Global reference information models for product chains in agriculture: A case of apples and pears

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Introduction

The importance of collaboration in the agricultural product chain.
There are growing demands towards companies with regard to quality, delivery time, assortment and product life cycle of products. One of the decisions available to companies is to collaborate more with their suppliers and with their customers to improve performance. By making agreements about product characteristics and delivery conditions with other companies they try to better satisfy customer demand and increase efficiency in the chain. Hereby they hope to gain competitive advantages within their branch.

In recent years there is a growing interest in extending these agreements to other parties in the production column, parties which are not direct suppliers or customers of the companies involved. As a result we see an increase in collaboration in product chains, collaboration that spreads out from companies that produce primary raw materials to companies that produce consumer products.

This growing interest in chain collaboration already has lead to many projects in the field of chain management. E.G. in the porc meat chain projects are carried out regarding integral chain management (in dutch:IKB). Through IKB a system of integral quality assurance and environmental assurance has been developed for the biggest part of the chain.

IKB in this chain has lead to adjustment of the production processes of the chain participants and the exchange of product data (partly with EDI).

In this paper we define an agricultural product chain as a sequence of economically and/or legally independent companies that perform a necessary role in the different stages of the production column, who produce together an end-product for a consumer market. Basically there is a market between any two succesive stages in the production column.

Information exchange between organizations in the agricultural chain

A basic aspect of collaboration between organizations is the exchange of information, information associated with the receiving, processing and selling of materials and products. Porter (1985) argues that the use of information technology may lead to competitive advantages of the companies involved; advantages with regard to new forms of relationships with customers, new product characteristics, quality and delivery time of the product and services, etc.

In agriculture the involvement of chain aspects in information management becomes increasingly important. Specific characteristics of the sector that have to be reflected by the information systems are the dynamics and uncertainty in the goodsflow and quality-aspects of the products (Trienekens, 1993). Because of these characteristics collaboration in agricultural chains is often aimed at guaranteed quality of products, and also at quality of the production process (usually taking into account social, legal and environmental constraints). Quality information, about the products ánd about the production process, therefore is of major importance.

Information modelling

From experiences in organizations in the agricultural sector it is learned that information models have a structuring effect on the initiation and execution of information system projects (Beulens, 1991).

In an information model the information system of an organization is described. It consists of a datamodel, in which the data are described that are used or produced in the organization; and of a process model in which the activities are described which take place in the organization. For every process is specified what data are used and what data are created by the process.

Information models can be used for:

- identification of information systems
- standardisation of data for the development of information systems
- integration of information systems for different organizational functions

Information modelling usually is aimed at individual companies, as a part of information strategy planning. The most important use of information models until now was in the field of identifying (and developing) informa-tionsystems for single enterprises.

Information modelling in product chains

Because of the structuring effects of information models on the design of information systems for individual companies, it seems obvious to develop these models for product

chains as well. An information model for a product chain would then describe the processes and the data that are relevant for chain management.

The key issue with regard to collaboration between organizations in the agricultural product chain seems to be exchange of information between companies. It therefore is obvious that collaboration in chains has everything to do with integration and standardisation of information systems. In the process of developing information systems for product chains, standardisation and integration are key issues. They lead towards more 'openess' of information systems, i.e. towards better cooperation between systems of the collaborating companies.

This can even lead to automatically collaborating information systems of partners in the chain (e.g. the linking of operational systems via EDI).

The process of developing an information model takes a considerable amount of time and money. To improve the use of information models, it seems therefore appropriate to develop models that can be used for more then one situation in practice. In doing this we seek affiliation to the so-called branch-information models that have become available in Dutch agriculture the last 8 years; these are socalled reference information models that describe the data and processes of an 'average' farm in a specific branch (e.g. poultry or dairy farm) (Beers and Udink ten Cate, 1993).

They have partly proved to be a valuable tool to design specific information systems for a farm (e.g. they have been of the utmost importance for certain EDI projects in which a class of farms cooperates in exchanging information with the auction).

So, to make available more general knowledge and experience about information use in a product chain, we aim in our research project at reference information models (Greveling, 1988).

The research project

The research project aims at a method for developing reference information models for product chains.

Research questions

The most important research questions in the process of information modelling for product chains are:

- What is the object system for the information modelling process; i.e. what has to be the contents of the chain information model?
- How can we make reference information models, information models that apply to more then one occurrence of a product chain in practice (generalizations with regard to the same class of products, with differing partners; or even generalizations with respect to differing classes of products and partners that are different but have the same role within a chain).

So in our project we try to find answers with respect to contents and applicability of reference information models of product chains. In searching for these answers we aim at formulating a method for designing these models.

Research method

We used different kinds of research methods. On the one hand we did theoretical research by studying literature and organizing discussion meetings between scientists. During this process we used the knowledge and experience from the development projects for reference information models for individual farms.

On the other hand we performed empirical research by extensively interviewing the participants of the chain for apples and also interviewing experts in the field of interorganizational information exchange within the sector involved.

Because of the new field of science we were dealing with, this combination of research methods proved to be very fruitfull.

The case of the product chain for apples

The test case we use in this paper is the apple chain. In this product chain, an increase in collaboration must lead to better quality, delivery conditions and prices of apples for the end consumer. Also it helps the fruitgrowers to cope with environmental constraints that have an impact on the use of crop protection means and on the use of fertilizers.

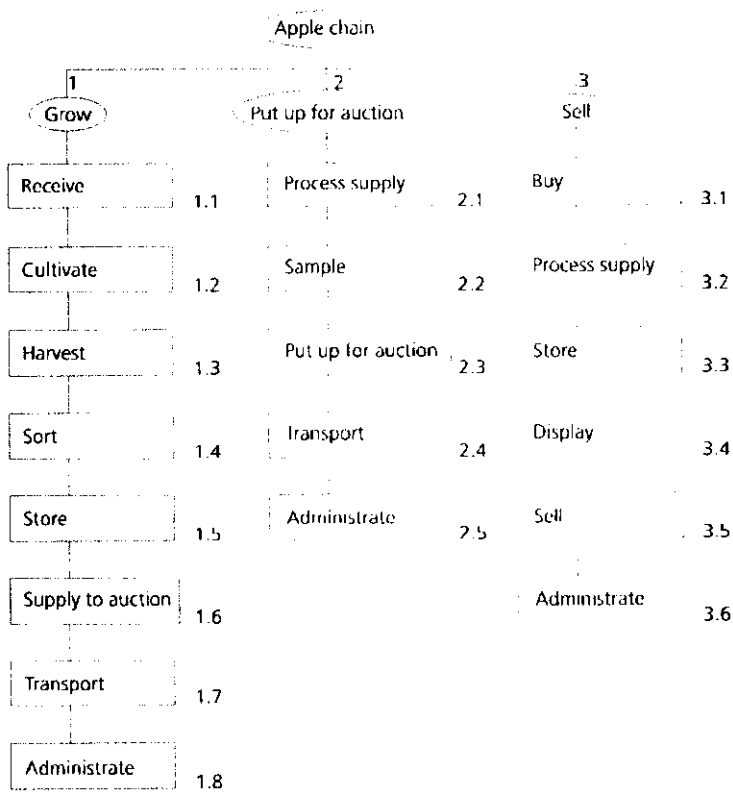

Figure 1. Processes in the apple chain

Contents of information models for product chains

The field of interest of information models for chain management

As described above, information models can be used to understand the information system of an organization in a structured way and can be used as a basis for the development of (automated) information systems for the organization. In fact they describe the information required to manage an organization. Information models for individual organizations describe the integral information system.

The aim of the development of chain information models is to support chain management. Because of the complexity of an information model that would describe all processes and data of all participants in a product chain, we aim at developing information models that can be used for issues regarding chain management, and not issues that are important for the management of individual chain participants only. We therefore seek to describe typical chain processes and data that are to be used for chain management.

[Because of this 'limited' interest with regard to processes and data in the chain, a very important point with regard to the design of chain information models is that during the design process we have to think about interfaces with the information models of the individual chain participants. However, we will not deal with this question in this paper; further research will have to give answers to that problem. Here we will confine ourselves to the description of the two major issues of chain information models, contents and scope (reference aspects).]

Applicability of chain information models

An information model can be used for many different management purposes, for which we often use only part of the model. For example if we are talking about optimizing product quality in chains, we may be less interested in issues of profit distribution in the chain. If we are interested in optimizing the use of personell and machine capacities in the chain we may not, or less, be interested in deliverytimes of products between chain participants. Or if we are dealing with some strategical issues (product development, competition, etc.) we may less be interested in interorganizational financial aspects.

So there can be different areas of interest regarding product chains, areas of interest that will match with certain domains in an information model.

We believe that a chain information model should apply to all the important questions regarding chain management. The character of a chain information model therefore has to be of a general nature.

A disadvantage of designing general applicable information models, is that they tend to become very complex. This depends on the level of detail that is chosen. If the level of detail of a general model is to low, then more detailed models concerning certain object areas can be deduced from such a general model. In that case the general model may guarantee the consistence, coherence and coordination between the various types of detailed models.

So, we search for a model with processes and data that are of importance for chain management (as we have seen in section 4.1) and which is general applicable. There are different roles and processes with associated information needs in a chain. Our first choice is to ensure that the information needs associated with the coordination and collaboration of vital primary processes throughout the chain, are involved in the process of developing

the information models. Primary processes seem to be the basis for information exchange between chain participants.

Reference aspects of information models for product chains

In the previous section about the content of a chain information model, we restricted the modelling process on the one hand to the processes and data that are relevant for chain management, and on the other hand we wanted to design multi-purpose information models. So in the modelling process we have to take into account all management aspects and in the same time we have to minimize the processes and data to be involved to those that have to do with chain management. We concluded that primary processes should be taken as the starting point for the selection of relevant processes for our chain information models.

With regard to the reference aspect of information models we have to take into account some other demands. With a reference model we should on the one hand be able to describe all possible chains that deal with a specific product; and on the other hand the level of detail should not be too abstract, so that the model can be used in practice.

Structural differences between chains

Information models for individual organizations contain all processes and data which are relevant for the organization (e.g. Martin, 1989). A reference information model is an information model designed for an 'average' organization, i.e. a model that can be used by more then one organization, usually organizations from a certain branche (e.g. dairy farms). As we have seen before, these models already exist in Dutch agriculture.

To design a reference information model for a product chain however is of a different nature. There not only exist differences between individual companies, e.g. one chain store can be different from another, but there are also differences between the number of participants in chains (that produce the same end-product). *Figure 2* shows an example of two different apple chains.

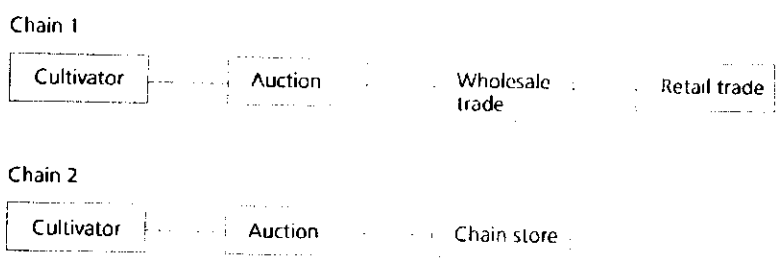

Figure 2. Different structures of the apple chain

With regard to the reference aspect of chain information models, the difference between the organizational structure of chains with the same product leads to an important question:

- How to describe chain-processes of chains independent from the participants in particular chains?

The answer to this question could be to distinguish the chain participants from the chain processes. This means in our case that we have to find the processes that are the same for every apple chain, regardless of its structure. So the description of processes for the production of a certain defined product should be the same for all chains who produce this product.

Primary and secondary processes in product chains

The primary processes in different chains with the same goal (in our case the production of the apple for the end-consumer) seem to be the same in nature. They always concern processes like purchasing, receiving raw materials, producing the product, storing and conditioning the product, selling, delivery and service.

From the figures 1 and 2 we can learn that though the number of participants and therefore the number of processes differs for the two chains, the nature of the primary processes is the same.

On the other hand most secondary (management) processes seem to be different for every chain. This is in the first place caused by the many differences between the management of individual companies with the same end-product. This problem was also encountered during the earlier projects for the development of reference information models for individual companies. For the development of chain informationmodels the problem is even bigger because of the different (number of) participants with each their own end-product in every chain. Examples of differences between chain participants are to be found in production planning systems, financial systems, the personell function, the marketing function, etc.

To determine the processes that have to be part of the reference model, we therefore aim in the first place at the primary processes. So, as we have seen them as the basis for the contents of a chain information model (section 4), they are also the basis with regard to the reference aspect of reference chain information models. With regard to the secondary processes we have to decide which of them are of importance for chain management. However, first we have to describe the different nature of primary and secondary processes, in order to get clearer definitions to work with (see also Beers and Beulens, 1993).

For this purpose we use the management paradigm of de Leeuw (de Leeuw, 1982), which is strongly based on Blumenthal (1969). De Leeuw makes a distinction between management processes (executed by a 'managing system') and managed processes (in a socalled 'managed system'). Management processes are processes that plan and control other processes (e.g. production planning, finances, personell). Managed processes are processes that are planned and controlled. The primary processes as described above are managed processes and belong in terms of de Leeuw to the managed system. Secondary processes however can belong to a managing organ, but also to a managed system, because they also have to be managed.

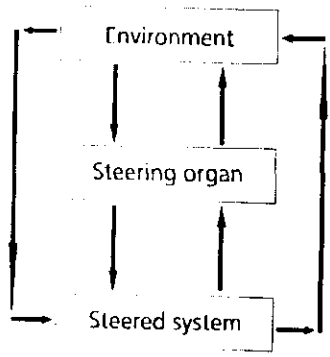

Figure 3. The management paradigm of de Leeuw

As described earlier the relevant processes for our project are in the first place the primary production processes, which are managed proces-ses, of the organizations involved. For us it is clear however that a lot of information produced by secondary processes (management processes) is also relevant at various places in the chain. Thus they cannot be left out of the information model. The management processes which are of interest for our project have to be connected to the goal of the chain which is the end-product. Processes of a certain participant in a chain are only of interest for another participant in sofar as they have consequences for their production process. So, the management (secondary) processes we are interested in are the processes that aim directly at managing the primary processes (e.g. production planning and control to transform input for the process into output). So, we leave out the secondary processes which are not directly connected to primary processes (e.g. parts of personell management, financial management, etc.). These last secondary processes often have to do with structuring the individual organization and not with the day to day operations.

So we can decide to the processes to be involved in the informationmodel: all primary processes and those secondary processes which directly manage the primary processes.

What we still need however, to find a clear and distinct definition of 'primary processes', is a broad definition of the product, the processes to produce, transport and service that product, and the information required for and incorporated in these processes. Further research has to find answers to these questions.

Apart from this distinction we learn from the model of de Leeuw that we also have to take into account environmental aspects of chain management (governmental regulations, law, etc). Therefore information about the product or the production process, from or to parties outside the chain should also be part of the chain information model.

The model of de Leeuw proves to be very usefull to understand and describe the behaviour of organizations and also of chains of organizations.

The minimal model

In this section we will give a first draft of a model which can possibly be used to decide on what processes and data have to be part of a reference information model of a product

chain. We call it 'the minimal model'. First however we will start with a recapitulation of the findings of the previous sections.

Demands to the minimal model
As described in section 4 we put the following demands with regard to the contents of a chain information model:
- a chain model only has to take into account these processes and data which are of importance for chain management.
- a chain model has to be a multi-purpose model. Detailed models of certain management areas or from a specific chain perspective have to be deduced from a multi-purpose general model.
- the processes which are of interest for chain management are primarily the primary processes. These processes directly aim at the goal of the chain, the defined end-product. Other processes of interest support these processes and can be deduced from these processes.

As described in section 5 we put the following demands with regard to the reference aspects of the chain information models:
- the primary processes in the chain have to be described independent from the chain participants (the primary processes in chains with the same product are the same in nature).
- management (secondary) processes which can influence directly primary processes should be described as well.
- influence from or to the environment of the chain, with regard to chain management, should also be taken into account. It determines the constraints of output- and process-conditions to be satisfied.

Components of the minimal model
The demands as stated in the previous section lead to the following components of the model:
1. Regarding to system theory (de Leeuw, 1982, in 't Veld, 1975) every system can be described as a black box with input and output. Management is not primarily interested in the contents of the processes, but rather in their behaviour of transforming input to output. They are primarily interested in the 'what' of the process and not in the 'how'. Every process has its constraints that set the scope within which the process has to be or can be performed. The primary processes thus describe the behaviour of the product chain within the constraints set to the processes. In the description of the product chain we then have to take into account primary processes, regarding their possible behaviour, with their input and output.
   For the information modelling process we are only interested in input and output in terms of information. This information is directly linked with the product or the goodsflow.
2. As we have stated before we also need to include management (secondary) processes of chain participants which can influence directly (other) primary processes. The information output of these processes can be used as information input for steer-

ing and control of primary processes. Examples of these processes are demand forecasting, inventory planning, etc. However we are not interested in these processes themselves (contrary to the primary processes), but merely in their information output as far as this is of interest for the primary processes. This also concerns information with regard to the behaviour of the process within certain limits (e.g. the specifications of the productionprocess for a certain product given by a customer to an enterprise).

With these processes we have completed the general system model as described in *figure 4*: a process with input, output and steering information.

Based on our empirical research and our experiences with product chain information modelling, we found out that also other, different types of information can be identified.

On the one hand this is information that can be considered as output information for the primary processes (reporting), and on the other hand we distinguish information that can be considered input of the primary processes (conditions to the processes).

3. Information output of processes, partly meant for management or for parties outside the chain, has to be taken into account as well (e.g. products in stock, the use of herbicides, legal/environmental information, tax reporting, etc.). The output as described above (under 1) is related to the product of the process. Therefore we will need another output factor which we will call 'report'. This is informa-tion about the (changing) status of the primary process: the materials used in the process, the process steps, the production means. (This status may for instance determine the ability of the process to perform jobs in the future).
4. Collaboration between chain participants means that one participant makes agreements with others and therefore places conditions upon the process of the others. (e.g. in the apple chain, chain stores place demands on the packaging materials of their suppliers). Downstream through the chain we have to do with information associated with the product being delivered, and upstream we have to do with requirements in order to satisfy customer demand and constraints. Also conditions can be placed upon chain participants from parties outside the chain. Think about governmental regulations (e.g. with respect to environmental issues, welfare of animals, etc.) or regulations of branch organizations.

   Preferably the conditions are in the form of constraints on by-products, raw materials and the processes and do not specify how these constraints are to be satisfied.

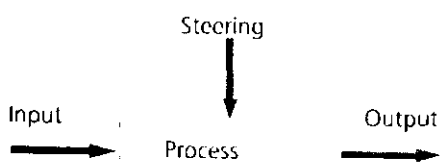

Figure 4. The system model

Because of the importance of these conditions to understand the behaviour of the primary processes and thereby the behaviour of the chain, we believe that they have to be taken into account in the information modelling process. Indeed, by the conditions the chain participants structure a great deal of their collaboration.
[The conditions are not the result (output) of other primary processes. Sometimes they are steering output of secundaire processes; e.g. a specific order for a certain product with certain conditions included. Often however they are output of tactical management processes that are of a different nature then the secondary (steering) processes as described above. So maybe in order to make a clear distintion between types of processes, we have to define a third class of processes like policy making or negotiating between partners (for basic agreements).]

This brings us to an extended system model as described in *figure 5.*

To illustrate the model, we will analyse and describe in the next section several processes that are part of the appple chain.

The minimal model applied to the apple chain

We illustrate the minimal model with two examples of processes: the primary processes of sorting apples at the cultivator, and of invoicing at the auction.

The information categories we recognise are input, steering and conditions, as input factors; and output and reporting as output factors (see *figure 4).* The figures speak for themselves.

Conclusions and further research.

In our research project we developed a modelling approach to describe the processes and data and their relations which have to be part of a reference information model for a product chain. The approach is called 'the minimal model' approach. It describes which processes (primary and secondary) in a product chain are relevant to be taken as part of a reference information model and it consists of a system model for these processes (a process with input, output and steering), which is extended with 'conditions' as extra input factor and 'reporting' as extra output factor. Input and output factors have to be understood as information flows.

We described several processes from the apple chain with the minimal model approach.

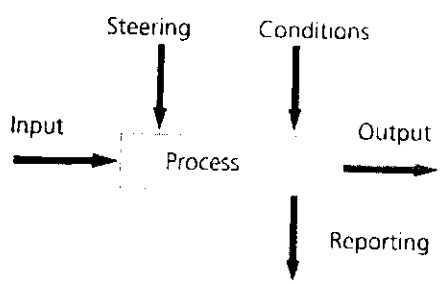

Figure 5. The minimal model

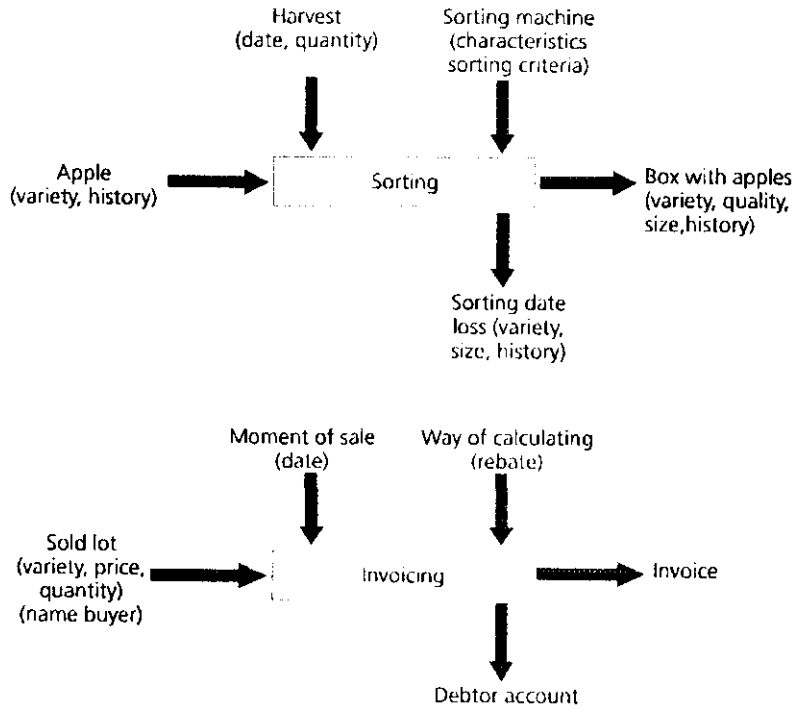

Figure 6. The processes of sorting apples and invoicing

As with most explorative scientific research, more questions were raised then answered. Although we have found interesting answers to some of our questions, a lot of them still remain unanswered.
The most important questions still to be answered are:

- is it possible to make all-purpose reference information models for chains? If so, can we deduce more detailed information models from these all-purpose models?
- can we find a solid method for selecting processes that are important for chain management and processes that are not; what criteria can we use in the selection and decomposition process?
- for this selection process: how do we define the borders of the different processes; e.g. can we find a strict definition of 'primary process'?
- The question to the validity of the minimal model

Further research has to deal with these questions. Besides more theoretical research, attention has to be given to the testing of the model and the use of the resulting reference information models in practice. By doing this we will come closer to the final goal of the project which is to develop a method for designing useable reference information models for product chains.

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