

Institut für Tierwissenschaften

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**Application concept for combined preventive quality management  
methods in inter-enterprise health management in pork chains**

Inaugural Dissertation

zur

Erlangung des Grades

Doktor der Agrarwissenschaften  
(Dr. agr.)

der

Landwirtschaftlichen Fakultät

der

Rheinischen Friedrich-Wilhelms-Universität Bonn

Vorgelegt am 24.01.2012

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Tag der mündlichen Prüfung: 16.03.2012

Erscheinungsjahr: 2012

Meiner Familie

### **Acknowledgement and Disclaimer**

The authors gratefully acknowledge from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project Q-PORKCHAINS FOOD-CT-2007-036245.

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## Abstract

### **Application concept of combined preventive quality management methods in inter-enterprise health management of pork chains**

Overall, this thesis aimed at establishing a concept to organize and evaluate services in inter-enterprise health and quality management with the help of team-oriented preventive quality management methods in a new and more efficient form. In this context, the question was addressed to which extent existing service offers still meet the actual customer expectations of farmers. Furthermore, it was of interest to find out which quality management methods are already known to the service providers of the sector and are integrated into their teamwork. Answering these research questions was a precondition for assessing the development potentials of future service offers and service organizations in inter-enterprise health management.

This methodology to develop an application concept for team-oriented quality management methods for such service providers was subdivided into six different phases.

While the *first three phases* (literature study, written enquiry (206) and 55 expert interviews) covered data collection, in *phase four* a proposal was made how to proceed with the expansion of network coordinators' service portfolios. When doing this, the categorization of products and services used by Kano served as a basis. *Phase five* included development of an application concept with preventive quality management methods. Subdivision of quality management methods into the relevant partial steps and merging these into a methodology enabled allowing for characteristics belonging to selected methods combined into one concept. The final *phase 6* included development of a structural equation model on the basis of the established findings visualizing causal relations between defined factors and the quality of coordination services. This model included seven latent variables, 16 formative and three reflective indicators.

In a diagram consisting of four quadrants ("QM+CS Stars", "CS Freeloader", "QM Question Marks" and "QM+CS Dogs"), it was possible to subdivide the network coordinators questioned into three clusters regarding the *offer of services in inter-enterprise health management (CS)* and the *use of quality management methods*. The compiled application concept for quality management methods supports development of network coordinators regarding the use of quality management methods towards "QM+CS Stars" by integrating partial steps of quality management methods into the normal operations of enterprises. In contrast to this, the modified Kano categorization enables to optimally consider customer expectations when expanding service portfolios. For example, services not demanded directly by farmers but which provide them with an enormous added value are classified as "attractive services". In addition to this, the causal relations demonstrated in the structural equation model regarding the quality of coordination services serve to increase the quality of existing and new services and thus to optimally satisfy customer expectations.

## Kurzfassung

### **Anwendungskonzept kombinierter präventiver Qualitätsmanagement-Methoden im überbetrieblichen Gesundheitsmanagement Schweinefleisch erzeugender Ketten**

Ziel der Arbeit war es, ein Konzept zu erarbeiten, wie sich Dienstleistungen im überbetrieblichen Gesundheits- (GM) und Qualitätsmanagement (QM) mit Hilfe teamorientierter präventiver QM-Methoden neu und effizienter gestalten und bewerten lassen. In diesem Zusammenhang wurde der Frage nachgegangen, in wie weit existierende Dienstleistungsangebote den tatsächlichen Kundenerwartungen von Landwirten noch entsprechen. Darüber hinaus interessierte, in welchem Maße QM-Methoden bei Dienstleistern des Sektors bereits bekannt sowie in deren Teamarbeit integriert sind. Die Beantwortung dieser Forschungsfragen war die Voraussetzung zur Beurteilung der Entwicklungspotentiale für zukünftige Dienstleistungsangebote sowie von Dienstleistungsorganisationen im überbetrieblichen GM.

Das methodische Vorgehen zur Entwicklung eines Anwendungskonzepts für teamorientierte QM-Methoden bei derartigen Serviceanbietern erfolgte in sechs Phasen. Während die *ersten drei Phasen* (Literaturstudie, schriftliche Befragung (206) und 55 Experteninterviews) die Datenerhebung umfassten, folgte in *Phase vier* ein Vorschlag für die Vorgehensweise beim Ausbau von Dienstleistungsportfolios von Netzwerkkoordinatoren (NWKs). Hierbei diente die von Kano verwendete Kategorisierung für Produkte und Dienstleistungen als Grundlage. *Phase fünf* beinhaltete die Erstellung eines Anwendungskonzepts präventiver QM-Methoden. Eine Untergliederung der QM-Methoden in die jeweiligen Teilschritte sowie das Zusammenfügen in eine methodische Vorgehensweise ermöglichte die Berücksichtigung der Merkmale ausgewählter Methoden kombiniert in einem Konzept. Die abschließende *Phase 6* beinhaltete basierend auf den ermittelten Erkenntnissen die Entwicklung eines Strukturgleichungsmodells, welches die kausalen Zusammenhänge zwischen definierten Faktoren und der Qualität von Koordinationsdienstleistungen visualisiert. In diesem wurden sieben latente Variablen, 16 formative und drei reflektive Indikatoren berücksichtigt.

In einem aus vier Quadranten („QM+CS Stars“, „CS Freeloader“, „QM Question Marks“, „QM+CS Dogs“) bestehenden Diagramm ließen sich die befragten NWKs in drei Cluster hinsichtlich des *Angebots an Dienstleistungen im überbetrieblichen GM (CS)* sowie des *Einsatzes von QM-Methoden* einteilen. Das erarbeitete Anwendungskonzept für QM-Methoden unterstützt bezüglich des QM-Methoden-Einsatzes eine Entwicklung von NWKs hin zu den „QM+CS Stars“, indem Teilschritte der QM-Methoden in die regulären Abläufe der Unternehmen integriert werden. Demgegenüber ermöglicht die modifizierte Kano-Kategorisierung, Kundenerwartungen optimal bei der Erweiterung von Dienstleistungsportfolios zu berücksichtigen. So werden z. B. Dienstleistungen, welche nicht direkt von den Landwirten nachgefragt werden, ihnen jedoch einen großen Mehrwert bringen, als „Begeisterungs-Dienstleistungen“ eingestuft. Ergänzend dienen die im Strukturgleichungsmodell aufgezeigten kausalen Zusammenhänge bezüglich der Qualität von Koordinationsdienstleistungen dazu, die Qualität bestehender sowie neuer Dienstleistungen zu erhöhen und dadurch optimal auf die Kundenerwartungen einzugehen.

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**List of abbreviations**

acc. to	according to
AIDA	Allianzen für Informations- und Dienstleistungsagenturen in der Fleischwirtschaft
APP	Actinobacillus Pleuropneumonia
AVE	Average Variance Extracted
CAC	Codex Alimentarius Commission
CCP	Critical Control Point
CP	Control Point
CS	Coordination Services
DIN	Deutsches Institut für Normung
DK	Denmark
DMAIC	Define – Measure – Analyze – Improve - Control
e.g.	for example
EMA	European Meat Alliance
EN	Europäische Normen
et al.	et alii (and others)
EU	European Union
ExLV	Exogenous latent variable
ff.	following pages
Fig.	figure
FMEA	Failure Mode and Effects Analysis
HACCP	Hazard Analysis and Critical Control Points
HCP	Hygienic Control Point
HM	Health Management
i.e.	that is
IKB	Integrale Keten Beheersing (Integrated Chain Control)
ISO	International Standards Organization
kg	kilogram
LV	latent variable
mod.	modified
NASA	National Aeronautics and Space Administration

No.	number
PDCA	Plan-Do-Check-Act
PLS	Partial Least Squares
PRRS	Porcine Reproductive and Respiratory Syndrome
PS	Partial Survey
QM	Quality Management
QS	Qualität und Sicherheit
QSG	Quality Assurance Guarantee
$R^2$	Coefficient of determination
Reg.	regulation
SEM	Structural Equation Model
SPF	specifically free of pathogens
TiGA	Tiergesundheitsagentur eG
US	United States

# 1. Introduction

## 1.1 Problem definition and objectives

In the past few years, the meat industry has established several inter-enterprise health management programs independently owing to decisive legal changes on European level (General Food Law, EU Hygiene Package) as well as on national level. They show increased engagement by participants of the food industry to meet customer requirements and explore new paths to guarantee quality and safety of their products.

Pork chains are characterized by the fact that many small and medium-sized enterprises have specialized on individual process steps, i.e. from the keeping of animals to meat trading. They have in common that often there exists a very complex relationship between customer and supplier. On the basis of these structures, implementation of measures covering multiple stages and encompassing several production chains to achieve common quality targets presents a major challenge. Before concrete activities can be carried out, the organizational structures necessary for this have to be established coordinating all participants involved. Petersen and coauthors (2010b) therefore suggest to transfer inter-enterprise coordination tasks to so-called network coordinators. Organizations or enterprises bundling tasks and offering services for their customers are defined as network coordinators. Through coordination of product and information flows, information asymmetries are reduced (Ellebrecht 2008, Schütz et al. 2009).

The scope of duties of these network coordinators can be quite varied and concentrate mainly on services in four areas: supplier, audit, process and crisis management (Schütz et al. 2009). Similarly to other industries, by combining suitable quality management methods, service processes can be optimized to avoid errors in animal-keeping enterprises and finally also in connection with the end product. In this regard, the EU Hygiene Package stipulates implementation of a concept based on hazard analysis and critical control points (HACCP) also for primary production. In addition to the HACCP concept, there also exist various other quality management methods suitable for services of the pork chain (Schmitz 2005).

So far, application of the principles of quality management with a measurement spectrum recommended in DIN EN ISO 9000 ff. or DIN EN ISO 22000 ff. is only known through progress reports and results of scientific projects. The manner in which they are used to support inter-enterprise health management in value chains in pork production is still largely unknown.

The aim of the thesis is hence to evaluate which activities in inter-enterprise health and quality management can be created with the help of team-oriented preventive quality management methods in a new and efficient way. When doing this, it is necessary to compare existing service offers with the demand of farmers mainly for coordination services. Furthermore, it has to be shown to which extent service providers of the pork chain are familiar with quality management methods and have already integrated them in their health management-relevant activities. In this regard, the following research questions are in the foreground:

- Which interrelationships exist between the “interest in information”, the “willingness to provide information” and the “demand for an exchange of information” between piglet producers and pig fatteners?
- To which extent support by third parties when realizing activities in inter-enterprise health management is necessary?
- Does successful coordination of inter-enterprise services influence the effectiveness of inter-enterprise health management?
- Is there a relationship between the popularity of quality management methods with network coordinators and their implementation in processes of health management by network coordinators?

Finally, a proposal is to be elaborated to find out which development potentials exist regarding an extension of the service spectrum for network coordinators. On the basis of this proposal, it has to be verified how the aspects of the three quality management methods HACCP, Failure Mode and Effects Analysis (FMEA) and Six Sigma can be integrated into processes of inter-enterprise health management. Furthermore, evaluation of the effects of defined influencing factors on the quality of coordination services is of interest.

## **1.2 Structure of the thesis**

Following the introductory chapter, Chapter 2 refers to the presentation of organizational preconditions for implementing customer requirements in inter-enterprise health management. Here, network coordinators organizing an inter-enterprise information exchange in the framework of existing quality management programs and initiatives in inter-enterprise health management are described. Literature examples specify in the following possibilities to produce safe food in high quality and enable process optimization with the help of preventive quality management methods such as HACCP, FMEA and Six Sigma as well as chain-oriented audit management. Then follows a representation of the Kano model categorizing product and service characteristics based on customer expectations as well as an overview of structural equation modeling.

On the basis of this theoretical background, Chapter 3 describes the methodical procedure regarding empirical surveys amongst farmers and potential network coordinators. Referring to this, the process of structural equation analysis is described in detail which is used to determine the causal relationships regarding evaluation of the demand for an exchange of information between piglet producers and fatteners.

Then Chapter 4 presents the results of the survey. These include customer expectations determined followed by the presentation of existing service offers of potential network coordinators. Support potentials in service offers by preventive quality management methods are also shown. In this regard, the level of implementation of quality management and the service supply with coordination services are compared.

Based on the findings of Chapter 4, a discussion of the results follows in Chapter 5. Various interrelationships between the effectiveness of health management systems and the offer of coordination services in health management, popularity of preventive quality management methods and their level of implementation and realization are shown. In addition to this and

in consideration of the Kano model, a proposal is developed how network coordinators should organize their service offers. Chapter 5 concludes with a concept for the integration of preventive QM methods into processes of inter-enterprise health management.

As a final comment, Chapter 6 presents a model to assess the effect of factors influencing the quality of coordination services in inter-enterprise health management of pork chains.

Finally, Chapter 7 summarizes the most important statements and results of this thesis.

## **2. Organizational development of inter-enterprise quality and health management in the meat industry**

### **2.1 Tasks and participants in inter-enterprise health management**

#### **2.1.1 Organizational structures of the pork chain and sector-specific features**

The local pork production is characterized by a high degree of specialization in connection with a strong subdivision of the production chain (Ellebrecht et al. 2009). Brinkmann and coauthors (2011) name four main production stages which range from breeding to the final pork product. After basic breeding and multiplying, piglet production follows. When the piglets weigh approximately 25-30 kg, they are transferred from piglet rearing which is mostly combined with piglet production within the enterprise to pig fattening farms. Dependent on customer requirements, the finishers are slaughtered when they have reached 78-80 kg (the Netherlands, Denmark and Spain), and approximately 95 kg in Belgium and Germany. After the pigs have been slaughtered, they are cut and further processed (Brinkmann et al. 2011). According to Petersen and coauthors (2010a), meat industry in Germany is set apart from other countries by its organizational concept of two stages. Different origins are summarized by means of animal trading organizations. Transport and marketing to national and international customers is done by these organizations. Frequently they equally support the customer supplier relationship between piglet production, piglet rearing and fattening stages (Petersen et al. 2010a).

In addition to the specialization on enterprise level, a regional specialization on certain production stages of pig rearing has also evolved. A backlog in piglet production in contrast to pig fattening exists above all in the Netherlands and Denmark (Haxsen 2010), whilst predominantly in Northwestern Germany the pig fattening stage is better developed (Haxsen 2010). This results in an active trading of pigs beyond national borders. While Northwestern Germany plays an important role as pig importer in this respect, trading in Denmark and in the Netherlands concentrates on the export of piglets (FAO 2011, BMELV 2010). Danish suppliers offer bigger piglet sections (>700) as well as uniform genetics with defined health status (Honold 2010). Haxsen (2010) emphasizes in addition to the possibility of offering bigger piglet sections, the better performance of Danish or Dutch origins as well as their cost advantages in production owing to larger enterprises.

Schulze Althoff (2006) as well as Cheung and coauthors (2012) take up in their theses the netchain concept of Lazzarini and coauthors (2001). This concept is based on the joining of horizontal networks within one and the same production stage as well as vertical connections within a production chain. According to Schulze Althoff (2006) and Trienekens & Wognum (2009), the netchain concept also applies to the structures of pork production. Poignée (2007) defines the term network “as the basis of inter-enterprise structures [...] which result from a combination of horizontal, vertical and/or diagonal network participants”.

Spiller and coauthors (2005) designate the cooperation of farmers organized by producer organizations such as farmers' cooperatives or animal marketing organizations as a horizontal cooperation. Vertical cooperations are, however, characterized by a working relationship based on contracts with upstream or downstream production stages. As an

example of this, Spiller and coauthors (2005) name the “Bestschwein-Programm” introduced by Westfleisch.

The new EU food law and the rising customer expectations due to a high export orientation in connection with higher constraints by quality programs put enormous pressure on the participants of the agricultural and food sector to produce safe food of high quality (Ellebrecht et al. 2009). Trienekens & Wognum (2009) stress that the activities of participants of a certain production stage can influence not only their own stage but the entire production chain. Therefore it should be aimed at establishing inter-enterprise approaches to optimize and safeguard the quality within pork production.

Brinkmann & Petersen (2010) name as the goal of inter-enterprise quality management in pork production integrating the supply chain from primary production with all tasks involved, i.e. from production to the management level and also including administration.

According to Petersen and coauthors (2010b), it is essential for optimizing the profitability of animal trade to deliver comprehensive additional information. Especially passing on information regarding the health status is more and more important in their opinion. Nüssel (2000) also stresses the advantages of integrating upstream and downstream stages in the quality management of enterprises. By means of well structured customer requirements, upstream stages can adapt to the demands and can thus work more economically (Nüssel 2000). Welp (2002) supports these statements by referring to the origin of many diseases already at the piglet production stage. Fattening enterprises therefore have to rely on advance information of the piglet producers regarding coordination of health management. Lehmann (2011) refers to the also increasing demand of consumers for additional information such as quality, safety and origin of the relevant products. Accordingly, he states the supply of suitable information as a competitive factor.

Ellebrecht (2008) stresses the increase in information for the receiver based on the degree of processing of information. In this, Ellebrecht (2008) relies on the four categories of information (describing, comparing, predicting and prescribing information) defined by Petersen and coauthors (1987) and adds as a further category with the lowest manifestation “digitalized information”.

Ellebrecht (2008) defines five groups (piglet producers, fatteners, farm veterinarians, slaughterhouse employees and official veterinarians) with a regular exchange of information regarding diseases.

A special demand for an inter-enterprise information exchange subsists in times of a crisis for example when epidemics or pandemics break out. Ellebrecht (2008) stresses the importance of a corresponding exchange of information to shorten periods of crisis. The basis for this is a collection and the exchange of additional data which are required in periods of crisis (Breuer et al. 2008, Slütter et al. 2010).

Ellebrecht (2008) undertook an empirical study to assess the usefulness of information for service organizations belonging to the pork chain. He sees a big advantage in knowledge of the contact structures of the enterprises affected in periods of crisis. This enables risk assessment regarding other enterprises and thus a structural approach when introducing preventive measures (Ellebrecht 2008).

Mack (2007) subdivides the pork chain in a green and a red side. While the green side consists of the living animal production (basic rearing, multiplying, piglet production, fattening), the red side includes the production stages of slaughtering and cutting/processing (Mack 2007). Regarding the goal of “production of safe food in high quality”, there exist different requirements on both sides. While quality and safety of the end products on the green side is substantially influenced by animal health, Rimbach and coauthors (2010) stress that on the red side the focus is on preventing pollutions and thus contaminations in all process stages. Karge (2002) contemplates in his thesis the quality assurance systems in broiler production. To this effect, he stresses that the quality of food products has its origin exclusively in agricultural production enterprises. Later production stages have to rely on the good quality of the supplied products and can maintain this at best (Karge 2002).

Since this thesis refers thematically to primary production, the focus in the following is on organizational and contextual preconditions and activities to optimize inter-enterprise health management.

Configuration of an inter-enterprise health management system is a very complex task owing to the many factors influencing health as well as the great number of participants to be included. According to Schütz (2009), the following nine elements present essential contextual components of an inter-enterprise health management system:

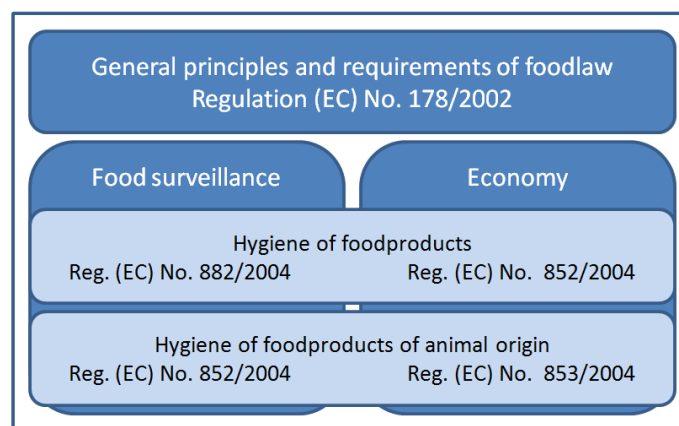
1. Health control (performance and health control during production, farm checks, regular external audits)
2. Herd-diagnostic evaluation (Analyses of performance and animal health with conclusions for management, husbandry conditions and organization)
3. Environmental analyses to determine risk and stress factors for the animals and management weaknesses
4. Public control to verify and safeguard legal conformity
5. Information and document exchange, registering for risk-oriented meat examination
6. Pre- and post-processing of special measures, epidemiologic monitoring
7. Drawing up preliminary reports for enterprise visits, internal audits, coordination of enterprise assessment and supplier rating
8. Delivery of early warning and alarm information
9. Compilation of health certificates

An example of the importance of the area of information and document exchange is the passing on of health information of piglets from piglet producers to fatteners. Torriani (2008) stresses the changing of animal groups or even farms as typical stressful situations for pigs. Prevalently antibiotics are administered prophylactically to the pigs in order to avoid potential diseases (Torriani 2008). Feedback and passing on of information beyond the individual production stages can make sense. Thus, the percentage of organ findings can be influenced by the management of piglet producing enterprises (van der Peet-Schwering et al. 2008).



### 2.1.2 Demand for services and necessary structures in inter-enterprise health management

The EU Hygiene Package consisting of four EU regulations is aiming at creating uniform conditions for the production of food in the EU based on the General Food Law passed in 2002. (see Fig. 1). The current food law encompasses all production stages of food production including feed production (Reg. (EU) No. 178/2002). In addition to these legal requirements, there exist many requirements on the basis of QM programs. According to Roosen (2003), they are based on ISO 9000ff., the HACCP concept as well as quite frequently on the Good Agricultural Practice (Gellynk & Kühne 2007). From these legal and also commercial requirements on inter-enterprise information management results a potential demand for services.



**Fig. 1: General Food Law and EU Hygiene Package**

The manifold requirements on health management in primary production aiming at the production of safe and high-quality food products are associated with high organizational efforts. According to Schütz (2009), the small and medium-sized enterprises of these production stages are not able to assure the need for coordination necessary for this. Petersen and coauthors (2007) describe new organizational structures by differentiating between three levels when realizing activities in quality and health management. While the upper normative level includes the requirements within the framework of laws and regulations as well as guidelines of national quality management programs, the pork chain is assigned to the lower operative level. The central level is also called the strategic level. It includes coordinating organizations which bundle requirements from level one and offer them as inter-enterprise services for the participants of the production chain (Petersen et al. 2007). Petersen and coauthors already described in 2001 the existence of coordinating organizations as a precondition for inter-enterprise health management. Here, it is necessary to assure an exchange of information between piglet producers, fatteners and slaughterhouses to optimally coordinate prophylaxis and treatment measures accompanying production.

According to Brinkmann and coauthors (2011), coordination of complex production chains is necessary for a smooth functioning of the integrated processes. Within the framework of

economics, the expression “coordination” is defined as “adjustment of partial activities with a view to a subordinated aim” (Gabler 2011).

Cheung and coauthors (2012) state the necessity of coordination mechanisms which Xu and Beamon (2006) define as a compilation of methods, in connection with the netchain concept of Lazzarini and coauthors (2001). These serve to manage the interrelations between the individual participants of the supply chain.

Ellebrecht (2008) designates coordinating organizations as network integrators and describes selection, control and development of suppliers and customers as their tasks. He sees farmers’ cooperatives as well as slaughterhouses as possible network integrators in the pork chain. In this connection, Schütz (2009) talks about network coordinators. As the tasks of network coordinators she states, on the one hand, services accompanying production for individual farmers such as the support for animal health and hygiene management, and, on the other hand, services for market partner associations accompanying production. The latter encompasses according to Schütz (2009), amongst others, support for enterprise-wide self-controls based on audit and monitoring activities.

Nathues and coauthors (2011) define monitoring activities as a specialist term for all types of indirect systematic recording, monitoring or control of an operation or process via technical means or other systems”.

Wohlgemut (2002) sees the tasks of network coordinators in updating cooperation and framework contracts and in marketing activities of the network.

This is in line with the activities of service providers with regard to the meat production mentioned by Ellebrecht (2008) and Schütz (2009). Wohlgemut (2002) stresses that network coordinators may be partners from within the network as well as network-external institutions which professionally offer the adoption of coordination services. Empirical studies carried out by Spiller and coauthors (2005) amongst production organizations and farmers resulted in the fact that farmers see the bundling function regarding pig marketing as the most important service. In addition to this, support in quality assurance was mentioned as “core service”.

In accordance with the tasks of service organizations in the pork chain described by Ellebrecht (2008) and Schütz (2009), network coordinators can be defined as follows: “Organizations with bundling functions which reduce interfaces for their members by coordinating and supporting product and information flows”.

According to Böhle (2010), services can be seen as an offer directly linked with production as well as an independent offer. An isolated observation of services leads to organizational concepts targeted especially at them and also technical support potentials being determined and realized (Böhle 2010). However, Böhle (2010) stresses that services stand out due to their special contact with customers of production services. They are characterized by a high degree of uncertainty and openness which is proportional to the diversity and complexity of services (Böhle 2010).

According to Schütz (2009), there are many different ways to define services. Bruhn (2010) differentiates between activity-oriented, potential-oriented, process-oriented and result-oriented services, the focus always being on the following aspects: human activities, potential of service providers, “uno acto principle”, i.e. consumption happens simultaneously with production, and immaterial goods. Bruhn (2010) defines services as “independent,

marketable achievements connected with provision and/or use of capabilities (potential orientation). Internal and external factors are combined within the framework of the process of service creation (process orientation). The factor combination of the service provider is used with the aim to achieve beneficial effects by means of external factors – human beings or their objects (result orientation).”

Lotz (2008) looks at services offered by trade associations which are described as cooperative link with the aim to achieve “fulfillment of operational subtasks based on common interests”. Individual trade associations offer in addition to the collective services increasingly selective services (e.g. advisory services) which only benefit individual service users in order to stand out from competitors. Lotz (2008) distinguishes between three different types of services in the service spectrum of trade associations. Economizing services which are to influence the profitability and efficiency of service users directly, coordination services and representation services. The latter comprise negotiation services as well as political representation of interests. Coordination services, however, include the fulfillment of legal requirements and can be subdivided into safety-affairs related services and cartel-formation services. Codes of behavior in connection with quality labels also belong to cartel-formation services according to Lotz (2008).

Schütz and coauthors (2008) provide an overview of the extensive and heterogeneous customer structure of the service users of network coordinators in the pork chain which consists of farmers, farmers’ cooperatives, technical advisors, farm-veterinarians, slaughtering enterprises and animal trading organizations.

In order to realize the contents of an inter-enterprise health management defined by Schütz (2009), recurring activities which serve to investigate circumstances and conditions to work on improvement suggestions on the basis of results determined beforehand as well as to control realization and success of defined optimization potentials stick out. Activities belonging to the following service activities are frequently offered in combination to achieve the high product and process quality striven for:

- organization of an inter-enterprise information exchange,
- organization and realization of monitoring activities,
- organization and realization of audits and consultations,
- support with data processing,
- as well as the issue of certificates

Offering an extensive service portfolio to support the processes in inter-enterprise health management requires the enterprises acting as network coordinators in addition to having contextual knowledge to show good organizational talents on the basis of the existing network and technical know-how to support data processing and communication skills. Schütz & Petersen (2010) define three dimensions in health management which have to be considered when developing new strategies. Consequently, they also form the basis for the offer in connection with the above mentioned service categories.

- *Advisory services:* According to Schütz & Petersen (2010), the advisory service in health management is above all to convey knowledge and support for decision finding. The controlling of stock as verified by veterinarians is a well-established example owing to existing requirements.
- *Techniques:* Independent of the type of advisory services, in addition to qualified personnel supporting hardware and software components should be available. These form the basis for an efficient communication and data exchange. Examples of this are information platforms to provide slaughtering and diagnosis data (ChainPoint, Infosys, Mais Aktuell, Qualifood) of results from salmonella monitoring (Qualiproof) or the health status (Danish, TIGA) (Schütz & Petersen 2010).
- *Organization of processes:* Schütz & Petersen (2010) define the term organization in this respect as “establishing, structuring and planned designing of inter-enterprise cooperation and the control and regulation of communication processes necessary for this”. Confidence is described as an important precondition for cooperation, information exchange and support of decision finding by external information. Mack (2007) stresses that positive experience with already known service providers strengthen the willingness for cooperation.

Schütz (2009) distinguishes three different organizational concepts of service providers regarding the degree of development of three defined dimensions: full-service providers, operating company and outsourcing approach. The selection of a suitable handling concept results from financial and personal resource equipment and the input from strategic company development. While the full-service provider establishes and offers all services independently, the concept of the operating company makes use of the advantage of bundling resources. This cooperation within the framework of planning, development and implementation quite often only refers to individual subordinated services which permit an extension of one's own service offers. The outsourcing concept, however, is based on a purchase of services by other service providers. The network coordinator is thus focusing on his primary tasks and plays only an intermediary role regarding other service offers (Schütz 2009).

Realization of the above mentioned service categories has a prophylactic character regarding the occurrence of diseases. This corresponds with the requirements of the EU animal health strategy “Prevention is better than cure” (European Commission 2007). The aim here is to create optimum conditions, if possible, to fight against animal diseases in Europe. For this purpose, the EU has established an action plan encompassing four columns. Column 3 “prevention, monitoring and provisions for crises in case of risks in connection with animals” includes, amongst others, identification and traceability as well as monitoring and provision for crises and crisis management. The requirement of “identification and traceability” is to function according to the trade structures beyond country borders and thus shows the demand for development and implementation of information and communication systems. The EU hopes for faster reactions in crises by more precision and up-to-datedness of animal-related data (European Commission 2007). The second demand of the animal health strategy “monitoring and precaution for crises/crisis management” is to

increase awareness of animal owners and veterinarians to enable an early detection of diseases (European Commission 2007).

In connection with prevention, the term prophylaxis is often used in health care. While Brauer & Tesak (2010) designate prevention in health care as an avoiding measure and equate prophylaxis with the term of prevention, Gerok and coauthors (2007) use the terms of prevention and prophylaxis synonymously. A special form of prophylaxis in veterinary medicine is metaphylaxis. In this regard, handing out drugs is called metaphylactic if the animals treated are regarded as infected although they are not showing any clinical symptoms yet (AGTAM 2010). Correspondingly, Frey & Löscher (2002) state the therapeutic and metaphylactic treatment of cattle and pigs with tulathromycin in connection with this topic. Following the reasoning in resolution B7-0295/2011 (De Castro 2011), the antibiotic resistance is a growing problem in humane medicine. In 2011, considerable damage was caused by coliform intestinal bacteria belonging to the bacterial family enterobacteriaceae (e.g. EHEC stem 0104). One cause for antibiotic resistance regarding enterobacteriaceae is deduced from the use of antibiotics in animal production. The current application demands an increased investigation of new antimicrobial means as well as other alternatives (vaccination, biological safety, resistance breeding) and fact-supported strategies in order to prevent animal infection diseases and combat these" (De Castro 2011).

### **2.1.3 Service offers within the framework of quality management programs as well as regional initiatives**

Despite the predominantly supra-regional trade also beyond country borders within the pork chain, there exist a multitude of locally established quality management programs. In order to achieve standardization of the requirements resulting from approval programs within the supplier chain, in 2002 the European Meat Alliance (EMA) was founded. It is based on the principle "safe food transparently produced". It is aimed at harmonizing different quality management programs by avoiding double audits and reducing cost by mutual recognition (Certus, IKB, QSG und QS ) (EMA 2008).

Ellebrecht and coauthors (2009) show the results of benchmarking national quality management programs regarding their degree of implementation in Figure 2.

As regards its content, the four programs which are part of EMA, i.e. QSG, IKB, QS and Certus, mainly aim at specific product requirements and also at the organization of salmonella monitoring activities during the pig fattening stage (Thelen 2008). When having a look at the four quality management programs mentioned, it becomes obvious that in contrast to the German quality management program QS, QSG, IKB and Certus have not integrated any self-control in their system. An independent control is, however, carried out for all programs by means of an independent certification body which in turn is monitored by an accreditation body. All four programs perform salmonella monitoring. IKB additionally undertakes residue monitoring to establish prohibited substances, while the QS system analyses supplementary feedstuffs. Accreditation of monitoring is based on EN ISO 17025. In all four programs, system audits are carried out which, with the exception of the QSG program, are partly undertaken without prior warning. Probable sanctions include the

possibility of exclusions as a last resort. With the exception of the IKB system, sanctions also consist of fines (Thelen 2008).



**Fig. 2: Benchmarking of national quality management programs in regard to their implementation levels (acc. to Ellebrecht et al. 2009)**

In addition to national QM programs which in some countries are already seen as national standard owing to the high degree of penetration (98% IKB in the Netherlands; 96% QSG in Denmark; >90% QS in Germany) (Ellebrecht et al. 2009), there exist a multitude of regional initiatives to optimize health management and also quite often to certify a defined health status of piglets. In the same way as national quality management programs, these smaller initiatives also focus on prevention measures which according to Schütz & Petersen (2009) represent a major part of contemporary health management measures. Nathues and coauthors (2011) describe the increased transparency in piglet marketing regarding the health status of piglets for customers as the aim to be achieved by health certificates and health passes issued by various institutions. Böckel (2008) also stresses the economic importance of animal health in livestock farming regarding product marketing and food safety. Nathues and coauthors (2011) see, however, the comparability of individual initiatives owing to the different criteria regarding investigation frequencies, sample sizes, laboratory methods and testing methods as critical. Therefore, the establishment of uniform German standards is desirable (Nathues et al. 2011). Nathues and coauthors (2011) state the size of the population under risk as well as the necessity of achieving a high safety regarding the investigation results as important criteria to be considered when defining a federal standard.

Regarding definition on certificates, it is stressed that one can only refer to no pathogens present when this can be assumed with a certainty of  $\geq 95\%$ . Otherwise, one should only talk about unsuspecting results. Nathues and coauthors (2011) prefer to take the latter formulation into consideration for a German piglet health certificate since rearing organizations and farmers are not of the opinion that closely meshed monitoring to prove that there are no pathogens is necessary.

On the basis of the many regionally existing initiatives, a group of cooperative pig marketers has formed from the AIDA project to establish a sector-specific standard for defining a health status of fattening piglets for the first time (Petersen et. al. 2010b). So far the standard includes a federally standardized procedure for monitoring fattening piglets (28-30 kg) which is characterized by a broad pathogen spectrum (PRRSV, brachyspira hyodysenteriae, salmonella, toxin-forming pasteurilla multocida, mycoplasma, APP). On the basis of a procedure standard, the procedural steps to determine the health status and the extent of sampling, the investigation methods and parameters have been defined. It is planned to extend this to other production stages as well. The standard provider is a federal, cooperatively organized association consisting of producer and marketing organizations (Tiergesundheitsagentur eG). Standard receivers are bundler organizations which carry out the relevant procedures for enterprises keeping animals and receive for this an accreditation according to this standard. This results in certification of the health status of animal populations involving the network coordinator, the animal owner and the farm veterinarian as well as the animal health agency. The main focus is on the issue of a certificate valid for six months which is made accessible as sale-accompanying information. On the basis of the PDCA cycle (Plan – Do – Check – Act), the animal health standard is to be improved continually. This so far exclusively German procedure is aiming at establishing an international standard “animal health and safety” in cooperation with organizations in Denmark and the Netherlands (Petersen et al. 2010b).

According to the great importance of piglet exports, Danish and Dutch organizations want to achieve transparency regarding the health status of their piglet sections. Seybold (2009) stresses that in particular Denmark is offering piglet sections with defined health status. According to information given by Danske Slagterier (2010), the Danish SPF system covers 96% of the Danish rearing and reproduction stock. SPF stands in this connection for “specifically free of pathogens” and refers to the declaration of the following production diseases: enzootic pneumonia (EP), actinobacillosis (APP), rhinitis atrophicans, pig dysentery, mange, lice, PRRS, edema diseases as well as the declaration of the level of salmonella. In accordance with the individual production stages and the status of the diseases taken into consideration, enterprises are subdivided into four categories. The red category refers to the basic rearing and multiplying enterprises. A precondition for the allocation to this category is that none of the above mentioned diseases are present. The blue category includes the production enterprises which apart from mycoplasma, APP6, APP12 and DK-PRRS, may not be tested positively for all other diseases mentioned. Enterprises belonging to the green category strive to be included in the blue category. Enterprises which merely declare the PRRS status are, however, not assigned to any of the three categories mentioned and are designated as conventional. Allocation to the relevant

category can be seen by the customers via the online SPF database so that they can include this information in their purchase decision (Danske Slagterier 2010).

The Dutch Product Board for Livestock and Meat (PVV = Productschap Vee en Vlees) has developed together with the Dutch farmers' association (LTO = Land- en Tuinbouw Organisatie Nederland) and the professional Dutch swine holder association (NVV) 2009 a health certificate for piglets, the so called Biggenpas (PVE 2009). In this health certificate information regarding feeding and rearing as well as animal health information on vaccinations, treatments and deworming within the framework of piglet export is listed (PVE 2011).

## **2.2 Principles and methods of quality management regarding coordinating service organizations**

### **2.2.1 Principles and methods of quality management**

The principles of quality management are summarized and described in literature according to the point of views and empirical values of the relevant authors quite differently.

Wagner (2007) refers to the eight principles of quality management defined in ISO 9000:2005 which represent basic values for a successful process-oriented quality management system.

- customer focus
- leadership
- involvement of people
- process approach
- system approach to management
- continual improvement
- factual approach for decision making
- mutually beneficial supplier relationships

According to him, the principle of a comprehensive and basic conviction to guide and manage an organization needs to be highlighted especially. With the aim to continually and in the long term improve the QM system he refers to the customer orientation, i.e. fulfilling all requirements from the outside regarding an organization. This addresses everybody interested in the company.

Koch (2010) states under the designation of principles of quality management three different principles. He also names customer orientation as a first principle which involves satisfying customers by a production of material goods and processes targeted towards customer requirements. The continuous improvement process presents for him also the second principle. For him this is the constant examination of the processes regarding possible organization potentials and their adaptation to increasing customer demands. Principle three, teamwork, serves in his opinion as a functioning cooperation of managers, employees, customers and suppliers.

Bruhn (2010) describes the 10 c's, i.e. principles for quality management, as preconditions for systematic and successful realization of quality management: customer orientation,



consequence, (delimitation from) competition, consistency, congruency, coordination, communication, completeness, continuity, cost-benefit orientation.

Linß (2011) portrays the structured process regarding QM methods using the example of the Plan-Do-Check-Act cycle (PDCA). Integration of the principles as objectives within QM methods thus enables their fixing within processes.

The designations, i.e. QM methods and QM tools and sometimes also QM techniques, are used by many authors synonymously. Kamiske & Brauer (2008) also state how difficult it is to define the terms uniformly. Neither the definition standard DIN EN ISO 8402 nor literature in general contains a definition of quality techniques. Kamiske & Brauer (2008) use the term of quality techniques as a kind of generic term for methods and tools in quality management. While they describe methods as procedures on a procedural level, tools or instruments are to be designated as means on the instrumental level. These rather visual means support problem detection, problem understanding and problem solving. QM tools are based mostly on mathematics and/or statistics. Successful application is only possible according to Kamiske & Brauer (2008) by a planned procedure. As an example for QM tools they state the “tools of quality” (Q7) (check sheet, histogram, control chart, pareto diagram, scatter diagram, brainstorming, cause-effect diagram).

McQuater and coauthors (1995) define quality tools as independent tools. They present an element with a clearly defined task. Quality tools are frequently used on their own and are characterized by their narrow focus (McQuater et al. 1995). They also state by way of example tools of Q7. In contrast to a tool, techniques have a broader application spectrum. Their application requires mostly more previous knowledge and experience. In a simplified form they are also called by McQuater and coauthors (1995) a collection of tools since an effective realization of techniques quite often builds on the application of several tools. As examples for techniques, McQuater and coauthors (1995) state, amongst others, statistical process control (SPC) and Failure Mode and Effects Analysis (FMEA).

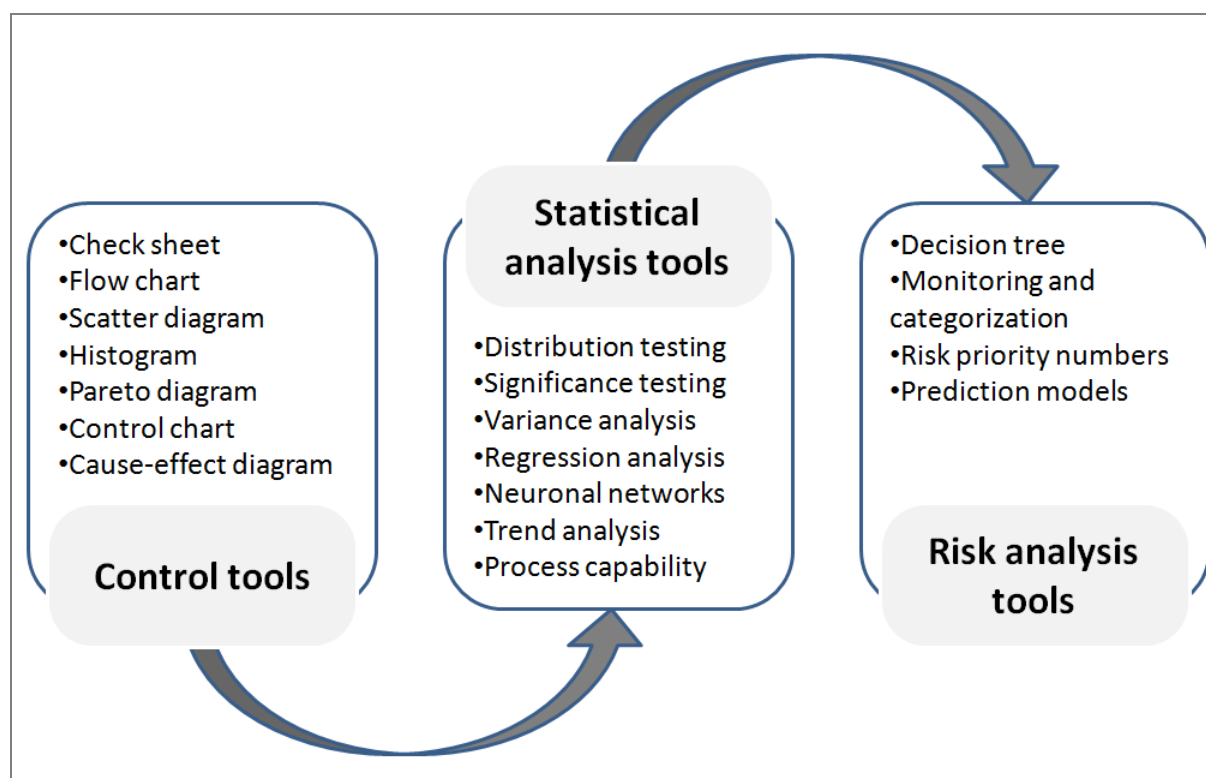
Reißiger and coauthors (2007) see the aim of methods for preventive safeguarding in the “avoidance of potential development errors and risks in the early phases of development of products and processes”. As an example for this they state FMEA.

Borghese and coauthors (2006) describe the use of preventive quality management methods in the early phases of the value chain (planning phase) aiming at preventing errors in the following production stages. When using certain methods in the early development phases, it is possible to save time and cost (Borghese et al. 2006).

In this thesis, the terms QM methods and QM tools are used. These are defined as follows according to the definitions of McQuater and coauthors (1995) for quality techniques as well as quality tools:

- Quality Management Method: “QM methods are based on a comprehensive process which includes several steps all focusing on one defined objective.” Examples for QM methods are the concepts Failure Mode and Effects Analysis (FMEA), Hazard Analysis and Critical Control Points (HACCP) and the Statistical Process Control (SPC).

- Quality Management Tool: “QM tools are simple to use and are applied to support single steps of QM methods. They are often based on a statistical procedure.” Regarding the aims of QM methods three groups are distinguished; these are shown in Figure 3.



**Fig. 3: Categories of quality management tools**

In the following four methodical procedures are explained which are important within the agricultural and food sector and which are representative for the area of the team-oriented QM methods:

*Hazard Analysis and Critical Control Points (HACCP)*

The Hazard Analysis and Critical Control Points (HACCP) system was developed in the 60s as a preventive method to evaluate and guarantee safety of food for astronauts in connection with the US space program developed by NASA (Kamiske & Brauer 2008).

The Codex Alimentarius Commission (CAC) founded by the Food and Agricultural Organization (FAO) and the World Health Organization (WHO) define food safety standards for international trade. These standards are targeted at protecting the consumers and safeguarding fair food trade. They serve as the basis for further standards and codes in the food industry (CAC 2011). In the Alinorm 97/31A established by the CAC, the term “hazard” is defined as the “biological, chemical or physical agent in or condition of food with the potential to cause an adverse effect” while Critical Control Points is defined as “step at which control can be applied and is essential to prevent or eliminate a food safety hazard or reduce it to an acceptable level” (Alinorm 1997).

Behind the HACCP concept there is a clearly structured procedure which is aimed at the assessment of risks and the establishment of a control system in food production regarding a

preventive avoidance of risks for food consumers (Alinorm 1997). Accordingly, the regulations Reg. (EC) No. 178/2002 and Reg. (EC) No. 852/2004 refer to the HACCP concept in all stages of food production (Reg. (EC) No.178/2002, Reg. (EC) No. 852/2004). Within the framework of the General Food Law, primary production has also been included by defining agricultural enterprises as food producers which are hence responsible for food safety (Reg. (EC) No. 178/2002). Since detailed implementation of the HACCP concept in primary production is considered as quite difficult, only HACCP-based self-control systems are prescribed (Reg. (EC) No.852/2004).

Implementation of the HACCP concept is done in seven steps from risk analysis to defining critical control points (CCPs), its limit values, introducing a monitoring system for each CCP and formulating and verifying corrective measures. This procedure is supplemented by a detailed documentation (Noordhuizen et al. 2008). Schmitz (2005) distinguishes between three different categories of critical control points which form the basis for a continuing improvement process. "Critical Control Points (CCPs)" designates risky process points. "Hygienic Control Points (HCPs)", however, refers to risks which can be controlled by means of good hygiene practices. Control points which are not categorized in CCPs or HCPs and have an influence on the quality of products are defined as "Quality Control Points (QCP)" according to Schmitz (2005).

In order to integrate the HACCP concept into the processes of the food chain, some structural steps have to be run through (Escriche 2006). After establishing an HACCP team, the products produced and their intended use are described. The production steps are graphically depicted by means of a flowchart. Finally, the enterprise is verified on the basis of the established flowchart with the information provided. After the bases and framework conditions of the production chain under observation have been made known, the seven steps of the HACCP concept start with risk analysis on the basis of the flowchart created.

#### Failure Mode and Effects Analysis (FMEA)

The Failure Mode and Effects Analysis (FMEA) was developed in analogy to the HACCP concept in the 60s by the American space organization NASA. The FMEA aims at discovering errors and risks at an early stage and to evaluate and avoid them (Kamiske & Brauer 2008). Regarding the time of application and the object of investigation, Kamiske & Brauer (2008) differentiate between three types of FMEA: construction FMEA for the development and construction phase, process FMEA for production processes as well as system FMEA to contemplate subordinated overall systems. When doing this, FMEA is considered as a preventive method applied preferably within the framework of planning and developing.

Schmitz (2005) describes five steps for the implementation of a Failure Mode and Effects Analysis: After carrying out a structural and functional analysis resulting in a functional structure as an overview of the system contemplated, the relevant products and processes as well as services with their corresponding functions (product and process features), fault analysis is done. During this procedural step, the functions of potential errors are assigned and linked to an error network based on causal relationships. Risk assessment is completed in step four. The basis for this is the risk priority number (RPN) which is calculated by

multiplication of the three parameters probability of occurrence, importance of the failure and probability of discovery, and presents a reference value for the probability of discovery. Finally, during an optimization phase, measures for avoidance and testing to improve the system, product, process or service contemplated are defined (Welz 1993, Schmitz 2005).

### Six Sigma

Six Sigma was developed in the mid 80s by Motorola on the basis of already present improvement methods (Gamweger et al. 2009). According to Kamiske & Brauer (2008), the term Six Sigma has two different meanings. On the one hand, Six Sigma stands for the accuracy of a process striven for (maximum standard deviation of six sigma). This corresponds to an accuracy of 99.999% (Gundlach & Jochem 2008). On the other hand, Six Sigma serves as a symbol for business processes of high quality (Kamiske & Brauer 2008). Gamweger and coauthors (2009) define Six Sigma as a process improvement concept implemented strictly top down to realize financially measurable improvement projects by means of selected experts and in a very structured way and with the help of methods and techniques.” From this definition, Gamweger and coauthors (2009) deduce five core elements of the Six Sigma approach:

- The philosophy *zero errors* includes the elimination of errors as a central element in the improvement strategy. This is based on the fact that the negative effect of errors increases while passing each production step up to distribution to the customer. Owing to this, an early fault detection is of great economic importance.
- *Process orientation and measurability*: Only fault-free processes can generate a high product and service quality which is the precondition for a high level of customer satisfaction and competitive advantages and thus enables turnover increases. Corresponding measurement systems enable the financial advantages of Six Sigma activities being transparent even for people not directly involved.
- *Rigorous project management*: Gamweger and coauthors (2009) mention two processes for applying the Six Sigma concept, i.e. the “design of the Six Sigma method” (DFSS) and the “DMAIC” cycle. The DFSS method so far is hardly applied in practice which explains why it is not very popular.

The DMAIC cycle is based according to Gamweger and coauthors (2009) as well as according to Klauke & Brinkmann (2009) on a five-step cyclical procedure which functions according to the basic principle of continuing improvement. DMAIC is an abbreviation for the terms “Define – Measure – Analyze – Improve – Control”. After defining and ascertaining the improvement objective, project planning and project release take place (Define). When analyzing the status quo, relevant data and information are put together (Measure). After this, a cause-and-effect analysis is carried out (Analyze) which is the basis for process improvement measures taking the main influencing factors and error causes resulting from this into account (Improve). Finally the achievement of the defined objectives as well as their compliance in future is verified (Control).

- *Problem-solving methods and statistical methods*: To support the individual phases of the DMAIC cycle, there are various tools available in a “toolbox”. Gamweger and coauthors (2009) differentiate here between two major groups of tools. Team-oriented problem-solving tools to support creativity as well as a structured procedure by the Six Sigma team are applied, on the one hand. On the other hand, statistical tools serve to substantiate improvement projects by optimally prepared data and facts.
- The *promotor concept* serves to adapt the qualification level of people involved by means of training and further education to their tasks (Gamweger et al. 2009). Wappis & Jung (2008) also stress that corresponding qualification of the employees is a precondition for successful use of methods and tools. They distinguish five different roles in this respect. “Champions” are managers who are responsible for project management, procurement as well as support of improvement projects, selection of employees and resource provision. Accordingly, they are important for the success of a project. “Master Black Belts” are also implementing projects just like champions. In addition to the support of champions, they have the responsibility for employee training and the implementation of very demanding projects. Furthermore, they have to assure support for creating the necessary organizational framework. “Black Belts” help the champions with project selection and implementation, together with their team. In large companies, they are often released from work for Six Sigma activities. “Green Belts” work in Six Sigma projects or take over their management, while “Yellow Belts” and “White Belts” integrate their knowledge in Six Sigma projects. In addition, they are responsible for continuous implementation of the optimizations achieved (Wappis & Jung 2008, Klauke & Brinkmann 2009).

#### Audit management:

It is the objective of audits to evaluate how procedures are performed within an organization (Gietl & Lobinger 2009). Kagermann and coauthors (2008) describe the audit procedure as a comparison between existing conditions and predetermined criteria. Two different control functions are mentioned: On the one hand audits serve as detective control mechanisms to identify and investigate deviations from defined standards; whereas on the other hand they are used as preventive methods by raising awareness for the correctness of processes and products (Kagermann et al. 2008). Kamiske & Brauer (2008) call audits modern information systems which aim at assessing the efficiency and suitability of quality-assuring activities.

Mack (2007) differentiates between three types of audits depending on the field of application: system audit, product audit and process audit. In case of system audits, the QM system of a company is audited (Linß 2011). It is examined to what extent the requirements of the QM system are fulfilled and the defined quality aims have been reached. In the process audit, an assessment of defined processes regarding their suitability and practical implementation is carried out. An assessment of product features with the underlying quality requirements is done within the framework of product audits (Linß 2011).

Linß (2011) defines six principles which should hold true for auditors or their relevant responsibilities:

- integrity
- objective presentation
- adequate professional care
- confidentiality
- independence
- procedure based on proof

In conformity with the origin of the auditors, Kamiske & Brauer (2008) speak of internal and external audits. As regular elements of quality management systems, internal audits are carried out by the company's own employees. The aims to be achieved are for example observation of quality development or a comparison of the efficiency of individual organizational units. External audits quite frequently lead to final certification and are, usually, done by specialized institutions or more rarely by customer auditors (Kamiske & Brauer 2008).

Linß (2011) explains six phases which are passed when carrying out audits. After placement of an *audit order*, the preparation of the audit begins. In the *preparatory phase* the necessary information and documents are gathered to provide information on the company to be audited, and show its processes, target values and results of the preceding audits. In addition to this, a corresponding checklist is prepared by the audit team which serves as a test program, on the one hand, and also as recordings of the auditors, on the other hand (Mack 2007, Linß 2011). The *audit being carried out* also involves enquiries, sifting through documents and observing conditions and situations in the form of visits and serves to test suitability and efficiency of the processes to be audited in relation to defined target provisions (Linß 2011). In the next step, a *quantitative assessment* is used for status determination of the capability of the products or processes observed. Linß (2011) summarizes a final discussion about the results and audit findings, determination of subsequent steps and further audits possibly necessary and the relevant motivation to implement measures as *result presentation*. In accordance with Mack (2007), the results of an audit are recorded in an audit report. *Audit evaluation* includes a correction phase for implementing and tracing corrective measures and their success is verified possibly within the framework of follow-up audits (Linß 2011).

When looking at the four QM methods mentioned, it becomes obvious that the aspects of continuing improvement, teamwork and including QM tools and statistical aids are over and over addressed so that these have to be seen as basic contents of these QM methods.

As a safeguard measure and to continually improve the efficiency of processes, Linß (2011) suggests the *Plan-Do-Check-Act (PDCA) cycle* of Deming. Pfeifer (2001) describes the PDCA cycle as a structured procedure to solve problems. After defining the problem areas, the analysis of problems and the prioritization of potential solutions (Plan), measures are specified and their implementation started (Do). Afterwards, the new situation is evaluated and compared with the target set (Check). Finally, the possibly necessary corrections are defined (Act) (Pfeifer 2001). The regulatory circuit system which develops by including the results in the planning processes enables continuing improvement of processes (Linß 2011).

The individual procedural steps of the methods described can be well assigned to the four steps of the PDCA cycle since a planning, implementation, evaluation and final correction phase is integrated.

According to Schmitz (2005), the formation of *interdisciplinary teams* is an important organizational aspect to assure meaningful and effective application of QM methods. Mortimore & Wallace (1998) stressed already in 1998 that HACCP should not be implemented by one person on its own but rather by an interdisciplinary HACCP team which should back the concept. In addition to team building, training the team members correspondingly is important. Gamweger and coauthors (2009) highlight that FMEA “absolutely has to be realized in a team”. When doing this, the project is offered an extensive knowledge and a great wealth of experience. Furthermore, cross-functional cooperation is supported as well as the acceptance of the results increased. In addition to this, Gamweger and coauthors (2009) mention the more rapid decision finding process. Kurzeja & Luckner (2008) say in regard to Six Sigma that finding approaches to solutions is usually done in a team. Consequently, as necessary abilities for Black Belts team building and team leading are mentioned (Müller 2008). Dereli and coauthors (2007) state the formation of an effective QM team as a first step towards successful auditing. Quality management methods are frequently supported by the use of *QM tools* (McQuater et al. 1995). Kamiske and Brauer (2008) categorize the seven quality tools defined by Ishikawa according to their application field in two main groups. Check sheets, histograms and control charts are targeted at failure recording, while pareto diagrams, scatter diagrams, brainstorming and cause-effect diagrams are to be used for error analysis (Kamiske & Brauer 2008). On the basis of this, categorization assignment of the tools to the individual procedural steps of the QM methods is possible.

Gamweger and coauthors (2009) state the expression “toolbox” in connection with Six Sigma. This means a collection of tools and techniques which can be assigned to the individual steps of the DMAIC cycle in order to support these.

### **2.2.2 Demand for methodical support in inter-enterprise health management**

As already mentioned above, regulation (EC) No. 852/2004 of the EU Hygiene Package explicitly requires introduction of an HACCP concept in the food chain or HACCP-based concepts in primary production (Reg. (EC) No. 852/2004). In addition to this, customer requirements regarding product quality owing to an increased export orientation in connection with more requirements by quality programs increase. This situation puts enormous pressure on the participants of the agricultural and food industry to produce safe food in high quality. Owing to this, there is increasingly forming a demand for integrating quality-assuring and quality-maintaining mechanisms in the pork chain (Ellebrecht et al. 2009).

Schmidt (2006) stresses that food scandals as well as an increase in allergy diseases lead to a sensitization of the consumers regarding the topic of food safety. In addition to modifications of legislation, the companies also react to the more critical consumer behavior. New standards are introduced to guarantee the safety of food and thus increase consumers' confidence in food (Petersen et al. 2010b).

According to Weindlmaier and coauthors (2008), the criteria of product safety, maintenance of quality and environmental compatibility during fattening, transport, slaughtering and meat processing to strengthen consumer confidence in the product group meat are decisive. In this respect, it is important to differentiate the risks occurring in meat production according to those which are important since they actually affect consumer health, and those which cause the greatest uncertainties on the consumer side. Frequently, individual cases are very much in the focus of consumers although these do not develop any threatening extent regarding health hazards when they are investigated in more detail (Weindlmaier et al. 2008). Amongst the reasons for this are according to Branscheid (2008) the requirements of federal risk management. The state is forced to intervene as a precautionary measure and to inform consumers and media about the possible risk when a justified health risk is assumed.

Bahlmann & Spiller (2008) point out that evaluation of products in the pork chain is carried out ex post. Owing to this, only a reaction to health-relevant questioning is possible. Introduction of process-accompanying measures in primary production is not desirable according to them.

Baines and coauthors (2004) also stress that prevention is decisive for the production of safe food. As an approach to this, they mention integration of preventive activities in industrial practices by revealing contamination potentials and eliminating them (Schmitz 2005, Schulze Althoff 2006, Mack 2007, Petersen et al. 2007, Schütz 2009).

Ellebrecht (2008) stresses that preventive measures against diseases play an important role for precautionary consumer protection in addition to its importance for efficiency.

### **2.2.3 Methodical support in inter-enterprise health management**

So far experiences of companies exist almost exclusively in connection with projects accompanied scientifically with the use of QM methods in the pork chain. Bahlmann & Spiller (2008) emphasize that an adaptation of QM methods to the processes of pork production is necessary in order to apply the methods effectively. Baines and coauthors (2004) mention four aspects which are quite frequently stated as arguments against the introduction of individual QM methods such as the HACCP concept on a company level:

- Quite often there are no visible indications regarding the existence of risks (such as pathogens)
- In relation to the size of the enterprises which are mostly quite small, development of an HACCP concept is very complex
- In order to evaluate the risks in accordance with the situations constantly changing in the enterprises, extensive specialist knowledge is necessary
- Cost for the development and maintenance of the HACCP-Systems are incurred

Although the law requires application of HACCP-based self-control systems, Baines and coauthors (2004) mention difficulties regarding implementation of HACCP in primary production. Schmitz (2005) on the other hand points out that with the support of service organizations, the principles of preventive QM methods can be absolutely used in agricultural enterprises.



In the following, some approaches for the application of preventive QM methods in animal production or in health management are presented.

Noordhuizen and coauthors (2008) write about the HACCP-based quality and risk management in dairy farming. They justify their designation “HACCP-similar applications” on the grounds that the “materials” looked at more closely are living animals which show biologically determined variations. According to this, it is not possible to talk exclusively about the black and white principle as is the case with goods, here possibly occurring grey areas have to be included as well. Noordhuizen and coauthors (2008) stress that an HACCP-relevant system is always an enterprise-specific system since each enterprise is different regarding management and conditions for animal rearing.

Schmidt (2006) contemplates and evaluates QM systems in meat processing already in use as well as those planned. Since the HACCP concept is included as a basis in QM systems, it was integrated as a first measure in the enterprise part of the thesis. Based on this, implementation of the QM systems contemplated was done.

Schmitz developed in 2005 a model to apply preventive QM methods in the area of advisory services for enterprises in the agricultural and alimentary sector. The initiative for this resulted from the challenge that the enterprises in the food sector were forced to implement self-control systems. Schmitz (2005) subdivided the two QM methods FMEA and HACCP in individual modules and combined them to a methodical procedure. This resulted in the structure for a self-control system which is targeted at risk assessment and risk control. On the basis of an empirical study carried out in enterprises of the agri-food industry, Schmitz (2005) developed three support instruments:

- a methodology guideline for the selection of suitable modules
- a concept for software support
- and a concept for the use of a software-supported methodology guideline for advisory services

A new approach for linking risk analysis and risk assessment permits according to Schmitz (2005) by means of a software-controlled application rapid and systematic identification of control points of the three categories CCP, HCP and QCP. This also enables small enterprises to implement and maintain a self-control system without having to consider an unclear number of control points (Schmitz 2005). Schmitz (2005) suggests linking of the software-based methodology guidelines which rest upon a knowledge database with integrated workflow-based audit, document and action management systems. This enables the management of requirements of standards, regulations or programs in a chain-oriented quality management system. By way of example, Schmitz (2005) states standardized controlling procedures for documents which can be organized regarding their set workflow. An audit workflow instrument supports all phases of auditing, i.e. from planning to post-processing. With the help of action management, measures can be suggested, planned and understood for example by advisors (Schmitz 2005).

Welz (1993) evaluates the effects of diseases of pigs on the quality of the end product, i.e. pork, with the help of FMEA. In this regard, he investigates diseases as “quality-inhibiting”

factors. In order to calculate the risk on the basis of the risk priority number, he defined criteria for the parameter considered, i.e. importance of a disease on the quality meat production taking into account the following aspects: effects on product and process quality, economic importance, importance for the consumer and applicability for all diseases. Welz (1993) could highlight five parameters for which the four mentioned criteria apply. As a result of this, the parameters mortality, effects on production, limitations regarding further processing, duration of disease as well as trade limitations were considered when determining the importance (Welz 1993).

Breuer (2011) developed a concept which can be used by veterinary authorities to support cross border crisis management preparation. He suggests the application of quality management methods for a final concept check. One example is the integration of FMEA in the risk assessment procedure using the extent of losses as well as the probability of appearance as measures (Breuer 2011).

Jantke (2006) applied the FMEA for risk classification of hazards regarding product safety and quality of meat and meat products. The objective was to identify points in production as well as in supporting processes which possess a high risk potential. Based on this knowledge, activities of risk reduction could be successfully organized.

Mack developed in 2007 a concept for inter-enterprise advisory services in health management of meat-producing chains. The concept involved software applications for the areas of audit and document management.

Klauke & Brinkmann (2009) introduced Six Sigma within the framework of a project in meat production. When doing this, they had a look at the quality of carcasses by carrying out an evaluation regarding the parameters of slaughtering weight and lean meat percentage based on Six Sigma. By considering the required limit values regarding meat processing, Six Sigma target values as well as limit areas were defined (Klauke & Brinkmann 2009).

## **2.3 Methods for representing and evaluating empirically researched correlations**

### **2.3.1 Methodical and theoretical approach to structural equation models**

Johnsen (2008) describes multivariate processes as methods to verify highly complex structures where more than two variables are included at the same time. Multivariate analysis methods can be subdivided into primary structure-discovering processes and primary structure-testing processes according to Backhaus and coauthors (2011b); the former group deals with the revelation of hitherto unknown relationships between variables. Structure-testing processes are preceded by the definition of approaches to certain correlations on the basis of theoretical assumptions between objects (Johnsen 2008; Backhaus et al. 2011b).

Structural equation models (in the following referred to as "SEM") can be classified in the second group. They are based on theory-testing hypotheses, i.e. as a first step they include the formulation of well-founded theoretical hypotheses which are to be verified by means of the data collected (Bünthe 2005, Johnsen 2008). Dalbert (1983) defines theory-testing

hypotheses as follows: “[...] Hypotheses can be described as “theory-testing” since they take the validity of constructs with expected references for granted.”

According to the assumptions of Lee & Song (2010), the structural equation analysis is the most important statistical method to evaluate several hypotheses by means of influences of latent variables and indicators to other variables (taking measurement errors into account).

### **Nomenclature**

Structural equation models include two types of variables, i.e. *manifest variables* which are also called measurable variables, as well as *latent variables*. The latter are characterized by the fact that they cannot be measured directly but have to be deduced from manifest variables. Owing to this, latent variables are also described as hypothetical constructs (Johnsen 2008). In the structural model, hypothetical relationships between latent variables are presented (Weiber & Mühlhaus 2010). When doing this, they are subdivided into exogenous and endogenous constructs. Exogenous latent variables are considered as independent (Götz & Liehr-Gobbers 2004, Bünthe 2005) since they do have an explanatory function within the model but are not explained within the model itself (Backhaus et al. 2011b). Endogenous latent variables arise in contrast to this from other latent variables and can also influence other latent variables (Backhaus et al. 2011b). Therefore, the synonym of dependent variables is used for them as well (Götz & Liehr-Gobbers 2004, Bünthe 2005).

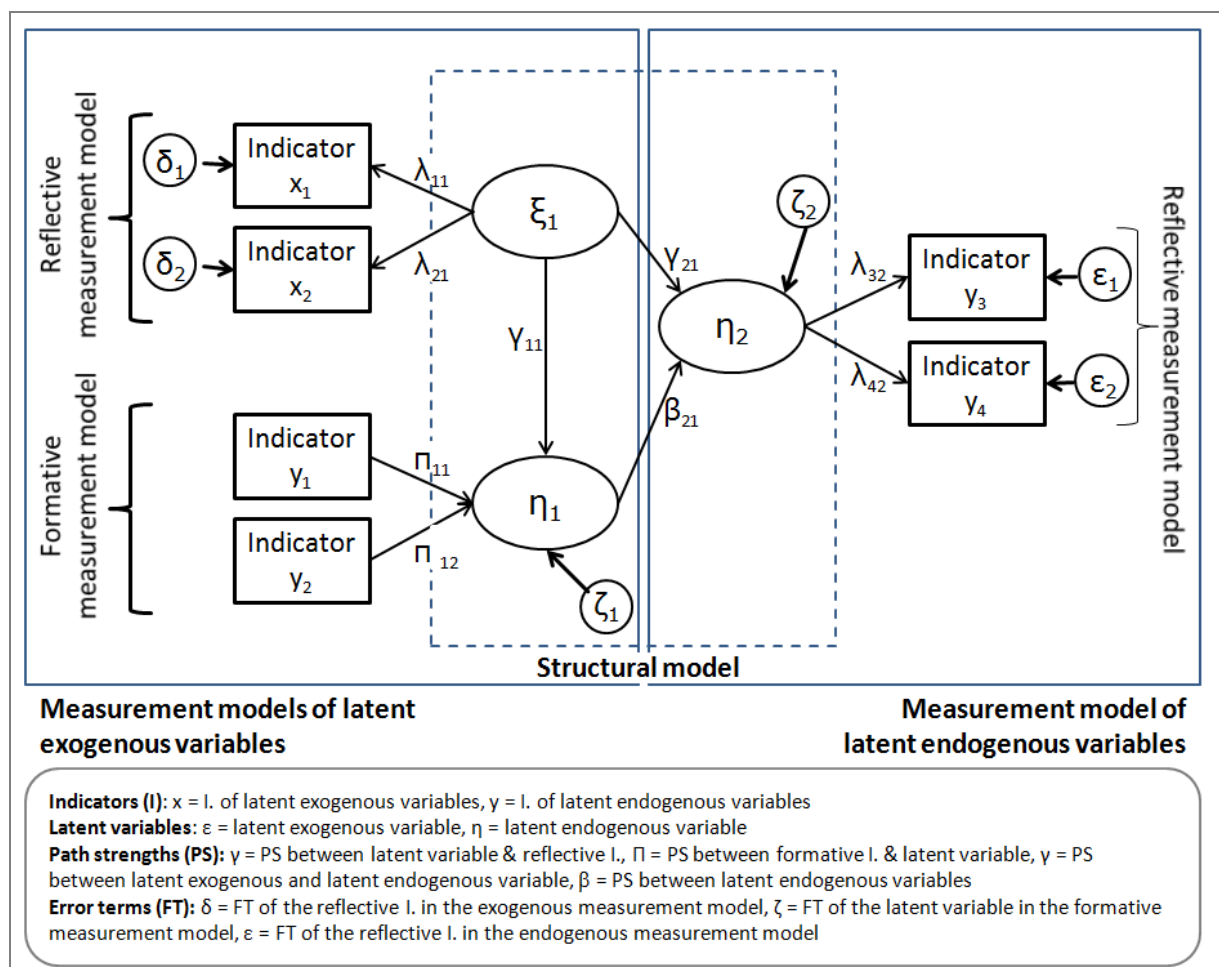
Normally, structural equation models consist of one structural model and two measurement models (Weiber & Mühlhaus 2010). The structural model which represents the relationships between the latent variables is based on theoretical assumptions. Its form must equal a causal chain, i.e. it must not contain any loops (Götz & Liehr-Gobbers 2004). Path coefficients are calculated by means of regression analyses (Bünthe 2005) and describe the strength of relationships between endogenous and exogenous variables (Johnsen 2008).

In addition to the structural model, a structural equation model usually contains two measurement models. These serve to determine the latent variables by means of indicators. Results achieved during data collection such as surveys which enable calculation of the constructs to be determined are suitable indicators. In doing this, a distinction is made between formative and reflective indicators depending on the orientation of the causal relationship between variables and indicators (Götz & Liehr-Gobbers 2004, Bünthe 2005, Weiber & Mühlhaus 2010, Backhaus et al. 2011a, Backhaus et al. 2011b). From this also results the subdivision made by Eberl (2004) as well as Götz & Liehr-Gobbers (2004) into reflective and formative measurement models.

In reflective measurement models, the indicators result causally from latent variables. In consequence, modifications of variables also lead to modifications of indicators. A strong correlation between reflective indicators is demanded (Eberl 2004, Weiber & Mühlhaus 2010). Reflective measurement models can be described by the following formula (Götz & Liehr-Gobbers 2004):  $y = \lambda_y \eta + \varepsilon_y$ , whereby  $y$  represents the reflective indicator and  $\eta$  the latent variable.  $\lambda_y$  stands for the regression coefficients of the construct regarding the indicator. This explains the influence of the variable on the indicator.  $\varepsilon_y$  describes the measurement error of the indicator (Eberl 2004, Götz & Liehr-Gobbers 2004).

In contrast to the reflective measurement model, the latent variable is caused by the indicators in the formative measurement model. A correlation between the indicators is not necessary (Eberl 2004, Götz & Liehr-Gobbers 2004). Since the variable results from the indicators, integrity of the indicators is essential for correct determination of the variables (Diamantopolous & Winklhofer 2001). Götz & Liehr-Gobbers (2004) define the variable in a formative measurement model “as the weighted sum of its indicators” and describe it with the following equation:  $\eta = \Pi_{\eta}\gamma + \delta_{\eta}$ , whereby  $\eta$  represents the latent variable and  $\gamma$  the formative indicator.  $\Pi_{\eta}$  designates the magnitude of influence of the relevant indicator on the variable, while  $\delta$  signifies a possible measurement error of the variable.

The following figure 4 shows an exemplary structural model as defined by Götz & Liehr-Gobbers (2004).



**Fig. 4: Simple path diagram for creating a structural model (acc. to Götz & Liehr-Gobbers 2004)**

**Structural equation analysis method**

In structural equation modeling there exist two different methods, i.e. the covariance-based method and the variance-based method (Jahn 2007). The covariance structure analysis estimates the causal structure of a model as a whole and verifies the variable relationships at large (Weiber & Mühlhaus 2010). It is based on the statistical method of confirmatory factor

analysis (Fuchs 2011). The aim is to achieve an optimal reproduction of the variance and covariance matrix (Weiber & Mühlhaus 2010). In order to evaluate the dependency relationships of the latent constructs, variances and covariances of indicators are used (Fuchs 2011). The calculated construct values are not employed for the evaluation (Weiber & Mühlhaus 2010).

Fuchs (2011) designates the variance structural analysis based on the PLS method (partial least squares) as a complementary alternative to the covariance structural analysis. The basis of this method is an iterative regression-analytical least squares evaluation founded on a principal component analysis as well as on a canonical correlation analysis (Fuchs 2011). The starting point for this evaluation are the calculated construct values (Weiber & Mühlhaus 2010). The objective here is to predict the actual observation values as precisely as possible (Weiber & Mühlhaus 2010, Fuchs 2011).

According to Jahn (2007), the PLS-based methods have only been used widely in the recent past. Fuchs (2011) states the software programs LISREL, AMOS or EQS which have been available for quite a long time now, as one possible reason for the previous concentration on covariance-based methods. In the past few years, software packages consistent with variance-analytical methods such as LVPLS, PLS Graph or SmartPLS have been developed and further developed. (Weiber & Mühlhaus 2010, Fuchs 2011).

A major advantage of PLS-based methods is the fact that they can also be used for relatively small sample sizes (Jahn 2007, Fuchs 2011). Accordingly, in formative measurement models, the tenfold of the indicators which maximally influence a construct or of the latent exogenous variables which maximally aim at a latent endogenous variable is taken as the relevant characteristic. In case of reflective measurement models, the minimum sample size is defined by the tenfold of the maximum number of regression paths on one of the endogenous constructs (Weiber & Mühlhaus 2010). As a consequence, samples with sizes between 30 and 100 are already sufficient for PLS analysis (Fuchs 2011). In contrast to this, the minimum sample size for covariance-based methods is between 200 and 800. An additional benefit of the variance analysis is that no distribution assumptions need to exist, whereas covariance-based approaches require a multivariate normal distribution. Accordingly, Fuchs (2011) emphasizes the higher flexibility of the PLS method in contrast to the covariance-based method.

This higher flexibility ensuing from the lower requirements on the underlying database also results, however, in less assessment criteria being available for evaluating the model quality. The PLS method must therefore fall back on non-parametric methods (Fuchs 2011).

### **Procedural steps**

The first procedural steps of the two causal-analytical approaches are identical according to Weiber & Mühlhaus (2010). The methods for the last steps in model evaluation and model assessment are based, however, on different procedures (Weiber & Mühlhaus 2010).

Since this thesis deals with the PLS method, the procedures for this approach are explained here.

The structural equation analysis can be subdivided into five procedural steps:






1. *Development of hypotheses*

During the first step hypotheses are developed which are to be tested with the help of the data collected (Bünthe 2005, Johnsen 2008).

2. *Development of a path diagram and specification of a model structure*

The hypotheses made are transferred to a path diagram taking into account the construction rules (see Table 1) for structural equation models according to Backhaus and coauthors (2011b). The inherent latent variables are defined in detail and specified by the assignment of suitable measurement indicators (Weiber & Mühlhaus 2010). In accordance with the direction of action of the measurement indicators, the measurement conception for the measurement models is defined thus determining their orientation (reflective or formative) (Weiber & Mühlhaus 2010).

**Table 1: Construction rules for structural equation models (mod. acc. to Bünthe 2005, Diamantopoulus et al. 2008, Backhaus et al. 2011b)**

Element	Symbol	Explanation
x, y		Measurement variables (indicators) which can be observed directly are depicted in boxes.
H, E		Latent variables are enclosed in an oval.
E, $\delta$		Residual dimensions (measurement error variables) are characterized by circles.
$\Lambda_x, \lambda_y, \gamma, \beta$		Causal relationships between two variables (path coefficients) or indicators and variables (factor loading) are depicted by means of a straight arrow (path). An arrow only ever has a variable as a starting point and a dependent variable as an endpoint.
$\Phi$		A curved arrow interprets a non-causal (i.e. correlated) relationship. This is only permissible between latent exogenous variables or between residual dimensions.

In the next step, the correlations of the path diagram are transferred to an equation system. Lee & Song (2010) define the structural equation (1) which describes the interrelation between latent variables as well as the equations of the measurement models of the latent endogenous variables (2) and the latent exogenous variables (3) as follows. The characters used are explained in Table 2.

$$(1) \eta = \gamma\xi + \beta\eta + \zeta$$

$$(2) y = \lambda(y) + \varepsilon$$

$$(3) x = \lambda(x) + \delta$$

According to Bünthe (2005) and Johnsen (2008), the equation development and calculation is mostly done by software programs such as AMOS or SmartPLS especially developed for structural equation analysis.

**Table 2: Explanation of the characters used in the equations (mod. acc. to Weiber & Mühlhaus 2010)**

Character	Significance
$\eta$	latent endogenous variable
$\xi$	latent exogenous variable
$\gamma$	path coefficient between exogenous and endogenous variable
$\beta$	path coefficient between two endogenous variables
$\zeta$	residual variable to an endogenous variable
$x$	indicator for a latent exogenous variable
$y$	indicator for a latent endogenous variable
$\lambda$	factor loading
$\delta$	residual variable to the indicator x
$\varepsilon$	residual variable to the indicator y

### 3. Identification of the model structure

In order to guarantee the identification of the model, it is verified whether the equation system can be solved unequivocally. The precondition for this is according to Backhaus and coauthors (2011b) that the number of equations set up is greater than or equal to the number of parameters to be evaluated. Furthermore, it has to be determined if the empirically collected data suffice to identify the data presented (Bünthe 2005, Johnsen 2008).

### 4. Assessment of reflective measurement models

Since the majority of measurement models used in science is of a reflective nature and this thesis also refers to reflective measurement models, here exclusively the assessment of reflective measurement models is discussed.

The assessment is based according to Nitzl (2010) on the assessment coefficients known from factor analysis. It is assumed that each indicator is achieved via measurements from a latent variable whereas random and systematic errors alike influence the result. In this respect, the two criteria, i.e. reliability and validity, are assessed (Nitzl 2010). Whereas reliability designates the extent to which “repeated measurements of a context with one and the same measuring instrument also lead to the same results“ (Weiber & Mühlhaus 2010), i.e. includes no random errors, a valid measurement describes a measurement where both types of errors equal zero (Weiber & Mühlhaus 2010).

On the basis of empirical data, the causal model is estimated via a three-stage estimate algorithm (Weiber & Mühlhaus 2010).

- determination of the construct values for each latent variable
- determination of the path coefficients of the structural model using the construct values from stage 1
- determination of the mean values and constants for the regression relationships

This is an iterative process which is carried out alternately on the basis of the structural model (internal estimate) as well as on the basis of the measurement models (external estimate). It will end when the convergence criterion is as follows:

$$CV_j^I - CV_j^A \leq 10^{-5}$$

whereas:

$CV_j^I$  = result construct value of the latent variable j from the internal estimate

$CV_j^A$  = result construct value of the latent variable j from the external estimate

is deemed to have been fulfilled (Weiber & Mühlhaus 2010).

In order to assess the model quality, Nitzl (2010) is suggesting four assessment criteria which in part already result from the described estimate algorithm: indicator reliability, construct reliability, average variance extracted (AVE) as well as discriminant validity. The indicator reliability designates the variance proportion calculated by the corresponding construct. It is calculated according to Weiber & Mühlhaus (2010) by means of the squared factor loading and should take on a minimum value of 0.4. In order to assess the convergence validity which is defined by “the closeness of agreement of two or several attempts to carry out a construct measurement” (Fuchs 2011), Fuchs (2011) suggests to measure the test values’ construct reliability as well as the average variance extracted (AVE). The construct reliability (synonyms: factor reliability, composite reliability, internal consistency) measures how well the construct is represented by the assigned indicators. It is based on the following formula (Fuchs 2011) and is calculated by means of relevant software programs such as SmartPLS within the PLS algorithm (Weiber & Mühlhaus 2010).

$$(4) \quad \text{rel}(\xi_j) = \frac{(\sum \lambda_{ij})^2}{(\sum \lambda_{ij})^2 + \sum_i \text{var}(\varepsilon_i)}$$

According to Ringle (2004), the construct reliability should result in values of at least 0.6. Another widely used criterion to assess the internal consistency is the Cronbach Alpha coefficient. Since according to Ringle (2004) and Fuchs (2011), this often underestimates the internal consistency, the above explained construct reliability should be used preferably. Minimum values for Cronbach’s alpha are predetermined by Weiber & Mühlhaus (2010) with 0.7.



The average variance extracted (AVE) describes the ratio of the proportion of the declared variance regarding the measurement error of a latent variable and is based on the following formula (Fuchs 2011).

$$(5) \quad \text{DEV}(\xi_j) = \frac{\sum \lambda_i^2}{\sum \lambda_i^2 + \sum_i \text{var}(\varepsilon_i)}$$

According to Fuchs (2011) AVE values above 0.5 are a precondition for an acceptable AVE so that the common variance of the indicator variables is greater than the influences of the measurement errors. The Fornell-Larcker criterion serves to check the discriminant validity according to Weiber & Mühlhaus (2010). The criterion is assumed to be confirmed if the square root of the AVE value is greater than all correlations with other factors.

##### 5. *Assessment of the structural model*

In connection with the assessment of the structural model Weiber and Mühlhaus (2010) also mention four assessment criteria: path coefficients with their t values, coefficient of determination  $R^2$ , effect size  $f^2$  and the Stone-Geisser criterion  $Q^2$ .

Weiber & Mühlhaus (2010) define path coefficients as “standardized partial regression coefficients”. They lie on an interval from -1 to 1. The value zero signifies that there is no influence on the dependent value, the values minus one and one signify that there is a strong influence on the dependent variable (Fuchs 2011). The sign of the path coefficient indicates the direction of the response relationship and confirms or refutes the assumption regarding the direction of the response relationship in the causal hypotheses (Weiber & Mühlhaus 2010). According to Chin (1998), path coefficients  $\geq 0,2$  or  $\leq -0,2$  are important. In contrast to this, Lohmöller (1989) only states a minimum value of 0.1 or -0.1. Henseler and coauthors (2009) mention the bootstrapping procedure to determine the t values of the path coefficients. According to Rasch et al. (2006), the t test serves to contradict the zero hypothesis, i.e. to determine that there is a difference between the groups to be compared. As a counterpart to the zero hypothesis an alternative hypothesis (the actual working hypothesis) is formulated which assumes a difference between the mean values of the groups. A significant t test result is always synonymous with refusing the zero hypothesis. A distinction is made between targeted and non-targeted hypotheses. The relevant determination is based on contextual reasons. The assignment of the alternative hypothesis always depends, however, on direction and test strength. While non-directed hypotheses support the assumption that the difference between the values is not equal to zero without speculating about the sign of the difference, targeted hypotheses are based on assumptions in which direction the mean values deviate (Rasch et al. 2006). The t test for non-targeted hypotheses is carried out according to Manderscheid (2012) as a two-tailed test. One-tailed t tests do, however, apply to targeted hypotheses. In order to determine the level of significance of a one-tailed t test, the p value of a two-tailed t test which refers to the error probability can simply be halved

(Ostrowski 2007, Weiß & Rzany 2010). T values  $\geq 1.96$  (with an error probability amounting to 5%) designate in case of two-tailed t tests according to Fuchs (2011) a significant influence of a variable on another variable. Weiber & Mühlhaus (2010) additionally mention the threshold value  $t \geq 1,65$  which refers to a significant influence with an error probability of 10% in case of two-tailed t tests.

The coefficient of determination  $R^2$  refers to the proportion of the declared variance of an endogenous variable in relation to the overall variance (Nitzl 2010). Fuchs (2011) designates this as the “central criterion for the assessment of structural models within the framework of PLS analyses”. It is calculated for all endogenous variables and lies between zero and one (Fuchs 2011). According to Nitzl (2010), the required minimum values are dependent on the research question. Many authors, however, quote the three-step assessment system developed by Chin (1998). According to him, a coefficient of determination of  $R^2 \geq 0.67$  is substantial,  $R^2 \geq 0,33$  is moderate, and  $R^2 \geq 0.19$  is weak.

The effect size  $f^2$  determines if an important influence is exerted on an endogenous variable by an exogenous variable. To carry out the relevant calculation, the coefficient of determination is calculated once within the whole model ( $R^2$  (ExIV included)) and once without the considered exogenous variable ( $R^2$  (ExIV excluded)). This enables assessment of the total effect of a variable on an endogenous variable via the following formula (Nitzl 2010):

$$(6) f^2 = \frac{R^2(\text{ExLV included}) - R^2(\text{ExLV excluded})}{1 - R^2(\text{ExLV included})}$$

Fuchs (2011) assesses the influences of the exogenous variable on the endogenous successor for values amounting to  $f^2 \geq 0.02$  as low,  $f^2 \geq 0.15$  as moderate, and  $f^2 \geq 0.35$  as high.

The Stone-Geisser criterion can be determined via the blindfolding procedure according to Henseler and coauthors (2009). The Stone-Geisser test assumes systematically that a certain portion of the empirical data are missing and uses the compiled PLS model in order to estimate the missing data. This process ends as soon as each data point has been estimated once. Depending on the reconstruction capability of the dataset by means of the PLS model, the prediction relevance  $Q^2$  of the module can be estimated (Nitzl 2010). Henseler and coauthors (2009) determine  $Q^2$  values  $> 0$  as relevant for prediction.

### 2.3.2 The Kano model

Using scales for statistical analyses is in particular common in economic science (Thomas et al. 2002). On the basis of different measurement levels, four scales can be distinguished (Behnke & Behnke 2006):

- Nominal scale: assignment of scale values to characteristics (without further significance)
- Ordinal scale: ranking of elements by means of the assignment of numbers
- Interval scale: determination of gaps between measurement values

- Ratio scale: statements regarding relations between measurement values and definition of point of origin

If surveys are used to determine the status quo or evaluate certain significances and facts, the use of ordinal scales is ideal since this enables ranking of answer options (Behnke & Behnke 2006).

A special type of scaling is suggested by Kano and coauthors (1984). In the Kano model, the correlation of objective and subjective quality is shown defining the objective quality by the level of achievement of product characteristics and the subjective quality by means of customer satisfaction (Kano et al. 1984).

Kuo and coauthors (2011) explain that in the Kano model achievement of a characteristic does not necessarily lead to customer satisfaction. Owing to this, the Kano analysis is amongst two-dimensional quality models. In contrast to this, customer expectations in one-dimensional quality models are deemed to be satisfied if the characteristics required are achieved, and vice versa (Kuo et al. 2011).

According to Jochem & Geers (2010), the two-dimensionality of the Kano model comes from Herzberg's motivation theory (1966). This is based on a survey carried out by Herzberg in 1966 with 203 employees regarding their satisfaction or dissatisfaction (Jähnig 2007). From the survey resulted a subdivision of the contemplated aspects into hygiene factors (dissatisfied respondents or dissatisfiers) and motivators (satisfied respondents or satisfiers). While hygiene factors are expected by employees and their non-fulfillment leads to dissatisfaction, fulfillment of motivators results in an improvement of employees' satisfaction (Jähnig 2007).

Kano and coauthors (1984) classify product characteristics according to customer expectations into five groups which are also called quality elements. This categorization enables an assessment of the extent to which product characteristics are especially valued by customers and therefore have priority when it comes to their implementation (Kano et al. 1984, Berger et al. 1993).

In order to be able to assign product characteristics to individual categories, Kano and coauthors (1984) as well as Berger and coauthors (1993) realize a survey on the topic of customer satisfaction. This is based on bipolar questioning. Customers are to state their satisfaction by means of existing (functional questioning) and non-existing (dysfunctional questioning) selected product characteristics on a five-digit scale (like, must-be, neutral, live with, dislike). In the Kano assessment table (see Table 3), the answers of functional and dysfunctional questions for each product characteristic are compared individually.

**Table 3: Kano assessment table (Berger et al. 1993)**

Customer expectation		Dysfunctional				
		1. like	2. must-be	3. neutral	4. live with	5. dislike
Functional	1. like	Q	A	A	A	O
	2. must-be	R	I	I	I	M
	3. neutral	R	I	I	I	M
	4. live with	R	I	I	I	M
	5. dislike	R	R	R	R	Q

Customer requirement is: A = Attractive, M = Must-be, R = Reverse, O = One-dimensional, Q = Questionable, I = Indifferent

Owing to the combination of answers, a subdivision of the characteristic queried into five groups of quality elements is done and these are represented in the Kano diagram (Fig. 5) (Kano et al. 1984; Berger et al. 1993):

- “Must-be” quality element: high customer satisfaction in case of non-fulfillment; no increased satisfaction in case of fulfillment → Basic requirement
- “One-dimensional” quality element: customer satisfaction increases/decreases proportionally to the level of fulfillment of the product characteristic → Performance requirement
- “Attractive” quality element: no customer dissatisfaction in case of non-fulfillment; high degree of customer satisfaction in case of fulfillment → Unexpected extra performance
- “Indifferent” quality element: no influence on customer satisfaction in case of fulfillment/non-fulfillment of product characteristic
- “Reverse” quality element: high degree of customer satisfaction in case of non-fulfillment of a product characteristic; high degree of dissatisfaction in case of fulfillment of a product characteristic

Jochem und Geers (2010) explain that by fulfilling the basic requirements not mentioned and taken for granted by the customer, dissatisfaction is prevented in the Kano model. Satisfaction can only be achieved, however, by implementing the performance requirements acting proportionally to the degree of fulfillment. Additional fulfillment of not expected extra performance leads to a high degree of customer satisfaction (Jochem & Geers 2010) which according to Prefi (2007) enables a proper differentiation between products and services of competing products on offer as well as offer of services.

In the Kano analysis, products or product characteristics can refer to material goods and also to services and their features. Correspondingly, Berger and coauthors (1993) and Lin and coauthors (2010) for example mention in their theses products and services in parallel. Similarly to contemplating product characteristics, different types of requirements in connection with customers result from the assignment of service characteristics to quality elements. These are also shown in Figure 5.

Bruhn (2008) defines customer expectations with reference to services as follows: "With regard to the performance of a company, customer expectations designate a psychological status referring to the future use of services offered by a service provider." In accordance with this definition, service quality is also defined in addition to the services offered by the expectations of customers. Depending on the assignment of a characteristic to diverse quality elements, a different degree of customer satisfaction results from its fulfillment (Jochem & Geers 2010). Berger and coauthors (1993) as well as Lin and coauthors (2010) also stress that the respective type of requirement of a service characteristic influences the effect on the service quality at the time of fulfillment. Control of customer expectations is therefore in addition to performance optimization an important success factor in quality management.

Geng and coauthors (2011) use the Kano analysis for example to categorize product characteristics as well as product-related services according to the quality characteristics defined by Kano.

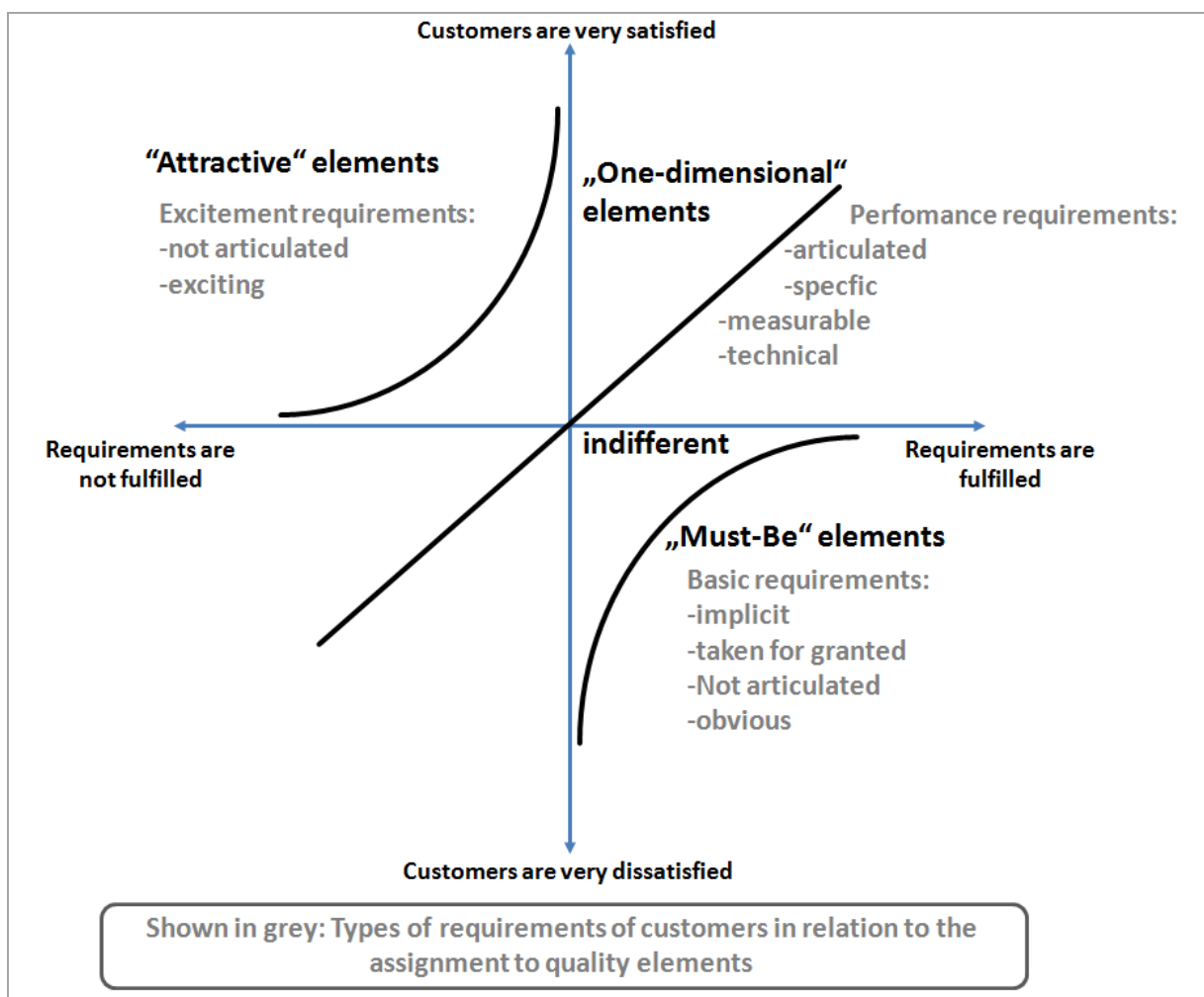


Fig. 5: Kano diagram supplemented by the types of requirements of customers (mod. acc. Kano et al. 1984, Berger et al. 1993)

Kim and coauthors (2008) based the development of new services, amongst others, on their categorization in terms of the Kano model. By means of a morphological analysis, all basic characteristics and their features within a service process were put together (morphological box). On the basis of a benefit assessment of individual characteristic features, new combinations were determined. The best combinations were assigned to the individual quality elements by means of a Kano analysis. The results of benefit assessments and Kano analysis could be used for drawing up promising service structures (Kim et al. 2008).

Huiskonen & Pirttilä (2008) classify service elements with the help of the Kano model. The objective was to define the most important services from the customer's point of view and also present differences between individual groups of consumers. When doing this, services were subdivided into three groups on the basis of the Kano model: "Expected service element", "One-dimensional service element" and "Attractive service element". In addition to this, Huiskonen & Pirttilä (2008) defined further values. They designated for example services as "attribute service elements" if there are only two different versions, i.e. existing or non-existing. "Attribute service elements" can in turn be represented in all of the three previously mentioned groups.

Otzmann (2005) mentions the Kano model in connection with targets in quality management. The author explains that a high degree of customer satisfaction is an important requirement for the economic success of a company. This can be reached in particular if customer needs regarding the expected product quality are exceeded. Otzmann (2005) makes use of the Kano quality elements here. According to him, factors of excitement form an important basis for increasing customer satisfaction. In this context, Otzmann (2005) as well as Jochem & Geers (2010) mention time dependence regarding assignment to quality elements. In the course of time, attractive factors develop to one-dimensional factors and one-dimensional factors become basic factors.

### 3. Methods and procedures

During an EU-wide research and development project (FP6-036245-2), experts and participants of several pork chains from Germany, the Netherlands, Denmark, Spain and France were available for empirical investigations on development potentials in inter-enterprise health management. On the one hand, gilt rearers, piglet producers and pig fatteners as the relevant target group, and, on the other hand, their service providers, such as pig traders, farmers' cooperatives or consulting organizations, were questioned.

In order to assess the significance of principles and methods of quality management regarding service providers in inter-enterprise health management, the empirical analysis was carried out in five principal phases.

In the *first phase*, a literary analysis was concerned with characterizing sector-specific peculiarities of activities relevant for quality management in the agriculture and food industry. The main focus here was on organizational structures of the pork chain and the challenges of inter-enterprise health management.

In the *second phase*, first of all customer expectations of the farmers as service users were registered. Here the main focus was on getting a public opinion regarding the demand for an exchange of information relevant for health management.

In order to verify the assumed organizational support of farmers, service providers with existing or future planned functions as network coordinators were included in the collection of data. It was aimed at determining the extent to which they are already using quality management methods within the framework of health management activities and to which extent they are already coordinating activities in health management (*phase 3*). In order to conclude *phase three*, the questioned network coordinators were classified in a cross diagram with regard to the implementation level of quality management methods as well as their coordination results in health management.

*Phase four* dealt with an estimation of development potentials regarding the methodical substantiation of activities in health management. Additionally a proposal was formulated for the extension of coordination services in inter-enterprise health management on the basis of the Kano analysis. Based on the results, a concept was developed how preventive quality management methods could be integrated into processes of inter-enterprise health management of pork chains (*phase 5*).

Finally and as a kind of outlook the assessment of factors affecting the quality of coordination services on the basis of the structural equation analysis (*phase 6*) was carried out.

The following figure 6 presents an overview of individual methodical steps which are thoroughly explained in the next subchapters.

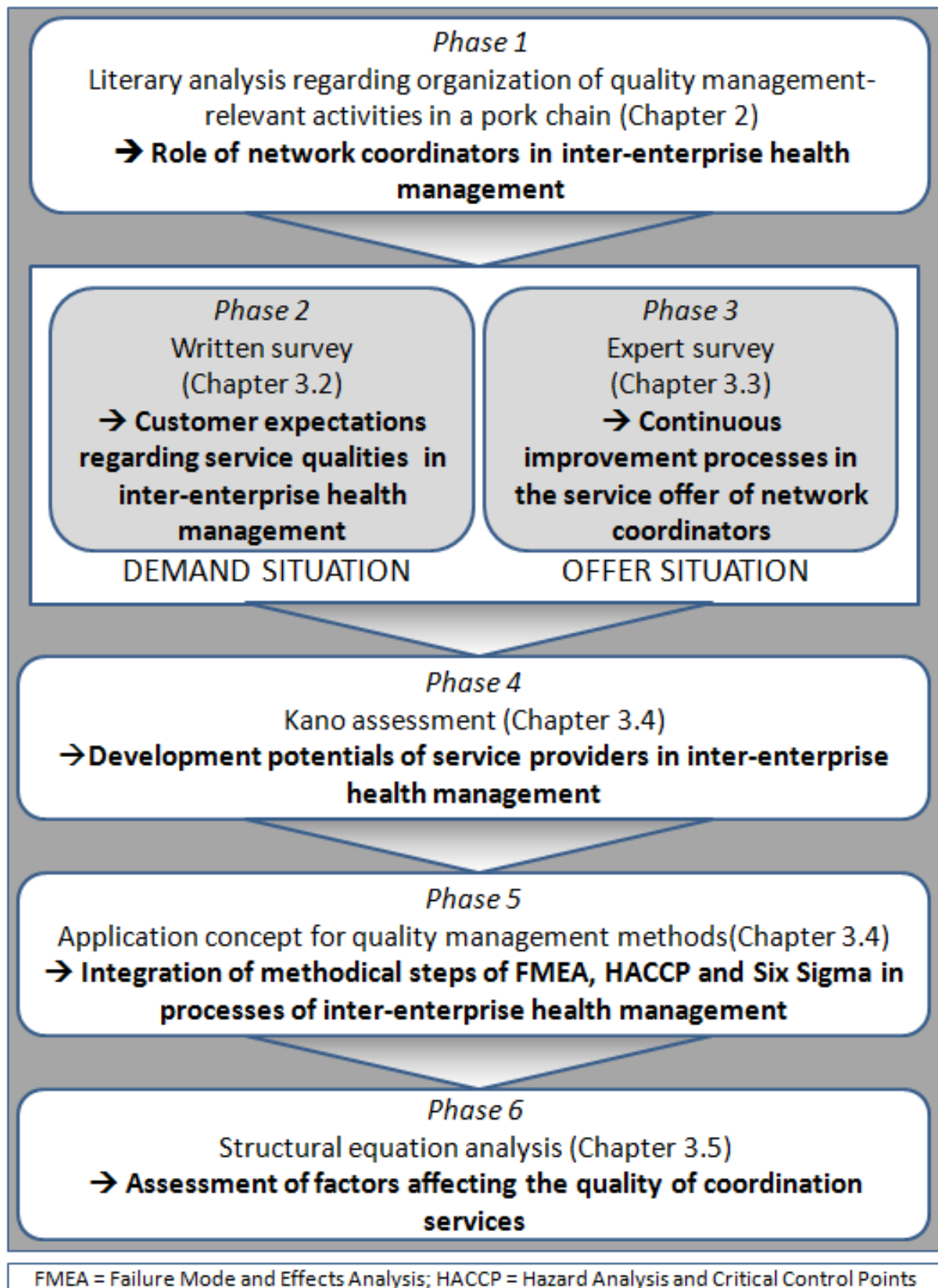


Fig. 6: Overview of methods and procedures



### 3.1 Selection of test enterprises and experts

The empirical investigations conducted aimed at evaluating the use of quality management methods in inter-enterprise health management of pork chains.

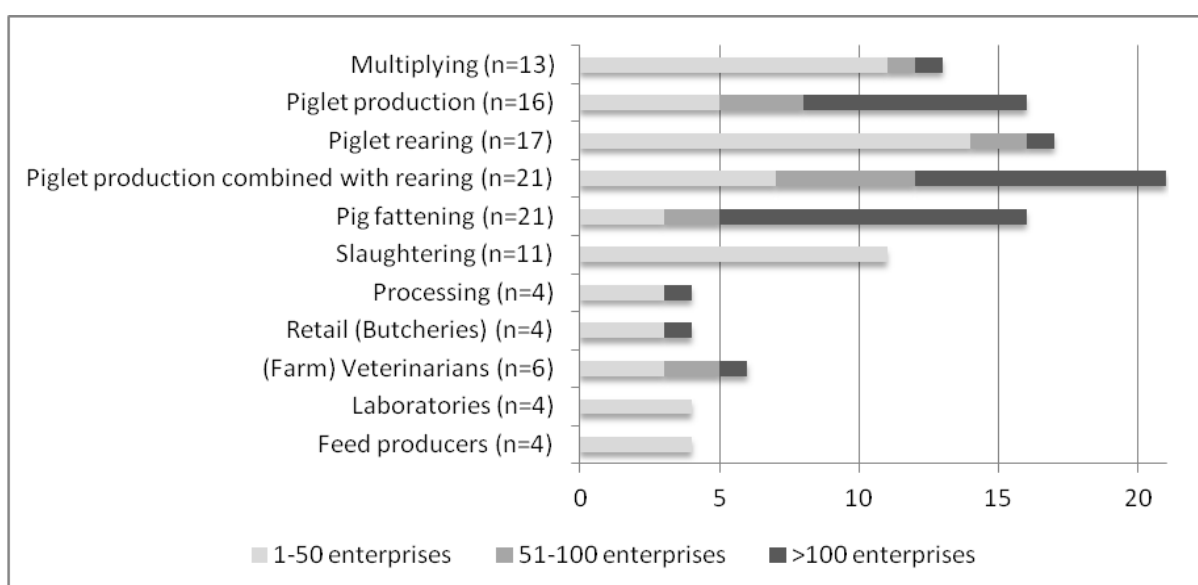
In order to achieve this, it was planned to question the directly involved participants in the primary production, on the one hand, and on the other hand, the potential network coordinators. Consequently by evaluating the demand for an inter-enterprise information exchange in health management as well as for support with activities in health management of piglet producers, piglet rearers, piglet fatteners as well as gilt rearers, customer expectations of the farmers was ascertained. In addition to this, the assessment of the status quo regarding the application of quality management methods in service organizations as well as their degree of coordination services in health management was determined. Data collection involved three partial surveys (see Table 4). Since various types of organizations and enterprises (farmers' cooperatives, pig marketing organizations, slaughterhouses, etc.) can take over the role of a network coordinator there is no concrete target group as is the case with the target groups of the primary production. Owing to this, the possible participants of partial survey three were contacted previously by phone and the fulfillment of the participation criteria (service offer for at least two production stages, offer of or interest in services in inter-enterprise health management) as well as their willingness to participate was ascertained. By this measure, the targeted sample of 55 organizations was reduced to 30 experts to be invited.

**Table 4: Extent and characteristics of the target groups belonging to the three partial surveys**

		Extent of the samples according to target groups		
		Survey No. 1	Survey No. 2	Survey No. 3
<b>Target group</b>		Farmers	Farmers	Service providers/ experts
<b>Total number of persons invited</b>		213	512	30
<b>Response rate in % (absolute)</b>		47.9% (102)	20% (104)	70% (21)
<b>Characteristics of participants</b>	<b>Piglet producers</b>	61	13	-
	<b>Piglet rearers</b>	-	6	-
	<b>Piglet fatteners</b>	41	64	-
	<b>Closed system</b>	-	14	-
	<b>Gilt rearers</b>	-	7	-
	<b>Managing directors</b>	-	-	13*
	<b>Quality assurance representative</b>			7*
	<b>Consulting/ customer acquisition</b>			2
	<b>Miscellaneous</b>			3
*) Four experts have a double function (managing director + quality assurance representative)				

The enterprises of the first data collection were distributed geographically over Northwestern Germany. They were characterized by an average enterprise size of 236 pigs (55-600) in piglet-producing enterprises and 1231 fattening sections (360-5500) in fattening enterprises. The second data collection included pig producers from Southern Germany and also gilt rearers from Central Germany with the following average enterprise sizes: 1019 gilts in gilt-rearing enterprises (14-2400), 155 pigs in piglet-producing enterprises (12-500), 763 piglets in piglet-rearing enterprises (40-2100) as well as 558 fattening places in pig-fattening enterprises (25-3100).

25 of the questioned service organizations from partial survey three are located in Germany, two in Denmark, one in Spain, one in France, as well as one in the Netherlands. Almost all of the enterprises focus their services on the production stages of piglet production, piglet rearing and fattening. Relatively often, the directly preceding or succeeding phases, i.e. multiplying and slaughtering, are included as well. With about one third of the enterprises questioned, veterinarians and feed advisors are also incorporated in the service spectrum. Processing, retail and laboratories are only very rarely taken into account in the service offer. Figure 7 shows an overview of the number of enterprises which are supported in the individual production stages of service organizations. It is obvious that the customer base, especially in piglet production and pig fattening, is relatively large. In these production stages the majority of organizations questioned has more than 100 customers. Whereas in case of veterinarians, processing enterprises and retailers with more than 20 % of the enterprises there still is a quite large customer base, the number of customers in feed production, laboratories, slaughterhouses and gilt reproducers predominantly amounts to less than 50 enterprises. This correlates, naturally, strongly with the average size of enterprises dependant on the relevant production phase.



**Fig. 7: Relative number of service users in each production phase regarding the organizations questioned**

### 3.2 Written survey to estimate customer expectations

The expectations of pig farmers in their function as customers of coordination services stood in the foreground of the first empirical studies. Of special interest was the *demand* for an information exchange between piglet production and fattening and the *interest* in information of the other production stages and the *willingness* of the animal owner to provide information. The partial survey was done in writing and offered the possibility to survey an extensive and geographically distributed sample with relatively low cost and time involved. The people questioned could thus determine on their own when they wanted to answer the questions and were also not influenced by the interviewers.

Disadvantages such as low response rates or that it was not possible to elaborate further were minimized as far as possible by previous phone contacts, inclusion of multipliers such as producer or bundler organizations, as well as by providing a contact for queries.

When questioning the farmers (213), this was done in a traditional way, i.e. by sending them the questions via mail with cover letters and stamped addressed envelopes. In order to gain access to a larger sample, producer or bundler organizations were included in the distribution of the questionnaires, if possible.

The partial survey included, above all, closed questions with predetermined answers. This made it easier for the participants to provide answers and enabled a comparable evaluation of the respective answers. In addition to this, it was possible to enter individual information in free-text fields at eight different places. The majority of the questions (13) was based on four-point Likert scales. These were oriented each so that one reflected the lowest manifestation and four the highest manifestation.

Before the survey began, a pretest with 5 experts was concluded which evaluated the questionnaire regarding size and scope, comprehensibility and conclusiveness. After a subsequent adjustment of the questionnaires, they were sent out. The response time for the farmers was limited to one month.

As the main participants of the primary production in the pork chain, only piglet producers and fatteners were questioned to ascertain their demand for an exchange of health information. The customer expectations regarding coordination services were questioned indirectly in this context insofar as piglet producers and fatteners first of all stated their interest in the information relevant for the health management of the other production stage on a scale of four. As a second measure, they were asked to state their willingness to provide information affecting health management to piglet producers or pig fatteners on a scale of four. The two scales of four used as well as the relevant scoring are shown in the following Table 5.

**Table 5: Scales of four to evaluate the demand and passing on of information in inter-enterprise health management**

	<b>Opinion of the farmers questioned regarding the interest in information</b>	<b>Scale value</b>	<b>Opinion of the farmers questioned regarding the willingness to provide information</b>
Scale	Yes, in general	1	Yes
	Not on a regular basis	2	Upon consultation
	To a limited extent (only in case of acute problems)	3	To a limited extent (only in case of acute problems)
	No, in general	4	No, in general

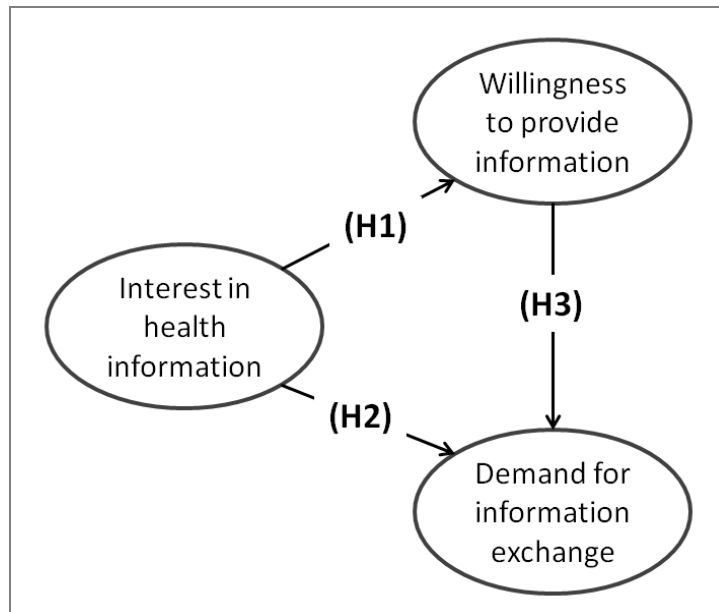
In order to represent statistical interrelations, the methodology of structural equation modeling was chosen. In this respect, the definition of three latent variables was first defined:

- LV1: “Interest of piglet producers/fatteners in information of the other production stage” (in the following called “interest in information”)
- LV2: “Willingness of piglet producers/fatteners to provide information to the other production stage (in the following called “willingness to provide information”)
- LV3: “Demand of piglet producers and fatteners for a mutual exchange of information (in the following called “demand for information exchange”)

The variables refer to data and facts which concern the information exchange in inter-enterprise health management. For reasons of simplicity, this expression is shortened in the following to information.

Based on logical considerations, three hypotheses for the relationships between the variables were formulated in the following which form the basis for creating the structural model (Figure 8).

- (H1): The greater the interest in information of the other production stage (piglet production/fattening), the greater the demand for a mutual exchange of information and thus for coordination services.
- (H2): The greater the interest in information of the other production stage (piglet production/fattening), the greater the willingness of the other production stage to provide own information and also to make use of coordination services.
- (H3): The greater the willingness to provide own information to the other production stage (piglet production/fattening), the greater the demand for a mutual exchange of information and thus for support in inter-enterprise health management.



**Fig. 8: Structural model to represent the interactions of three latent variables, i.e. interest, willingness and demand regarding health information and coordination services**

After defining the frame of the structural model shown in Figure 8 for the three latent variables, specific measurement indicators were established. For this, the scale values of several detailed answers to individual questions were averaged and thus values assigned to more exhaustive thematic blocks. The subsequent Table 6 shows which of these measurement indicators was available for calculating the three variables. The formulas to calculate reflective measurement models are explained in Chapter 2.3.1.

**Table 6: Assignment of the generated measurement indicators to the three latent variables**

Latent variables (LV)	Measurement indicators (I)
Interest in inter-enterprise health management (LV1)	Interest in I <sub>1.1</sub> : Enterprise information (amongst others, veterinarians, advisors) I <sub>1.2</sub> : Disease data (amongst others, diseases, treatments) I <sub>1.3</sub> : Health status (amongst others, PRRS, salmonella, organ findings) I <sub>1.4</sub> : Performance data (amongst others, daily weight gain, feed efficiency, slaughter weight) as well as I <sub>1.5</sub> : Actual exchange of information with participants of the chain I <sub>1.6</sub> : Use of computer programs for data processing I <sub>1.7</sub> : Participation in quality management programs
Willingness to provide information relevant for health management (LV2)	Willingness to provide information on I <sub>2.1</sub> : Enterprises (amongst others, veterinarians, advisors) I <sub>2.2</sub> : Disease data (amongst others, diseases, treatments) I <sub>2.3</sub> : Health status (amongst others, PRRS, salmonella, findings reports) I <sub>2.4</sub> : Performance data (amongst others, daily weight gain, feed efficiency, slaughter weight)
Demand for mutual exchange of information relevant for health management (LV3)	Necessity of agreement with farm veterinarians of piglet producers and fatteners regarding I <sub>3.1</sub> : Diseases I <sub>3.2</sub> : Vaccinations I <sub>3.3</sub> : Deworming I <sub>3.4</sub> : Group treatments I <sub>3.5</sub> : Individual animal treatments I <sub>3.6</sub> : Laboratory results as well as I <sub>3.7</sub> : Participation in farmers' cooperatives I <sub>3.8</sub> : Planned exchange of information with participants of the chain

Regarding the three measuring models, it was furthermore necessary to define the relevant direction of action. For this purpose, the dependency between measurement indicators and variables was considered. It is assumed that a change of the variable results in a change of measurement indicators. Therefore, these are reflective measurement models. Owing to this, the structural equation model consisting of two measurement models and the structural model could be created (see Figure 9).

The software SmartPLS (Ringle et al. 2005) was used to construct and evaluate the structural equation model. By inserting the variables and their relationship and adding the relevant indicators, the structural equation model could be visualized in SmartPLS (see

Figure 9). By means of the PLS algorithm, the latent variables could be estimated in an iterative process.

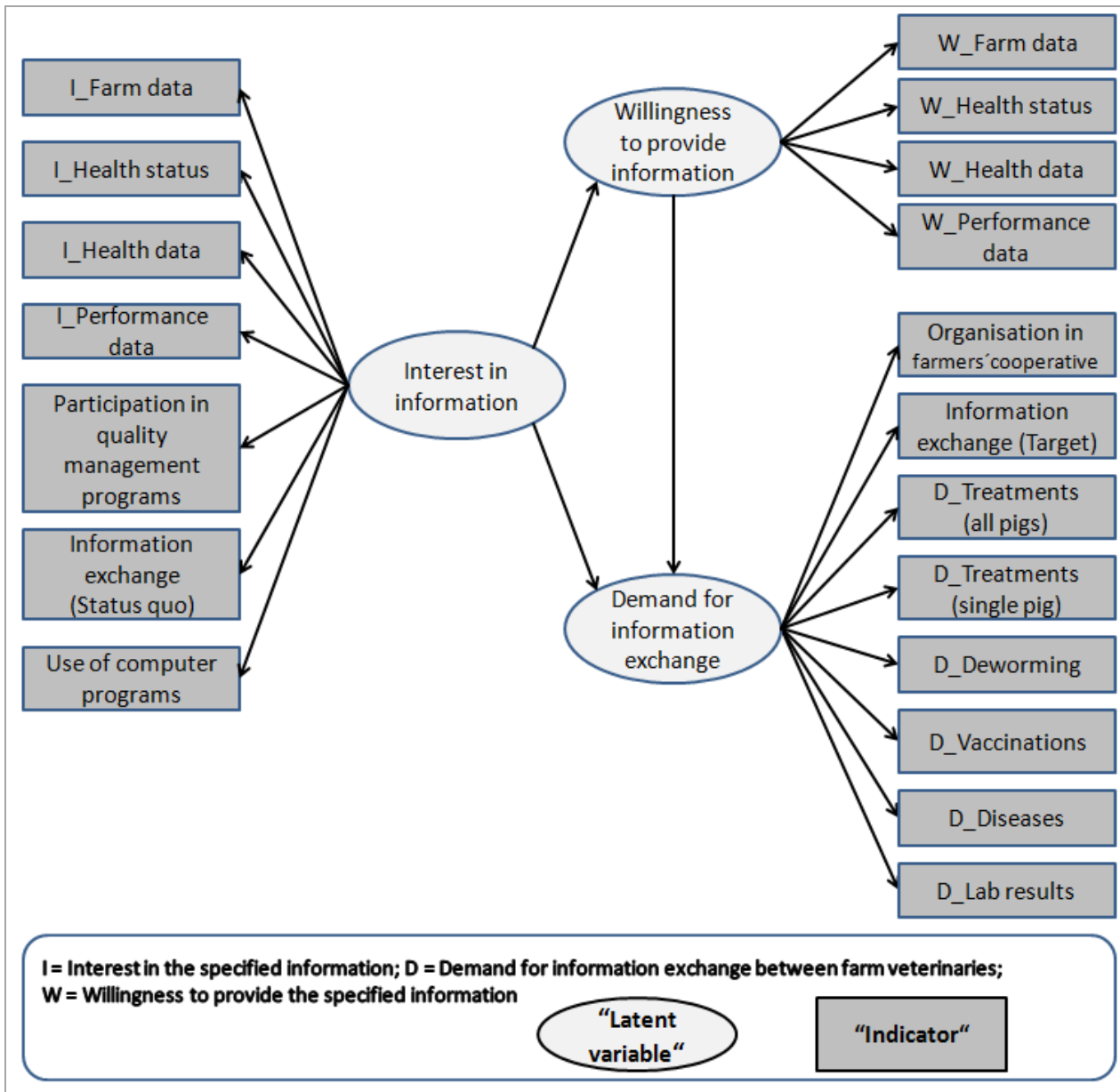


Fig. 9: Structural equation model

In order to evaluate the applicability of the model, the quality of the reflective measurement model was assessed in a first step. The three assessment coefficients, i.e. indicator reliability, factor reliability and average variance extracted were determined in order to define the convergence validity. The relevant indicator reliabilities were calculated from the squared standardized factor loadings. The internal consistency reliability (extracted via the composite reliability) as well as the average variance extracted (AVE) were calculated with the help of the PLS algorithm for the latent variables. All three values were compared with the minimum values requested in literature (see Chapter 2.3.1). Thus, the level of fulfillment of the individual assessment criteria could be determined. The square roots of the factor reliabilities

were calculated in order to verify the discriminant validity and compared with the correlations of the latent variables whereby the correlations of the considered latent variables with other latent variables have to be less than  $\sqrt{AVE}$  in order to fulfill the discriminant validity.

After carrying out the assessment of the reflective measurement model, the quality of the structural model was assessed. This was also based on four assessment criteria. The coefficient of determination  $R^2$  which reflects the proportion of the declared variance of an endogenous variable could be deduced from the calculations of SmartPLS. Depending on the relevant manifestation, it was possible to carry out a classification in weak, intermediate and substantial. Subsequently, the bootstrapping procedure in SmartPLS was performed. When considering the standardized path coefficients, it was possible to evaluate if these were above the required minimum value of 0.2 (see Chapter 2.3.1). The calculated relevant t values enabled an assessment of strength and significance of the relevant response relationship between the constructs.

The calculation of the effect size  $f^2$  was only done for the variable (LV3) "Demand for information exchange" since the paths of two latent variables are aiming at this. It was calculated by means of the following formula:

$$(1) f^2 = \frac{R^2(\text{ExLV inclusive}) - R^2(\text{ExLV exclusive})}{1 - R^2(\text{ExLV inclusive})},$$

whereby  $R^2(\text{ExLV inclusive})$  for the regularly determined coefficient of determination and  $R^2(\text{ExLV exclusive})$  for the determined coefficient of determination applies, for which the relevant variable for the path size is excluded from the structural model. The result was compared with the minimum value of 0.02 required by Fuchs (2011).

In order to assess the prediction relevance, the Stone-Geisser criterion  $Q^2$  was calculated with the help of the blindfolding procedure in Smart PLS. Values of the construct cross-validated redundancy  $\geq 0$  were interpreted as relevant for the prediction regarding the reflectively measured variables.

In a further step, the structural equation model was separately calculated once more with the data of the target group piglet producers or fatteners. This was done to consider differences in the expectations within this special customer supplier relationship when interpreting the calculation results.

A literature study resulted in the prioritization of the most important prerequisites for effective health management. By means of the information given by the farmers in the partial surveys (PS) one and two regarding

- involving advisors (PS1)
- carrying out initiatives to realize monitoring activities (PS2)
- and the form of investigation results available to them (PS2) and their means of processing (PS1),

gaps regarding necessary support measures could be discovered. These analyses were based on *hypothesis (4)*, i.e. that *many activities in health management can only be realized with the support of third parties for farmers owing to the high degree of organizational effort involved.*



In the partial survey three, the questioned network coordinators could state via the answer scales given in Table 7 to what extent they offer defined services relevant for health management or to what extent these are requested from them by the farmers.

**Table 7: Answer scales for information regarding the services offered by network coordinators and services demanded by farmers and their rating**

Scale	Service offer	Service demand
1	Not at all	Not at all
2	Planned	Requested once
3	Orally agreed	Requested several times
4	Written agreement (manual)	Regularly under discussion
5	Successfully realized according to the manual	Requested by the majority

The sequence mentioned regarding weighting of the answers resulted in measurement values between one and five which were shown and compared in a diagram.

The results of the surveys in connection with inter-enterprise information exchange and the coordination of services in health management of pork chains represents the starting point for further evaluations regarding the organization of network coordinators.

### 3.3 Survey of experts on service offers provided by network coordinators

After a telephone pre-selection of the experts to be invited (Chapter 3.1), the group of experts to be contacted was complete. Since the relevant experts in their function as service providers are already working with computer and internet on a regular basis, partial survey three made use of the online survey software “Unipark”. The software permitted creating a dynamic questionnaire with integrated filter functions so that the participants were automatically referred only to the questions relevant for them on the basis of the answers given. Furthermore, it was possible to integrate several languages into the software which were transferred automatically back to the main language for evaluation purposes. Since the participants came from five different European countries, one and the same questionnaire was provided in a German and in an English version.

For matters of simplicity and ease of evaluation, the survey mostly contained closed questions with predetermined answers. Text boxes enabled entry of individual additional information. Since the survey quite often evaluated the status quo or an assessment regarding meanings and facts was to be provided, the use of ordinal scales seemed ideal since these made it possible to determine a ranking order regarding answering options. For this purpose, the answers given in the expert survey were classified hierarchically and values assigned to the relevant answers so that later on statistical evaluation was possible. A pretest with five experts showed that answering the questions took approximately 25 minutes and resulted in some corrections and additions. Subsequently, a cover letter with a link leading to the questionnaire was sent out via mail to the experts. The response time including reminders was limited to three months.

The questionnaire consisted of an introductory chapter and two main sections. The seven introducing questions were used to classify the experts and their organizations regarding

their tasks, functions and customer base. The two content sections both referred to activities of network coordinators in inter-enterprise health management. While part one served to determine coordination services (18 questions), part two contemplated the level of implementation of quality management methods (14 questions).

Considerations regarding the contents were based on the nine elements of health management which according to Schütz (2009) are elementary components of an inter-enterprise health management system. It became quite clear that the service categories organization of an inter-enterprise information exchange, support for data processing, advisory service and auditing, organization of certificates and organization of monitoring sessions are part and parcel of many of these elements and are thus seen as essential elements to support inter-enterprise health management. Table 8 shows assignment of service categories to the elements of health management. The sum of possible assignments is mentioned in the penultimate line. The defined service categories form the substantive basis for determining coordination services in inter-enterprise health management.

**Table 8: Assignment of service categories to the elements of health management (mod. acc. to Schütz 2009)**

Elements of health management	Organization of inter-enterprise information exchange	Support for data processing	Advisory service/audit	Issue of certificates	Organization of monitoring sessions
Health control	x	x	x	-	x
Herd diagnostic evaluation	x	x	x	-	x
Environmental analyses	x	x	x	-	-
Verification/safeguarding of legal conformity	-	x	x	-	-
Information and document exchange	x	x	-	x	x
Pre- and post-processing of special measures	x	x	x	-	x
Creation of preliminary reports	x	x	x	x	
Delivery of early warning/alarm information	x	x	x	-	-
Compilation of health certificates	x	x	x	x	x
<b>Sum of possible assignments of results to individual elements</b>	<b>8</b>	<b>9</b>	<b>8</b>	<b>3</b>	<b>5</b>

x = Important part of the element; - = No part of the element

### 3.3.1 Recording the extent of coordination tasks with sector-specific service providers

The first part of the survey covered the question to which extent activities in inter-enterprise health management are coordinated by network coordinators and defined results are certified. The experts were required to state to what extent they are planning projects in defined areas or implement such projects in order to measure the effectiveness of an inter-enterprise health management system. In this regard, projects were understood to be harmonized activities by means of which a predetermined aim is to be reached taking defined framework conditions (cost, time, personnel expenditure, etc.) into account. Definition of project activities was based on the nine elements of health management. A scale of five was used to state the status of different project activities assigned to the health management elements (Table 9).

**Table 9: Scale of answer options for the indication of the project status in inter-enterprise health management**

Scale	Project status
1	No project exists at the moment
2	A project is planned
3	A project has been in existence for a short time (< 1 year)
4	A project has been in existence for a longer time (> 1 year)
5	Successful project with measurable results

The answers for the individual sub-items of each health management element were looked at more closely, and the maximum value for the sub-items for an element considered as decisive in order to assess project activities. Thus, the project activities for each of the nine elements could be determined.

Since so far no prioritization of the nine elements of the health management exists in literature, a uniform weighting was assumed when aggregating the values for each element to form an overall level of implementation. Accordingly, the average was calculated for all network coordinators. The level of implementation and thus the effectiveness could be determined by means of the scale mentioned in Table 10.

**Table 10: Scale for assessing the effectiveness of an inter-enterprise health management system**

Scale	Effectiveness of health management
1	No activities in health management
2	Health management activities are planned
3	Comprehensive health management has been in existence for a short time (<1 year)
4	Comprehensive health management has been in existence for a long time (>1 year)
5	Successful health management with measurable results is performed

Questions regarding the three areas of audit management, monitoring sessions and certifications served in the next stage to determine the degree of coordination of services in inter-enterprise health management. With the exception of three questions, all of them were based on a scale of five using the same orientation as in the previous part (1 = lowest score; 5 = highest score). Taking different weightings into consideration, it was possible to determine an overall value for the coordination services of network coordinators in inter-enterprise health management with the help of an arithmetic mean. This value served to assign the network coordinators on the scale mentioned in Table 11.

**Table 11: Scale to assess the accumulated coordination services of network coordinators in inter-enterprise health management**

Scale	Implementation level of coordination services
1	None
2	Planned
3	Oral agreement
4	Written agreement (manual)
5	Successful implementation based on a manual

The results regarding the effectiveness of activities in inter-enterprise health management and the offered coordination services were compared in a correlation diagram in order to prove *hypothesis (5)*, i.e. that *effective inter-enterprise health management is characterized by a successful coordination of inter-enterprise services*.

### 3.3.2 Determining the degree of popularity of quality management methods with network coordinators

Determination of the degree of application of preventive quality management methods by network coordinators was based on *hypothesis (6)* i.e. that *most network coordinators did not know about preventive quality management methods regarding the relevant terms, however, the principles or partial aspects of these are subconsciously integrated into their processes*.

Questions regarding concrete usage of methods referred to three methods: Failure Mode and Effects Analysis (FMEA), Hazard Analysis and Critical Control Points Concept (HACCP) as well as Six Sigma. As a first step, the experts questioned were to evaluate the degree of popularity of quality management methods by means of the answer scale given in Table 12.

**Table 12: Scale of answer options regarding the popularity of quality management methods**

Scale	Answer options
1	Not known
2	Already heard of but no details known
3	Already heard of; coarse classification possible
4	Already familiar with methods
5	Already experienced in application of methods

On the basis of the arithmetic mean of the answers received, the degree of popularity of the quality management methods with network coordinators was made possible.

Subsequently, questions regarding the preconditions for the application of preventive quality management methods defined in the previous chapter were asked:

1. Existence of a quality management team
2. Approximation of the activities to the Deming cycle
3. Use of tools proven in quality management

Ten of the 14 questions referred to assessments of the meanings or developments or evaluation of the status quo. For answering these questions, a scale of five was linked with the answers with one representing the lowest score and five the highest one. Four more questions referred to the existence or non-existence of teams or qualifications as well as to the frequency of team meetings. Here, two answer options were defined also but they did not correspond with the characteristics of the ordinal scale.

The scale of five helped to calculate the degree of fulfillment for the three defined preconditions taking the weighting of the individual aspects into account. On the basis of the arithmetic mean of the three degrees of fulfillment classified as equal, the actual level of implementation of quality management methods could be determined for each network coordinator. Since the raw data were mostly based on scales of five, the level of implementation was also evaluated by means of a scale of five (Table 13).

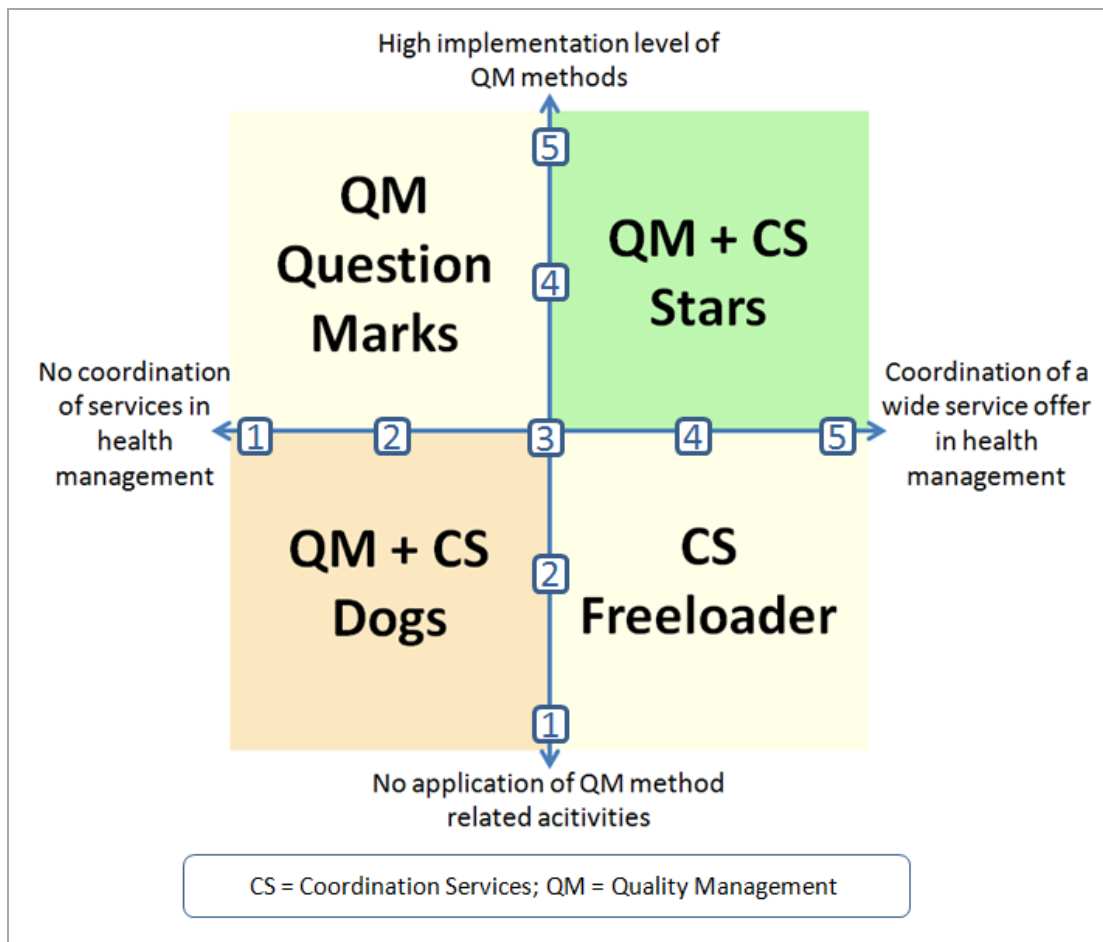
**Table 13: Scale for the assessment of the level of implementation of quality management methods with network coordinators**

Scale	Level of implementation
1	No application
2	Implementation planned roughly
3	Concretely planned quality management activities, first implementations
4	Main structures for quality management methods exist; several aspects are applied
5	Preconditions for the implementation of quality management methods exist; many aspects are applied

The results regarding the popularity of quality management methods and their actual application were compared in a correlation diagram in order to verify hypothesis (5).

### 3.3.3 Classification of network coordinators according to their coordination services offered as well as their quality management competence

Based on the assessment of coordination service offers in inter-enterprise health management and the level of implementation of QM methods, the network coordinators were positioned in a cross diagram. By modifying the Boston Consulting Group Matrix (BCG 2011), benchmarking of the network coordinators could be done. For this, first of all the axes and later on the four quadrants were defined. Figure 10 shows the modified matrix to assess the network coordinators. The abscissa shows the degree of coordination services offered by network coordinators in health management which is based on the scale defined in Chapter 3.3.1 (Table 11). The scale to assess the level of implementation of quality management methods from Chapter 3.3.2 (Table 13) represents the ordinate of this cross diagram. The four quadrants were designated as “QM+CS Dogs”, “CS Freelander”, “QM Question Marks” and “QM+QS Stars” whereas QM and QS serve as abbreviations for quality management or coordination services. By positioning the network coordinators within the diagram, assignment to the individual quadrants and thus characterization of the network coordinators could be done. This enabled an assessment of the connection of QM methods and coordination services offered and the development potentials of network coordinators.



**Fig. 10: Matrix to assess the network coordinators according to their coordination offers in health management and the level of implementation of quality management methods**

### 3.4 Formulation of a proposal for further development of coordination services

Based on the results of the surveys as well as on the literature study, the Kano procedure was modified and simplified regarding its application for health management services. On the basis of demand characteristics as well as information from literature and data collections, services are subdivided into expected services, one-dimensional services, attractive services and indifferent services. In addition to this categorization services could be upgraded resp. degraded depending on their manner of implementation. This depends especially on the level of consideration of customer requirements.

In a further step, a concept for integrating preventive QM methods into processes of inter-enterprise health management of pork chains was developed. This was based on the three methods FMEA; HACCP and Six Sigma, integrating the objectives of process optimization and risk prevention. After a modularization of these methods, they were integrated into three main phases each consisting of several methodical steps.

### 3.5 Structural analysis to assess the quality of coordination services

When developing a model to define the quality of coordination services, first of all literature research was used as a basis. This was supplemented by the evaluation of three partial surveys defining the factors of influence on the quality of coordination services. Table 14 shows the hypothetical relationships of latent variables in the structural model. The precise definition of the individual latent variables (LV1-LV7) was done by an exact definition of their contents. These measurable indicators were integrated by means of formative measurement models in the structural equation model. In addition, it was established that the quality of coordination services influences three measurable criteria. These were added as reflective indicators.

**Table 14: Overview of hypotheses between exogenous latent variables and endogenous latent variable**

Path		Hypothesis
Exogenous latent variable	Endogenous latent variable	
LV1: Health Management Competence	LV7: Quality of Coordination Services	The higher LV1, the better LV7 is.
LV2: Quality Management Competence		The higher LV2, the better LV7 is.
LV3: R&D Activities		The more LV3 exist, the better LV7 is.
LV4: Organizational Competence		The higher LV4, the better LV7 is.
LV5: Service Quality		The better LV5, the better LV7 is.
LV6: Target Group Orientation		The better LV6, the better LV7 is.
LV = Latent Variable		

In a final step the assumed relationships were illustrated in a clearly defined structural equation model.

## **4. Differences and similarities in application of preventive quality management methods in inter-enterprise health management**

### **4.1 Customer expectations regarding coordination services**

Chapter 4.1 is subdivided into two subchapters. In Subchapter 4.1.1, the causal relationships between the interest in information and the willingness to provide information as well as the demand for an information exchange of the customer groups piglet producer and pig fattener are evaluated. The assessment is based on the methodology of structural equation modeling. Subchapter 4.1.2 refers to the concrete demand of farmers for services in inter-enterprise health management and compares this demand with the actual offer of services by network coordinators.

#### **4.1.1 Structural model to describe the relationship of latent variables**

Before the assessment of the quality of the structural equation model, a pretest to verify correct assignment of measurement indicators to the relevant variables was conducted. Some indicators of the variable “interest in information” and “demand for information exchange” showed minor factor loadings which suggest a minor significance of the indicators for the variable. In order to determine the constructs more clearly, the indicators with a factor loading less than 0.4 were eliminated. The final structural equation model is shown stating the factor loadings (by means of arrows between the latent variables and indicators), path coefficients (by means of arrows between the latent variables), the corresponding t values of the path coefficients (in brackets after the relevant path coefficients) and the coefficients of determination  $R^2$  of the endogenous latent variables in Figure 11.



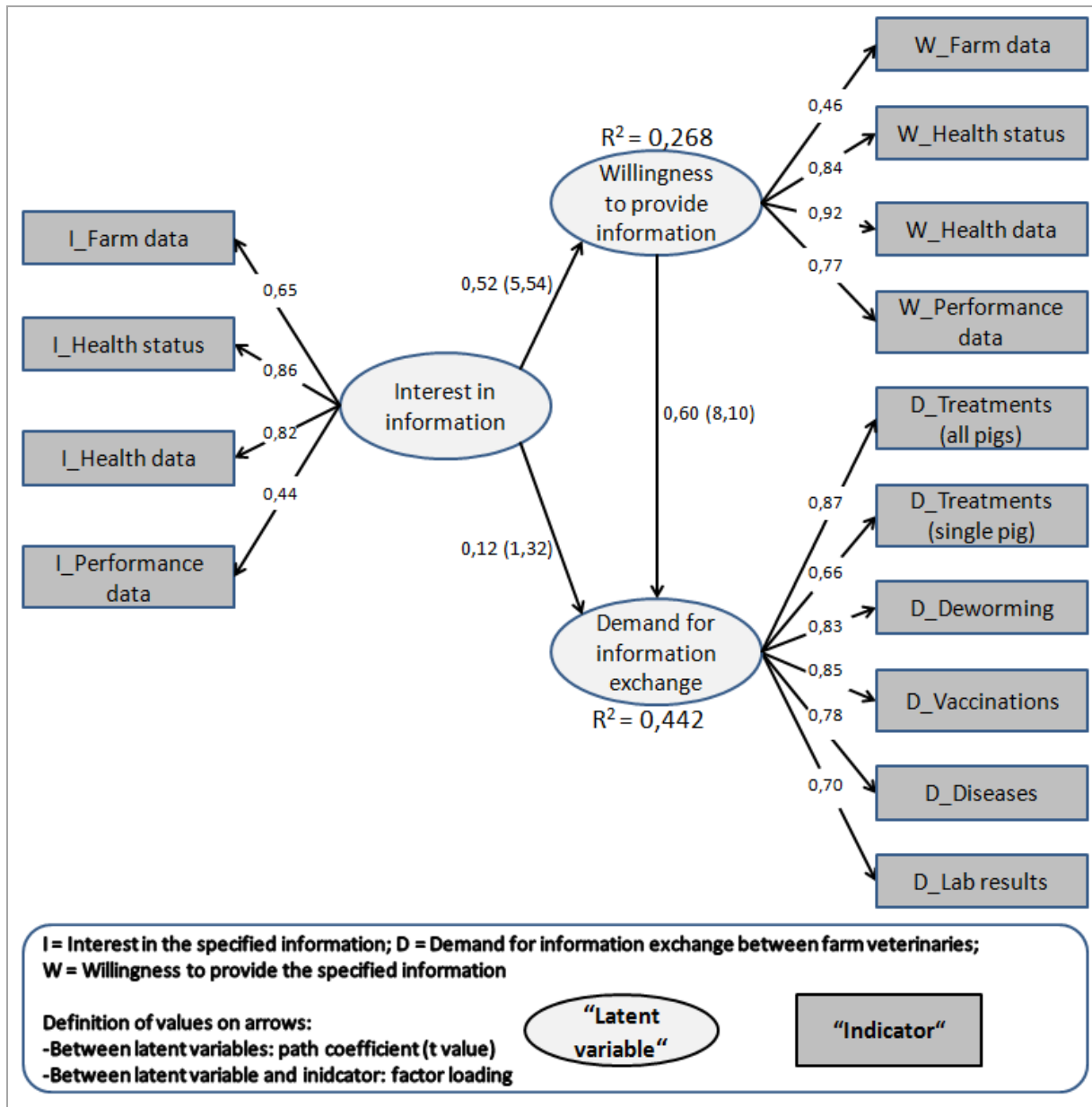


Fig. 11: Structural equation model

### Assessment of the reflective measurement model

The convergence validity determined in the course of the quality assessment results in the following values for the three assessment coefficients, i.e. indicator reliability, construct reliability and the average variance extracted (AVE).

The positive factor loadings (see Figure 11) between the indicators and the variables confirm the assumed directions of action. Twelve of the 14 indicator reliabilities calculated show values above the required minimum values of 0.4 for a relationship to be confirmed statistically (see Table 15). Only the reliabilities of the indicators “interest in performance information” and “willingness to provide farm information” are very low with values amounting to 0.20 or 0.21 and consequently support measurement of the variables only to a lesser extent. For contextual reasons they were, nevertheless, retained in the model.

**Table 15: Factor loadings and the resulting indicator reliabilities**

Latent variables Indicators	Interest in information	Willingness to provide information	Demand for information exchange	Indicator reliability
I_Farm data	<b>0.646575</b>			<b>0.42</b>
I_Health data	<b>0.816112</b>			<b>0.67</b>
I_Health status	<b>0.861689</b>			<b>0.74</b>
I_Performance data	<b>0.443222</b>			<b>0.20</b>
W_Farm data		<b>0.460342</b>		<b>0.21</b>
W_Health data		<b>0.922264</b>		<b>0.85</b>
W_Health status		<b>0.843948</b>		<b>0.71</b>
W_Performance data		<b>0.768432</b>		<b>0.59</b>
D_Deworming			<b>0.831157</b>	<b>0.69</b>
D_Diseases			<b>0.779943</b>	<b>0.61</b>
D_Lab results			<b>0.696870</b>	<b>0.49</b>
D_Treatments (all pigs)			<b>0.864939</b>	<b>0.75</b>
D_Treatments (single pigs)			<b>0.661300</b>	<b>0.44</b>
D_Vaccinations			<b>0.849227</b>	<b>0.72</b>
I = Interest; W = Willingness; D = Demand for information exchange between farm veterinarians				

The values of the composite reliability to measure the internal consistency, i.e. reliability, are far above the threshold value of 0.6 (see Table 16). The indicators of the variables thus correlate strongly with each other and can reflect the latent variable very good accordingly. The values of the assessment criterion Cronbach's Alpha which is also used for determining the internal consistency are with the exception of the value for the variable "interest in information" above the minimum value of 0.7. However, in publications it is referred to the fact that Cronbach's Alpha "tends to underestimate the internal consistency when applying PLS." (Nitzi 2010). Owing to this, the values of the composite reliability to assess the internal consistency estimate are seen as relevant (see Table 16).

**Table 16: Comparison of the values determined to verify the convergence validity of the structural model with the required minimum values**

Latent variables	AVE	Composite reliability	Cronbach's Alpha
<b>Interest in information</b>	0.615231	0.904773	0.872230
<b>Willingness to provide information</b>	0.505763	0.794849	0.657248
<b>Demand for information exchange</b>	0.591305	0.845844	0.743940
<b>Required minimum value</b>	$\geq 0.5$	$\geq 0.6$	$\geq 0.7$
AVE = Average Variance Extracted			

Verification of the discriminant validity based on the Fornell-Larcker criterion showed that the square roots of the AVE values of the three variables were greater than the correlation of the individual variables regarding the other latent variables (see Table 17). Thus it could be confirmed that the indicators of each construct differ from those of the other constructs and can be consequently regarded as autonomous.

**Table 17: Square roots of the AVE values and correlations to other latent variables for each latent variable to verify the Fornell-Larcker criterion**

Latent variables	$\sqrt{AVE}$	I → W	I → D	W → D
Interest in information	0.71	0.52	0.42	
Willingness to provide information	0.77	0.52		0.66
Demand for information exchange	0.78		0.42	0.66

AVE = Average Variance Extracted; D = Demand for information exchange; I = Interest in information; W = Willingness to provide information

Finally, Table 18 summarizes the results of the quality assessment of the reflective measurement model and contrasts these with the relevant required nominal values. The following color code shows the degree of fulfillment of the individual criteria: dark grey (completely fulfilled) and light grey (not/partly fulfilled).

Since the assessment criteria with the exception of two indicators are completely fulfilled, a valid construct measurement is assumed. Subsequently, the assessment results of the structural model are presented.

**Table 18: Comparison of the criteria requirements for quality assessment with the results of the considered reflective measurement model**

Assessment coefficient	Definition	Target values	Results of the present model
Indicator Reliability (IR)	Variance proportion of the indicator explained by the relevant variable	> 0.4	<b>This is true for 12 out of 14 indicators! (see Table 15)</b>
Composite Reliability (CR)	Degree of correlation of the indicators of a construct	≥ 0.6	<b>CR (I)=0.79 CR (W)=0.85 CR (D)=0.90</b>
Average Variance Extracted (AVE)	Degree of explanation of the construct variance by means of the assigned indicators	≥ 0.5	<b>AVE (I)=0.51 AVE (W)=0.59 AVE (D)=0.62</b>
Discriminant validity	Difference of measurements of different constructs	$\sqrt{AVE} >$ correlation of the latent variables with other variables	<b>This is true for all! (see Table 17)</b>

Explanation of the highlighted colors in the results column: dark grey = completely fulfilled; light grey = not/partly fulfilled

### Assessment of the structural model

On the basis of the values for the coefficient of determination  $R^2$ , one can deduce that the variables “willingness to provide information” with a value of 0.27, i.e. weak, and the “demand for information exchange” with a value of 0.44, i.e. on average well, can be explained with the construct acting on them.

The consistently positive path coefficients (see Figure 11) between the individual variables confirm the hypothesis-conform structure of the structural model. The effects, on the one hand, of the “interest in information” on the “willingness to provide information” with a path coefficient of 0.52 as well as the effect of the “willingness to provide information” on the “demand for information exchange” with 0.60 have to be characterized as important. They are far above the minimum value for path coefficients of 0.2 (see Chapter 2.3.1) often demanded in publications. Only the direct effect of “interest in information” on the “demand for information exchange” has to be considered as very low owing to a path coefficient of 0.12. This is also confirmed by the t values for the path coefficients as a result of the bootstrapping procedure. The values of the two paths ( $I \rightarrow W$ ) and ( $W \rightarrow D$ ) are far above the minimum value of 1.96 describing a highly significant relationship with a maximum error probability of 1%. Only the value of the path ( $I \rightarrow D$ ) shows with 1.12 merely a weak significant manifestation with an error probability of 10%. There is, however, via the variable “willingness to provide information” a directly measurable effect on the variable “demand for information exchange” which combined with the direct effect results in a total effect of 0.42 with a t value of 4.9. Table 19 contains the path coefficients determined and their relevant t values.

**Table 19: Path coefficients and the relevant t values of the structural model**

Paths	Path coefficients	t values of the path coefficients
Interest $\rightarrow$ Demand	<b>0.12</b>	<b>1.32</b>
Interest $\rightarrow$ Willingness	<b>0.52</b>	<b>5.54</b>
Willingness $\rightarrow$ Demand	<b>0.60</b>	<b>8.10</b>

The determined effect sizes confirm the results of the path coefficients. The effect size of the path ( $W \rightarrow D$ ) shows with a value of  $f^2 = 0.46$  an enormous influence of the willingness to provide information on the demand for information exchange. The low value of the effect size  $f^2 (I \rightarrow D) = 0.01$  shows that only a negligible effect results from the interest in information on the demand for information exchange.

The positive redundancy values “construct cross-validated redundancy” ( $Q^2$ ) as a result of the blindfolding procedure show that the model for the two dependent variables is prediction-relevant, i.e. suitable for the predictions regarding the development of the demand for an information exchange ( $Q^2 = 0.250$ ) or the willingness to provide information ( $Q^2 = 0.135$ ). Table 20 shows the determined results of the assessment of the structural model in form of a summary and compares these results with the required minimum values requested in publications.

In further model calculations, the structural equation model was analyzed based on the separate datasets of the pig producers or the questioned pig fatteners. The results show with two exceptions no significant differences regarding the results of the whole sample of all pig farmers. The path (I→D) which shows only a very low path coefficient in the model and is also only weakly significant owing to a t value of 1.32 can be determined as highly significant with an error probability of 1% when looking at the results of the pig fatteners with a t value of 3.6. The path coefficient demonstrates, however, a direct influence of the exogenous variable “interest in information” on the endogenous variable “demand for information exchange” with a value of 0.33 when exclusively looking at the results of the pig fatteners. The calculated effect size  $f^2$  could also be determined as weak for pig fatteners with a value of at least 0.10, whereas it only shows a negligible effect within the whole sample with 0.01. In contrast to this, the lower value of the effect size when looking at fatterer data ( $f^2 = 0.19$ ) compared with all pig owners ( $f^2 = 0.46$ ) only shows a medium influence of the “willingness to provide information” on the “demand for an exchange of information”.

**Table 20: Comparison of the requirements of the criteria for quality assessment with the results of the considered structural model**

Coefficient of quality	Definition	Target values	Results
Coefficient of determination $R^2$	Percentage of the determined variance of an endogenous variable	$0.19 \leq R^2 < 0.33 =$ weak $0.33 \leq R^2 < 0.67 =$ moderate $R^2 \geq 0.67 =$ substantial	<b>LV (W): <math>R^2 = 0.27</math> (weak)</b> <b>LV (D): <math>R^2 = 0.44</math> (moderate)</b>
Standardized path coefficients (PK)	Standardized partial regression weights	$\geq 0.2$ ( $\geq 0.1$ )	<b>PK (I→D): 0.12</b> <b>PK (I→W): 0.52</b> <b>PK (W→D): 0.60</b>
t values of the path coefficients	Size and significance of the response relationship between constructs	$t > 1.29$ : EP of 10% $t > 1.65$ : significant with EP of 5% $t > 1.96$ : highly significant with EP of 1%	<b>t (I→D): 1.32</b> <b>t (I→W): 5.54</b> <b>t (W→D): 8.10</b>
Effect size $f^2$	Influence of the exogenous variables on the endogenous variables	$0.02 \leq f^2 < 0.15 =$ low $0.15 \leq f^2 < 0.35 =$ medium $f^2 \geq 0.35 =$ high	<b><math>f^2(I \rightarrow D) = 0.46</math></b>
			<b><math>f^2(W \rightarrow B) = 0.01</math></b>
Stone-Geisser criterion $Q^2$	Quantity of the prediction relevance	$\geq 0$	<b><math>Q^2(W)=0.14</math></b> <b><math>Q^2(D)=0.25</math></b>
D = Demand for information exchange; I = Interest in information; EP = Error probability; LV = Latent variable; W = Willingness to provide information Explanation of the highlighted colors in the results column: dark grey = completely fulfilled; light grey = not fulfilled			

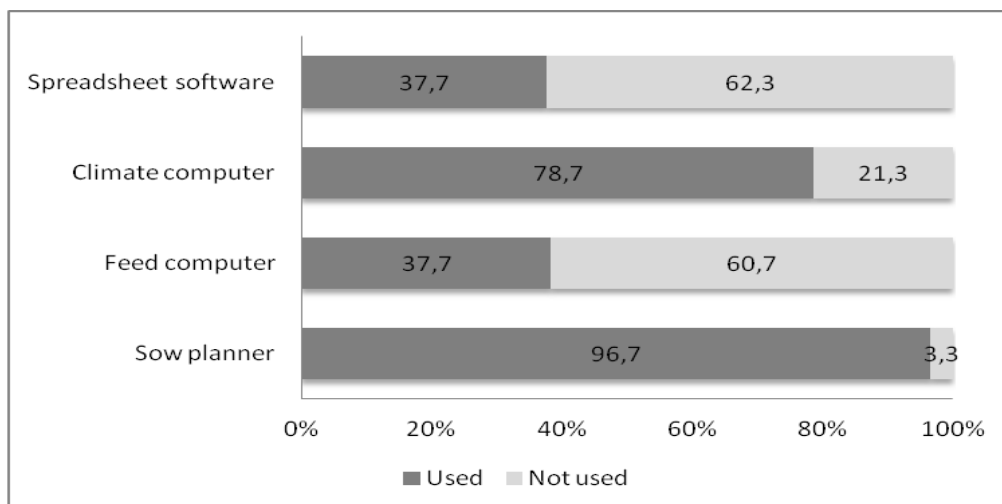
In the following chapters, amongst others, the information of service organizations regarding their service offers in inter-enterprise health management is evaluated. Here it is also

considered which production stages the organizations serve so far and which services they are offering up to now to their customers.

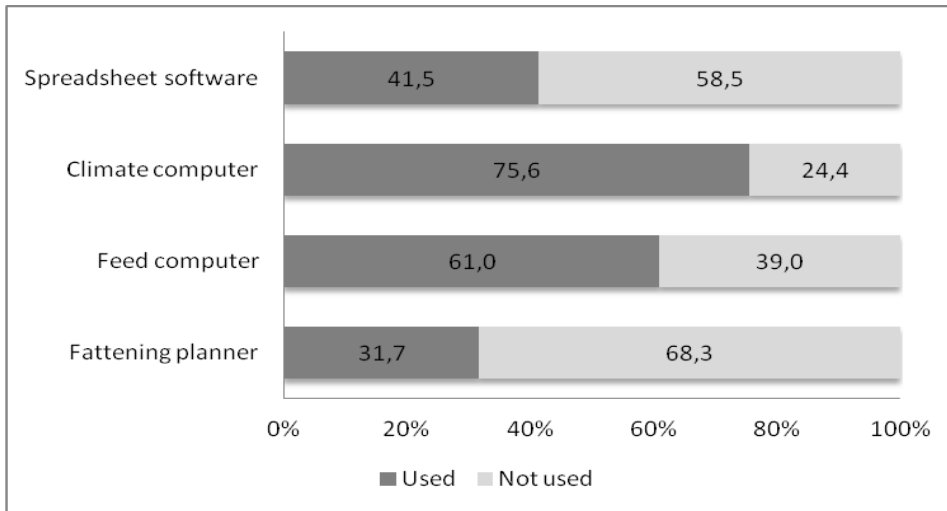
#### 4.1.2 Demand for coordination services

In the previous section it was analyzed to what extent there is a demand for an organized information exchange by piglet producers and fatteners. In addition to organizing an information exchange which forms the basis for many activities in inter-enterprise health management, there exist, however, further essential components of inter-enterprise health management. When looking at the nine elements which form part of health management (see Chapter 3.2), the survey conducted shows that in addition to the coordination of inter-enterprise information exchange, four other service categories, i.e. data processing, consulting and auditing, monitoring and the issue of certificates, encompass the basic offers of the customer groups piglet producers and fatteners. These support the farmers effectively in their enterprise-specific health management.

In the following, it is considered which preconditions piglet producers and fatteners have owing to the existence of peripheral hardware and software for digital communication to the network coordinator. Possibilities for data processing by the farmers themselves become evident due to the degree of penetration of systems for management support such as sow/fattening planners, feed and climate computers as well as spreadsheet software. Figures 12 and 13 provide an overview of the relevant usage frequencies of the computer programs mentioned by piglet producers as well as pig fatteners.



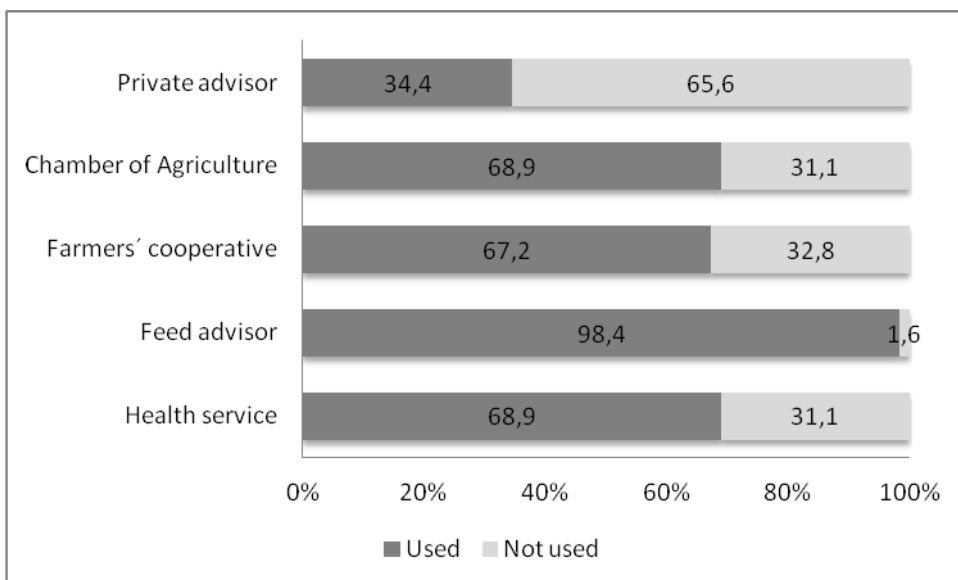
**Fig. 12: Use of computer programs by piglet producers (n=61)**



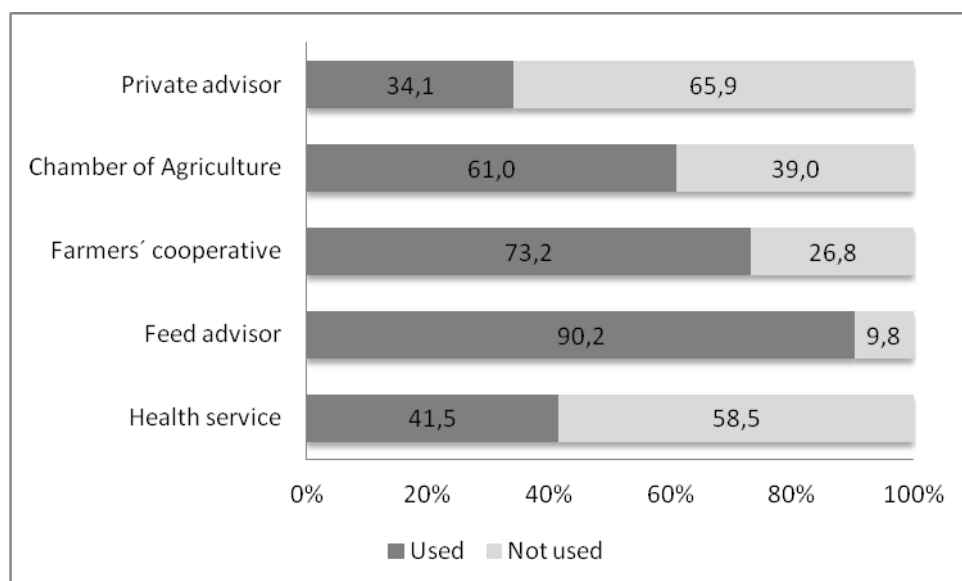
**Fig. 13: Use of computer programs by pig fatteners (n=41)**

More than two thirds of the piglet producers and pig fatteners use a climate computer while the usage rate of feed computers with pig fatteners (61%) is significantly higher than with piglet producers where only 38% use them. Sow planners are, however, used by almost all piglet producers. These support their production rhythm and thus present the basis for their work planning. Fattening planners are in contrast to this only used by 31% of the pig fatteners. Only about 41% of the piglet producers and fatteners use spreadsheet software which is important for further evaluations.

Piglet producers and fatteners show a similar answering structure when looking at the usage patterns regarding various advisory services within the framework of health management (see Fig. 14 and 15).



**Fig. 14: Use of advisory services by piglet producers (n=61)**

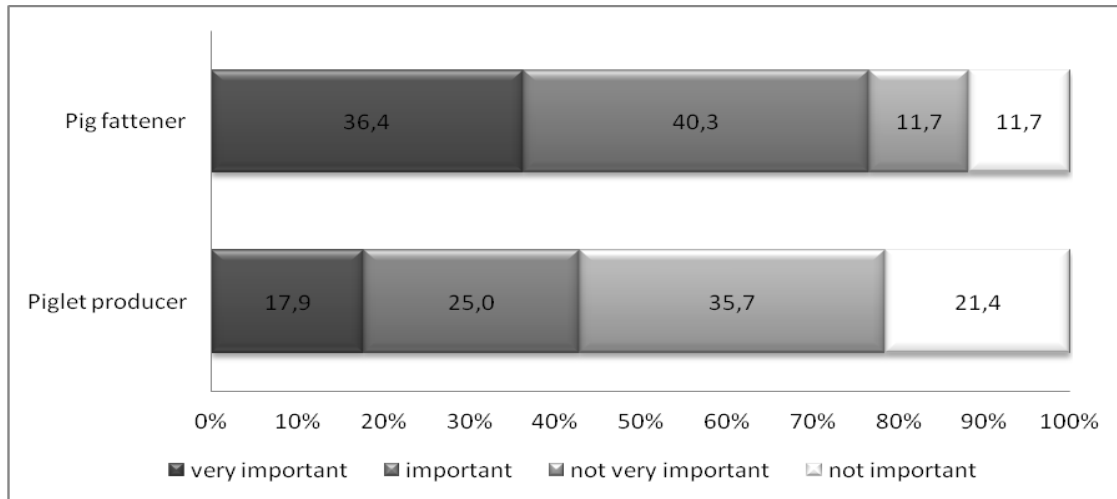


**Fig. 15: Use of advisory services by pig fatteners (n=41)**

Since the profitability of the enterprises largely depends on the performance of the pigs which is determined, amongst other things, by their daily weight gain and feed conversion, more than 90% of the pig fatteners and almost all piglet producers rely on feed advisory services. The biggest difference between piglet producers and pig fatteners is about using advice offered by the health service. Piglet producers use this service with 69% by far more often than pig fatteners where only 42% use this service. Advisory services offered by the Chamber of Agriculture and the farmers' cooperatives are used by more than 60% of the enterprises. On the whole, the farmers mainly rely on organized advisors. Private advisors are only used by about one third of the farmers. In summary, the use of consultations by piglet producers and pig fatteners can be considered as quite high which confirms the need for external support.

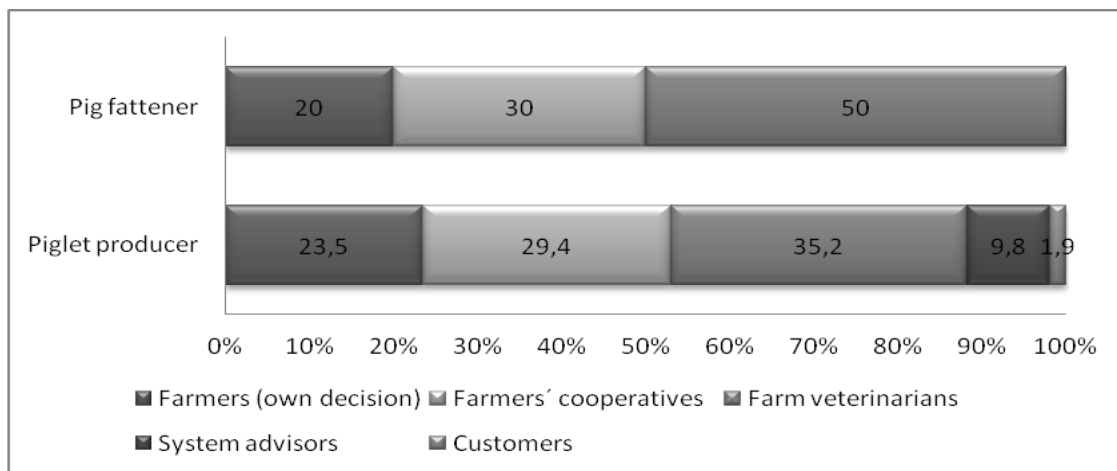
The health status of piglets is an important purchase criterion for pig fatteners. In this regard, estimates on the importance of a piglet health certificate for piglet producers for their marketing activities and for the pig fatteners for their purchases were determined (see Figure 16). More than 75% of the pig fatteners attach a high or even very high importance to the piglet health certificate for their purchase of piglets. In contrast to this, only 42% of the piglet producers stated that they consider a piglet health certificate as important or very important for their marketing purposes. Only 21% of the piglet producers and only about 12% of the fatteners indicated that for them the health certificate for piglets has no meaning whatsoever. The clear estimation of the fatteners, i.e. that the piglet health certificate is very important, has a major influence on the demand of this very complex coordination service consisting of local audits, laboratory investigations, status classification and status communication.





**Fig. 16: Importance of a piglet health certificate for piglet producers for piglet marketing (n=27) respectively pig fatteners for piglet purchasing (n=77)**

The health certificate is predominantly based on the health status of the animals. For this, it is necessary to carry out monitoring activities on a regular basis to determine the status regarding defined diseases. Figure 17 provides an overview which participants within the meat-producing chains have already initiated monitoring programs for the piglet producers and fatteners.

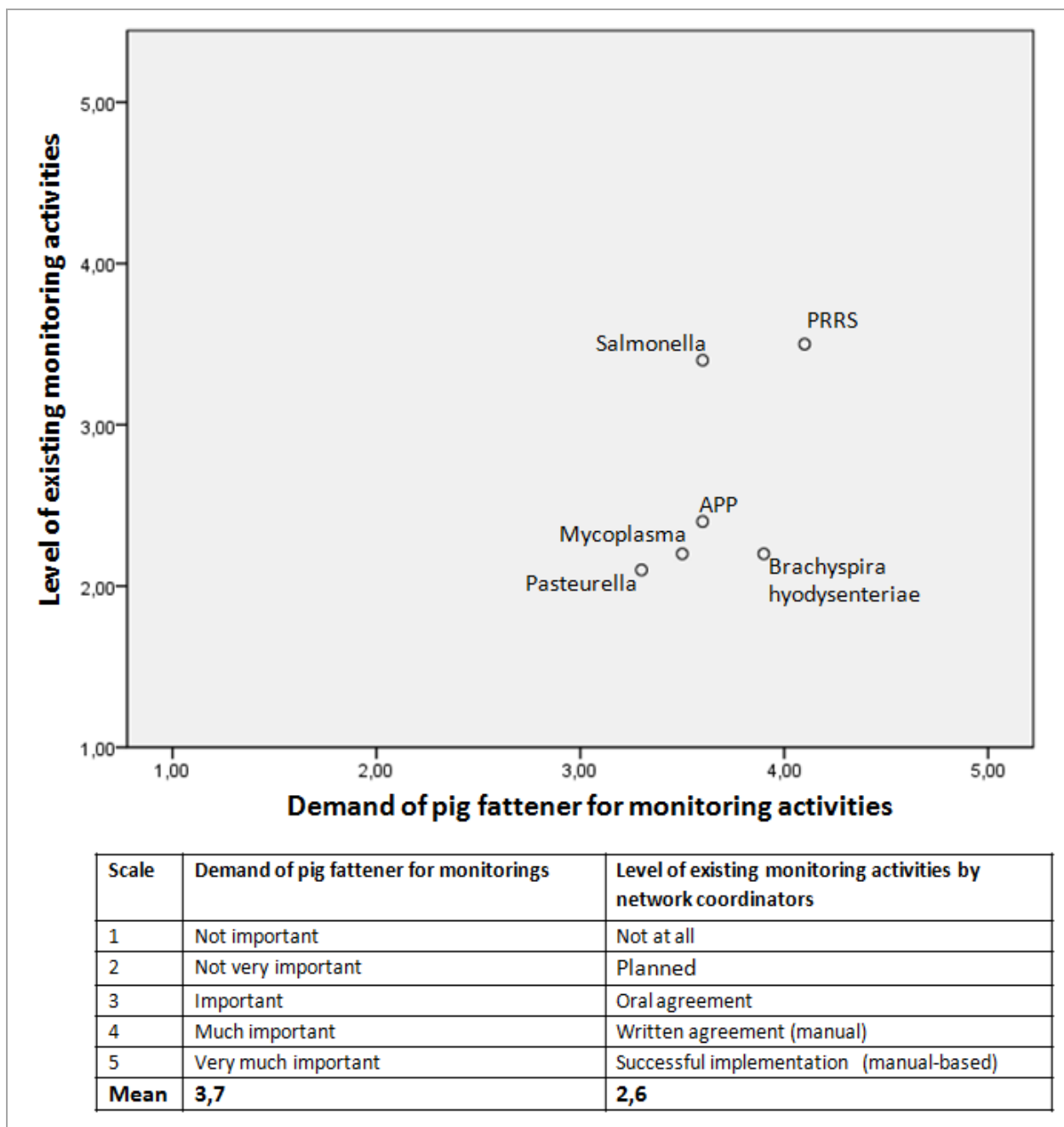


**Fig. 17: Initiation of monitoring activities on piglet-producing farms (n=13) and on pig-fattening farms (n=64)**

Of the animal owners questioned, one fifth of the fatteners or one fourth of the piglet producers have already placed an order for coordination of monitoring activities. The greatest influence on this decision had the farm veterinarians with 35% of the piglet producers and 50% of the pig fatteners. The farmers' cooperatives cover with (almost) 30% a huge percentage regarding introduction of the current investigation procedures.

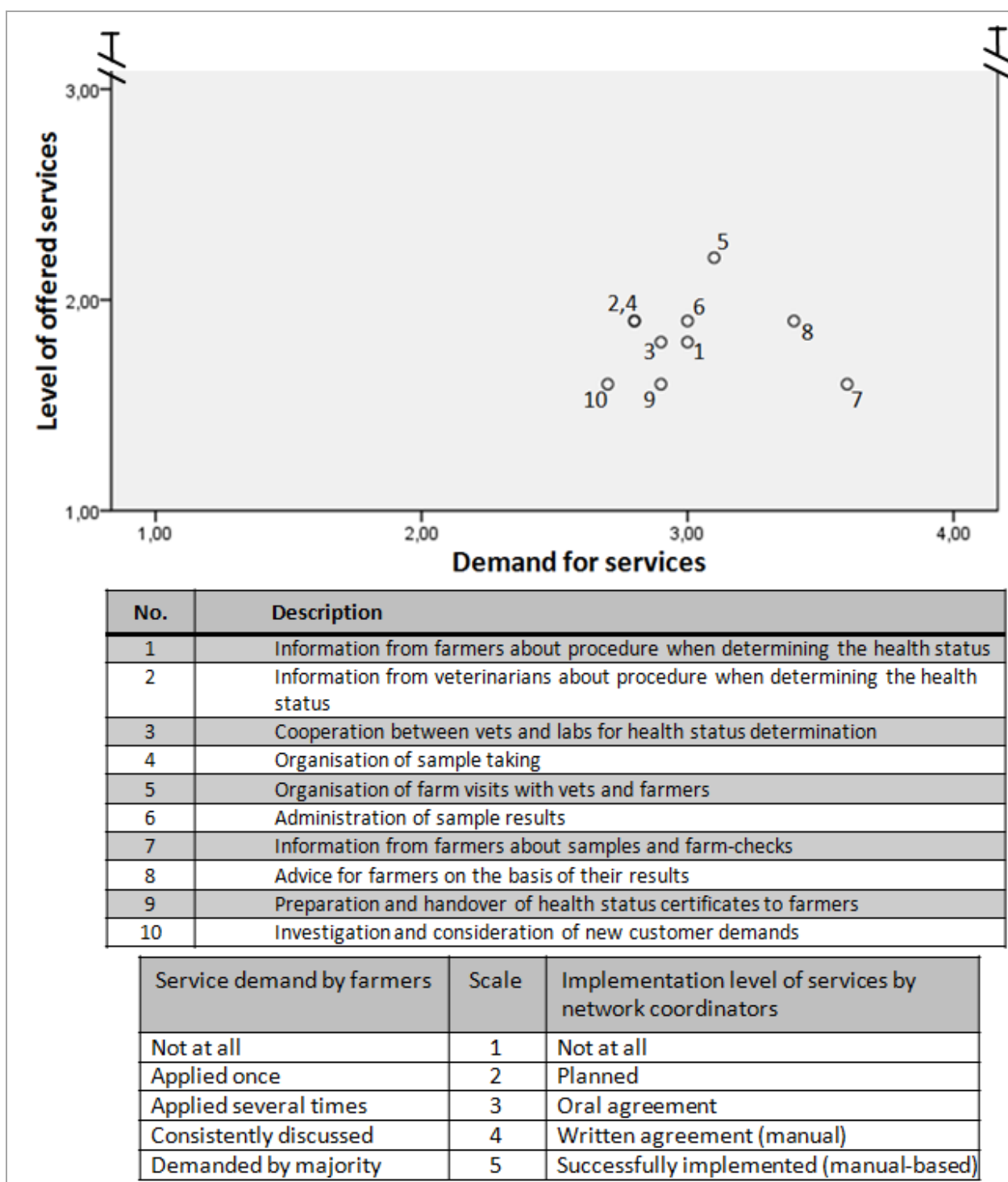
In order to assess the current situation regarding offer and demand for services in health management by means of two concrete examples, in the following the offers of service providers are compared with the demands of farmers or their significance to farmers. The

first example compares the importance of information on the piglet health status (PRRS, brachyspira, salmonella, pasteurella, mycoplasma, APP) for pig fatteners with the degree of organization regarding their realization and certification by service organizations. Figure 18 shows that the importance of the relevant status information for fatteners is evaluated with medium to high by network coordinators on the whole, whereas the coordination offer of the network coordinators depending on the investigation parameters varies. While offers regarding PRRS and Salmonella monitoring cover a large extent of the demand, monitoring activities in connection with other diseases lag behind.



**Fig. 18: Representation of the meaning of status information of piglet producers for pig fatteners and the actual coordination offer of the corresponding monitoring activities by network coordinators (n=15)**

The second example shows the results when determining offer and demand for services which are directly linked with status determination (Fig. 19). In this regard, a big difference between demand and offer can be observed. The demand for the questioned services is between 2.7 and 3.6 which corresponds to a repeated or regular demand. In contrast to this, however, the implementation level of the relevant services is assigned to a value between 1.6 and 2.2 on the offer scale. This means that the relevant service offers are quite often still in the planning phase. The biggest divergence between offer and demand consists in relation to the “information of the farmers regarding results of monitoring and farm visits”. While this service is requested increasingly by the farmers, this service is not even considered in the plans of some organizations.



**Fig. 19: Representation of offer and demand for services within the framework of determining the health status of network coordinators for farmers (n =19)**

The results of the surveys regarding inter-enterprise information exchange and the coordination of services in the health management of pork chains show a unique need for action regarding the expansion of coordination services for the primary products in the pork chain. In the following chapter the status quo of the offered coordination services based on a survey of service organizations is considered in detail and its methodical support is evaluated.

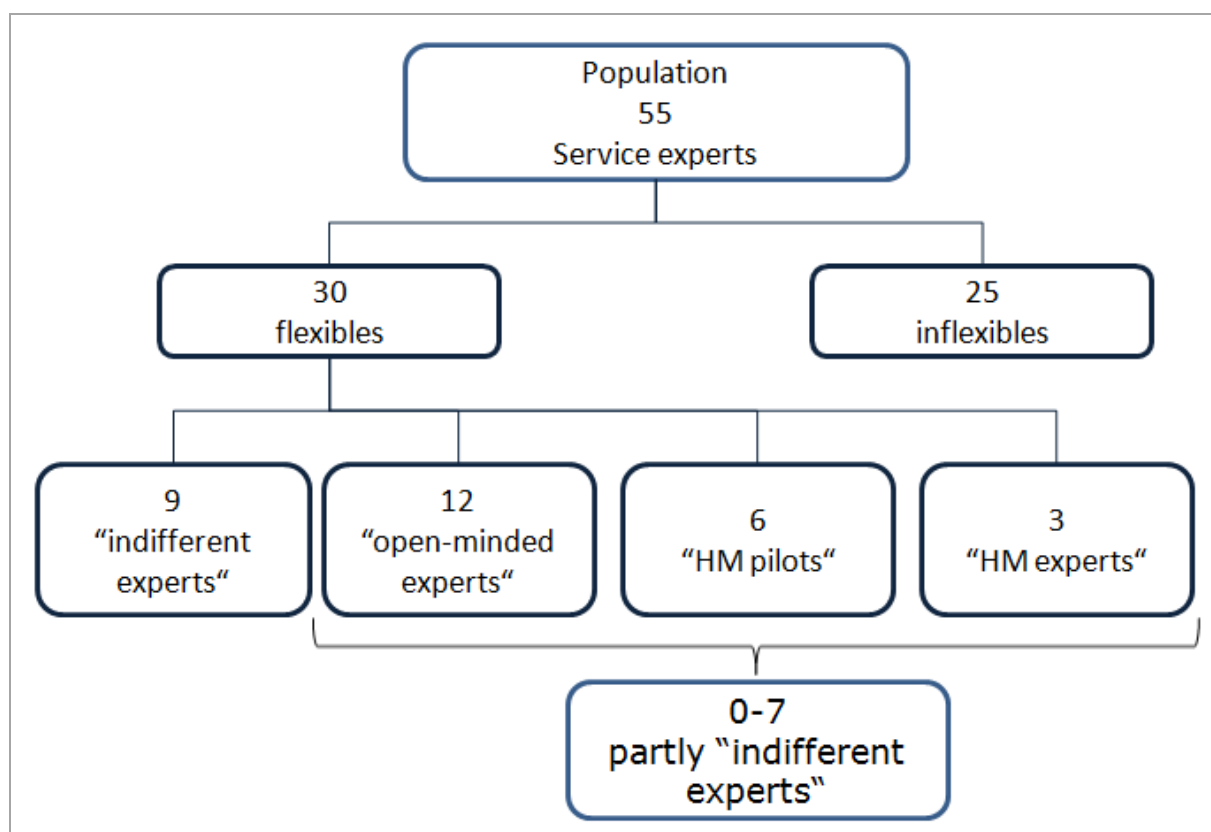
#### **4.2 Service offers of network coordinators**

The population of the survey was made up of experts from service organizations for the pork chain. 25 enterprise representatives did not see coordination tasks in the area of inter-enterprise health management for their organization as a possibility of extending their service offer and as a long-term goal. Of the 30 remaining contact partners of potential network coordinators, nine had to be eliminated from the assessment since they had seen the questionnaire but did not fill it in. In the following, they are called “the indifferent experts” or “the indifferents”, in short.

In accordance with their interests and involvement in tasks in inter-enterprise health management, the experts questioned from the 21 network coordinators can be divided in three categories. 12 experts stated that so far they have not supported any health-management-relevant activities within the framework of their own projects and have also not planned such activities. Their focus is on the marketing of pigs and offers for production-accompanying performance monitoring. Despite this, they were very open-minded and interested in this topic (“open-minded experts”). Six of the questioned interview partners have been carrying out for some years now projects in cooperation with scientists regarding an extension of their service spectrum by offers in inter-enterprise health management and have accordingly already gained experience in this area (“HM pilots”). Regarding three of the network coordinators questioned, health management is shown in their portfolio as the most important service (“HM experts”). Between two of the three “HM experts” exists a relationship, i.e. they are not mutually independent. Whereas the one organization focuses on research activities, the other one is responsible for implementation of health management activities in the pork chain.

Seven participants from the groups of “HM experts”, “HM pilots” as well as “open-minded experts” have not completely filled in the questionnaires so that the sample sizes were partly reduced. When it comes to these questions, they are correspondingly assigned to the group of “indifferent experts”.

Figure 20 shows an overview of the final sample and its categorization in the above mentioned groups.



**Fig. 20: Categorization of sample**

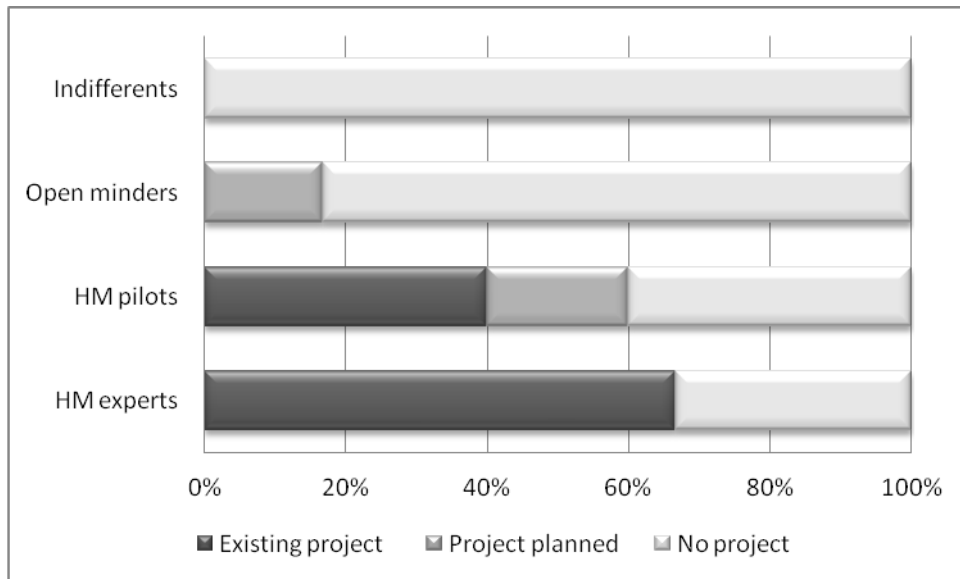
#### 4.2.1 Project activities for further development of coordination services

All the answers given by experts have been compared with a possible target or reference system for services in inter-enterprise health management in order to quantify the extent of existing and planned project activities. As a reference model to rank the extent of coordination services, the nine health management elements suggested by Schütz (2009) with nine elementary components are used. Only 16 of the experts participating in the study provided answers for all of the nine elements.

Eight representatives of network coordinators carry out projects to improve coordination of the area of responsibility called *health monitoring*. Another representative is in the planning phase. *Herd diagnostics* is closely related to voluntary organization of monitoring activities and local audits. The number of mentions in this field shows a significant difference between coordination of herd-diagnostic evaluations for piglet producers in contrast to those for pig fatteners. Ten respondents carry out projects on monitoring activities for piglet producers at the moment, and two plan to do so in future. In contrast to this, only three respondents state, however, activities in this area for pig fatteners.

The issue of *health certificates* for piglet producers and pig fatteners also shows that activities for piglet producers are by three and a half times higher than those for pig fatteners. Two experts have not provided any information regarding their project activities in connection with the *provision of early warning and alarm information*. Four experts state concrete projects, two have plans for such projects and eight respondents do not carry out any

initiatives in this area. Figure 21 provides an overview of the response behavior of the four groups, i.e. HM experts, HM pilots, open-minded experts and indifferent experts regarding this question.



**Fig. 21: Project status of the three groups of HM experts, HM pilots and open-minded experts regarding the provision of alarm and early warning information (n=30)**

One third of the respondents state projects to *safeguard legal conformity*, two plan an extension of their project activities and one representative of a network coordinator does not carry out any initiatives in this regard. In the area of *information and document exchange*, ten experts have experience with services. Projects on the *creation of preliminary reports* and/or internal audits are only answered in the affirmative by four participants in the survey. Eight participants had the ambition to initiate projects on *preparation and post-processing of special measures* in the near future, two plan such activities and six respondents could refer to ongoing project activities.

Another focus of inter-enterprise health management is on carrying out *environmental analyses* to determine risk and negative factors for the animals and management weaknesses. One third of the respondents is realizing projects within this framework or is at least planning this for the near future.

The following Table 22 states the number of ongoing and planned activities in the areas of the nine elements belonging to health management and classifies these into the four groups HM experts, HM pilots, open-minded and indifferent experts.

**Table 21: Number of answers regarding project activities (in total and in the relevant groups) referred to the nine elements of health management (n=30)**

Elements of inter-enterprise health management	Mentions according to groups				Project status		
	E	P	O	I	No project	Project planned	Project exists
Health control	3	6	7	14	20 [E(2),P(1),O(3)]	1 [E(0),P(1),O(0)]	9 [E(1),P(4),O(4)]
Herd-diagnostic evaluation	3	6	7	14	18 [E(0),P(2),O(2)]	2 [E(1),P(1),O(0)]	10 [E(2),P(3),O(5)]
Environmental analyses	3	6	7	14	21 [E(1),P(3),O(3)]	1 [E(0),P(1),O(0)]	8 [E(2),P(2),O(4)]
Verification/safeguarding of legal conformity	1	6	7	16	19 [E(1),P(0),O(2)]	2 [E(0),P(1),O(1)]	9 [E(0),P(5),O(4)]
Information and document exchange	3	6	7	14	20 [E(2),P(1),O(3)]	0 [E(0),P(0),O(0)]	10 [E(1),P(5),O(4)]
Pre- and post-processing of special measures	3	6	7	14	22 [E(1),P(3),O(4)]	2 [E(0),P(0),O(2)]	6 [E(2),P(3),O(1)]
Preparation of preliminary reports	3	5	6	16	26 [E(2),P(3),O(5)]	0 [E(0),P(0),O(0)]	4 [E(1),P(2),O(1)]
Delivery of early warning/alarm information	3	5	6	16	24 [E(1),P(2),O(5)]	2 [E(0),P(1),O(1)]	4 [E(2),P(2),O(0)]
Preparation of health certificates	3	6	7	14	20 [E(2),P(1),O(3)]	2 [E(0),P(2),O(0)]	8 [E(1),P(3),O(4)]
Number of mentions per group: E = "HM experts"; I = "Indifferent experts"; P = "HM pilots"; O = "Open-minded experts"							

The focus of project activities is on the areas of health monitoring and certification, information exchange and verification of legal conformity. Individual organizations also coordinate accompanying analyses. The percentage of respondents who do not see an area of activities for the future in many fields of coordination of health management activities is still quite high.

In the following, the offer of coordination services in the three areas of audit management, sampling and preparation of certificates is presented in more detail.

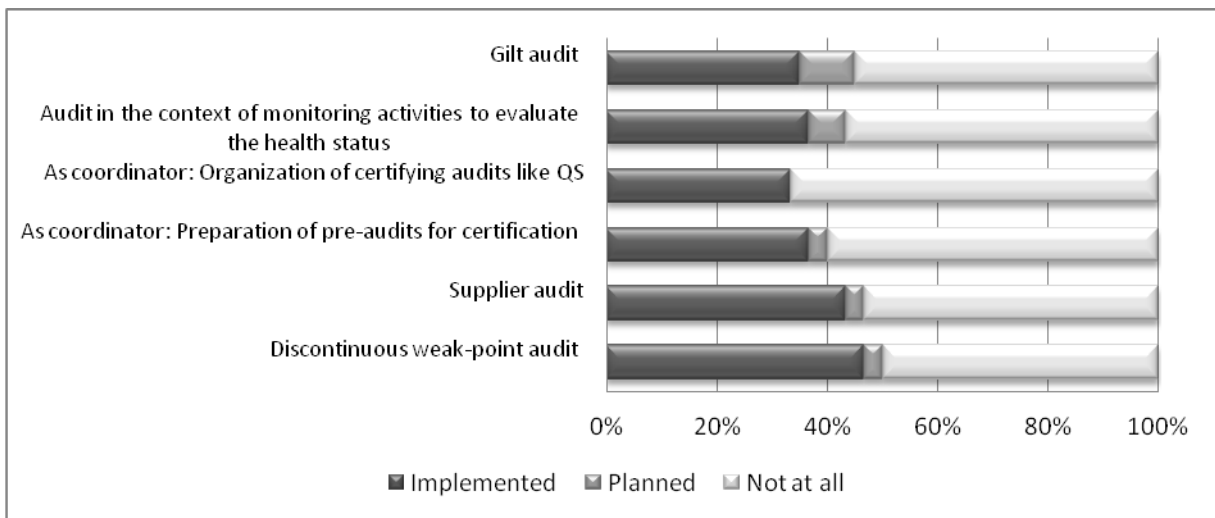
Eleven of the network coordinators questioned carry out *audits* in the area of health management which go beyond national quality management programs (such as QS or IKB). Frequently, these are enterprise-specific audits of the relevant producer organization.

Amongst the auditors, there are seven veterinarians, six agronomists and four accredited agriculturists. Two auditors each are masters of agriculture or have participated in further-education measures in the area of animal science. Two of the eleven respondents did not state any of the qualifications mentioned for the auditors, while auditors from the agricultural and veterinarian area are represented in five organizations. Four participants can fall back on



an inter-enterprise pool of auditors when selecting their auditors. One enterprise even has access to a national auditor pool, while for the majority and hence six respondents there is an enterprise-wide pool of auditors available.

Within the framework of the survey, the different types of audits coordinated by the relevant network coordinators and the basis of agreements between customers and service providers to do so, could also be ascertained (see Fig. 22). 19 experts provided information. Nine respondents carry out one or several of the audits mentioned on the basis of written instructions. Regarding five network coordinators, they are based on oral agreements. Weak-point audits which are mentioned in 14 positive responses and supplier audits which are mentioned in 13 positive responses are carried out most frequently. These offers exist for all network coordinators belonging to the group of HM pilots and for two of the three network coordinators belonging to the group of HM experts. Product audits (gilt) are only offered by seven network coordinators. Eight respondents belonging to the group of “open-minded experts” do not offer any services in this area, while two respondents of this group did not answer the question at all. Only one member of this group stated product audits (gilt) as part of their service offer. Audits to evaluate the health status and pre-audits for certification audits as well as their preparation and post-processing are part of the service offer of at least ten network coordinators.

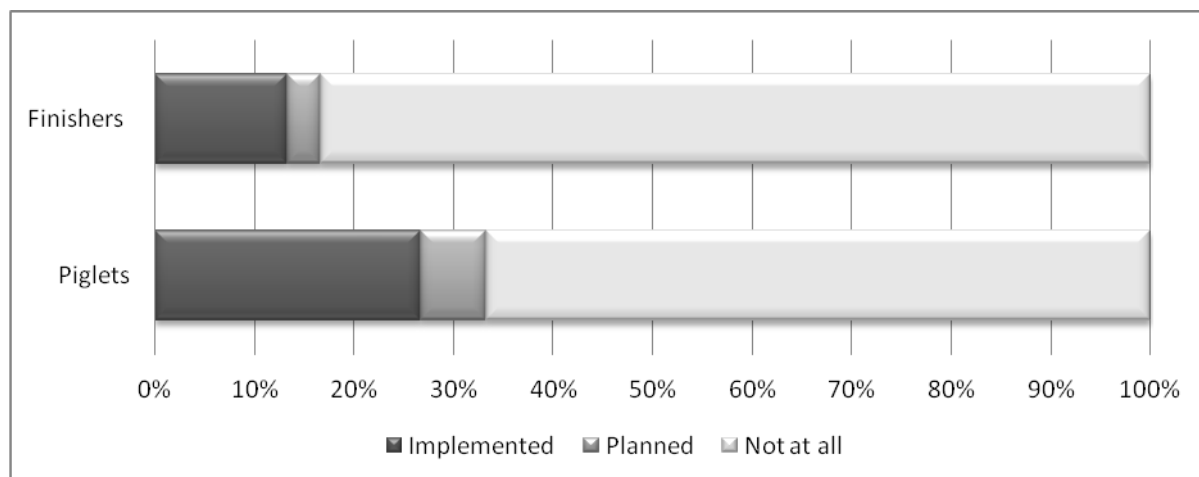


**Fig. 22: Implementation level of defined audits by network coordinators (n=30)**

Audits to assess the health status are usually connected with sampling for laboratory investigations. When doing this, the process for determining a pathogen or antibody status for defined diseases is established. Eleven network coordinators have written process instructions for defining sampling. Amongst these are all members belonging to the group of “HM experts” and “HM pilots”. One respondent (“open-minded expert”) only concludes oral agreements, while six other network coordinators either do not offer any samplings or coordinate them possibly on an individual basis. There is no standardization in this respect.

16 respondents from network coordinators provided information regarding comparability of sample results by standardization of sampling and sample processing as well as analysis in

the laboratory. Figure 23 shows that a standardized procedure when classifying the health status is by far more common for piglet producers than for pig fatteners. With eight of the respondents, sample analyses for piglet producers are defined (6 in writing, 2 orally). In contrast to this, only three network coordinators have agreed on the sample analyses in writing and one orally with the laboratories for pig fatteners.



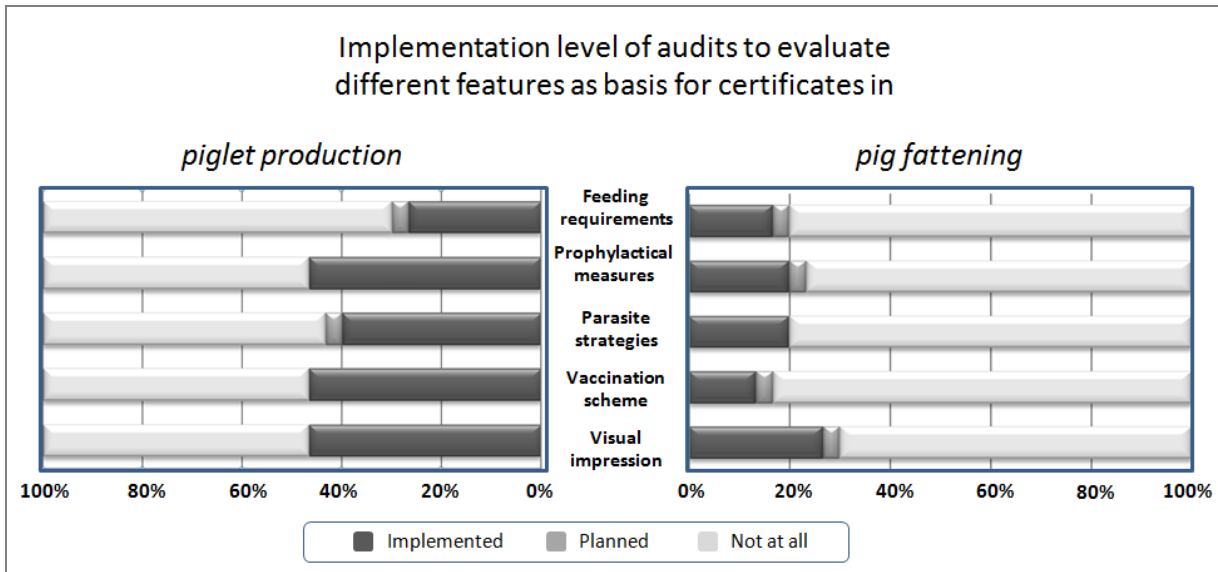
**Fig. 23: Standardization level of sample analyses in laboratories for piglet farms resp. fatteners (n=30)**

17 respondents (19 mentions) have positively answered the questions regarding the indication of additional information which enables conclusions as to the origin of the health status of the enterprise of origin. This applies to all respondents of the groups “HM experts” and “HM pilots”. In contrast to this, three respondents of the group “open-minded experts” did not provide any additional information. With nine experts, the validity of the *certificates* issued amounts to six months. Three respondents link certificates with delivery batches, while two network coordinators only renew the certificates once a year. One respondent stated that certificates in basic rearing and in multiplying expire after one month and in production after three months.

In most cases (8), it is the network coordinator being responsible for the procedure to determine the health status and carry out monitoring sessions. With further 5 network coordinators, the guidelines are established by a regional body, whereas with only one participant a national body and with another one an external service organization is responsible for the specifications. In consequence, ten of the 14 network coordinators who have commented on this, issue the certificates themselves. The three service companies for which external enterprises issue certificates are amongst those where a regional body is responsible for the procedure. One respondent stated that a veterinarian has the responsibility for issuing the certificates.

Figure 24 provides an overview of the level of implementation of various audits with piglet producers and fatteners which serve as the basis for corresponding certificates. In the area of piglet production, the frequency of audits is by far higher as in fattening enterprises. With the exception of audits to confirm feeding regulations, any other audits are offered by at least twelve network coordinators. In contrast to this, only eight organizations at the most carry out

audits in pig fattening. Approximately half of the audits for piglet production and fattening are based on oral agreements.

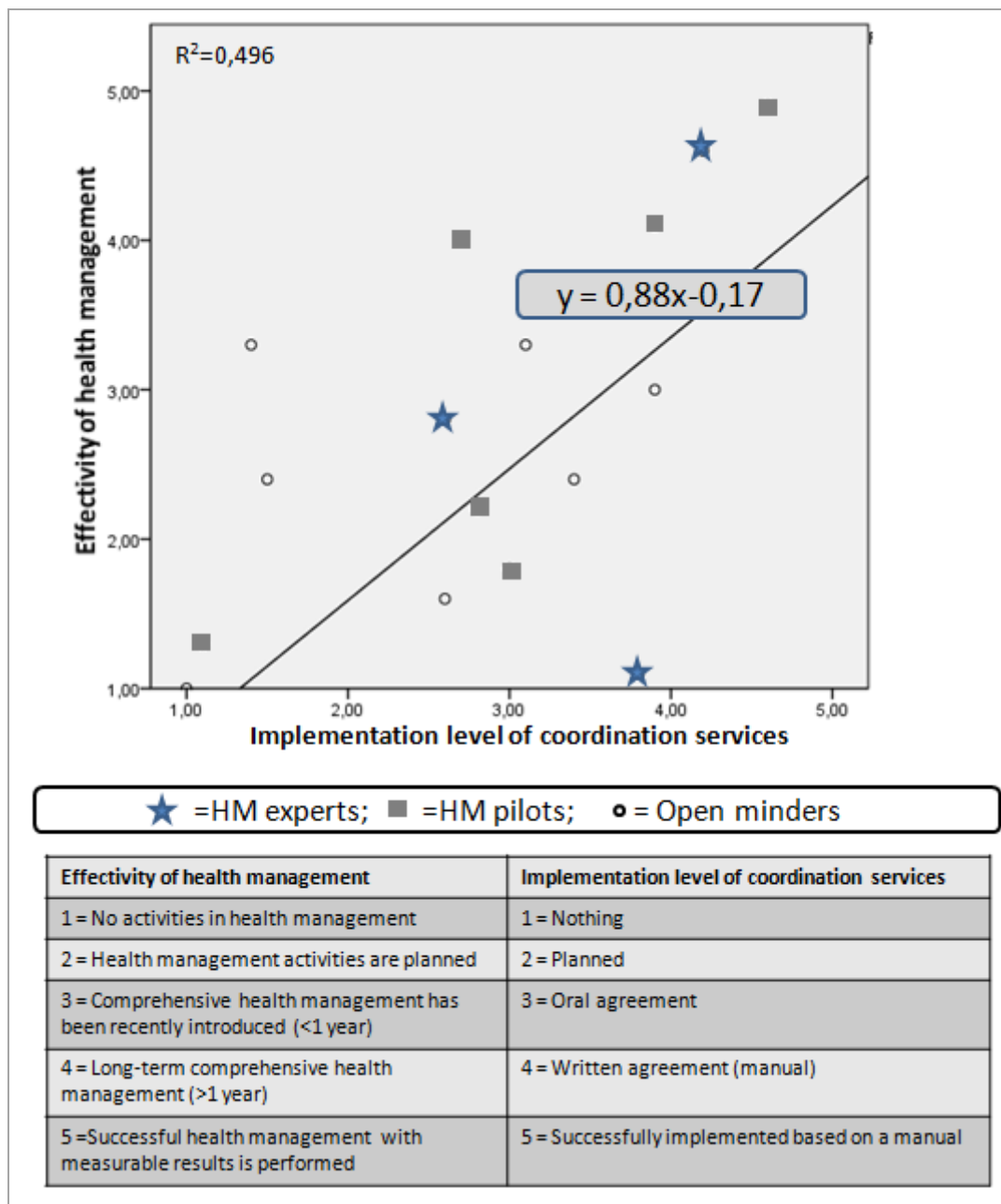


**Fig. 24: Implementation level of audits for the evaluation of different features as basis for certificates in piglet production resp. pig fattening (n=30)**

The following concentrates on the type of certificates offered. The majority of respondents state that they confirm for the customer group of piglet producers their participation in voluntary monitoring sessions. Also forgoing certain drugs within defined groups of production or special treatment and vaccination strategies are amongst them. With regard to the preparation of certificates for a health status, only few of the other respondents plan to extend their service offer. The groups of “HM experts” and “HM pilots” devote special attention to certifying the health status of animal populations in connection with international trade with living animals. Six respondents belonging to the group of “open-minded experts” do not see any service offer here: in connection with pig fattening, the service offer of one third of the respondents includes the preparation of certificates regarding use of antibiotics, participation in monitoring sessions, transport times, adherence to waiting times, genetic origin and the health status. Further three network coordinators plan to extend their service offer in future in this direction. While all members of the group of “HM experts” certify the health status for pig fatteners, this is not offered yet by anybody from the group of “open-minded experts”.

From the aggregation of the coordination services offered in the individual areas results an overall value for each network coordinator which states the level of implementation of coordination services in inter-enterprise health management. This value is compared in Figure 25 with the effectiveness of the health management system determined from the project activities described beforehand. The effectiveness of inter-enterprise health management correlates in accordance with the equation  $y=0.88x-0.17$  with the offer of coordination services in inter-enterprise health management (correlation coefficient: 0.704) and is mutually significant at the level of 0.01. In terms of project activities, 16 experts questioned presented complete datasets which were included in the correlation calculation.

The network coordinators belonging to the group of “open-minded experts” concentrated on the lower left area. The effectiveness of health management varies considerably with the other groups, regarding the level of implementation of coordination services in inter-enterprise health management they range with one exception in the upper two thirds.



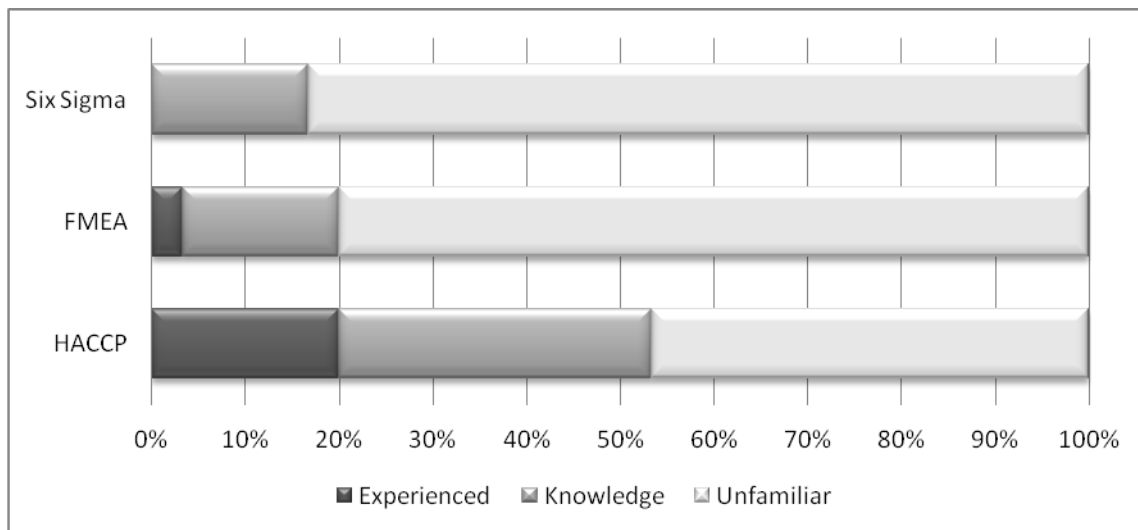
**Fig. 25: Correlation of the effectiveness of health management and the implementation levels of coordination services in health management per network coordinator (n=16)**

#### 4.2.2 Project activities to implement quality management (QM) methods

In the following, it is described in further detail what the experts questioned know about QM methods such as Six Sigma, FMEA and HACCP. From this, the popularity of QM methods with network coordinators is deduced and it is compared with the level of implementation of QM methods.

19 experts provided information regarding what they know about QM methods. Six Sigma and FMEA are completely unknown to two thirds of a partial group consisting of 21 experts from the overall group. Only one expert stated that he has already been trained in FMEA. The remaining respondents possess little or medium knowledge of these methods but do not have any practical experience (Fig. 26). With one exception, those respondents having stated that they possess knowledge of Six Sigma and FMEA belong to the group of “HM pilots”. By comparison, the HACCP concept was only unknown to three experts (“open-minded experts”), eight respondents stated general knowledge, two have been trained and four already have application knowledge. From the latter, three belong to the group of “HM pilots”.

On the whole, one can say that the designation and definition of complex, team-oriented preventive quality management methods are unknown to the majority of the service enterprises questioned.



**Fig. 26: Knowledge of quality management methods by network coordinators (n = 30)**

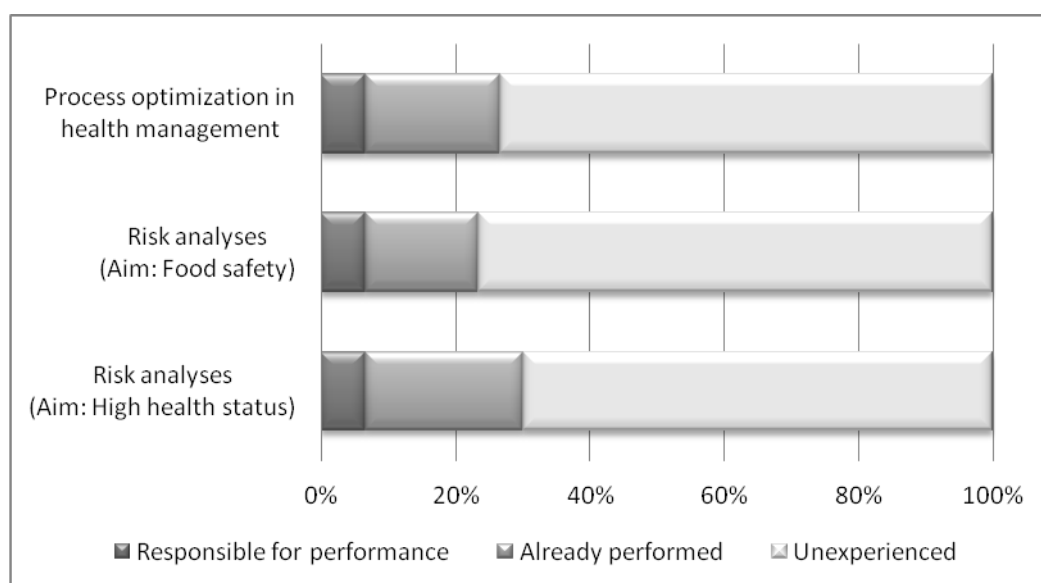
If one has a look at the results regarding the level of implementation of partial essential aspects and principles of preventive QM methods explained in literature, 17 respondents provided information regarding this in terms of QM competence. For example, implementation of *interdisciplinary teams* is a key element in many organizations. One third of the organizations (10) work in teams regarding implementation issues in inter-enterprise health management. Seven of them belong to the groups of “HM experts” and “HM pilots”.

The basic composition of the teams is similar. Advisors of farmers’ cooperatives are part and parcel of each team in their function as network coordinators questioned. In a similar way, farm-veterinarians and farmers are involved in most health management teams. External

advisors, scientists, laboratory members, external veterinarians and employees of slaughterhouses were in contrast to this only mentioned by five teams as members.

The teams are organized very differently. While two teams meet once a week and one team once a month, the meetings of other teams take place less frequently (two teams meet once every three months, four teams once every six months, and one team once a year).

13 respondents provided details on experience of the team members regarding risk analyses and process optimizations (Fig. 27). Ten respondents have already carried out process optimizations or risk analyses or are responsible for them. Those respondents who have stated that they have no experience with risk analyses and process optimizations belong to the group of “open-minded experts”.



**Fig. 27: Experiences of network coordinators in process optimization resp. risk analyses (n=30)**

Many participants of the survey have already qualified for quality management. Ten team members are quality managers, seven have qualified as quality systems manager and another four are external auditors. Five times the function of junior quality systems manager was mentioned.

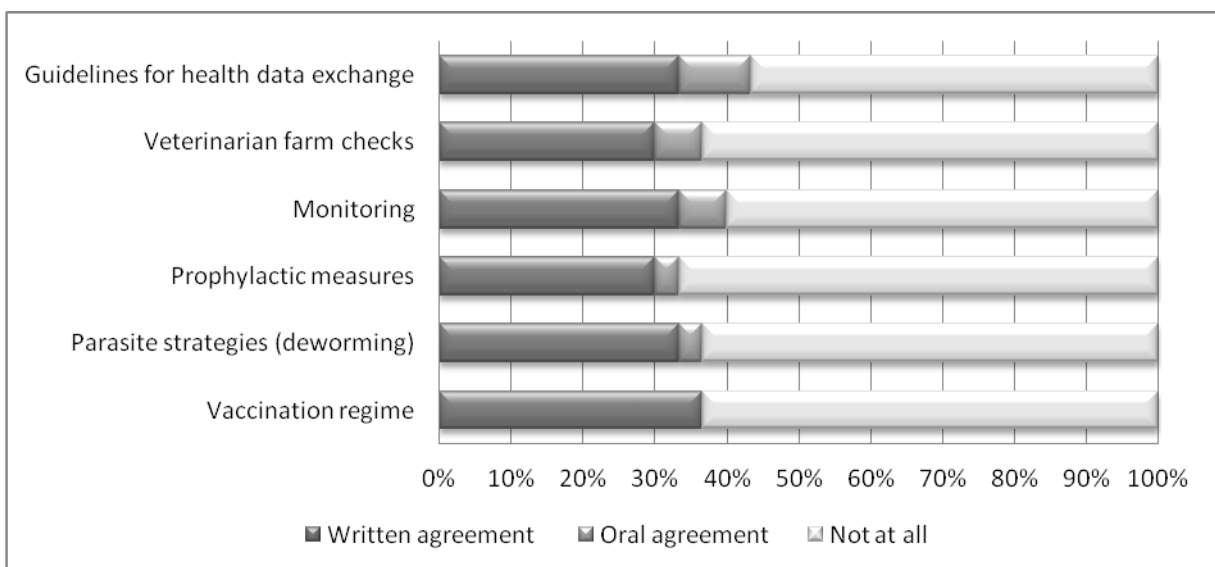
14 of the respondents provided information on the status of projects regarding risk assessment and ten on the status of projects for process optimization. Seven participants did not mention any project activities in any of the areas, whereas five respondents stated a successfully completed project in at least one area, and five mentioned an existing project.

At the beginning of project implementation defining target values marks the planning phase. Regarding this, it was determined to which extent *requirement profiles* for the products, i.e. piglets and finishers (18 mentions) as well as process descriptions for processes in health management (16 mentions) already exist. Regarding services for piglet producing enterprises, specifications concerning the features of health status, weight, uniformity of the batch, race and vaccination status were queried. Only three of the respondents stated that they do not have any requirements regarding the health status of piglets. These have to be

assigned to the group of “open-minded experts”. Two work with oral agreements, whereas 12 experts do not only rely on written requirements but also control their adherence. All participants of the group “HM pilots” have specifications on these five features.

In connection with fattening enterprises, target values regarding the characteristics of health status, weight, lean meat percentage, meat depth and fat depth were taken into account. With six respondents, these are based on written specifications. Eleven participants have not reached any agreements regarding this, the majority of these can be assigned to the group of “open-minded experts”.

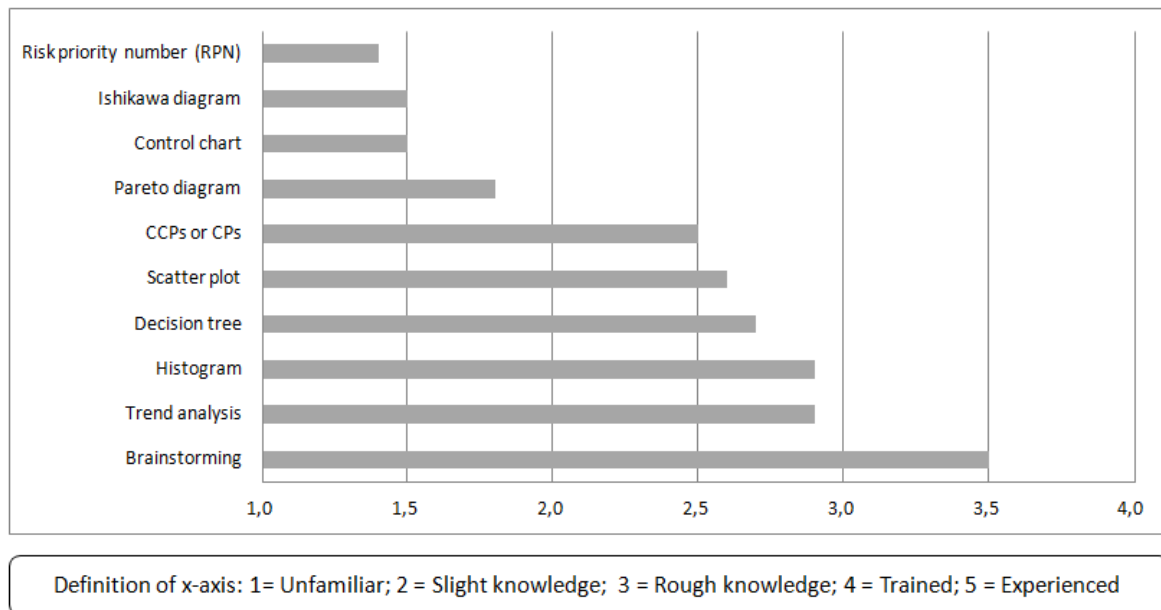
16 respondents provided information on the existence and type of *process descriptions*. One third of the experts have written process descriptions for selected processes in health management (see Figure 28). Oral agreements hardly exist at all.



**Fig. 28: Existence and form of process descriptions for selected health management activities (n=30)**

QM tools are similarly to the QM methods unknown to most of the participants (see Fig. 29). 17 respondents provided information regarding this issue. Brainstorming is at least familiar to most respondents. Only two respondents belonging to the group of “open-minded experts” stated that they are not familiar with this term. Trend analysis, histogram, decision tree, scatter diagram and determination of critical control points are roughly familiar. Except one member of the “open-minded experts” who is experienced in the application of CCPs, the group of “open-minded experts” does not have any experience with these five QM tools. The majority of this group is not familiar with these five QM tools or they can only roughly categorize them. In contrast to this, half of the members belonging to the group of “HM pilots” have already gained user experience in some of these five QM tools. Only a small percentage of this group is completely unfamiliar with QM tools. Two of the three “HM experts” stated in connection with three of these five QM tools that they have practical experience with them. Regarding risk priority number, Ishikawa diagram, control chart and pareto diagram, the majority of the respondents stated that they are not familiar with them or that no further details are known to them. No group-specific differences could be ascertained

in this respect. Finally it can be said that only seven experts had stated practical experience with at least one of the QM tools mentioned.



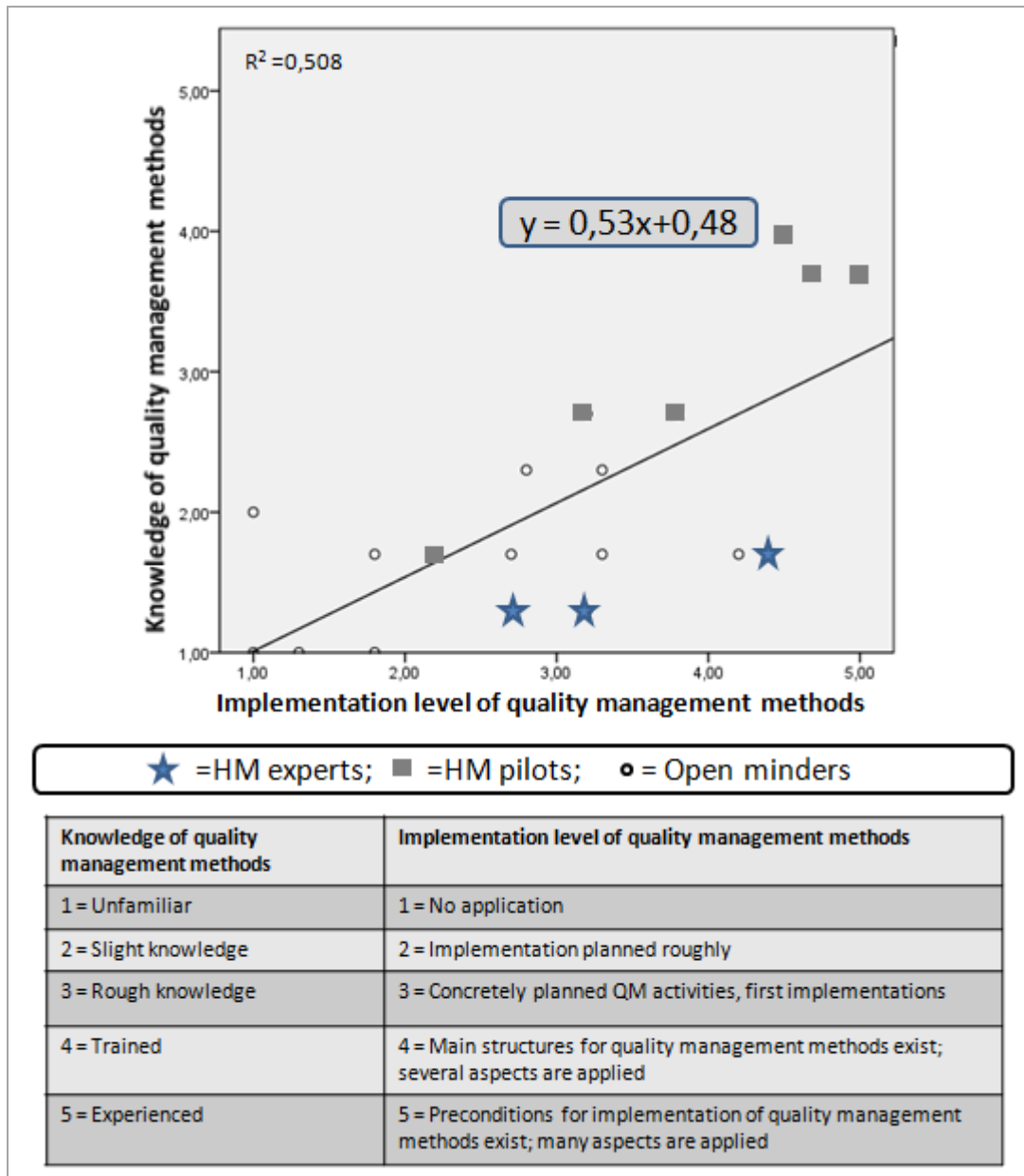
**Fig. 29: Knowledge of quality management tools (n=17)**

Aggregation of the levels of implementation of the three partial aspects of the QM methods

- (1) Existence of a QM team
- (2) Implementation of aspects of the Deming cycle
- (3) Application of QM tools

resulted in the relevant level of implementation of QM methods with network coordinators. This implementation level correlates (coefficient of correlation: 0.713) in accordance with the following equation:  $y=0.528x+0.482$  with the knowledge of QM methods (see Fig. 30) and is mutually significant on a level of 0.01. Only the 19 respondents who have stated being familiar with QM methods are included in this comparison.





**Fig. 30: Correlation between familiarity and level of implementation of quality management methods (QMM) with network coordinators (n=19)**

The group of “HM experts” is far down in the diagram which explains the little knowledge about QM methods. Regarding the level of implementation of QM methods, the results show that “HM experts” have already implemented the elementary components of the methods (positioning in the central part or to the right of the diagram) to a large extent. The five participants with the highest level of knowledge regarding QM methods can all be assigned to the group of “QM pilots”. This group also shows a relatively high level of implementation regarding the methods. The group of “open-minded experts” is positioned in the lower part of the diagram which shows that there exists only little knowledge about the QM methods queried. Seven of the ten participants are situated in the left half of the diagram. This shows a low to medium level of implementation of QM methods regarding the “open-minded experts”.

### **4.2.3 Relationship between experience with team-oriented quality management (QM) methods and coordination services**

If the survey results regarding the offer of coordination services (Chapter 4.2.1) are compared with the answers on the level of implementation of QM methods (Chapter 4.2.2), the network coordinators can be positioned in a cross diagram (see Fig. 31).

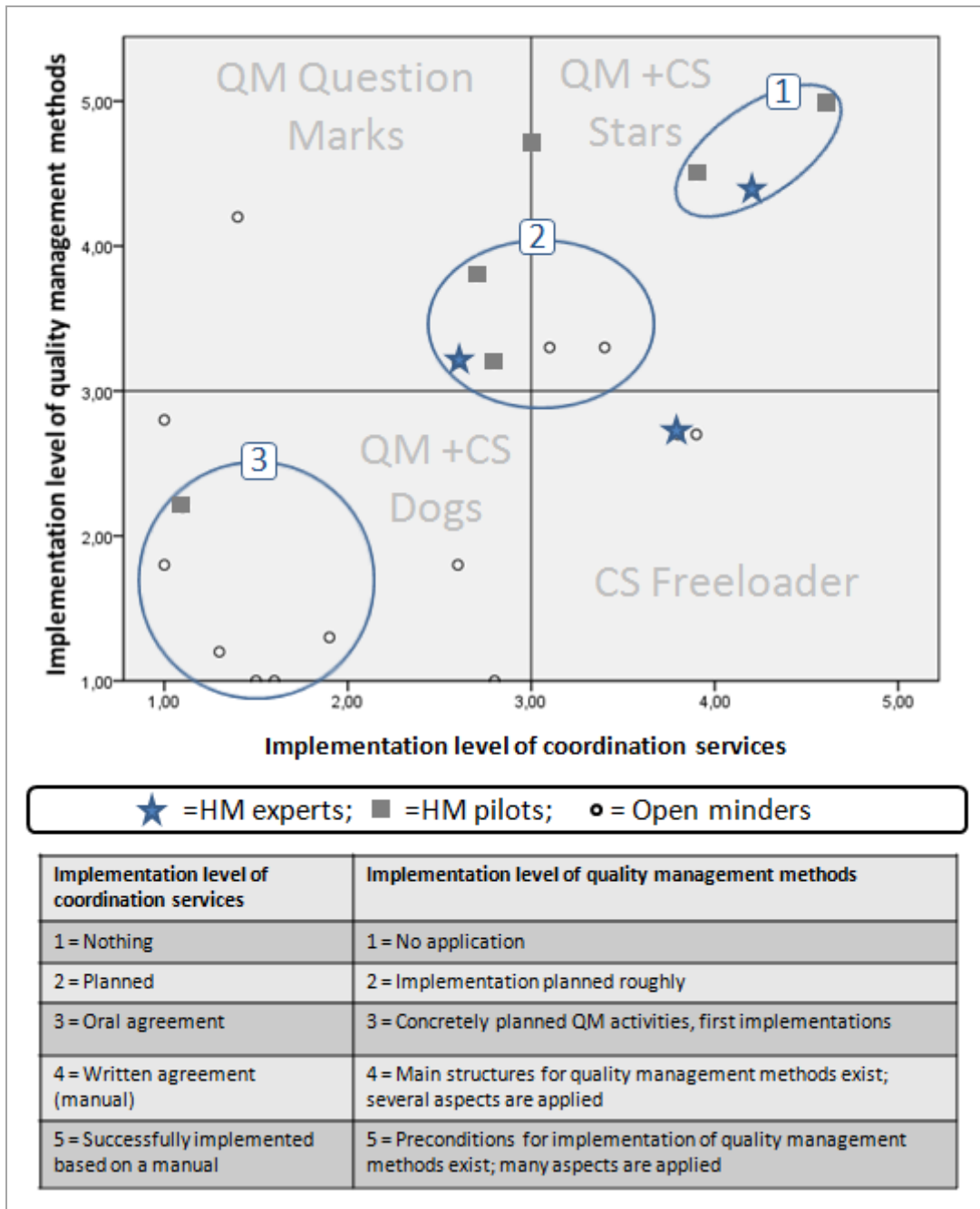
Distribution of the network coordinators is done in four quadrants according to the distribution suggested by the Boston Consulting Group. The first quadrant, i.e. "QM + CS Stars", includes those organizations which have an extensive offer of coordination services and also support them with the help of QM methods methodically (6). In contrast to this, network coordinators assigned to the third quadrant, i.e. "QM + CS Dogs", are characterized by a clear offer of coordination services and also by no or only poor application of QM methods (9). The second or fourth quadrant involves organizations which are only doing well in one specific area. While network coordinators with a high degree of implementation regarding QM methods combined with a small offer of coordination services are positioned in quadrant two, i.e. "QM Question Marks" (4), the fourth quadrant, i.e. "CS Freeloader" contains enterprises showing an extensive offer of coordination services but which hardly use any principles of QM when doing this (2).

When having a look at the scatter diagram, three clusters become apparent. The first cluster consists of three enterprises demonstrating the characteristics of "QM+CS Stars". These are network coordinators who have already been elaborating for many years strategies to support the health management of enterprises within the framework of different projects and are supported on a regular basis by scientists at this. Two of the three network coordinators are further characterized by their size (>1000 employees). Two of the respondents from cluster one can be classified in "HM pilots" and one in "HM experts".

The second cluster is situated with five network coordinators at the bottom of the two upper quadrants. Concerning their supply of coordination services, all five of them are issuing certificates. In connection with three of them, these are based exclusively on audits carried out, and regarding two of them, these are based on sampling. All organizations included have already implemented partial aspects of the QM methods, the focus being mostly on interdisciplinary teamwork.

Six network coordinators form the third and biggest cluster. This is situated relatively closely to the origin of the coordination axes. The respondents of cluster three only offer to a very limited extent services for health management and often use no QM methods at all. Five of these enterprises are relatively small and have only 70 employees at the most. Five of the six respondents from cluster three belong to the group of "open-minded experts".

Finally it can be said that a major part of the network coordinators are situated on a diagonal from the third to the first quadrant.



**Fig. 31: Positioning of network coordinators according to their implementation level of quality management methods and their range of coordination services offered**

## 5. Concept of combining preventive quality management methods in service organizations

### 5.1 Ranking of customer requirements and service offers

The demand for coordination services quite often refers to the exchange of additional information between customer and supplier of animals, when trading animals (Petersen et al. 2010b). According to Ellebrecht (2008) between piglet producers and fatteners already exists a regular exchange of disease data. On the basis of this, in structural equation modeling causal relationships between the “*interest of piglet producers or fatteners in health management-relevant information*” of the other production stage, the “*willingness to provide the other production stage with this information*” and the “*demand of piglet producers and fatteners for an organized exchange of information*” are shown (Chapter 4.1.1).

Three hypotheses made at the beginning could be verified by means of the structural model:

- (H1): *The greater the interest in information of the other production stage (piglet production/fattening), the greater the demand for a mutual exchange of information and thus for coordination services.*
- (H2): *The greater the interest in information of the other production stage (piglet production/fattening), the greater the willingness to provide own information to the other production stage and also to make use of coordination services.*
- (H3): *The greater the willingness to provide own information to the other production stage (piglet production/fattening), the greater the demand for a mutual exchange of information and thus for support in inter-enterprise health management.*

From the survey resulted that there is an interest in information (average value for the answers: 3.1) among piglet producers and fatteners and also the willingness to provide information (scales see Tab. 22) (average value for the answers: 3.4). The interest refers to an exchange of information which is possible but does not take place on a regular basis, while the willingness to provide information exists almost always after a corresponding agreement.

**Table 22: Scales to assess information regarding interest in information and willingness to provide information**

Interest in information	Scale value	Willingness to provide information
Basically yes	4	Basically yes
Not on a regular basis	3	Upon agreement
To a limited extent (only in case of acute problems)	2	To a limited extent (only in case of acute problems)
Basically no	1	Basically no

The structural equation model confirms the relationship between “interest in information” and “willingness to provide information” and also between “willingness to provide information” and “demand for an exchange of information”. From the results of the survey and the causal

relationships determined, one can deduce an existing demand for an exchange of information between piglet producers and fatteners. This can, however, not be realized by small and medium-sized enterprises of primary production on their own (Schütz 2009).

The support of data processing and data exchange between piglet producers and fatteners can thus be recommended to network coordinators who want to develop their service offer in this area. Both, the extent and the willingness of the support by the piglet producers and the fatteners have to be considered positive.

According to Ellebrecht (2008) the benefit of information increases for the receiver with its level of processing. Customer expectations of piglet producers as well as fatteners regarding information and communication systems are a precondition for successful implementation. There already exist such offers with farmers' cooperatives and advisory organizations on an individual basis and mostly limited to certain groups of data. Since a lot of information is valuable for advising several production stages, the extension of such offers and their combination with further offers in health management makes sense. Especially the provision of information regarding the health status is considered important by Petersen and coauthors (2010b).

In addition to organizing an exchange of information between the participants of pork chains, coordination of monitoring, audits as well as issuing health certificates are services increasingly asked for. Owing to this, hypothesis (4) was made, i.e. *that many activities in health management can only be realized with the support of third parties for farmers owing to the high degree of organizational effort involved.*

In order to verify this hypothesis, results of three partial surveys amongst farmers and potential network coordinators were used. The partial surveys aimed at assessing the demand for defined services by farmers and the service offer by network coordinators.

A current example for the offer of coordination services is the issue of certificates regarding the health status of piglet-producing enterprises. Piglet health certificates are issued to increase transparency regarding piglet health for the customer (Nathues et al. 2011). The health status of piglets is an important purchase criterion for fatteners (Petersen et al. 2010b). This is confirmed by the results of the survey where 75% of the fatteners attribute a high or even very high importance to the piglet health certificate. Only 42% of piglet producers shared this opinion. In Denmark, certification of piglet producers has already been established for some time. Interested fatteners can have a look at the health status of potential suppliers (piglet producers) via web.

This high importance of health certificates, which influences the purchase decision of pig fatteners (Petersen et al. 2010b), results in competition for piglet producers. They increasingly take part in voluntary monitoring programs so that they do not suffer any disadvantages when marketing their piglets. Despite this fact the main initiators of monitoring activities are the farm veterinarians as well as farmers' cooperatives.

To assess the current offer situation in connection with services in demand, offer (of network coordinators) and demand (of pig fatterer) regarding defined monitoring activities in piglet production and specific coordination services were compared. For APP, mycoplasma,

pasteurella and brachyspira hyodysenteriae, an enormous difference between offer and demand can be established. The by far higher demand shows that in this regard there is a need for action which is already taken into consideration within the framework of the current TiGA initiative (Petersen et al. 2010b). In contrast to this, with a demand just as high regarding diseases of salmonella and PRRS, offer and demand can be rated as balanced. Legal requirements for quality assurance programs require a high degree of salmonella monitoring also in piglet production. The great importance of the PRRS status and the monitoring offer already geared to this, can be ascribed to the fact that PRRS is considered to be one of the diseases causing the greatest economic losses for farmers.

Comparing offer and demand of selected coordination services in inter-enterprise health management shows that in this respect there is a big gap. A medium to high demand is often confronted with no or only a reduced number of offers. Many network coordinators, however, stated that planning activities exist so that an extension of these coordination services can be expected in the next years.

In the previous section, the interest of farmers in exchange of information and the existing support need of farmers regarding activities in inter-enterprise health management is determined. Consequently, these are demands placed by the customers on network coordinators. In the following, the focus is on activities of service providers. In a first step, assessment of project activities of network coordinators regarding the nine elementary components of health management defined by Schütz (2009) is carried out. Planned, existing and finished projects served as a measure of effectiveness of health management systems. Finally, the extent of an health management-relevant service spectrum was assessed. Confrontation of these two aspects served to assess hypothesis (5), i.e. that *effective inter-enterprise health management is characterized by a successful coordination of inter-enterprise services*.

The high demand of pig fatteners for a certified health status for piglet producers already mentioned above, explains the results on projects in the area of health certificates. Most of the network coordinators questioned organized marketing of piglets and are hence directly confronted with the requirements of fatteners as their customers. In accordance with the demand behavior, project activities of service providers are more pronounced in this area for piglet producers than for fatteners. The fact that diagnostic evaluations usually present the basis for the preparation of health certificates, leads to a comparable answer structure regarding projects in herd diagnostics. Another cause for the higher number of projects in this area for piglet producers is to be seen in the fact that piglet producers have a pronounced support need regarding development of health-relevant issues, as described above.

A breach of for example cross-compliance regulations leads to subsidy cuts and thus has direct financial disadvantages for farmers. This background information implies a great demand of farmers for support to be able to comply with legal requirements which is reflected in their broad offer (9 existing projects with 12 mentions).

As can be seen in Chapter 4.1.1, there is a requirement for support in inter-enterprise exchange of information. In addition, exchange of documents and information is a prerequisite for most elements of health management which explains the large percentage (10 existing projects with 16 mentions) of projects in this area.

Finally it can be summarized that there exist many project activities in the areas of animal health, verification of legal conformity and exchange of information and documents which can be explained by their great importance for the efficiency of enterprises.

Half of the network coordinators queried (11 of 21 mentions) is carrying out audits regarding health management at their customers which exceed national QM programs. These are characterized by a very high degree of organizational effort: distinguished by a written audit plan and an audit protocol as well as an interdisciplinary audit team. In addition to audits, frequently monitoring sessions are offered which permit concrete definition of pathogen or antibody status and thus form the basis of health certificates. Ten network coordinators are in the possession of written procedural instructions to define sampling. This includes all members of "HM experts" and "HM pilots".

Carrying out audits usually serves to verify certain standards in connection with the enterprise. Depending on the desired targets, processes, products or systems are audited (Mack 2007). In combination with sampling, they often serve as the basis for issuing certificates confirming the health status of an enterprise which are required for participating in some quality management programs and are beneficial for marketing of animals.

In order to guarantee comparability of sampling results, it is not only important to standardize sampling, but also sample processing and analysis in the laboratory. 16 respondents provided information on standardization of analyses of piglets and 14 of fattening pigs. The far higher degree of standardization of sample analyses for piglets (Fig. 23) is caused by the higher demand for transparent health information for piglets.

An interrelationship of the two aspects of effectiveness of health management (on the basis of the project status in the nine elements) as well as the offer of coordination services in inter-enterprise health management and thus the underlying hypothesis (5) could be confirmed by a mutually significant positive correlation. From an increase of the level of experience in health management achieved by project activities also results an extension of the service offer. The results confirm the assumption that the "open-minded experts" so far have not been strongly involved in project activities, while project experience of the other two groups vary enormously. With regard to the level of implementation of coordination services, it is apparent that the two services, i.e. sampling and certificates, are offered mostly in combination and thus answers are often similar. Four out of six "HM pilots" do not offer any audits, they concentrate on sampling and certification of the health status. In contrast to this, five "open-minded experts" who are offering audits do not show any initiatives regarding offers in the areas of sampling and certificates.

The following Table 23 shows the most important aspects regarding demand of farmers and the relevant offer of network coordinators.

**Table 23: Customer expectations (farmers) and offer (network coordinators) of coordination services**

Subjects	Customer expectations	Service offer
<b>Health status of piglet producer</b>	<i>Health certificate for piglet producer.</i> - <b>High</b> (fattener) - <b>Medium</b> (piglet producer)	<i>Monitoring sessions:</i> - <b>Medium</b> (salmonella, PRRS for piglets) - <b>Low</b> (only about 1/3 is offering monitoring sessions regarding brachyspira, pasteurella, mycoplasma, APP for piglets)
		<i>Certificates</i> (via additional information regarding the health status): - <b>High</b>
		<i>Health certificates</i> (preparation, organization of issue as well as handing over to farmers): - <b>Low</b>
<b>Preparation of HM-relevant issues</b>	<i>Support with preparation of health-relevant issues:</i> - <b>High</b> (piglet producers)	<i>Execution of HM-relevant audits:</i> - <b>Medium</b>
		<i>Advisory services for farmers on the basis of results:</i> - <b>Medium</b>
		<i>Information of farmers on results of monitoring sessions / visits:</i> - <b>Low</b>
<b>Inter-enterprise information exchange</b>	<i>Support of exchange of information between piglet producers and fatteners:</i> - <b>High</b>	<i>Information of farmers and veterinarians on procedures for status determination:</i> - <b>Medium</b>
Explanation of assignment of the results to the three categories (low, medium, high) on the basis of the percentage of positive mentions for demands or offers (0-20%); medium (>20%-50%); high (>50%)		

## 5.2 Essentials of preventive quality management (QM) methods in service organizations

So far, experience regarding use of QM methods in the pork chain is still rather limited. Exceptions to this are co-operations between enterprises and scientists within the framework of research projects where individual QM methods were processed or partly modified by way of example for processes in animal or meat production (Welz 1993, Schmitz 2005, Mack 2007, Klauke & Brinkmann 2009). Bahlmann & Spiller (2008) stress that adaptation of QM methods to the processes of pork production is necessary so that their effective use is enabled. In the second part of the expert survey amongst network coordinators, the popularity of selected QM methods and their level of implementation was queried. The latter was carried out by asking about the existence of essential components (QM team, procedure similar to the PDCA cycle, QM tools) of preventive QM methods (see Chapter 2.2) so that the



level of implementation could be determined even without knowledge of the underlying methods. This part of the survey was based on hypothesis (6):

- (H6): *Most network coordinators do not know about preventive quality management methods regarding the relevant terms but are using the principles or partial aspects of these already subconsciously in their processes.*

The few literary examples regarding application of QM methods in the agricultural field also confirm the results achieved in the survey of experts which refer by way of example to the three methods of Six Sigma, FMEA and HACCP. While only three respondents do not know HACCP at all, 13 or 15 network coordinators stated that they are not familiar with FMEA or Six Sigma. The higher degree of popularity of the HACCP concept is due to the legal requirement to introduce the HACCP concept in food companies (in primary production HACCP-based concepts) (Reg. (EU) No. 852/2004). Considering that the regulation was already enforced in 2005, it is quite astonishing that 3 respondents stated that they had never heard of the HACCP concept. These have to be assigned to the group of “open-minded experts”. Regarding knowledge and methods, there is a great difference between the individual groups. The group of “HM pilots” already involved in scientific projects stands out regarding all three methods due to their edge in knowledge.

This can be explained with the fact that most organizations concentrated so far on the production related performance control and pig marketing. Additional services such as offers in inter-enterprise health management have only been integrated to a greater extent into the service offers in recent years. When establishing such a service offer, the potential benefit of methodical support of activities in health and quality management for the participants becomes only gradually obvious. It can be foreseen that from the benefit perceived, a demand for methodical support will result.

Regarding the level of implementation of preventive QM methods, the three partial aspects, i.e. existence of a QM team, orientation along the PDCA cycle and use of QM tools, are considered more closely.

Many authors stress the importance of teamwork regarding effective application of preventive QM methods (Mortimore & Wallace 1998, Schmitz 2005, Kurzeja & Luckner 2008, Gamweger et al. 2009). In more than half of the enterprises, the work in interdisciplinary teams to solve HM-related issues has already been permanently incorporated. These consist in their majority of farmers, farm-veterinarians and advisors for the network coordinators. Co-operation between veterinarians and farmers is already demanded within the framework of veterinary farm support which involves, amongst others, joint enterprise visits on a regular basis. In addition to this, as part of programs of the farmers’ cooperatives, joint visits of veterinarians and farmers usually take place.

To a lesser extent, external advisors and external veterinarians, scientists, laboratory and slaughterhouse employees are involved in the teams. Support within teams by further disciplines is not necessary for all issues owing to their professional specialization. Accordingly, it has to be assumed that these professionally specialized experts are involved only in case of specific issues or acute problems.

From the overall relatively low frequency of team meetings it can be deduced that the focus regarding the content of the teams considered is on higher-ranking strategic issues and not on the individual operational level.

As already explained in Chapter 2.2, the PDCA cycle involves the four procedural steps of planning, implementation, evaluation and correction (Pfeifer 2001). These were established by means of the aspects of existence and control of compliance with requirement profiles for products and process descriptions as well as the project status (planning, realization, successful termination) in the areas of risk assessment and process optimization.

As already mentioned several times, here the great demand for a legally drawn up health status for piglet-producer also becomes apparent. The majority of network coordinators is in possession of written requirement profiles to determine this status. "HM pilots" have specifications for all of the five piglet characteristics queried (health status, weight, uniformity, race, vaccination status). With fattening pigs, the characteristics of health status, weight, lean-meat content, meat depth and fat depth are taken into consideration. Here, oral specifications predominate. These different manifestations are due to the sphere of action of network coordinators. Most of the network coordinators have no slaughterhouse incorporated but are service providers for piglet production and fattening. Product specifications for slaughter pigs are, however, predetermined by slaughterhouses. Owing to this, network coordinators rely in connection with their requirements or information processing for fatteners on those of the slaughterhouses. Consequently, the only two respondents with an integrated slaughterhouse have indicated the highest score, i.e. "written specification and external control" regarding specifications.

Regarding process descriptions, there exist agreements with more than half of the respondents but they vary greatly when it comes to realization with respect to their degree of detail. Only few oral agreements exist in connection with processes. Since activities in health management can greatly influence the quality of the products piglets or finishers and also a uniform procedure for all enterprises of an organization is desirable, written specifications are necessary here. All members belonging to the group of "HM pilots" have written instructions regarding the processes queried. In contrast to this, only three network coordinators belonging to the "open-minded experts" have oral or written agreements regarding all processes.

The degree of popularity of QM tools is similarly to the one of QM methods very low. Only the term "brainstorming" which is quite frequently used in everyday language, is known to all respondents with the exception of two ("open-minded experts"). Regarding one or several of the QM tools, i.e. trend analysis, histogram, decision tree, scatter diagram and determination of critical control points, half of the "QM pilots" and two of the three "QM experts" have already application experience. This is, however, true for only one respondent of the group of "open-minded experts". Trend analysis, histogram, decision tree and scatter diagram appear to be clear when it comes to the expression itself. CCPs are known in connection with the legally prescribed HACCP concept. The risk priority number, Ishikawa diagram, control chart and pareto diagram are completely unknown to the majority of network coordinators. These four aids refer strongly to the methods of quality management and might not be sufficiently clear by their expressions alone. Consequently, they are not very popular.

When comparing the two aspects of popularity of QM methods and their level of implementation, it was possible to ascertain a mutually positive significant relationship. This helped to confirm hypothesis (6).

When positioning the network coordinators in the scatter diagram, it becomes obvious (see Figure 30) that the three “HM experts” carry out QM-method-relevant activities but do not have any knowledge of the methods queried. They merely have already heard of the HACCP concept but do not know any details in this regard. Therefore, the hypothesis applies to them above all. In contrast to this, FMEA is known to all “HM pilots” (6 mentions) with one exception and Six Sigma with two exceptions. The five respondents most knowledgeable regarding the QM methods queried can accordingly also be assigned to this group. This is due to the co-operation with scientists who have already integrated QM methods within the framework of projects into the pork chain. The level of implementation of “open-minded experts” varies greatly, while their knowledge about QM methods is little.

Table 24 presents an overview of the levels of implementation of essential criteria of the components defined in Chapter 2.2 in connection with preventive QM methods with the service enterprises queried.

When positioning the network coordinators queried in a scatter diagram regarding the level of implementation of QM methods on the ordinate as well as the level of implementation of coordination services on the abscissa, three clusters can be distinguished (see Figure 31) which are moving about a diagonal from the third to the first quadrant. This confirms that the two aspects, i.e. offer of services in health management and application of QM methods are closely linked.

Cluster one is positioned in the first quadrant “QM+CS Stars” and forms the objective for all other network coordinators. Cluster two is positioned along the lower edge of the first and second quadrant. When the network coordinators of this group are extending their service offer according to the demand of their customers in inter-enterprise health management, development into “QM+CS Stars” is possible. Cluster three is close to the origin of the coordinate axes in quadrant three “QM+CS Dogs”. The lower available capacities could be the reason for the fact that they cannot offer a broad service spectrum. Probably they restrict themselves to support for marketing pigs.

When exclusively looking at the levels of implementation of QM methods, it becomes apparent that seven of the ten network coordinators positioned in quadrant 2 (“QM Question Marks”) and 1 (“QM+CS Stars”) have been supported for quite some time within projects scientifically. It can be assumed that the scientific input contributes decisively to the introduction and application of preventive QM methods. Their positioning in the right two thirds shows additionally that a major part of scientifically supported respondents also has an extensive service spectrum in inter-enterprise health management.

**Table 24: Levels of implementation of essential criteria of components of preventive QM methods with network coordinators**

Individual components of QM methods	Criteria assessed regarding individual components of QM methods	Level of implementation
<b>QM team</b>	Existence of interdisciplinary QM teams	<b>Medium</b>
	Team meetings on a regular basis (at least once a month)	<b>Low</b>
	Experience of team members regarding risk analyses and process optimization	<b>Medium</b>
	Qualification of team members	<b>Medium</b> (Half of them has QM-qualified members in their teams. Frequently, several qualified members are with one network coordinator. On the whole, 24 QM qualifications were stated.)
<b>Orientation along PDCA cycle</b>	Planning	<p><i>Written requirement profiles for piglets (health status)</i></p> <p>- <b>Medium</b></p> <p><i>Written requirement profiles for finishers (health status)</i></p> <p>- <b>Low</b></p> <p><i>Existence and form of process descriptions</i></p> <p>- <b>Medium</b></p>
	Implementation/evaluation	<p><i>Control of implementation of requirement profiles for piglets (health status)</i></p> <p>- <b>Medium</b></p> <p><i>Control of implementation of requirement profiles for finishers (health status)</i></p> <p>- <b>Low</b></p> <p><i>Regular update of existing process descriptions:</i></p> <p>- <b>Low</b></p> <p><i>Projects on risk assessment and optimization of processes</i></p> <p>- <b>Low</b></p>
<b>Application of QM tools</b>	Brainstorming	- <b>Medium</b>
	Trend analysis, histogram, decision tree, scatter diagram, CCPs	- <b>Medium</b>
	Pareto diagram, Ishikawa diagram, control chart, risk priority number	- <b>Low</b>
CCP = Critical Control Point; PDCA =Plan-Do-Check-Act; QM = Quality Management		
Explanation of allocation of results to the three categories (low, medium, high) on the basis of the percentage of positive mentions regarding implementation of QM methods: low (0-20%); medium (>20%-50%); high (>50%)		

Finally, it can be said that within the service organizations present on the market, there exists a broad spectrum regarding the offer of coordinating services in health management and also regarding application of preventive QM methods. Enterprises with a high number of employees are quite often better prepared to offer a broad service spectrum owing to the capacities available. In contrast to this, introduction of QM methods is closely linked to scientific support.

### 5.3 Proposal for further development of coordination services

From the results of this thesis follows that an extension of many activities in inter-enterprise health management (e.g. determination of the health status and certification) is necessary and the relevant implementation only possible with the support of potential network coordinators. At present, especially support for the three areas of animal health, animal well-being and food safety and quality is discussed. In the following, the need for action within these three areas is explained further (see table 25).

**Table 25: Further development potential in the service sector of network coordinators**

Fields of action	Current need of action	Measures of network coordinators	Application of QM methods
Optimization of animal health	Improved protection of animal populations against the propagation of epizootic diseases	Coordination of engage and exchange of information between agricultural enterprises and authorities in certain regions in cases of crisis	Guarantee of high data quality (Six Sigma)
Improvement of animal welfare	Changeover of production systems (e.g. doing without castration of boars or docking of tails)	Coordination of team advisory service in individual enterprises and value chains	Determination, evaluation and reduction of risks of production failures or non-conformity regarding customer requirements (FMEA)
Improvement of food safety and quality	Changeover of production systems to reduce antibiotics use	Coordination of team advisory service Coordination of exchange of information of results from voluntary residue and resistance monitoring between piglet producer, fattening and slaughtering enterprises	Inter-enterprise improvement processes regarding optimization of management to reduce disease pressure (Six Sigma); definition of critical control points (HACCP); risk assessment (FMEA); formulation, implementation and verification of corrective measures (FMEA, HACCP)
FMEA = Failure Mode and Effects Analysis, HACCP = Hazard Analysis and Critical Control Points, QM = Quality Management			

An important aspect in the field of action of *animal health* is optimization of the protection of animal populations before the propagation of epizootic diseases. In particular in cases of crisis it is of great importance to provide relevant information to the corresponding participants at short notice (Breuer 2011, Kasper et al. 2008, Slütter et al. 2010). On the one hand, enterprises have to be informed contemporary about information important for them by authorities. On the other hand, the provision of information enables targeted risk management adapted to the relevant risk. This is dependent on entering possibilities for information in databases being already created before the crisis, and, if necessary, rapid internet-based collection and processing enabled (Slütter et al. 2010).

Network coordinators organizing trading with animals for farmers, collect already relevant data regarding master data of enterprise locations such as current contact data and information on trade relations. In addition to this, network coordinators organize services in health management, such as processing of slaughtering data or support within the framework of legally prescribed documentation duties regarding health-relevant data (population register, food chain information). In this context, the extension of their offer by data processing functions of information relevant for times of crisis is advisable before such periods of crises. By corresponding technical extensions, activation/transferring of information saved could take place at short notice. In addition to this, relevant information can be supplied to farmers via push-services (Schulze Althoff 2006, Ellebrecht 2008, Schütz 2009).

Regarding an exchange of information in times of crises, high data quality is of utmost relevance. To guarantee the data quality especially required by authorities, the use of Six Sigma seems to be ideal. Within the framework of an improvement project, content-related and technical requirements can be improved continually already before crises (Brinkmann et al. 2009).

Docking of tails and the foregoing of castration of boars are discussed in connection with the well-being of pigs (*animal welfare*) as customer requirements (Beuck 2011). Docking of tails aims at reducing the risk of tail-biting which had become an increasing problem in intensive pig production. Regarding animal welfare, tail docking is no longer permissible as a routine measure so that the pressure on the taking of alternative measures is increased (Commission Directive 2001/93/EC).

In most of the enterprises, castration of male pigs is undertaken additionally in one operation. The background for this is that this measure aims at preventing the so called "boar odor" which causes a modification of the meat regarding its taste and odor (Hügel 2010). In addition, with a voluntary abandonment of castration, operational management regarding diecious fattening had to be adapted accordingly (Hügel 2010).

Many network coordinators have integrated regular farm visits together with the farm veterinarian in their health management programs to process health management-relevant issues. In this context, extension of team advisory services to detect risks regarding the appearance of aggressions with pigs seems ideal. These are often based on behavior disorders which can be influenced by corresponding measures in management. On the basis of Failure Mode and Effects Analysis, realization of a detailed cause-and-effects analysis

regarding the weak points in management seems to make sense, since this can lead to changes in the social behavior of pigs. Within the FMEA team, relevant measures to remove identified weak points should be detected and carried out. The objective is to reduce the risk of aggression.

In connection with *food safety and quality* the subject of reduction of antibiotic treatments as well as resistance formation is mentioned frequently. Prophylactic or metaphylactic application of drugs in pig production results in partly high use of antibiotics.

Starting from the zero tolerance limit of export markets regarding residue values of tetracyclines in meat, residue management in a slaughtering and processing enterprise was implemented within the framework of the research network FIN-Q.NRW. This enables an enterprise-specific risk assessment regarding tetracycline residues. Depending on the risk determined, realization of improvement measures by the responsible management to prevent diseases makes sense. Inter-enterprise information often forms the basis for taking measures since especially the situation of a change of enterprise presents a critical phase for the health of the pigs. Six Sigma appears to be optimal for the structural procedure for inter-enterprise realization of improvement projects by network coordinators.

In contrast to this, the HACCP concept is ideal for identifying measurement points regarding assessment of residues and FMEA for risk assessment.

Many authors highlight the importance of advisory services in interdisciplinary teams (e.g. consisting of farmers, veterinarians and advisors as well as scientists) since it will allow integrating different views when planning and implementing methodical procedures (Berns 1996, Mack 2007, Schmitz 2005, Schulze Althoff 2006, Schütz 2009).

Bruns (2011) describes cooperation between science, economy and public institutions to initiate and implement inter-enterprise project activities in the area of quality management and food safety. One objective is based on realizing innovation projects (Bruns 2011). Economic partners who have been cooperating for some time with science within the framework of such projects are designated as members of the group "HM pilots" in this thesis. Concrete project examples refer to regional activities to introduce monitoring sessions, e.g. for salmonella and PRRS, in the piglet producing stage. Unification of such regional monitoring offers for piglet producing enterprises to reach a standardized procedure are designated by Bruns (2011) as an example of organizational innovation.

Prioritization of services should be done taking the expectations of farmers into account in order to make a suggestion regarding the order of extension of the service spectrum of network coordinators. This procedure follows the Kano concept explained in Chapter 2.3.2 and uses the division suggested by Huiskonen & Pirttilä (2008) regarding services into "expected service element", "one-dimensional service element" and "attractive service element". Advisory services, realization of audits and sampling as well as issue of certificates are considered as superior service offers. In this regard, two service elements can be distinguished, i.e. on the one hand, the individual service on its one, and on the other hand the type and form of its design as service element is looked at.

Regarding the former, it is assumed that services with a strong demand are expected by most customers. If they are not offered, the customers, i.e. here piglet producers and fatteners, are dissatisfied. Services which are often talked about but which are not demanded by the majority, are assigned to the group of one-dimensional services. They do not necessarily result in dissatisfaction if they are not offered, but customer satisfaction would be increased if they were integrated into the service offer. Services rarely or never asked for are either not important for farmers or their added value cannot be evaluated by them. By adding information from literature and from current projects to assess the importance of these individual services for the economic success of agricultural enterprises, a subdivision into two categories is done. If a service is important for the customers, this is called "attractive service element". Such a service is at the moment not expected by the majority of farmers, it results, however, in increasing customer satisfaction if it is integrated into the offer portfolio. If no significance can be detected for the customer, a service not asked for is rated as indifferent and can therefore be ignored.

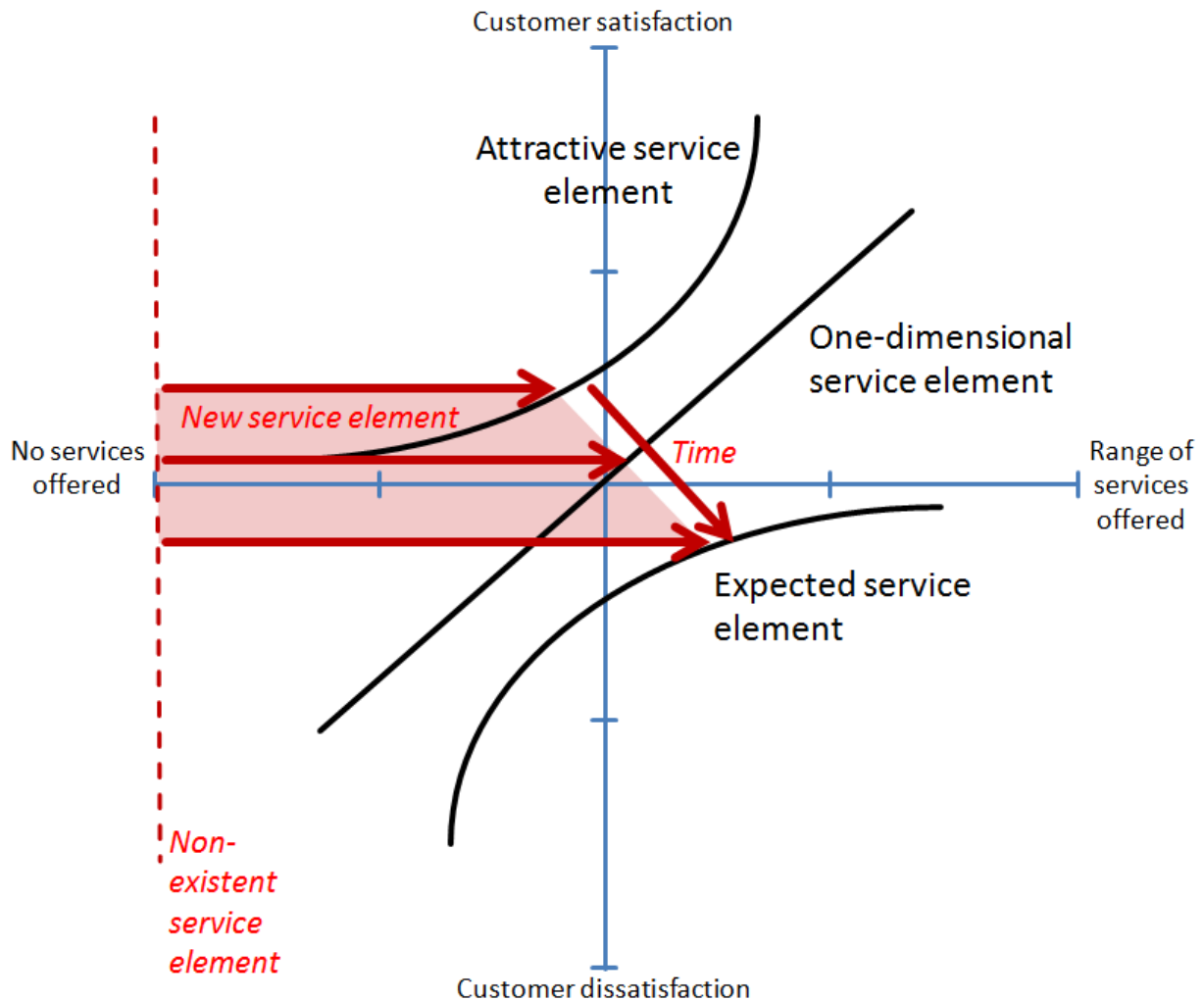
The type and form of services was called the second service element. In particular for services closely linked with organization of communication between animal rearing enterprises and their customers, the degree of data processing has an important influence on the benefit according to Ellebrecht (2008) and thus also on the enthusiasm of its receiver. In addition to this, preparation and post-processing of activities such as audits or monitoring sessions and advisory services based on results lead to a relief from time constraints for the farmers and consequently have a positive influence on customer satisfaction.

The target of network coordinators should be to offer in addition to services to be assigned to the "expected service elements" as well as "one-dimensional service elements", also those called "attractive service elements". In particular the latter often enable a differentiation regarding competitors (Lotz 2008). In addition to the offer of specific services, the organization of activities and usage of results has a high priority. When services offering an added value to farmers with relatively low additional effort, are well organized and designed, this is also called "attractive service element" of a service offer.

According to the resources available it is possible to chose amongst three different approaches: full-service provider, operating company or outsourcing approach (Schütz 2009).

Extension and adaptation of the service spectrum is a continuous process which needs to be examined time and time again. Accordingly, the assignment of service elements is changing as shown in Figure 32 corresponding to the familiarization effect with time, i.e. from "attractive service elements" to "one-dimensional service elements" and from "one-dimensional service elements" to "expected service elements" (Otzmann 2005).





**Fig. 32: Representation of the “lifecycle” of services regarding the assignment to Kano quality elements (mod. acc. to Oetzmann 2005)**

In the second part of Chapter 5.2 a concept for the integration of preventive QM methods into processes of inter-enterprise health management of pork chains is presented on the basis of former application experience of QM methods. Regarding the two objectives of process optimization and risk prevention which seem to be relevant for the pork chain, integration of the three methods FMEA, HACCP and Six Sigma into the concept is ideal. When creating a concept, it has to be assured that internal and inter-enterprise processes of primary production are taken into account.

Therefore, in a first *step* an interdisciplinary team consisting of all participants involved (piglet producer, probably piglet rearer, fattener, farm veterinarian and network coordinator) is put together. Then the responsibilities are defined for the individual procedural steps whereas the main responsibility should be with the network coordinator since he is controlling the higher-level processes. *Part two* consists of the preparatory phase. This is done within a team and encompasses process description, setting targets and definition of potential risks or deviations from the objectives. It ends with a root-cause analysis and the definition of control points. These control points are defined according to CCPs. The objectives are,

however, extended in addition to food safety by food quality and the previously defined process deviations.

The following procedural steps are combined in *part three*. They take place process-related and are often carried out by only one or two persons belonging to the team. Part three starts with an examination if the control points were adhered to. This is carried out by the relevant process responsible, i.e. the farmer, for example, (hygienic measures), the veterinarian (sampling) or the network coordinator (data evaluation). These examinations are undertaken continuously within defined rhythms. When determining deviations, an assessment of potential failure effects on the basis of the two key performance indicators, i.e. probability of occurrence and discovery, is done. Hence, a simplified form of risk priority number takes effect since definition of the importance of failures in live animal production involves a considerable effort. In accordance with the level of error, corrective measures are defined and realized. This calculation of the level of failures and definition of corrective measures is effected under the responsibility of the network coordinator being supported contents-wise by the veterinarian or farmer. Realization is done by the responsible process engineer. Part three ends with verifying success of the corrective measures for which the network coordinator is responsible. Depending on the result, the process is completed or it begins anew with the definition of corrective measures. Since part one and two are not process-related, they are not carried out continuously. They should, however, be verified in longer intervals and adapted accordingly in case of process changes. Figure 33 provides an overview of the three parts of the concept presented and suggests supporting QM tools for the individual procedural steps. The essential preconditions (QM team, modeling the PDCA cycle, use of QM tools) which are described in Chapter 2.2 for preventive QM methods, are taken into account in this concept. Finally it has to be stressed that for successful implementation, a clear definition of responsibilities and procedural steps and strict adherence to them, is absolutely necessary.

The following illustration shows a suggestion for the extension of the service spectrum of network coordinators in inter-enterprise health management of pork chains and a concept for support of these services by means of preventive QM methods. As can be seen from Figure 31, the degrees of implementation of health management-relevant coordination services and QM methods are changing in proportion to each other. Accordingly, step-by-step design of both aspects is helpful. Regarding development of the service offer of network coordinators it makes sense to plan an extension of the service spectrum as a first step. In the next step, it should be considered which objectives of services can be supported methodically or if by changes implemented in the service offer special aspects regarding already implemented methodical procedures have to be taken into account. Here it is quite helpful to fall back on the experience of universities and research institutes who can quite often resort to several years of experience within the framework of research projects.

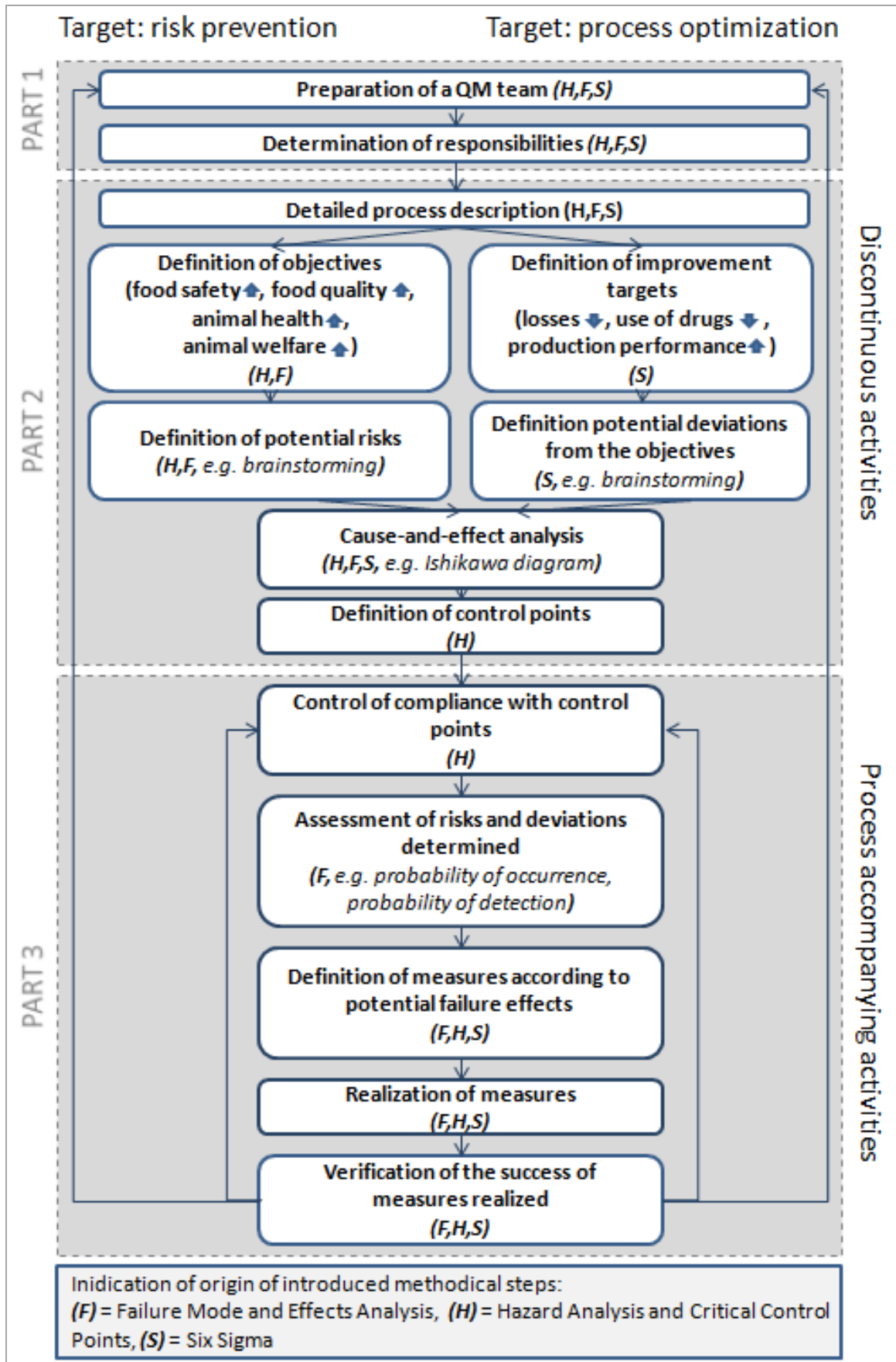


Fig. 33: Procedural steps regarding the use of preventive QM methods in processes of inter-enterprise health management

## 6. Model for assessing the quality of coordination services

In Chapter 4.2 it became apparent that many network coordinators offer services with similar, partly even identical objectives for the two customer groups of piglet producers and pig fatteners. Frequently, these services are based on written guidelines laid down internally, sometimes they only rely on oral agreements (see Chapter 4.2.1). Four network coordinators from the survey have built up the service area of their enterprises in a way that the underlying quality management system corresponds with DIN EN ISO 9000 and the standard conformity is audited and certified on a regular basis.

Comparability of the quality of individual service offers would be desirable in order to be able to correctly evaluate the frequently certified results regarding advisory services, audits and sampling of potential customers. The findings from own empirical studies on influencing factors regarding the “quality of coordination services” (LV7) serve, on the one hand, to formulate concrete proposals for an optimization of the service offer, and, on the other hand, they facilitate comparability of service offers on the basis of a calculation of the quality of coordination services via known influencing factors. The model depicted in the following is used to assess the causal relationships between defined variables, such as “health management competence” and “quality of coordination services”.

The model is based on the assumption that the quality of coordination services in inter-enterprise health management of pork chains is determined by a multitude of influencing factors. Bruhn (2010) mentions in his definition on services the combination of internal and external factors. When doing so, he designates factors lying outside the scope of influence of the service provider (customer, objects included) as external factors, and individual characteristics (personnel, equipment) as internal factors. When defining the influencing factors specified as latent variables (in the following abbreviated to “LV”), internal factors (resources of network coordinators regarding service design in inter-enterprise health management) as well as external factors (farmers, veterinarians, products and operational processes) play an important role.

Since quality and safety of end products of the producing enterprises is strongly influenced by animal health (Schulze-Althoff et al. 2007), a high health status of animal-keeping enterprises presents an important selling and purchasing criterion for pigs. From this results for example a low use of drugs which has a high priority due to the resistances occurring more and more in human medicine (Köck et al. 2011). Inter-enterprise and on prevention oriented health strategies such as a vaccination management adapted to the relevant enterprise, play an important role here. Van der Peet-Schwering and coauthors (2008) stress in this context also the influence of management in pig production on the percentage of organ findings.

In primary production as well as in the stages of slaughtering and further processing, methodical support of processes for early identification and thus possibly reduction of risks and errors makes sense. Kamiske & Brauer (2008) suggest the use of the quality management methods HACCP and FMEA to achieve these objectives. Another starting point of preventive quality management methods is continuous optimization of processes and their

constant approximation to the “state of the art”, which is also the objective of Six Sigma, according to Gamweger and coauthors (2009).

The two aspects mentioned, i.e. the offer of support services to optimize inter-enterprise health management (LV1: “*Health management competence*”), on the one hand, and the application of preventive quality management methods to identify and avoid risks and for process optimization, on the other hand (LV2: “*Quality management competence*”), present the first two variables to determine the quality of coordination services. The two variables LV1 and LV2 are closely linked with each other. It is assumed that an increase of “quality management competence” also leads to an increase of “health management competence”. This hypothetical assumption is shown in the structural model by means of an arrow between the variables “LV2 → LV1”.

The heavily subdivided and very heterogeneous customer structure of network coordinators described by Schütz and coauthors (2008) and the necessary integration of a multitude of different participants (veterinarians, laboratories, slaughterhouses and possibly further specialist advisors) in addition to the farmers as direct customers, requires a thoughtful organization of services from preparation and realization up to post-processing (LV3: “*organizational competence*”). Schütz & Petersen (2010) designate advisory service, techniques and organization of processes as service categories of network coordinators in inter-enterprise health management. From this results that in addition to time and personnel management, advisory services and technical support represent a criterion for the quality of coordination services, e. g. regarding comprehensibly and clearly arranged representations. This “*service quality*” (LV4) is closely linked with “organizational competence” regarding its contents. Optimizing the degree of organization will presumably also lead to an improvement of service quality. An additional connecting arrow in the structural equation model represents this hypothetical assumption.

Further development of services and integration of innovative approaches often connected with scientific support within the framework of projects, enables network coordinators to continually optimize their service offer and thus secure their customers’ competitiveness towards customers of other network coordinators (LV5: “*R&D activities*”). The last latent variable “*target group orientation*” (LV6) encompasses determination and consideration of customer requirements according to the existing customer structure.

The six factors mentioned above which are to be considered when assessing the quality of coordination services exist as latent variables in the structural model (Fig. 34). To determine the variables, the measurement indicators described in the following are used.

“*Health management competence*” is defined by the offer of services to define and optimize the health status in primary production. Accordingly, here the aspects auditing and advisory services, sampling and preparation of certificates taken into consideration in part one of the expert survey are included. Part two of the expert interviews referred to the determination of the implementation level of preventive QM methods regarding activities in inter-enterprise health management. The three areas queried here, i.e. existence of a quality management team, application of quality management tools and orientation along the Deming cycle, are part and parcel of “*Quality management competence*”.

The great need for coordination with farmers, veterinarians, laboratories, slaughterhouses and specialist advisors regarding many services in inter-enterprise health management requires regular and targeted co-operation on the basis of an organized exchange of information between all parties involved. These co-operations and definition of elaborated concepts for reaching common superior objectives based on a detailed distribution of tasks, are part of “*organizational competence*”. By informing farmers and veterinarians in advance so that they can prepare upcoming activities such as site visits or sampling, they can be supported with their individual preparations. Evaluation and clear display of results and the ensuing recommendations help the participants to quickly react to possibly negative results. These possibilities for the farmers to participate in activities of inter-enterprise health management with little own effort and to be informed exhaustively about procedures and results, characterizes good “*service quality*”.

“*R&D activities*” enable testing of innovative approaches often within the framework of pilot projects and consequently finding out about development potentials. Scientific findings can thus lead for example to new ideas regarding extension of service offers. Determining the need for support of the customer and assessing and evaluating customer satisfaction with the existing service offer enable consideration of “*target group orientation*” when designing the service spectrum. The results from Chapter 4.1 to assess customer expectations regarding coordination services are included here. A further aspect of “*target group orientation*” would be the assessment of services according to the categorization suggested by Kano into basic service elements, one-dimensional service elements and excitement service elements (Huiskonen & Pirttilä 2008). The significance of individual services regarding customer satisfaction could be taken into account when extending the service offer. The characteristics of the relevant latent variables mentioned in this chapter are defined as components of individual variables and consequently as formative indicators.

The objective of coordination services in inter-enterprise health management is support of agricultural enterprises regarding optimization and safeguarding of animal health which in turn has a positive influence on the performance of pigs and on high quality and safe end products for the consumer. In consequence it can be said that the health status of an enterprise and product quality and safety are positively influenced by a good coordination of services in inter-enterprise health management.

Since customer expectations are integrated into the quality of coordination services via the variable “*target group orientation*”, it can be assumed that this will positively correlate with customer satisfaction. In consequence, good services of high quality lead to high customer satisfaction of service users (farmers). Owing to this, the three criteria “*health status*”, “*product quality and safety*” and “*customer satisfaction*” can be defined as reflective indicators resulting from the variable “*quality of coordination services*”.

From these considerations results the structural equation model shown in Figure 34 which can be used as a framework to determine the interrelationship for calculation of the quality of coordination services. The indicators and latent variables highlighted in dark grey can already be determined from data and results on which this thesis is based or are following from this. Indicators and variables which have not been determined within the framework of

this thesis, are highlighted in light grey. Hence, they inform about the current research requirement which is necessary for further calculation of the structural equation model mentioned.

The results show that participants belonging to the groups of “HM experts” and “HM pilots” possess a higher competence as those from the group of “open-minded experts” in health management and also in quality management. The former is expressed by extensive offers of coordination services in the areas of auditing, realizing monitoring sessions and the preparation of certificates which are integrated into the service portfolio of all participants belonging to the groups of “HM experts” and “HM pilots” (Chapter 4.2.1). Regarding determination of quality management competence, three defined preconditions for the application of preventive quality management methods were queried: existence of quality management teams, orientation along the Deming cycle as well as application of quality management tools. In all three areas the members of the two groups of “HM experts” and “HM pilots” showed a higher degree of implementation than the members of the “open-minded experts” group (see Chapter 4.2.2).

Since the focus of this thesis is on primary production, the nine elements of health management were used regarding assessment of project activities. Customer profiles were determined in connection with target group orientation, i.e. all respondents stated information about their service users. Determination of customer requirements referred to especially defined services playing a role in inter-enterprise health management.

On the whole, it became evident that many different aspects have to be considered in order to comment on the contents of the individual latent variables. The overriding question shows the problem, on the one hand, that possibly used complex terms are unknown (such as the individual quality management methods), on the other hand they do not offer information on important partial aspects. Detailed breakdown of latent variables in individual indicators is expedient regarding detailed result interpretation and accurate advisory services on optimization potentials. In contrast to this, the high level of subdivision results in a multitude of individual questions which enormously increases the extent of the questionnaire. In this regard, the form of a dynamic questionnaire which is the basis of this survey has proved very positive. A written survey seems to be more practical since the respondents can decide on their own when they want to answer the questions and there is also no influencing by the interviewer (Kromrey 2009, Henkel 2010, Kuß & Eisend 2010). The dynamic structure helped in a similar way to personal interviews by means of superordinated questions to forego aspects not relevant for the respondent. In doing this, the questionnaire is individually adapted to the situation of the respondent.

Regarding available results, it has to be taken into account that they mainly refer to primary production. In order to extend the focus to the whole of the pork chain, additions by aspects of services for the succeeding production stages should be made.

The model itself was designed for application in the pork chain. Its use in other fields is, however, possible by modification of the corresponding latent variables which present influencing factors regarding the quality of coordination services and definition of corresponding indicators even across sectors.

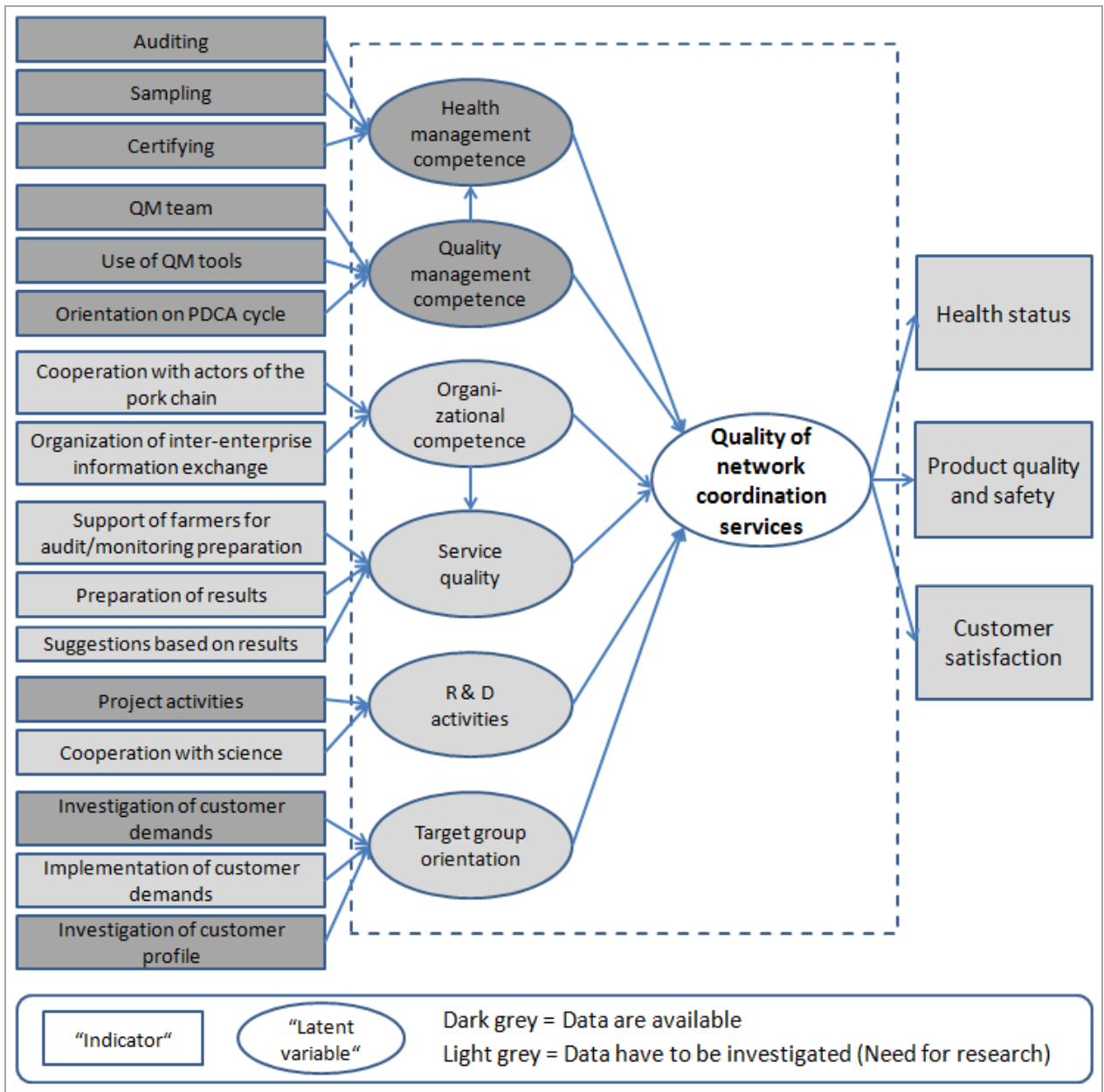


Fig. 34: Structural equation model for evaluating the causal relations between the quality of network coordination and defined latent variables



## 7. Summary

This thesis aimed at determining and assessing the way in which team-oriented preventive QM methods regarding coordination services are used in inter-enterprise health management. When doing this, it was evaluated to which extent service organizations support their activities by the use of preventive QM methods.

A confrontation of sector-specific customer requirements of piglet producers and pig fatteners and the present or future service offer of network coordinators followed. In this connection, three empirical studies were carried out. The first two were written surveys of 206 farmers. The third study involved a survey of 55 potential network coordinators in Germany, the Netherlands, Denmark, France and Spain questioned regarding their service and quality management competence.

The literature study had already shown that the farmers demand support for their activities in health management and an inter-enterprise coordination of monitoring and audit processes. Regarding the use of preventive quality management methods in the field of pork production, from literary analysis resulted only little information. Only some research projects provided examples for using the HACCP concept, FMEA, Six Sigma and audit management, which in turn accounted for the development of bespoke models.

On the basis of the literary analysis, customer requirements regarding service quality in inter-enterprise health management were assessed from the results of the two partial surveys with farmers and experts of potential network coordinators. Special emphasis was devoted to recording the interest of piglet producers and pig fatteners in health-relevant information of the other production stage and the willingness to provide own information. Based on the structural equation analysis, causal relationships between the “interest in information”, the “willingness to provide information”, and the “demand for an exchange of information” between piglet producers and pig fatteners is calculated. Expert interviews of potential network coordinators included two aspects. On the one hand, the existing and planned offers of health-management-relevant coordination services were determined, on the other hand, the survey was used to ascertain the level of implementation of preventive quality management methods in health-management-relevant processes.

Comparison of customer requirements determined and the actual offer by network coordinators showed gaps in the service offer in several of the nine activities previously taken as reference model in health management. On the basis of the Kano analysis, categorization of services was done and finally a proposal regarding further development of the service offer was elaborated. In addition to this, a concept was established on how to support processes in inter-enterprise health management methodically by preventive quality management methods. In the outlook part, development of a structural equation model was undertaken which shows the variables influencing the quality of coordination services by way of a summary.

As a first result, a positive interdependence between the “interest in information”, the “willingness to provide information” and the “demand for exchange of information” between piglet producers and pig fatteners could be determined. From this and on the basis of additional survey data result the following customer requirements of farmers: organization of

an exchange of information, support with data processing, offer of advisory services, realization of monitoring sessions and preparation of certificates on the health status. Corresponding to categorization of product and service characteristics according to Kano, prioritization regarding service introduction is displayed within the framework of a proposal. The services characterized as basis services and one-dimensional services should possibly be integrated into the service offer of network coordinators. Differentiation from other service providers is possible, on the one hand, by the offer of so called excitement services, but, on the other hand, also by an extremely customer-friendly design of the services offered.

Positioning of network coordinators according to the extent of their services offered and the level of implementation of quality management methods in a diagram established on the basis of the BCG matrix, clearly showed the differences between the levels of implementation within the three defined groups of “HM experts”, “HM pilots” and “open-minded experts”. “HM pilots” which are characterized by long-term co-operations with scientists, stand out due to the higher level of implementation of quality management methods in comparison with other groups. “HM experts” are set apart by the fact that health-management-relevant services have a high priority in their service portfolio. This can be seen from the relatively high level of implementation of corresponding services. In contrast to this, the majority of the “open-minded experts” is positioned in the third quadrant, i.e. close to the origin, which shows the so far very small number of initiatives in the two areas displayed.

From the second part of expert interviews resulted that the popularity of quality management methods with network coordinators is very low. Nevertheless, some network coordinators already implement certain aspects of quality management methods. Owing to this, a concept was developed to show how the most important methodical steps of preventive quality management methods, i.e. HACCP, FMEA and Six Sigma, can be meaningfully combined for the core processes in inter-enterprise health management for the service providers in the pork chain. This concept consists of three parts. After the preparatory phase during which a quality management team involving farmers, veterinarians and advisors is defined, responsibilities are determined. Part 2 contains activities carried out with the support of the team as a whole (process description, objectives, definition of potential risks or deviations, cause-and-effect analysis, definition of control points). Realization of these methodical steps is necessary when introducing quality management methods and when there are changes in the processes. The final methodical steps are summarized in part three. They are carried out in a process-related form and thus continuously. This only involves the individually responsible persons (monitoring of compliance with control points, risk assessment, implementation of measures, verification).

Finally, a structural equation model is presented (Chapter 6) which aims at assessing the effect of defined influencing factors on the quality of coordination services. This enables support of network coordinators regarding reaching a decision to optimize their service quality and comparability of the quality of services of various network coordinators.

Development of the model is based on definition of six latent variables (health management competence, quality management competence, organizational competence, service quality, R&D activities, target group orientation) which all influence the latent variable “quality of

network coordination services". From a detailed content description of each individual variable resulted the definition of formative indicators. In addition to this, three variables resulted from the literature study which are positively influenced by the quality of coordination services: "health status", "product quality and safety" and "customer satisfaction". These were added as reflective indicators of the variable "quality of network coordination services" in the model.

Assignment of the results originating from this thesis to the variables and indicators mentioned in the model enables a statement regarding which variables can already be determined or in which areas data surveys still have to be carried out. It becomes evident that in connection with the latent variables "organizational competence" and "service quality" and the indicators "cooperation with science", "implementation of customer demands", "health status", "product quality and safety" as well as "customer satisfaction", further research still needs to be done.



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## **Acknowledgement**

It is my pleasure to gratefully acknowledge all those who have contributed to the completion of this thesis.

First, and foremost, I would like to thank Prof. Dr. Brigitte Petersen for giving me the opportunity to write my thesis at her department, for guiding me through the thesis and, most importantly, for all the knowledge she has offered to me. My thanks also go to Prof. Dr. Wolfgang Büscher for the co-supervision of the thesis.

Many thanks go to Prof. Dr. Matthias Wüst for chairing the defence of the thesis.

Of course, I would like to thank all colleagues at the department for their cooperation. Particularly I would like to thank Dr. Detert Brinkmann, Dr. Maren Bruns, Thorsten Klauke, Stefanie Slütter, Tilman Wilke and Juliane Lang for their ideas and fruitful discussions.

My special thanks go to my family who always supported me during my studies, as well as during the period of time that I spent writing my thesis. Especially, I would like to thank Alexander as well as my parents for their encouragement during the last months of my thesis.

My thanks go to all partners of the Q-PorkChains project for their scientific input. Especially I would like to thank Dr. Jacques Trienekens and Dr. Nel Wognum from Wageningen University, as well as Dr. Richard Lehmann from the University of Bonn, for the delightful and fruitful collaboration. Further thanks go to all interview partners and experts within and outside the project who made it possible to collect the data which have been essential for my work.

Last but not least my thanks go to the European Community for their financial participation.