ERASMUS UNIVERSITY ROTTERDAM

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Master Thesis

Cost and Benefit Analysis of Traceability in egg supply chain-Case study

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Abstract

Recently, the global food industry has been challenged by a series of incidents such as avian flu, BSE, and melamine milk. As a result, each actor in the food supply chain, especially consumers, are more concerned about food safety and quality issues. Under such circumstances, a food traceability system can be a good way to regain consumers confidence. However the economical effect of implementing a traceability system is still not clear for producers, distributors or retailers.

This thesis assesses the cost-benefit structure of implementing a traceability system, and investigates how the costs and benefits allocate along the supply chain. This is researches through a case study of a traceability system implemented by the Gebr. van Beek group in an egg supply chain. The general structure, data, techniques, and quality control procedures are discussed in the case. Finally, a cost and benefit analysis of this case is presented. From this case analysis, it is found that distributor paid the most of cost of traceability implementation. The major costs are third party service cost and hardware cost. The major benefit of this system generates from market and sales profit.

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Contents

1. Introduction

1.1 Background

In the last decade, our global food industry was continuously challenged by crisis and hazards from avian influenza such as H9N7, and BSE which is also called as mad cow disease to melamine mixed milk. In 2009, a Chinese milk manufacture added excess melamine into milk powder and sold these milk powder to consumers, caused hundreds babies' death. In this incident, after the first pots of toxic milk powder been discovered, producer cannot track all the toxic milk powder from the same batch which makes first time recall failed. We have seen more and more cases of labeling fraud and poisoning attacks in our food industry on newspapers all over the world. Recently, in several western European countries, horse meat being sold as beef in many restaurants and supermarkets. This is a typical fake and shoddy goods case. In this incident processed beef and horse meat do not have a complete traceability system. These incidents get public, especially consumers' attention on food safety issues in food supply chain. As a consequence of increasing worries from consumers after each scandal, sales of relevant food products drop significantly. It indicates the fact that food industry is heavily rely on food quality, and low quality food product not only affect people's healthy but also the healthy on a commercial level (Jansen-Vullers et al., 2003). Different parties, from government, companies, to some non-profit organizations, are all involved in facing such scandals. These organizations have to manage risks to supply safe food products. Building a complete food products traceability system can help government and food industry itself in bringing consumer back and building consumer's confidence again.

According to Niiyama (2008), a food traceability system is a system which is able to follow the movement of food through specified stages of production, processing and distribution. Practically, a complete food traceability system can trace each single product from retailer's shelf back to its production unit (e.g. vegetable to farm, sugar

to production flow line, or bread to the person who made it). For mixing food with different materials, each material should be able to trace to its place of origin with the assistance of traceability system. A food traceability system assists to find causes of quality problems and identify reliable players in food supply chain. It improves the reliability of products information. Therefore an effective traceability system gives consumers more confidence of their food's quality.

On the other hand, traceability is not only a consumer-oriented function. A system which can pass accurate, timely and complete products' information efficiently throughout the whole supply chain can increase productivity and reduce cost significantly (Regattieri et al., 2007).

It is indicated by Hobbs (2003) that a food supply chain with traceability is able to help actors in the supply chain to minimize risk and save cost related to food caused diseases. For example, traceability has a positive function on reducing medical expenditure which may cause by food borne disease (Can-Trace, 2007), and reduce extra personnel cost. A traceability system can reduce the number of recall products and the time spend on recall actions (Can-Trace, 2007). Can-Trace in 2007, pointed that traceability can be beneficial to reduce the cost which are generated from keeping market and customers confident. An ICT based traceability system can increase the efficiency of the supply chain (Moschini, 2007). It increases the efficiency of manufacturing, storage, and procurement.

Incidents in food industry are always associated with legal liability. Incidents which caused by problematic food lead to economic loss such as penalties, losing market share, and brand reputation damage (Hobbs, 2003 & Can-Trace, 2007). A well functioned traceability system makes any liability of defective products more clear in the supply chain. In another situation, as Hobbs (2003) & Can-Trace (2007) explained, food supply chain with traceability can reduce the information operation cost for all the actors (e.g. producer, distributor, and retailer). It improves the integration of

information system in the supply chain. An effective food traceability system is beneficial to food producers, retailers, consumers, and public sectors, yet it is likely to cost a lot.

1.2 Problems

It is claimed by other researchers theoretically that implementing a traceability system in food supply chain benefits companies in the following aspects: it lowers products recall cost, and it helps companies to avoid liability claims, increase market share, and improve the supply chain. Traceability is mostly conducted electronically which is argued by scholars to be more efficient and economical compared to paper work (Alfaro and Ra ̍bade, 2009 & Chryssochoidis et al., 2009). The advantage of saving labor costs has been discussed as well (Buhr, 2003).

However, even in Europe, where the most advanced traceability systems are developed, laws and regulations are normally the initial motives for firms to implement a traceability system rather than economics reasons. This does not mean that firms ignore the economic benefits when they implement a good traceability system, but it might be unclear for companies what the actual and exact potential benefits are which they can reap from a traceability system. Some companies even implemented their traceability system only for the purpose of meeting governmental requirements. On the other hand, there is no certain answer for questions like "who pays" and "who gains" of implementation of a traceability system. In practice, the insufficient understanding of the benefits of a traceable supply chain affects the progress of its implementation. The insufficient understanding of traceable supply chain's benefits makes people who implemented traceability system less confident.

The topic of traceability raised broad attention among researchers. However, there are so far not so many studies concerning the cost-benefit relationship of the implementation of a traceability system in egg supply chains. There are no empirical analyses of how benefits and costs are allocated in traceable egg supply chain among different actors. The aim of this study is to *analyze the cost-benefit structure of implementing a traceability system.* The study is a case study, based on Gerbr. Van Beek Group's case. The Gerbr. Van Beek is a Dutch egg company specialized in fresh

egg and egg products' production and trading. It plays different roles in the egg product supply chain including production, processing, packaging, and distribution. This company established a traceability system 6 years ago. Our main research question is:

> *Can the implementation of a traceability system in an egg supply chain generate benefits that surpass its costs?*

This analysis takes the Gerbr. Van Beek Group's case as an example because of two reasons. First the group established a complete traceability system, including hardware and software, as a response to avian flu issues. Second this is a typical egg company in western Europe which represents multiple roles in the egg supply chain. This case could be the entry point to analyze the traceability topic in the egg industry. Several sub-questions may help answer the main research question. The first two sub-questions are: **1.** what are the major costs that a traceability system implementer in the egg supply chain can expect and **2.**what are the major benefits that a traceability system implementer in the egg supply chain can expect.

A traceability system influences all actors in the supply chain. Different actors (e.g. producers, distributors, wholesalers) in the supply chain have different perceptions of the allocation of costs and benefits that come along with implementation of a traceability system. These actors in the chain have different motivations to implement a traceability system due to the consideration of different cost-benefit relationships. Another purpose of this study is to find how the costs and benefits allocate along the supply chain. Therefore other sub-questions are: **3.** how do benefits of implementing a traceability system allocate among different players in the egg supply chain and **4.** how do costs of implementing a traceability system allocate among different players in the egg supply chain. In order to answer these questions, we explained which player in the egg supply chain can benefit more from the implementation of a traceability system; and which actor (e.g. producer, distributor, retailer, and consumer)

spends more for the traceability system.

The paper has the following structure. Section 2 presents a brief review of previous research concerning traceability issues in supply chains in general and the food industry supply chain in particular, as well as the existing studies of traceability costs and benefits. Section 3 is a preliminary analysis based on literature and situations in some other food supply chains. Section 4 introduces the methodology applied in this research. This is a case study base on Van Beek Group. we introduce Cost-Benefit Analysis method to compare the cost and benefit of its traceability system. Costs and benefits structures are also presented in order to define the allocation of costs and benefits. Section 5 introduces a structure of traceability system in general. In section 6, we discuss the most common traceability technologies. Section 7 presents an analysis of the case study including system structure, data, and identification technology of Gebr. Van Beek's traceability system. In the next chapter, there is a cost-benefit analysis based on Gebr. Van Beek Group's case. After the analysis section, there is a chapter of discussion. In the last part, conclusion, limitations, and recommendation sections are provided.

2. Literature review

In this section, we present papers from influential journals and conferences in relevant fields such as British Food Journal, Food Engineering, and IEEE. These existing studies concerning traceability issues contribute to our further discussions. In general, the literature review is presented in a chronological order. First, we introduce the development of the theoretical concept of traceability. Second part of this literature review is about common instruments of traceability system. Then we move to the application of traceability system in different food sectors. The fourth part discusses benefits of traceability system from different point of views. Some similar or relevant studies of the cost and benefit analysis of traceability system are included as well. In the end we will discuss the gap between practical situation of traceability implementation and the theoretical research.

Pugh (1973) was one of the first pioneers to make contribution to product traceability. The establishment of basic principles of product traceability was made by Pugh.

Years ago, scholars such as Akkermans, Borst, and Top (1997) have done research about the requirement of traceability system and its global influences. Some others, for instance, Gordijn and Akkermans in 2001 had a relevant study as well. Stein in 1990 researched the concept of traceability of products both outside the production and inside the supply chain. Ramesh et al. (1995) studied the relevance of products traceability between inside and outside production system. Abbott (1991) raised the research concerning how a traceability system can contribute to product recall.

There were also controversial opinions, Moe (1998) proposed the idea which against tracing products. However Moe and other scholars such as Kim , Fox, & Gruninger, (1995) studied a concept of traceable resource unit (TRU), it is a concept that can be applied when product measurements are hard to measure or describe individually with particular characteristics in a traceability system.

With the development of ICT, new technologies have been applied to products traceability. Great introduction of the use of ICT instruments in products traceability had been made by researchers Sahin, Dallery, and Gershwin (2002). Other scholars such as Morissey and Almonacid (2005) also studied the importance of ICT to improve and develop product traceability system in supply chain. These scholars studied relevant topics about traceability in general. However instruments such as bar code and Radio Frequency Identification (RFID) are the tools in practice to implement the concept of product traceability. Jansen-Vullers et. al. in 2003 and 2004 studied different systems and application which helps product traceability from a instrumental point of view.

Even though different methods have been studied for years, but the bar code is still the most popular method to trace product in supply chain. Cheng and Simmons (1994), and T öyryl ä (1999) have conducted researches about the application of bar code for traceability. There are problems of using bar code to trace product and it might be feasible to use RFID method to replace bar code in traceability system (Sahin, 2002).

After some basic theories of traceability have been built and developed based on different industries cases, researchers established their studies of traceability in food industry. In 1998, Moe and other scholars such as Trienekens and Beulens (2001) studied the practical requirements for traceability and the benefits of using traceability system in food supply chain. Some researcher analyzed the aspects of using ICT instruments for instance, RFID to trace food products. Opara (2003) presented a study concerning traceability issues in agriculture sector. Schw ägele (2005) and Regattieri et al. (2007) illustrated food traceability problems from a regulatory perspective. In 2007, Kelepouris et al. presented a structure of how RFID can be used for food products traceability.

There are some studies of traceability system focused on particular food sectors. For

instance, Frederiksen et al. (2002) illustrated how traceability system is applied in fish supply chain in Denmark. In 2007, Regattieri et al. concluded experimental evidence of food traceability based on a cheese supply chain.

Years ago, there have been more and more traceability systems implemented practically. Therefore, some researchers took different points of view in order to illustrate the benefits of traceability. From an economic point of view, the benefits that can be generated from traceability are found from the increase of market share, the reduction of the cost of recall, cost reduction from avoiding liability, and cost-saving from supply chain improvement (Can-Trace, 2004 & Moschini, 2007). In the following paragraphs, we will discuss each of these points.

Some existing papers demonstrate how traceability can contribute to increasing market share. This is very relevant to our case, because quality and safety for poultry or egg business are very important. Consumers select the products they think are safe and healthy. Traceability is a method to improve the situation of food safety, which as a reason for customers to pay a premium for safer food products (Pouliot & Sumner, 2008). Olsson (2008) discussed the value of implementing a traceability system in supply chain from a marketing and branding perspective, which he indicated that increasing product traceability can help firms in retaining market share, improving brand image, and protecting product reputation. Sparling et al. (2006) elaborated the incentives of implementing a traceability system from a marketing perspective. He explained that besides of reasons associated with products problems and regulatory standard, market issues are motivations for firms to implement traceability as well. Such as new market entry, repositioning in current market, and increases product price and profit.

Besides the marketing benefits, Hobbs (2004) and Mai (2010) discussed the importance of a traceability system in reducing recall cost and liability cost. From a consumers' point of view, Hobbs (2004) explained that traceability helps consumers to

trace any products with problems back to its origin, and makes it easier to replace such products and furthermore to trace the parties which are liable to these products. Therefore improving traceability will reduce customer cost and simplify recall procedure. In egg industry, eggs are produced and transported in large batch. Without a precise traceability system, recall may generate a huge amount of loss. Mai (2010) argued that in the supply chain, downstream companies can take the advantages of traceability to shift liability to upstream companies, thus minimize the risk of food scandals.

Lastly, there are also several scholars studied the relationship between traceability and business efficiency. Frederiksen et al. (2002) and Poghosyan et al. (2004) studied different cases and concluded that increase efficiency is one of the reasons to increase traceability, traceability helps to improve the situation of products damage control, products recall, food quality control, production operation and even the whole supply chain in general. Golan (2004) demonstrated that traceability system can reduce the cost of distribution, improve supply chain planning, and even increase sales of some high value goods. Buhr (2003) gave another reason for companies to implement traceability in food supply chain. He believes traceability can minimize the asymmetry of information along the whole supply chain.

On the other hand, traceability helps company to improve the overall product quality. Wang (2009) presented a case based on a fishery supply chain in which a traceability system was applied, and he found that the incentives of implementation of traceability are improvements of product quality, the safety and health of food products, and management requirement. To expand foreign markets and meet international food requirements is another incentive for firms to implement traceability system.

Recently, some researchers tried to quantify the cost-benefit relationship of traceability in food industry as what are performed in this study. A cost-benefit analysis structure was introduced by Chryssochoidis (2009) based on a natural

mineral water company which implemented an ICT based traceability system. According to his study, the benefits of ICT traceability system can be concluded as: reduce personnel cost, reduce operational cost, decrease inventory level, cost reduction from more efficient recall activity, and lower risk (e.g. accuracy in operation and management, obey regulations). Compare to our research, Chryssochoidis involved less information about cost-benefit allocation. Another case study about traceability system's cost-benefit relationship using a similar research method is from Mai (2010), but it used assumptions to analyze potential benefits and part of costs. In our case, the actual costs and benefits are analyzed.

In conclusion, there are several major incentives for companies to implement traceability systems in food industry, for instance, reduce recall cost, increase the level of food safety, reduce personnel cost, and increase operational accuracy. Furthermore, the ICT based traceability system contributes to supply chain management as well, for instance, Kärkkäinen (2003) discovered a cost reduction in retail sector by implementing an IT based traceability system. The IT based traceability system can lower the inventory level, the efficiency of stock check, and decrease stock loss. Kim and Sohn (2009) studied the relationship between the implementation of a Radio Frequency Identification system (RFID is a technology that uses radio waves to automatically identify objects) and the products' loss rate in logistics sector. They discovered a negative relationship which indicates that with the implementation of a RFID traceability system, the total products loss rate in logistics sector decreased.

From the previous studies, we can conclude that existing researches discussed traceability system mainly focused on the importance or potential advantages of applying a traceability system in supply chain and the instrument which may help the implementation of a traceable supply chain. Besides, in some traceability studies on general level, specific instruments (e.g. RFID) have been discussed. There are similar studies in food supply area which are concerned with individual aspects of food

product traceability.

Economically we can categorize the benefits of companies generated from the implementation of food products traceability as qualitative benefits and quantitative benefits. Quantitative benefits include several aspects such as increasing market share, reduction of liability cost, reduction of operational cost, reduction of recall activity, and savings of personnel cost. However, an integrated and practical study which is applicable to real industrial case, especially in egg industry, with economic meaning is rare.

Therefore the following chapters present a traceability structure in eggs supply chain and will discuss and compare the economic implications and prospects of bringing traceability system along eggs supply chain. Finally this study gives answer to our research question: can the implementation of a traceability system in a European egg supply chain can generate higher profit against its cost?

3. Preliminary Analysis

Before we move to our official analysis on the case, we first discuss some preliminary expectations. Based on the above literature review, we can have a basic image of the questions I am going to answer in the following chapters. We present the preliminary analysis from sub-questions to the main question with their hypotheses.

Sub-question 1. What are the major costs which a traceability system implementer in the egg supply chain can expect?

The implementer who take the initiative of implementing a traceability system bears a large share of the cost. If we take a bar-code system as an example, in a traceability case study of vegetable industry of Bevilacqua et. al.(2009), the system consists of hardware, software, and personnel. Among these, hardware should at least include tags attached on products, readers which are used to recognize information, and computer which process and store data. Software includes basic working systems such as MS Office, and programs for traceability functions. There must be labors trained to operate the entire traceability system. Besides, outside consultant, internet connection, and audit may incur extra costs, too.

Therefore we formulate a hypothesis for the sub question 1, as following:

H0:The costs of implementing a traceability system in the egg industry are the same as for a traceability system in other industries (e.g. vegetable industry), which includes hardware cost, software cost, personnel cost, and operational cost.

After discussion about cost, we need also consider the benefit for implementer upon the implementation of a traceability system in the egg supply chain. Therefore we propose the second sub-question.

Sub -question 2: What are the major benefits of implementing a traceability system in an egg supply chain?

Such costs listed above can generate benefits. Based on our literature review, benefits may include market growth benefit, recall reduction, savings from liability cost, labor cost, and operational improvement. Under the requirement of official regulations, for some food products, only products with traceability have the opportunity in certain market. A traceability system provides both trace and track information. Therefore, the recall activity from consumer side can be short and direct. Under the monitoring of traceability system, liable party is clearly investigated if there is a liability problem. Hence companies in food supply chain can avoid undeserved liability cost. From previous research on ICT application in traceability system, using new technologies to manage traceability work can increase efficiency and save personnel cost. With reliable information collected and processed by traceability system, the overall operational accuracy should be higher.

Based on the literature review, we present a hypothesis for sub-question 2.

H0: Like other industries, the benefits of a traceability system in egg supply chain include market benefit, personnel saving, recall and changing saving, savings from liability cost, and operational savings.

It is not enough to only answer the question of what are the cost and benefit, but it is necessary to know where are these costs and benefits, who pays the costs, who takes the benefits. We come up with two more sub-questions. **Sub-question 3: how do costs of implementing a traceability system allocated among different players in the egg supply chain? Sub-question 4: how do benefits of implementing a traceability system allocated among different players in the egg supply chain?**

First, supposedly there are producers, distributors, retailers, and consumers in a food

supply chain. Second, because of the food safety regulations are normally bounded with product, we suppose that the initiative of traceability system implementation is on the producer's side. Then, in order to run a traceability system, producer will pay for tags, readers, computers, and software. Producer will also need to train their employees. Distributors and retailers in this supply chain have to purchase readers, computers, and software if necessary. They need to train their employee as well. In the end, consumers pay a premium for products which are traceable. Therefore we propose the following hypothesis.

H0: In egg supply chain, producer, distributor, retailer, and consumer equally bear the cost of traceability system implementation.

On the other hand, each actor in the supply chain takes different benefit from the same traceability system. Producer is expected to have higher monetary benefit such as higher revenue from market growth, recall cost reduction, savings from liability cost, and personnel savings. Distributors and retailers can avoid wrongfully charged liability cost, they can shift the cost to where it should be. A traceability system can increase their operational efficiency. For consumers, the most important thing which a traceability system can bring to them is products with higher quality and better guarantee on food safety. Therefore, it is not difficult to find that producers and consumers can benefit more from the traceability system (Table.1). They should be more willing to implement traceability system.

Actors in supply chain / Benefit Components	Producer	Distributor	Retailer	Consumer
Market Growth	●			
Recall reduction	●			
Savings from liability cost	●	●	●	
Operational improvement	●	●	●	
Personnel saving	●			
Higher quality of product				●
Food safety guarantee				●

Table. 1. Different actors benefits of traceability system along supply chain

According to the above discussion, we present a hypothesis to assist our further analysis.

H0: Producer receives the most monetary benefit from the implementation of a traceability system in egg supply chain.

Finally after the discussions of sub-questions, we come to our main research question. **The main research question is: can the implementation of a traceability system in an egg supply chain generate higher profits against its costs.** In order to make the answer of this question clear, we propose the following hypothesis to assist the analysis.

H0: The costs of the implementation of a traceability system are less than the benefits of the implementation of a traceability system in an egg supply chain.

In the following chapters, we will conduct the study according to questions and hypothesis of this preliminary analysis.

4. Methodology

In this research, there are two parts consisted in methodology. In the first part a semi-structured interview is conducted in the company Gebr. Van Beek Group. There are two departments in the company Gebr. Van Beek Group participated in the interview which are regional operation department and supply chain management department. Directors responsible for these departments are representatives of their departments. Therefore, this interview was conducted at the company's decision making level. The purpose of conducting this interview is to study the structure of traceability along egg supply chain and the cost/benefit structure of implementing a traceability system throughout the supply chain. The questions appeared in the interview are designed and standardized based on several sub-topics (Dibb et al., 1997).

- Information about the company Gebr. Van Beek Group
- Product supply chain
- Traceability system structure
- Data, instruments, and controls of the traceability system
- Cost and benefit of the traceability system

The results from this interview contain both qualitative and quantitative information. In general, the first four sections of question provide information for qualitative analysis for the company Gebr. Van Beek Group's egg supply chain and its traceability system along the supply chain. The fifth section of questions provides a part of quantitative data for cost-benefit analysis of traceability in their supply chain.

According to the interview, we first present a structured analysis of the traceability along Gebr. Van Beek Group's egg supply chain, including the procedures and technologies are introduced. By building a clear structure of traceability along supply

chains we define the role which traceability plays. We describe the detail of each process (e.g. order of traceability operation activity, place of traceability operation where it executed); and then discuss the relationship between the processes. The structured analysis illustrates the required information for traceability in each procedure. Technological instruments of this traceability system are introduced as well. The study of the traceability procedure flow along the supply chain helps to improve the current structure.

The second part of our methodology is a quantitative analysis which analyze the data extracted from the interview and presents an inside company investigation. In this part, we define the cost allocation of implementation of a traceability system along the Gebr. Van Beek Group supply chain. The cost is attributed to each process of the supply chain. Then the analysis will help us to find out the monetary cost of implementing a traceability system in egg supply chain, including the initial hardware investment, the cost of consumable items, the personnel cost, and some other operational costs. Through the quantitative analysis, the author presented the benefits which are directly generated from the traceability system. Finally, we use a cost-benefit analysis (CBA) method to analyze economic results of the implementation of traceability system within Gebr. Van Beek Group's egg supply chain. In previous studies, Mai (2010) used the idea of CBAs as well in one of his traceability studies, but the purpose was to analyze a fish supply chain. From the comparison study, we try to discover if implementation of such a traceability system is really beneficial to egg supply chain or the major implementer. The main research question and sub-questions which the author wants to answer from this study are:

Main research question：can the implementation of a traceability system in egg supply chain can generate higher profits?

Sub-question 1. What are the major costs which a traceability system implementer in the egg supply chain can expect?

Sub -question 2: What are the major benefits that a traceability system implementer in egg supply chain can expect?

Sub-question 3: What is cost allocation of implementing a traceability system among different players in the egg supply chain?

Sub-question 4: What is the benefits allocation of implementing a traceability system among different players in the egg supply chain?

In the second part of analysis, which is the cost-benefit analysis (CBA), the net present value (NPV) is one of the most important instruments in CBA. The formula of NPV is as following (Boardman et al., 2006):

$$NPV = \sum_{t=0}^{n} \frac{NB_t}{(1+r)^t}$$

In this equation, *n* represents the total number of periods of the traceability system project in Gebr. van Beek Group. The *t* is the time of the cash flow. NB_t is the net benefit of implementing a traceability system. It equals to total benefit in time *t* (B_t) minus total cost in time *t* (C_t). The *r* represents the discount rate, which is the rate of return that could be earned on an investment in the financial markets with similar risk. In our analysis, a real discount rate of euro is applied. In this study, 5% as the suggested real discount rate by Florio (2006) is set as a base-case in CBA. We also present a sensitive analysis to test the uncertainty in different economical situations with discount rate from 2% to 7%. We assume that, due to the limited size, the implementation of this traceability system in Gebr. van Beek Group does not change market price of any inputs. The time frame is six years based on the result of company project investigation. We assume the first cash flow occurs at the end of each year. Since the equipments and tags used in the traceability system have very short lifetime,

so we do not take depreciation into account. Another assumption in this analysis is that scrap value of items in traceability system is considered as zero.

In the whole study Microsoft Excel is applied to calculate costs, benefits, net present value, and make graphs.

5. Structure of a traceability system

In general, the operation of traceability system consists of personnel, software, and hardware. These three factors are involved in almost all the stages of a traceability system along supply chain. They appear in different functions. By functions, a traceability system, especially a food traceability system contains at least four parts (Fig.1). These four parts are the characteristics of product, product information and data, trace and track of product, and traceability techniques (Regattieri, 2007). These parts join hands with each other, go through the whole supply chain with product, and finally make a complete traceability system.

First, in any traceability system, normally products should be characterized by their physical characteristics. For example, weight, height, color, and volume. For food product, ingredients, materials and product quality guarantee period are important factors which a traceability system should identify as well. A well developed traceability system can even identify the packaging, cost, and the perish conditions of a product.

The second part of a traceability system is the product information and data in the system. These information and data are fundamental source to trace and track a product through a food supply chain. Normally only one or two types of data go with product through the whole supply chain. These data and information in traceability system should have the ability to represent its product, which means such data can tell people the movement or status of each product, such as some detail of production, time, or place. Different systems are designed to manage different types of data (e.g. digits, dots, strings). In recent years, the confidentiality of data and the automatic alarms for expiration date of food product are becoming essential attributes of traceability data design (Regattieri, 2007). Eventually, any data in the system need storage. There are requirements on traceability data storage.

The third part is the trace and track of product. In a traceability system, we follow the product from its production to its consumption. We know when it was produced from what materials at which place. A traceability system records the entire product life in the food supply chain. The traceability also includes all the stages i.e. processing, packaging, storage, distribution, and recall. Therefore almost all the things related to this product route are in a traceability system. We can find lead time information, container of food, product process activities, manual operation record, automatic operation record, product movement, and storage information in the traceability system. In some advanced traceability cases, we find that even production or packaging equipment and employee are identifiable in the traceability system.

The last part is the traceability techniques have been used in traceability system. Nowadays there are several different solutions available for traceability such as numerical code, bar code, and radio frequency identification (RFID). Different choices of solution will lead to different equipments in a traceability system, different tags, readers, software system, and data are required in different technical solutions. A suitable technical instrument should be compatible with the characteristics of products and its production procedure. The level of data accuracy and reliability are another two criteria to choose a suitable technique. Besides, cost is one of the most important concerns for choosing a traceability technique.

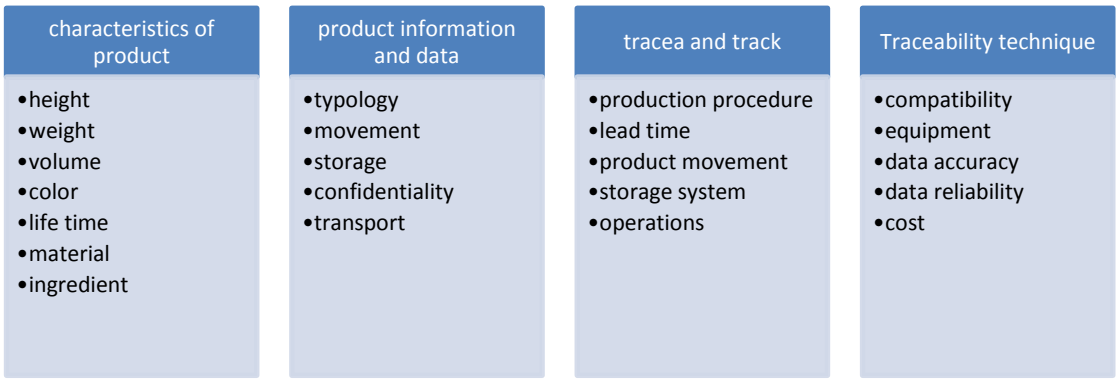

Fig. 1. Four parts of traceability system

This general introduction of traceability system provides a picture of most traceability systems applied in different industries. The four parts described above of traceability system will be used in our case study. The relevant information of these four blocks will be discussed on the Gebr. Van Beek case.

6. Traceability techniques

A functional traceability system records data of product from its production to the end of supply chain which includes process, packaging, storage and retailing. All the information related to the product is in the system. Currently, the most widely applied techniques for traceability system are alphanumerical code, bar code, and radio frequency identification (RFID) (Regattieri et. al., 2007).

Alphanumerical code is a method that records a combination of numbers and letters in different forms on products' labels. Sometimes it is written on product directly or on product's package. Food products normally do not have an extra label, therefore, alphanumerical code is usually placed on food or its packaging.

This is not a complex technical solution, it does not involve advanced design of data and equipment. Its operation basically only needs personnel to write codes on product. Because it does not need advanced software and equipment to process data, so it is also an economical technique for traceability. However, just because of such characteristics of alphanumerical code, it takes a lot of employees to operate. Employees are involved in manually writing and reading codes. This behavior of the alphanumerical code method generates problems and risk. The accuracy and reliability of data in this method are challenged, sometimes the level of data quality is low (Regattieri et. al., 2007). Besides, there is no unified standard of this method. Therefore, different actors in one supply chain interpret alphanumerical codes differently.

Nowadays, alphanumerical code is not as widely applied as before since bar code has been invented. Bar code has many advantages which cover the shortages of alphanumerical code. Bar code is one of the modern techniques with good accuracy, fast operational speed, and high level of automation (Regattieri et. al., 2007). The

introduction of bar code has brought traceability systems into more reliable and economical times. At this moment, many industries apply bar code in their supply chain operations. In all the industries which has a bar code system in their supply chain, including food industry, their products move from one point to another in the supply chain with a bar code tag. By using the tag with bar code, each actor in the supply chain can find out information and data behind this product by scanning its bar code with a reader. This procedure needs human efforts. It is more advanced than alphanumerical code. However, there is still a possibility, in a bar code system, of generating inaccuracy and inefficiency. Another short coming of bar code system is its perishable tag. Normally the bar code tag is a piece of thin paper attachment which attaches on the product. In a humid environment or a high temperature, the attachment is damaged or removed easily. This is one of the largest problems when bar code technology is applied with food products.

Another alternative of such techniques in traceability system is the radio frequency identification (RFID). RFID system uses tags with wireless microchips in order to replace the paper tag in bar code system. Hence, in a RFID system the tag does not need to read manually, or use a reader to scan each product. There is no necessary physical contact need to extract product information from RFID tags. The tag reading and scanning is faster and highly automatic compared to bar code or alphanumerical code system. RFID has some definite advantages, the tag of RFID is very small and compatible with almost all food products. Since there is a chip inside, the material and structure of RFID tag for food are designed to be more durable than normal paper tags. The material is environmental friendly as well, which means it is safe to attach on food product. The only concern is that the glue should be safe. If the product is liquid, then the attachment on its packaging or bottle will no longer have a "glue" issue.

Clearly, a RFID system has a higher efficiency than the previous two instruments. It saves labor cost. A supply chain and traceability system can improve its process by the implementation of a non-manual scanning RFID system. It speeds up the whole

traceability system and supply chain. Because the RFID system makes it possible to scan many products at once. Readers can get wireless signal from many chips at the same time. Therefore, a batch of products data can be identified quickly and simply. According to Regattieri (2007), there is a product loss of about 2% of total products value yearly in America, which due to theft by either consumers or internal employees, retailer's fraud, and operational mistakes. The more accurate the traceability system and its technical instrument is, the less products loss will happen. RFID system helps supply chain management team to control and monitor inventory and production more easily. Because of the high efficiency of RFID, it is possible to have product information more frequently, therefore, to obtain better understanding of the supply chain and the consumer behavior.

Typically in food industry, the frequent and continuous product data check can reduce the cost of perishable food products loss. The freshness of food is a important concern of any consumers and therefore such an on time traceability technique can improve the consumer satisfaction and customer service quality.

Each RFID tag is dedicated to a product, which means in a traceability system RFID can help to find the problematic product and its data in supply chain. It is significant for traceability to accurately locate a single food product instead of a batch with large volume of products. It is because the efficiency and automation advantages of RFID, RFID provides very accurate and reliable data to meet the trace and track requirement. It can locate a product in any place and any procedure. Therefore it makes recall or changing activities more efficient as well, by exactly control the product routing.

However, the essential reason which hinders RFID being applied to all industries is its relatively high cost (Bevilacqua, 2008). More specifically, the tag cost higher in a RFID system than tags in a bar code system. This fact significantly influences the cost and profit of some low price products, such as fresh eggs, fruits, mushrooms, and milk. Even though RFID has some very attractive advantages for food industry, the high tag

cost is still a problem.

7. The case of Gebr. Van Beek Group

In this study, we conduct the traceability analysis based on the case of Gebr. Van Beek Group and its egg supply chain. Gebr. Van Beek Group is a private Dutch family company. This family business has more than 80 years of history. In the beginning, Gebr. Van Beek Group was only a packing station, but it is now one of the market leaders in western European market specialized in the egg business. Gebr. Van Beek Group has its major business in The Netherlands, Belgium, Germany, Switzerland, and Japan with 400 million euro yearly revenue. Gebr. Van Beek Group provides 8.5 million eggs per each day from 200 farms to big customers (e.g. Unilever, Heinz), retailers (e.g. AH, Jumbo), and end users. For the last decades, after several acquisitions, Gebr. Van Beek Group built the ability to supply a wide range of eggs to retailers and consumers with high level of standards, especially in packaging, grading, and traceability.

In this study we choose Gebr. Van Beek Group's traceability system as the case because this poultry business can somehow give us opinions on global avian flu problems. Most detected viruses of avian flu only cause disease in poultry. However, there are avian flu viruses can also cause disease on human body. The first case of human disease caused by avian flu was discovered in Hong Kong 1997. Since then, it spread throughout Asia, Middle East, Africa, and Europe several times. In 2003, The Netherlands also discovered humans carrying the avian flu.

The Gebr. van Beek's traceability system is a system that, unlike other food traceability models, involves chicken activities and human activities. It requires much more information to complete traceability than other food traceability system which normally only record product volume and movement. Besides, Gebr. Van Beek Group's traceability system provides a different example of how to share information in the traceability system with different parties in the supply chain.

7.1 Structure of the traceability system

The traceability system of fresh eggs in Gebr. Van Beek Group starts from farms where chickens are raised. In 200 contracted farms, chickens are raised in four different conditions, which are enriched cage (15%), barn (55%), free-range (25%), and organic (5%). Basically, chickens in four different conditions lay four different kinds of eggs with different characteristics and product value. In the enriched cage, many chickens are knocked and living together. Normally these cages have a sloped floor with little gaps, therefore, eggs can roll out for pick up and chicken's dung can drop through the cage. In the cage, stretching wings is difficult for the chickens, and their movement is limited. Among the four conditions, chickens in the cage have the worst welfare. However, chickens in cages are more easy to control and check compared with the other three conditions. It is the cheapest way of poultry production.

Barn is a cage-free environment where chicken can move freely within a large barn. Hence, those hens have larger space to move, and flap their wings. In the barn, hens are cleaner and healthier than chickens in the cage. They can lay eggs in nests or perches. Besides, hens in a barn with large space can have more opportunities of socialize with other chickens. The large barn protect chickens from predators such as cats as well. So farms keep most chickens in a barn.

Some farms raise chickens in a free-range condition, which means chicken can walk freely inside and outside a shed. It is very different from hens that can only stay in a cage or a barn. Chickens can play as they wish on the grass. They can even eat natural things outside their barn. But since they walk out of the barn, hens faces problems from diseases and predator. Free-range eggs are therefore more expensive than eggs from cage and barn.

The fourth condition is "organic", where chickens are raised in an organic environment. The chicken itself is organic, and is fed with organic feed. Under such a

condition, genetically modified feed, animal products, and antibiotics are not allowed. But these are normally allowed in a free range condition. The welfare under organic condition is better than in free range. Chickens have better food and living environment with less stress. But organic eggs are also the most expensive.

After the chicken's farm, living condition, and stable have been decided, it is ready for the chicken to lay eggs. Everyday farm collects eggs and make the first package in the farm. According to EU regulations, it is mandatory to print egg's birth information on each egg's shell. Farm print a series number and letters on their eggs automatically. Then each batch of 1,800 eggs will be put into a pallet. Each pallet will have its own bar-code attached on it, in order to record product information and find every single pallet of eggs. After eggs are loaded onto pallets, they will be transported from farms to Gebr. Van Beek sorting and grading center.

In the sorting and grading center, eggs' quality and safety issues will be checked first. The eggs that passed the quality and safety checks will be cleaned. Then the eggs go through a sorting procedure in which they are sorted by their farms' code and living condition of chickens. After sorting, each category of eggs will be graded by its size (e.g. S, M, L, XL). When the sorting and grading procedures are finished, eggs are ready to be packaged into boxes. A sticker with a new traceability code, usually comprise of 10 to 13 digits, will be attached on each box automatically. All packaged eggs are moved to warehouse for a short storage. Finally, these boxes of eggs will be transported to distributors and customers.

Both retailers and consumers can contact Gebr. Van Beek B.V., and use the traceability code on egg's package to trace the egg back to any procedure along the supply chain. Gebr. Van Beek will respond to the questions within 4 to 24 hours. Through three different traceability codes in the system and a database that records data from each procedure, the whole traceability system gives all the actors in the supply chain opportunities to track products from production to consumption or trace

product back from the end of supply chain to its beginning. In the next chapters we will discuss the data and techniques which are involved in the system.

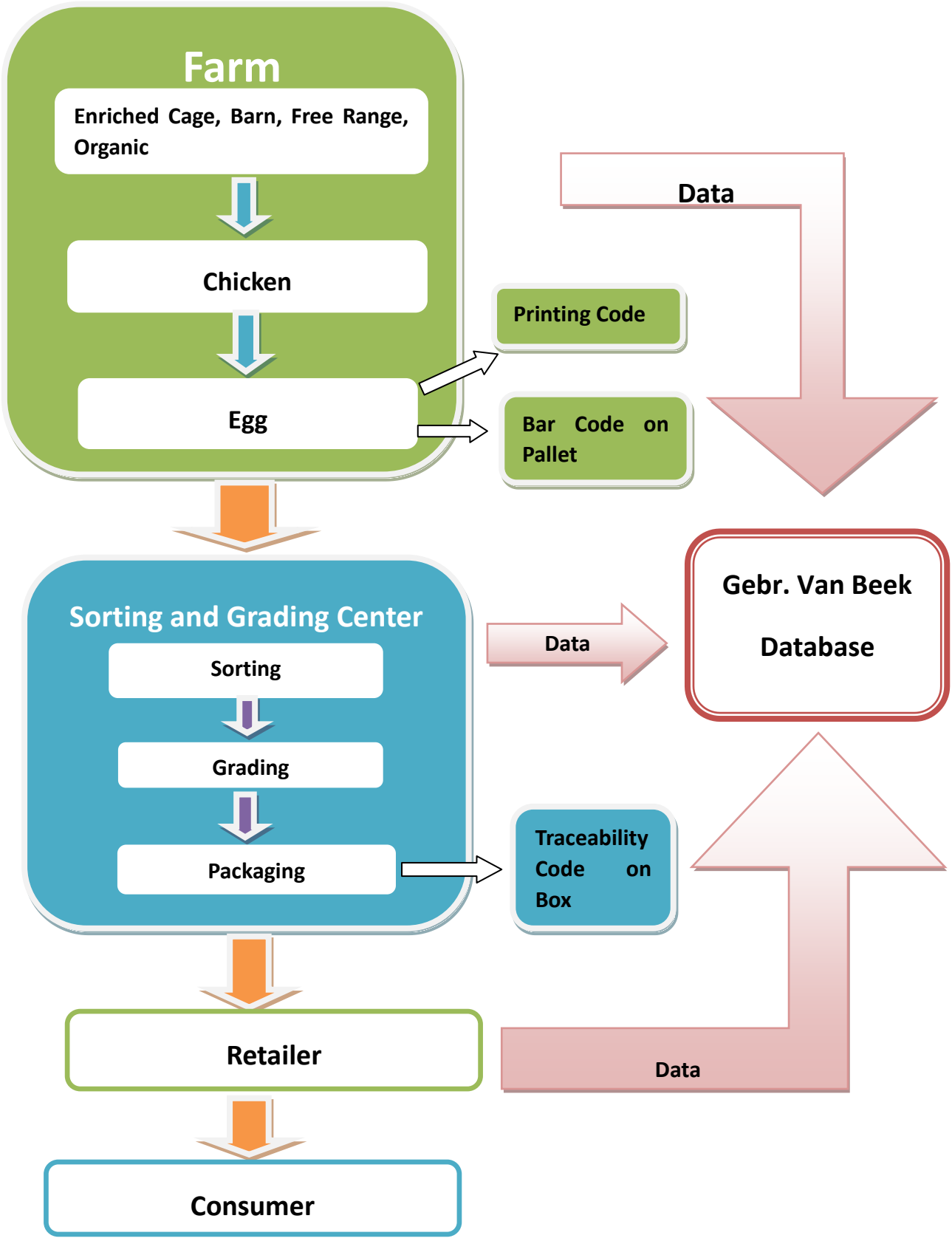

Fig. 2 Gebr. Van Beek Traceability System Structure

7.2 Data and information

Data and information of products is one of the most important parts in the whole traceability system structure (Fig. 1). Data is always a key to answer questions concerning a product in its supply chain, no matter if the data is about production or it is about the movement in supply chain. A well functional traceability comprises well selected data. These data should have the ability to explain every important thing happening along the supply chain with products as transparent as possible.

In the Gebr. Van Beek Group's traceability system, there are three codes that can represent the most important data and information of traceability. The first code is the code printed on each egg's shell by farm. It is a series numbers and letters(Fig. 3). Giving an example, 0 NL 12345 01, each part of numbers or letters represent different information. In the example, the first "0" means it is organic. In general, the first number tells us under which condition the hens laid this egg was raised. From 0-3, each number represents "organic", "free range", "barn", and "enriched cage". The following two letters is the country of origin. Here, "NL" means this egg is produced in The Netherlands. "12345" is the code representing the farm produce this egg. The last two numbers "01" is the number of the stable where the eggs was laid. This code is required by EU regulations to give consumers a basic traceability.

Fig. 3 printed number on the egg

When eggs are loaded into pallets, a piece of dedicated bar-code is attached on each of these pallets (Fig.4). There are actually not many movements of eggs between the

code been printed on eggs and this bar code attached on pallet. But the bar-code can indicate a lot more information than that printed code can. The bar-code in Gebr. Van Beek Group's database can match many different information of this pallet of eggs, for instance, the volume of these eggs, the weight of these eggs, the storage information, the date and hour when these eggs are laid and delivered, and all the information the code on eggs represent. Besides, this bar-code can help people find out more information about the chicken which laid the egg in database. Interestingly, using the bar-code, it is even possible to trace back what are the chicken's feed before the hens laid the egg. Because the eggs from Gebr. Van Beek Group are following the grandparent rule, which means the information of the grand parent of the chickens are laying eggs are recorded in their database. The activities and movements about eggs are done either automatically or manually. So the information of machines which are involved in production and the information of labors are also can be traced by just the bar code on pallets. This bar-code is mainly designed for the inside use of Gebr. Van Beek Group.

Fig. 4 bar-code for one pallet of eggs

The third code is a series of digits, normally consists of 10 to13 digits, printed on a small piece of sticker which finally attached on eggs box(Fig. 5). This traceability code is for the use of consumers and some retailers in case if they want to know more about the product. It helps consumers and retailers to change and return their product from Gebr. Van Beek as well. By checking this code with Gebr. Van Beek, people can find out the information about the egg itself, egg's production, farm information,

Gebr. Van Beek company's information, the time when the eggs are laid, chicken's information, machines and labors involved in production, and the distributor and retailer's information. This information is transparent and open to any client. Consumers can activate the traceability by input the code printed on eggs' shell in their website, or call Gebr. Van Beek with the code printed on eggs' package.

Fig. 5 bar-code of one box of eggs

Codes / Data	Codes on egg's shell	Bar-code with pallet	Codes on the package
Country of oringin	✓	✓	✓
Type of egg/living condition	✓	✓	✓
Farm	✓	✓	✓
Stable	✓	✓	✓
Weight		✓	
Time		✓	✓
Feed		✓	✓
Storage		✓	✓
Chicken		✓	✓
Machine		✓	✓
Labor		✓	✓
Volume		✓	✓
Company info			✓
Customer/ retailer info			✓
Grade of egg			✓

Table.2 Data in the traceability system

7.3 Quality control and inspection

In the food industry, strict inspection and quarantine systems protect consumers health and safety. In the Gebr. Van Beek's traceability system, different levels of inspections makes up an important part of the entire traceability. As we can see from the previous chapters, there are two important links in this egg production chain which are farms and Gebr. Van Beek's sorting and grading center.

First, the traceability system and all production procedures happening in both farms and sorting and grading center meet the requirement of EU regulations. Different types of eggs and their production are inspected by public organization yearly. For instance, each year the whole organic egg supply chain is inspected to issue a next year certification. Other types of eggs also have to pass national level and local level quarantines.

Second, each three month, Gebr. Van Beek Group conducts a farm level production check. This farm level check inspects all 200 farms. Including chicken health, quality of feed, recipe of chicken feed, heavy metal content in the farm environment, and toxicity test. If problems are diagnosed from this farm level check, for example, if chicken feed is discovered with heavy metal problem, they can trace it back to where the feed is produced and track the chicken which has eaten the problematic feed. Every inspection reports are kept in database.

Four times a year, randomly picked eggs from all four conditions (e.g. enriched cage, barn, free range, and organic) in different farms are send to food safety labs to have rigorous and scientific test. The content of these scientific tests including nutrition of each egg sample, quality of egg's shell, heavy metal content of all sample eggs, and toxicity test. Employees trace back from single piece of sample egg to its batch and destroy them if any unsatisfied result has been found from lab report. The farm which

produced the problematic egg might be punished.

There is a weekly egg quality inspection operating in the Gebr. Van Beek sorting and grading center. During this weekly inspection, a large volume of eggs from different farms are tested and checked. The content of this inspection includes egg's shell quality, freshness of eggs delivered from different farms, the size of eggs, and the weight of egg. The sorting and grading center returns eggs with insufficient test results and communicate farms about each test result, in order to maintain and improve quality together.

Beside of these regular inspections, Gebr. Van Beek invites a German non-profit organization KAT to inspect farm, production, feed, traceability, packaging, and all the procedures without pre-notice once a year. This yearly inspection is organized by KAT without any announcement of inspection time, place, person, and content. The KAT association is the most influential independent egg industry monitoring organization in western Europe. The KAT apply high level criteria for raising hens and egg production which is stricter and beyond EU regulations.

These quality control and inspection methods make the traceability system more trustable and transparent to the public. Inspections make not only the visible eggs are traceable, but also some invisible production materials traceable. The procedures of quality control makes the traceability system's function complete. On the other hand, these procedures are important parts of cost as well.

7.4 Traceability techniques

Some products, such as clothes and vegetables, have only one major traceability technique in their traceability system, either bar-code, or RFID tag. However, in this egg traceability system, there are two methods that have been used. A series of numbers and letters printed on egg shell and the bar-code for the traceability together.

"One egg" is the smallest unit of fresh egg product. Practically, the extreme traceability level is to a single egg as well. The egg is a low cost, fragile product with round shape, these properties limit the possibility of using RFID which is too expensive and difficult to attach on eggs. On the other hand, some people used to boil eggs with shell in water directly. Therefore, paper made bar-code attachment will melt in the boiled water. Nontoxic automatic printing on shell becomes the best solution to identify an egg and provides obvious information that everybody can read and understand.

However, the code on the egg is a mixture of numbers and letters which is printed automatically by printer, but the code is not automatically readable. It is not feasible for a person to read 1800 eggs in one pallet, or even more. Therefore, bar-code which can both be automatically printed and read is a more efficient instrument for a large volume of eggs. The code on shell is a basic identification for eggs required by EU, each digit or letter in it transmit fixed information. This code on shell does not contain all the necessary information to serve the purpose of traceability. A bar code which help people to find more information from database is significant for producer, retailer, and consumer. Therefore each group of eggs, either one pallet in sorting and grading center or one box on shop's shelf, has a bar-code.

Furthermore, ICT is involved in store and process data. In this Gebr. Van Beek case, a dual track ICT system supports the traceability system. One track is Microsoft Excel

which takes the role of primary data storage, and some simple function for data sorting and analysis. Excel in this traceability system is cheaper than a dedicated software. It is easy and fast to find traceability data in need. Data in excel is easy to read, it is not a complex system. The data and information exchange by excel file is convenient and feasible for anyone who has excel on his computer. The other program assists the traceability system is Navision system which is an ERP system. It monitors data and movement of product. It reacts fast to any unusual change.

8 The cost and benefit analysis of Gebr. Van Beek Group's traceability system

Gebr. Van Beek Group bears the most of the cost of the implementation of the traceability system in the supply chain. The current system was established 6 years ago. Major costs for this system include hardware cost, software cost, personnel cost, and third party service cost. Hardware in the traceability system includes equipments such as egg shell code printer, bar-code printer, computers, and bar-code scanner as well as some consumable items, for instance bar-code tag, and traceability code sticker. Software cost contains the purchase of Excel and Navision systems; and yearly update cost. There are 5 full time employees operating the traceability system. The majority of third party service cost is paid to 4 times per year food safety lab experiment and inspection. Among all these costs, the first installment of investment for code printer and software are perceived as initial costs. The rest of costs are yearly costs (Table.3).

Cost Components	**Cost per unit**	**Life time**	**Quantity**
Initial code printer	€1,000,000	10 years	
Tag each year	€233,333		
Bar-code reader	€400	3 years	10
Computers	€800	3 years	5
Initial software	€150,000		1
Yearly software update	€25,000		1
Personnel cost/year	€60,000		5
Lab experiment &inspection/ year	€150,000		4

Table. 3 Cost of Traceability system

The total cost of this traceability system in 6 years is €8,115,998. Among four major categories of costs, third party service, the lab experiment and inspection costs

€3,600,000 in 6 years. It takes the biggest share, 44.36% of total cost. Hardware and Personnel account for 29.77% and 22.18 of total cost. Software makes up 3% only. Therefore, the answer to sub-question 1 is clear. Major costs of this traceability system in egg supply chain are third party service cost, hardware cost, personnel cost, and software cost. The cost structure of Van Beek's traceability system is different from other industries' case. In the cheese industry (Regattieri, 2007), hardware including tags and readers are the major cost of its traceability system. The null hypothesis of sub-question 1 is therefore rejected.

After a large cost and time have been spent on building the traceability system, Gebr. Van Beek Group obtains benefits from the traceability system as well.
For Gebr. Van Beek Group, the most valuable benefit is perhaps the increased market share. The leading traceability system gives Gebr. Van Beek's product and service a better guarantee. This guarantee has attracted and kept 20% big and strict customers (e.g. Unilever, AH, and Heinz) for the last 6 years. This 20% of total customers contribute 80% of Gebr. Van Beek's yearly profit. This advanced traceability system in the whole egg industry which extend the basic EU requirements is now the winning advantage of Gebr. Van Beek Group.

Before the current traceability system had been implemented, most of the traceability systems were operated manually. There were 7 full time employees responsible for traceability works, now there are 5. Besides, the data which they were dealing was much less than now. Previously, the old traceability system cannot trace one box of egg back to exact batch. Therefore, if a few boxes of eggs are found with quality issues and need to be returned and destroyed, it results in the destroy of a very large volume. Normally all eggs produced on that same day in the same farm will be all destroyed. The current traceability can trace one box of egg back to one pallet or one hour's batch production. Therefore the cost of change and recall are much less than before. In this analysis we assume farm-level destroy incident happened once a year based on previous record.

Another obvious benefit of this traceability system is smooth and transparent information exchanged among farms, sorting & grading center, and retailers. Useful information such as shell quality, egg weight, and freshness can go through the traceability system to the party who needs to know and can use the information to make progress. The information about egg shell's quality from sorting & grading center and retailers helps farms to adjust and improve their feed recipe. The ICT dominates code type traceability system and increases the entire efficiency of traceability procedure. The previous system took 2-7 days to complete a whole traceability process, but it takes only 4-24 hours with the current system. These improvements make up operational benefits.

Benefit components	**Yearly calculation**	**Total**
Sales Profit	80% ×€400,000,000 ×1%[1]	€3,200,000
Labor	€300,000×7÷5-€300,000	€120,000
Recall &Destroy	€0.075×80,000×1[2]-€0.075×1,800[3]	€5,865

1. 80% of total profit directly associate to traceability system, average annual profit rate is 1%
2.the average cost of one egg now is €0.075, a medium size farm has 80,000 hens, normally one hens lays on egg a day.
3. one pallet has 1800 eggs.

Table. 4 Major benefits of traceability system, Gebr. Van Beek Group

Based on the data been given by Gebr. Van Beek's commercial department , the major benefits of the traceability system are market/sales benefit, labor cost savings, recall/ destroy savings, and operational improvement. Among the four parts, market/sales benefit accounts for 96% of total monetary benefit (Table. 4). In the preliminary analysis, we have proposed a hypothesis for sub-question 2 that major benefits including market benefit, labor cost savings, recall and changing savings, liability cost savings, and operational savings. Our case does not give evidence of liability cost savings. The benefit of operational improvement is hard to quantify in this case. Therefore the null hypothesis of sub-question 2 is rejected.

In the analysis of this 6 years traceability system. Initial cost for equipment and software are €1,150,000. Annual operating cost of traceability system in the first and the fourth year are €1,166,333. Operating costs in the other four years are €1,158,333. Major economical benefits consist of increased profit, labor cost savings, and savings from recall and destroy. In total, the three components make a yearly benefit of €3,325,865. Then we come up with the following table with net present value.

	2007	2008	2009	2010	2011	2012	Total
Cost	1166333	1158333	1158333	1166333	1158333	1158333	6965998
Benefit	3325865	3325865	3325865	3325865	3325865	3325865	19955190
Net benefit	2159532	2167532	2167532	2159532	2167532	2167532	12989192
NPV (5%)	2056697.143	1966015	1872396	1776652	1698318	1617446	10987524
Initial cost	1150000						
Project NPV							9837524

Table. 5 Cost and Benefit analysis (€) with 5% discount rate

From the above table, net present value of this traceability system project after 6 years is now in total a positive €9,837,524. But in order to test the traceability system's net present value in different economical situations with different overall discount rate, a sensitive analysis was performed with different discount rates from 2% to 7% (Fig.6). Even if the discount rate is as high as 7%, the 6 years net present value is still 9 million positive.

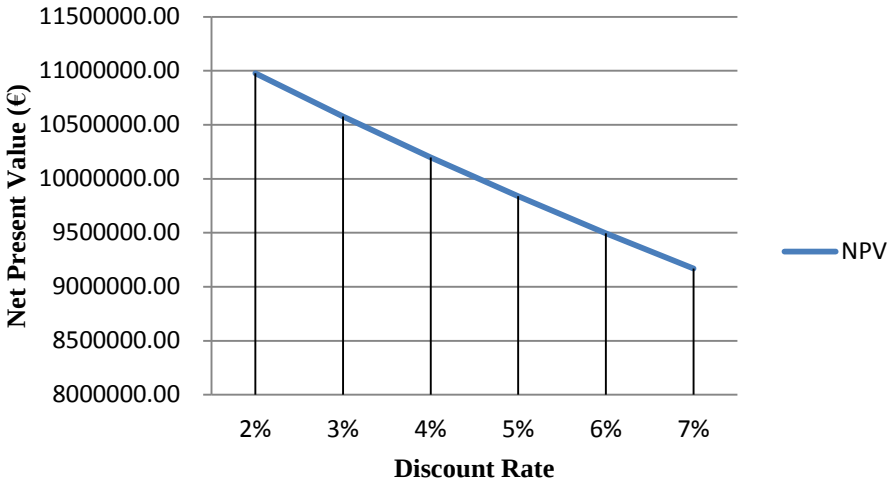

Fig. 6 Sensitivity analysis

In this case, retailers and consumers can report the traceability code on eggs' package to achieve traceability. Therefore we consider that both retailers and consumers do not need to make investment in the traceability system, neither for equipment nor software. In fact, this traceability system is mostly implemented by Gebr. Van Beek group. Gebr. Van Beek Group in this egg supply chain jointly with its farms plays both producer's role and distributor's role. Farms need code printer and other equipments to achieve fundamental traceability requirement, sorting & grading center build the central database, and package level traceability code. Hence the distributor and producer are both the major investor of the traceability system. We reject the null hypothesis of sub-question 3. The cost of implementing the traceability system is not equally allocated among each actors in the egg supply chain.

Through the analysis, we can find that market/sales benefit is the greatest benefit of implementing the traceability system in egg supply chain. If we separate Gebr. van Beek Group into two parts, producer (farms) and distributor, we could find that all the 200 medium-small sized farms have relatively stable production capacity. Increased volume of sales comes from increased number of farms. Therefore, each farm do not really benefit from the increased market share. The distributor role is actually the one which benefit from the traceability system the most. In previous preliminary analysis of sub-question 4, we assumed producer may benefit more than others. It is proved

here that producer is not the one benefit the most, but the distributor is. Therefore, we reject the hypothesis of sub-question 4.

Finally, considering the fact that Gebr. Van Beek makes both the most investment in and profit out of this traceability system in egg supply chain, and the result during 6 years is significantly positive. Therefore, we can conclude that in this case the implementation of the traceability system in egg supply chain generates higher profit than its cost. The null hypothesis of our main research question is accepted.

9 Discussion

In this study, we aim to use the case of Van Beek Group as an example for the egg industry only. The reasons why it is not possible to generalize the case in the whole food industry are: 1. egg production is different than other food products (e.g. cookies, juice). As the chicken is a part of egg production, chickens are included in the traceability system; 2. for some other food products, traceability systems may be centered in the original production site which is the farm in our case. However Gebr. Van Beek 's traceability system is centered in Van Beek's sorting and grading center. Therefore the structure of traceability system is different.

There are several reasons which make this single case is possible to generalize in egg industry. *First* the Gebr. Van Beek company is one of the typical egg companies in Europe. Just like Kwetters which is one of the other large egg companies in Europe. These egg companies' businesses are only about eggs. Their contracted farms link these egg companies to production activity. They all have sorting and processing units as well. These egg companies also take part of the logistics responsibility. The supply chain of Gebr. Van Beek Group is in general the same as other egg supply chains in Europe. Practically its traceability system can transplant in any other similar egg supply chain. In the company Kwetters, the major competitor of Gebr. Van Beek, a similar traceability system has been implemented from farms with the same traceability techniques.

Second, the largest benefit of this traceability system is the increased market share. The economic result of our analysis of Gebr. Van Beek case is a good representative of other egg distributors, dealers, or traders. Another large egg company similar to Gebr. Van Beek has also announced that traceability system helps to retain key customers such as Unilever, Heinz, and AH. These important clients show special concern for traceability, because these big customers provide high quality products and services to consumers with high level assurance. Therefore they require suppliers

to provide high quality products and satisfied assurance as well. Most farms in our case have stable production volumes. Farms' supply to Gebr. Van Beek group is not largely influenced by the implementation of traceability system. Retailers can always sell eggs with traceability and good quality, no matter which brand the egg is. Hence traceability system is a key to a wholesaler or distributor. The advanced Gebr. Van Beek's traceability system, which exceeds EU regulation prescriptions, is a good example for similar firms which have not yet implemented a complete traceability system.

However, the system has its limitation in promoting itself to the whole world egg industry. Different countries and regions have different laws and regulations concerning egg's quality, safety, and traceability. Some countries outside Europe have different egg sorting methods. Not all the countries require a printed code on egg shell. Therefore the first part of this traceability system, printed code on shell, may be not applicable by form and content in other regions. Some Non-EU countries may require different information regarding egg production and distribution for traceability. For instance, in China, code printed on egg's shell and grandparent information of chicken are not required in egg traceability.

In this Gebr. Van Beek's case, most farms are small to medium size. These farms do not directly supply eggs to retailers or consumers on a large scale. But in Asia and America, there are large farms which have direct contact with retailers. The Shendanegg company, one of the largest egg suppliers in China, has a huge complex with all the production and processing units together including farms, a sorting center, a packaging center, and a distribution center. Therefore egg supply chains vary in different countries. The same traceability structure and its cost-benefit relationship are therefore limited to apply to some Non-EU cases. Between above different models of supply chains, Van Beek's independent operation with farms gives it a much better point to ensure products quality in an independent way than a farm with "big production complex" could offer.

10 Conclusion & Recommendation

The increasing demand of consumers for food safety and healthy generates requirements for complete traceability systems. However, the study of traceability systems' economic value in supply chains is limited. In some food industries, the profitability of traceability systems' implementation was unclear.

In this paper, it has been discovered that the qualitatively perceived benefits of traceability systems in egg supply chains contains product quality improvements, operational efficiency improvements, information transparency and exchange improvements, and increasing consumer trust. These findings prove the existence of traceability system drivers that have been found in previous research, such as in Pouoliot & Sumner (2008), Frederiksen (2002), and Buhr (2003) and in particular proves the existence of such benefits in egg supply chain. This study also discussed quantitatively the benefits of adopting a traceability system in egg supply chain. In the egg supply chain, different actors may receive different benefits. But in general, such quantifiable benefits include market benefits, labor cost savings, and recall &change savings. These points support findings of Hobbs (2004), Mai (2010), and Can-Trace (2004). However, this is a single case study, the generalization is limited. Further study with more samples, especially samples in different countries of the world, is a need.

It is found in this case study that major cost factors of adopting a traceability system in egg supply chain are third party service, hardware costs and labor costs. This could be comparable for similar companies in egg industry. The cost benefit analysis of Gebr. Van Beek Group shows that implementing such traceability systems can generate higher profits than costs. The distributor and producer are the major implementers of this system in egg supply chain. The distributor takes the most benefits out of this system compared to other actors in egg supply chain. However, the

cost-benefit analysis is based on the perspective of companies' distributor roles. Therefore, the results and factors concerned in the analysis are limited to some cases and conditions. Further research with cost benefit analyses standing on different roles of supply chains is desired.

Besides, problems existed in current system are also interesting for further study. The data of product movements and status are stored in each company which implements the traceability system and manages their food business. There is a possibility of data fraud. Companies have the chance to change or remove data for their own purpose. On the other hand, the traceability system which has been studied in our case has different traceability codes in one system. Single code methods may increase efficiency and accuracy. Therefore the study of public database control and single code method for food traceability is suggested.

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