pair wise comparison.
Axiom 2: It is not possible that a decision maker has no concrete comparison between two criteria.
Axiom 3: A decision problem can be formulated in a hierarchical order.
Axiom 4: All criteria and alternatives, which are relevant for the decision problem, are integrated into the hierarchy. These hierarchy elements will be evaluated by priorities. And these priorities are compatible with the perceptions of the decision maker

In general, AHP consists of the following steps:
1. Definition of a specific decision making problem
2. Formulation of relevant criteria, which can be taken to structure the decision making process and selection of available alternatives (i.e. the decision hierarchy)
3. Pair wise comparison to weigh the criteria
4. Pair wise comparison to weigh the alternatives in view of each criterion
5. Synthesis of weights/priorities on the basis of a matrix calculation combining the weighting of criteria/alternatives
6. Sensitivity analysis to determine how sensitive the final alternative priorities are to changes in the criteria weights
7. Selecting alternatives with highest weights/priorities (Meixner & Haas 2002)

Example:

This part formulated an example of a decision model follows the steps, but in a specific variety, of the AHP described above. First step is the description of the problem : " Does the implementation of a quality system make sense?"
The next step is the selection of relevant criteria, which was be done in chapter 3. Now a specific variety of the AHP concept will be the basis of this cost-benefit analyses.
The hierarchy of the cost- and benefit factors are shown in the figures 7 and 8.

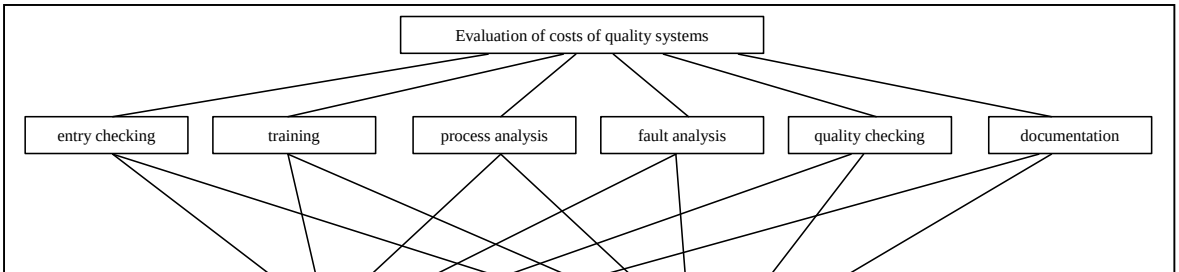

Figure 7: Hierarchy of costs of quality systems

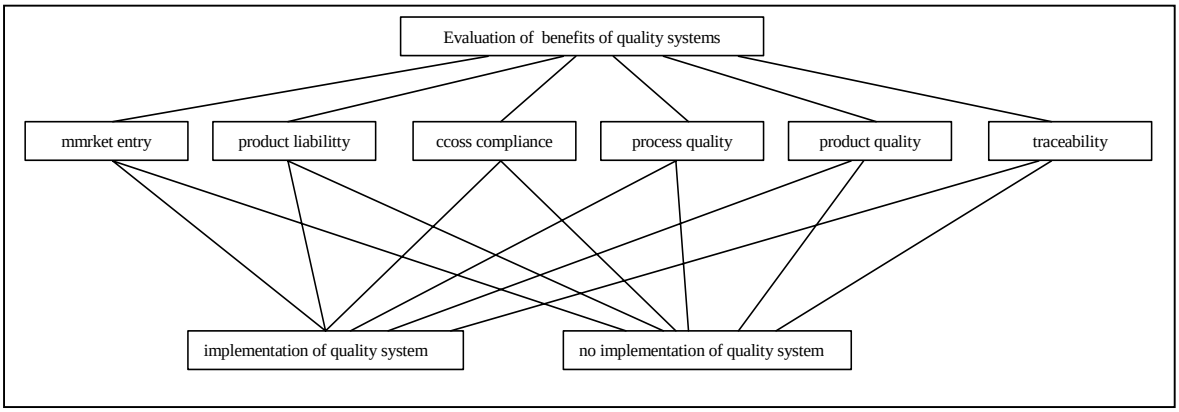

Figure 8: Hierarchy of benefits of quality systems

After the evaluation of these two hierarchies the quality manager gives the weights of the costs and benefits in due to the implementation or not implementation of a new quality system in the firm. The results of this procedure are shown in figure 9.

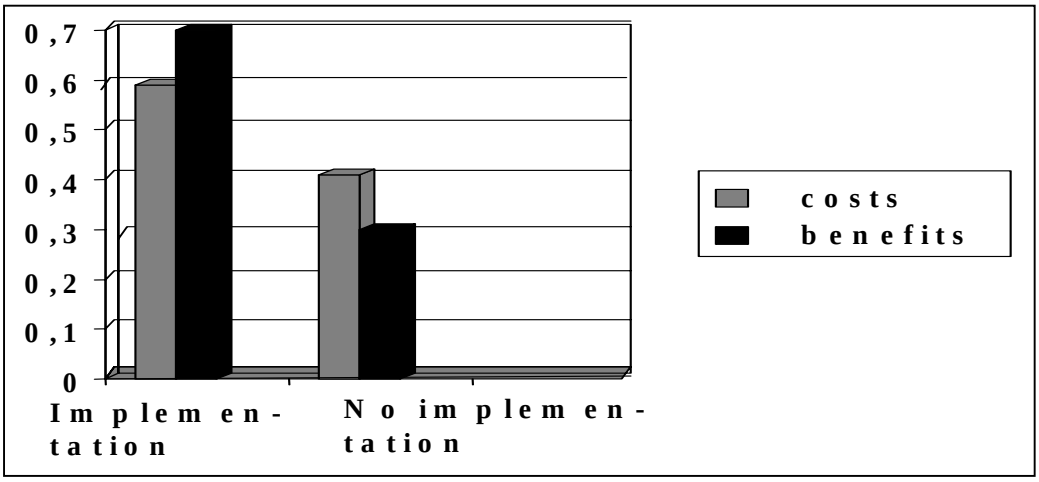

Figure 9: Weights of the cost/benefits of a quality system

The next step of this analysis will be the calculation of the relation between costs and benefits.

Table 1: Cost/Benefit ratio

	Costs Wc (i)	**Benefits Wb (i)**	**Bci = $\frac{Wb\ (i)}{Wc\ (i)}$**
implementation	**0,59**	**0,7**	**1,19**
No implementation	**0,41**	**0,3**	**0,73**

In due to this cost/benefit analysis the firm will implement the new quality system.

6 Conclusions

In conclusion: This paper has given an overview of the variety of quality systems in the agribusiness and food industry in Europe. The main aspect was to give an insight into a cost/benefit analysis of quality management systems and the description model for the implementation of different quality systems in firms.

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