

Mapping flows - An analysis of the information flows within the integrated supply chain

Aron Chibba*, Jonas Rundquist**

*) School of Business and Engineering, University of Halmstad, PO: BOX 823, S-301 18 Halmstad, Sweden E-mail: aron.chibba@set.hh.se, Tel: +4635167231; Fax: 4635

***) School of Business and Engineering, University of Halmstad, PO: BOX 823, S-301 18 Halmstad, Sweden E-mail: jonas.rundquist@set.hh.se Tel: +4635167231; Fax: 4635

ABSTRACT

Information sharing is an important factor for cooperating within an integrated supply chain. This paper presents a methodology for mapping information flows in an integrated supply chain and a case study, using the mapping methodology, from two Swedish multinational organizations. Eight cases were used in a retro perspective way to map, describe and analyze the information flow, which supports the physical material flow, from receiving an order to the point of delivery. This paper also describes two types of information flows: Direct information and indirect information. The case study presented in this paper focus on the direct information. The present study indicates the importance of an integrated, updated and smoothly operating information system. The complexity and the performance of the information flow and the physical material flow within each case were also analyzed from three main perspectives: 1) the right information, 2) at the right time, 3) to the right place. Over 30 semi-structured interviews have been made to map and describe the information and physical material flow. Key personnel involved in the process from order to point of delivery were interviewed. One conclusion of the study is that three types of disturbances were dominant in the cases: 1) Procedures to handle changes in an order from a customer, 2) lack of information within the internal supply chain, and 3) Procedures to handle information about delays in internal production or wrong material delivered.

Key Words: Mapping flows, Improvement, Information flow, physical material flow, supply chain performance measures

1. Introduction

Organisations have for a long time tried to optimize and improve the physical material flow within the integrated supply chain, trying to gain advantage in a competitive market. However, this is not enough. Organisations also need to improve the information flow, which is connected to this physical material flow. It could therefore be argued that improvements in the information flow along the supply chain would be favourable. Chaffe (2001) argue that better access to information of high quality has always been an important strategic goal for organisations. Timely information improves the outcome of strategic planning, supports judicious decision-making and eases the management of ongoing operations. Information logistics is a recently developed term, which has attracted an increasing research interest. Klein (1993) stated that *the concept of information logistics links the functions of business logistics and information management. It focuses on vertical coordination within firms and horizontal coordination within and beyond the boundaries of the firm. In a conceptual perspective, information logistics is a crucial element of a revised model of the firm. In an interorganizational perspective, information logistics refers to emerging telecommunication infrastructure.* Meanwhile, Chaffe (2001) describes information logistics as *“the process of acquiring, maintaining, transporting_and compiling information within and among entities”*. It is not easy to provide a distinct definition of information logistics, acceptable to all the actors involved, nor to provide a description of how to use the term developed in different environments (Chibba and Hörte 2003). Although the different perspectives of information logistics, it is clear that the perspective depends on the focus of the research or the researcher. Researchers from different disciplines, such as Logistics, Marketing, Information Management, Industrial Organisation, Operations Management etc could use the concept of information logistics. The perspective from Industrial Organisation often focus on the strategic, managerial and organisational aspects of creating new business and develop effective and human related work models (Chibba and Hörte 2003). Both the authors of this paper belong to the discipline of Industrial Organisation. Therefore, this research focuses to develop effective and human related work models. This research is performed in two multinational organisations. Firm A is a world leading producer of appliances and equipment for kitchen, cleaning and outdoor use for both private and professionals. Firm B’s primary task is to support the customers in their efforts to streamline communications to their customers, whether this is done electronically, via paper or cards.

1.1. Purpose and aim

The purpose of this paper is to develop and test techniques to map information flows within an internal supply chain e.g. how the information flow that supports the physical material flow. The aim is to find factors that could improve and rationalise the information flows and generate a better flow within the organisation. These factors could be further tested and could be used to develop supply chain performance measures covering the most important information flow aspects.

2. Information and physical flows

The physical material flow has been extensively described in the literature (see Table 1). The information flow has also been explored and described. However, Chibba and Hörte suggests that the information flow can be divided into two separate approaches; first, the

information (F) needed to produce the actual product or service. This information is directly connected to the physical material flow i.e. order-, delivery-, quantity information. Second, the information (-F) that is indirectly related to the physical material flow e.g. information about the customer, future markets, future changes or future customer demands (Figure 1). The classification of information flows and physical material flows was conducted by Chibba and Hörte (2003) and the results can be viewed short in Table 1.

Table 1 Model for classification of articles - Results (Chibba and Hörte 2003)

Perspective					
A. Model for description of the...			B. Method for calculation within the...		
1. Information flow (indirect)	2. Information flow (direct)	3. Physical material flow	1. Information flow (indirect)	2. Information flow (direct)	3. Physical material flow
<i>Priority 1</i> <i>14 articles</i>	<i>Priority 2</i> <i>138 articles</i>	<i>Priority 3</i> <i>138 articles</i>	<i>Priority 1</i> <i>0 articles</i>	<i>Priority 2</i> <i>26 articles</i>	<i>Priority 3</i> <i>22 articles</i>

The literature review focused on recently published literature, i.e. scientific articles related to information logistics from a supply chain (management) perspective. The focus of that study was to describe terms and concepts related to two different flows; the physical material flow and the supply chain information flow. The work classifies 140 articles, all of which related to two types of flows i.e. information flow and the physical material flow. A second classification divided the papers into those just describing the flows and those containing methods for calculating different performance measures related to the flows. The classification revealed that the majority of the papers just described the flows, often dividing them into steps or phases, as well as suggesting ways to connect the phases, through e.g. cooperation, organisation, management etc. Only a few papers describe calculation methods or how to estimate time related factors, costs, profits, benefits, potential opportunities etc of the flows.

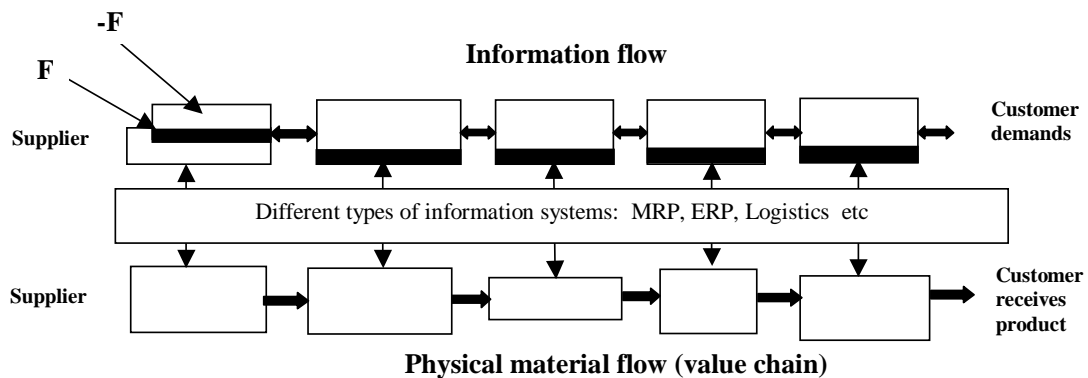


Figure 1 The physical material flow and the information flow showing two different approaches (indirect and direct information). Source: Chibba and Hörte 2003

The study made by Chibba and Hörte (2003) pointed out a need for more research about descriptive models and methods of performance assessment, within the area of indirect information flows in supply chains and methods for calculation within the information flow and the physical material flow. The study pointed out four research directions;

- (1) Develop and evaluate techniques to map information flows within a supply chain. The aim is to rationalise and improve the information flows and to utilize the information to generate value to the firm.
- (2) Investigate ways to track and evaluate indirect information that can be used to generate new business. The relevant information is primarily about customers, markets, future changes or future customer demands.
- (3) Investigate techniques to separate valuable information from non-valuable information in the information flows.
- (4) Develop supply chain performance measures covering the most important information flow aspects.

The present study will focus on two of these directions, namely 1) and 2).

2.1. Mapping information flows within a supply chain

Lueg (2001) argue that information can be understood as a flow of signals, while knowledge can be viewed as the interpretation of those signals. Some researchers (Nonaka and Takeuchi 1995; Lueg 2001) argue that information can be viewed as a preliminary stage or substance of knowledge creation. This perspective can be deemed a qualitative approach to “information”.

Hull (2002) argue that a data flow diagram (DFD) offers a general structure for supply-chain information. He points out that the DFD could be used to map typical supply-chain information flows. A DFD could be used both for push-oriented system and pull-oriented productions systems. The DFD consists of circles which represent processes, rectangles represents data stores or repositories for information and squares represent external entities, which are outside the scope (control) of the system, information flow is represented by full arrow and the primary flow direction by a dotted arrow. Hull states that the DFD is a primary structural component of a chain and understanding it is basic to reducing distortions. There are several ways to map flows, processes, activities or happenings within organisations and there are several software tools that could be used for help e.g. Business Viewer, Flowcharter 2003, MS PowerPoint, MS Visio. Another similar way to describe or map flows, processes, activities is presented by (Egnell 1994). He claims that there are several characteristics for a process:

- The process has a supplier that contributes with some sort of measurable object into the process. This object could be an either external or internal supplier, i.e. another process.
- The process consists of one or several activities that more or less transform the object into a more valuable, in advance fixed measurable result.
- The process should have a definite beginning and a definite ending be clearly defined, and have a well-defined start and a precise ending. There are so called interfaces between the processes.

- A process should be frequently repeated. That is, those activities that form the process are performed with more or less regular timeframes.
- A process should use the organisations recourses, for example, information, energy or working hours make the transformation from object to results.

The meaning with this concept can be stated as cross functional (Egnell 1994). Instead of focusing on the organisations various functions, we look into how all functions are connected across the functions, starting with demands and ending with product or service delivered. If all processes are connected (which seems to be the case in every organisation) within an organisation we have, a supply chain (internal or external).

It is a requirement in the latest revision of the ISO 9001:2000 standard to identify and describe all the key processes within an organisation. All organisations that have an ISO 9001 registration must work with the process concept, in order to achieve a process oriented organisation. One way to implement the process concept is to use a model. This model should have relevant terms. Harrington (1991) suggests that a process has a flow of sub processes and that a sub process has a flow of activities. But it can also be appropriate to use several levels. A sub process could be broken down to another sub process. The lowest levels are activities or work instructions, see the suggested model in Figure 2.

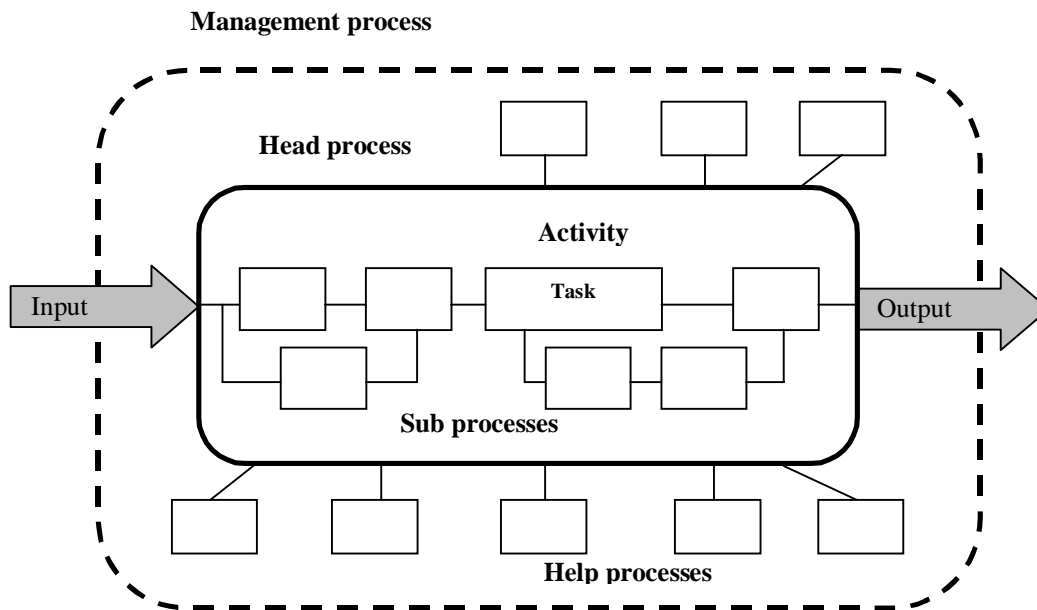


Figure 2 Illustration terms and hierarchy of the process concept free and developed after Harrington (1991).

It could be beneficial for organisations to work with a process model that everyone within the organisation understands. The overall objective with this work is to get a smooth flow from raw material to the end user, adding the lowest resources possible. Organisations must know how their processes are connected, which of them are key processes, what processes need to be further developed and improved and what recourses are needed and what resources are critical to the customers. In this paper we use the above presented process concept to describe the information flow in our eight cases. Figure 3 is an attempt to describe an ordinary flow of both data and information. Data are generated from different types of activities e.g. output data from either internal or external processes. The data can then be converted into different information formats e.g. oral, textual, or paper-

based (Kaye 1995). When the converted data reach the receiver, it must be analysed before it can be deemed information that will (hopefully) lead to knowledge (one can argue that there is an interpretation phase between information and knowledge) that can be used for a specific purpose, e.g. how to act or make a decision.

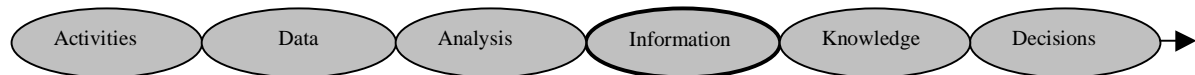


Figure 3 The process from activities to decision making, mapped (Source: Chibba and Hörte 2003).

This illustrates a simple but not uncommon process faced by organisations in day-to-day business. But there are some problem areas. Herbig and Kramer (1994) hold that information overload is the phenomenon of too much information overwhelming a consumer and leading to a judgemental decision-making. Another problem facing organisations is that the information ends up at the wrong destination and there also appears to be difficulty in obtaining the relevant information when needed, due to the fact that the required information becomes increasingly distorted as it moves along the supply chain (Hull 2002).

2.2. Distortions in the chain

Mason-Jones and Towill (1997) argue that the problem of distortion and magnification of order information still remains. They point out that the many decision processes, which still remain, block rapid data transference to where it is really needed. In particular, there is still much work to do to improve the order fulfilment processes from utilizing undistorted point-of-sales information. Mason-Jones and Towill conclude that the only way to reduce distortion and improve speed of response within a supply chain is to use and arm all players with information on true consumer demand. Chiu (1995) points out that deliveries of customer orders are often delayed due to various factors such as machine breakdown, material shortage, defective products, inadequate capacity and unexpected operating mistakes. Other disturbances could be such as: changes in order from customers or wrong material. There are several factors underlying these disturbances e.g. time pressure, information not on time.

3. Supply chain performance measures

In order to improve and make use of corrective actions e.g. reduce distortions within the integrated supply chain, it is important to have a suitable measure. To measure the information flow over the supply chain could give valuable information on what to improve. Beamon (1999) argue that there are three levels of performance measures; resources, output, and flexibility. Beamon gives example of supply chain performance measures of each level. Resources could be measured as total cost, distribution cost, manufacturing cost, inventory and return on investment (ROI). Output could be measured as sales, profit, fill rate, on-time deliveries, backorder/stockout, customer response time, manufacturing lead time, shipping errors, customer complaints. Flexibility could be measured as volume flexibility, delivery flexibility, mix flexibility, and new product flexibility. Beamon argue that one of the most difficult areas of performance measure

selection is the development of performance measurement systems. There are several questions that have to be answered, some are: What to measure? How often to measure? How and when are measures re-evaluated? It all depends what type of organisation and what the focus is. Chibba and Hörte (2003) argue that supply chain measures can be viewed from four different focus as depicted in Figure 4. This figure presents the integrated supply chain, which is based on SCOR (Stewart 1995) and has been divided into different types of measures (Chibba and Hörte 2003).

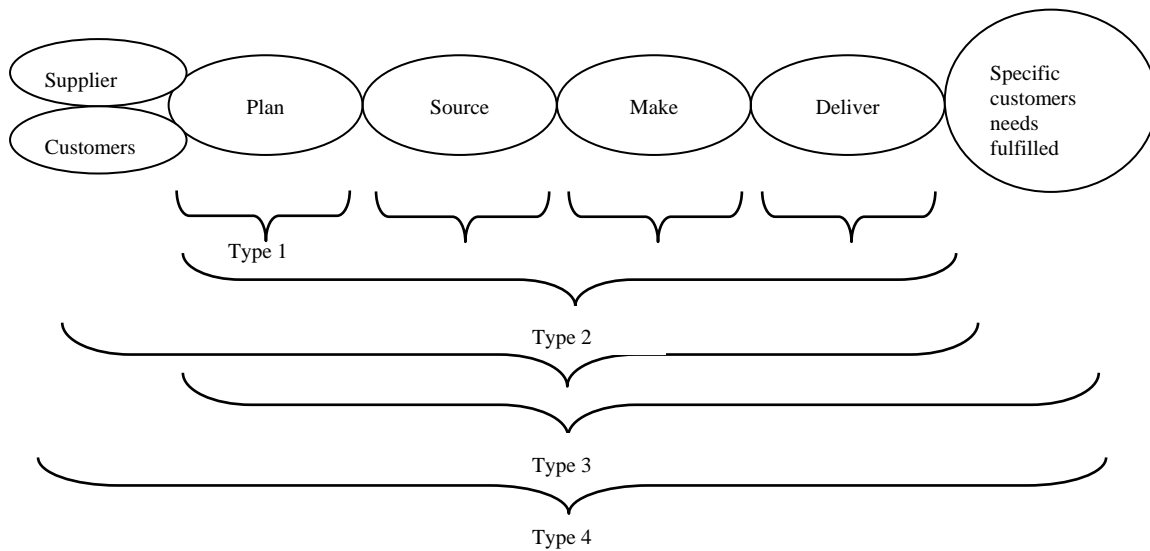


Figure 4 Four different types of measures of supply chain performance (Based on SCOR and free developed by: Chibba and Hörte 2003)

Type 1 – Functional measures

Often the first step in assessing performance is to analyse the way the order-related activities are carried out. To do this the most important issues – such as the order-entry method, order lead-time and path of order traverse – need to be considered (Gunasekaran, Patel et al. 2001). Other measures could be non-conformities, time to perform different activities within the function i.e. sub-processes. The production process in manufacturing organisations is often an activity that has a major impact on production cost, quality, and speed of delivery. Therefore, the production process needs to be measured, managed and improved and suitable metrics for it should be established. These metrics could fit under three headings (Gunasekaran, Patel et al. 2001): Range of product and services, capacity utilization and effectiveness of scheduling techniques. This type depict performance of a separate activity/function of the chain, e.g. flexibility (mix) of production – the ability to produce effectively a wide variety of different products.

Type 2 – Internal integrated measures

These measures depict performance across functional boundaries within the firm, e.g. quality (conformance) – the ability to manufacture a product whose operating characteristics meet established performance standards; Cost (total cost) the ability to minimize the total cost of production (labour, materials, and operating costs) – through

efficient operations, process technology, and or scale economies; Delivery (speed) – the ability to minimise the time between the receipt of a customer order and final delivery.

Type 3 – One sided integrated measures

A study of US food industry reports that poor co-ordination among supply chain partners is wasting \$30 billion (estimated) annually (Fisher 1997). This indicates the importance of establishing partnerships in a supply chain. The extent of partnership that exists between the buyer and supplier needs to be evaluated and improved. There are a set of criteria/parameters that needs to be considered in evaluating partnership (Gunasekaran, Patel et al. 2001). For example, the level of assistance in mutual problem solving supports the buyer-supplier partnership development. Several researchers has suggested partnership evaluation criteria in a supply chain: Level and degree of information sharing, the entity and stage at which supplier is involved (Toni, Nassimbeni et al. 1994), buyer-vendor cost saving initiatives (Thomas and Graham 1996), extent of mutual co-operation leading to improved quality (Graham, Dougherty et al. 1994), extent of mutual assistance in problem solving efforts (Maloni and Benton 1997). Other measures to consider are delivery performance, product price and flexibility of scheduling and production.

Type 4 – Total chain measures

Some researchers (Rushton and Oaxly 1991; Thomas and Graham 1996) claims that the largest cost component of logistics is transportation costs in the total chain . They claim that the trucking cost is always the highest among costs of total distribution cost. It seems therefore important to treat delivery and cost as a metric of high priority. Stewart (1995) identifies the following as the measures of delivery performance: delivery-to-request date, delivery-to-commit date, and order fill lead-time.

The presented measures are just some examples. The supply chain reference model metrics (SCORv5) is a tool that also presents several measures, which could be fitted under above presented types. This study focuses on both the internal integrated supply chain and the one sided integrated supply chain therefore the relevant measure will be both type 2 Internal integrated measures and type 3 One sided integrated measures. Type 2 depicts performance across functional boundaries within the firm, e.g. quality (conformance) – the ability to manufacture a product whose operating characteristics meet established performance standards; Cost (total cost) the ability to minimize the total cost of production (labour, materials, and operating costs) – through efficient operations, process technology, and or scale economies; Delivery (speed) – the ability to minimise the time between the receipt of a customer order and final delivery or speed of transmission of orders. Type 3 depicts performance across organisational boundaries and measure chain performance across supplier or customer boundaries, e.g. delivery (speed) – the ability to respond in a timely manner to the needs of your companies' customer.

3.1. Improvement of the integrated supply chain

There are several terms and concept that describes or explains continual improvement processes within organisations e.g. Kaizen, Six Sigma, Business Process Reengineering (BPR) , Total Productive Maintenance (TPM), Just-In-Time (JIT), Manufacturing Resources Planning (MRP). These concepts or terms have been adopted by organisations to improve the physical material flow. Womac, Jones et al. (1990) argue that organisations

have implemented specific pipeline process improvement techniques such as just-in-time (JIT) and manufacturing resources planning (MRP). Methodologies such as “lean manufacturing” have shown improvements to a whole host of industries, most notably the automotive sector where extensive research has been carried out. These methodologies have a strong focus on the physical material flow. Meanwhile Hull (2002) argue that once the information flows within the supply chain have been diagrammed or mapped, they can be analysed and improved individually. One can also identify information flow “circuits” which contribute to the bullwhip effect, and develop metrics for each. Jay Forrester identified the bullwhip effect in the 60’s. He identified a relation among companies that made mistakes and concluded that these get bigger once you are far from the final customer, or more upstream of the chain.

Hull claimed that by focusing attention on a company’s primary data flows, one might improve the overall reliability of the chain. Similarly, one may develop metrics to aid in reducing distortions. To compete effectively in the marketplace much pressure has been exerted on supply chains and individual companies to improve pipeline performance by optimising their response to customer demand. The major technology behind improved information flow was the advent of electronic data interchange (EDI). It offers greatly improved information flows and is an extremely important aspect within leading organizations in the fight to decrease lead-times (Evans, Naim et al. 1993). Today organisations make use of ERP (Enterprise Resource Planning) systems to integrate both customers and suppliers.

4. Methodology

In the present study we used a case study approach in a retro perspective way i.e. research on the cases that has already been finished. The reason for this choice of cases was the possibility of getting an in depth understanding, to get the context and to get the peoples perception of chain of activities. The first question we had to deal with was: What is the ideal number of cases? For a given set of available sources, the fewer the cases, the greater opportunity for depth of observation (Voss, Tsikriktsis et al. 2002). A project group was formed at each organisation to discuss which could be the suitable cases. These groups contained researchers, managers and employees involved in the process. After two gatherings at each firm we identified eight cases, four at company A and four at company B.

In order to capture the field data we used semi-structured interviews and a research protocol (checklist). This protocol (see Figure 4) was developed after a process oriented model (Harrington 1991). The reason for this protocol design was the possibility to map the information flow from the respondents, starting with the order and ending with product or service delivered. The protocol includes a field to describe the activity conducted by the respondent in the middle. The respondent was asked to describe the activity, the time and tools used and, if present, the documents that define the activity. To the right (see figure 4) the respondent was asked about what earlier activities that trigger the activity in focus and what complementary information that was needed to conduct the activity. This was documented in terms of what information that was included in the trigger, who (what person) conducted this activity, and how the information was transferred to the respondent. To the left (see Figure 5) the output of the activity was described in terms of what new activities were triggered by the output, who (what person) conducted this activity and how the information was transferred to the next person. Above the activity square indirect

information was documented according to the same terms as input and output. We piloted the research protocol at each firm and we made some suitable changes in the protocol e.g. a disturbance box (a field where the respondent freely could name problem areas within that specific case).

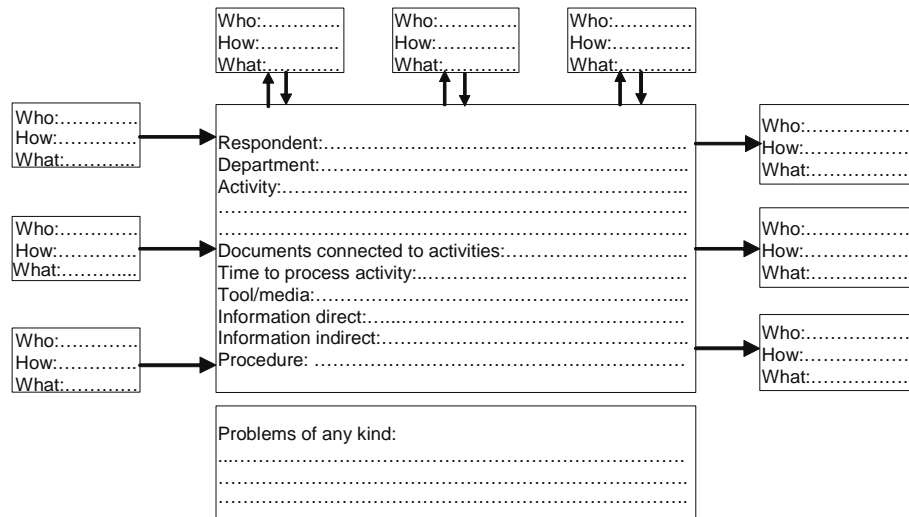


Figure 5 The research protocol

To get data needed to construct a model according to Harrington’s (1991) ideas, we decided to develop a selection technique for respondents based on the “snowball principle”. As the process and the participants of each case were unknown in the beginning and the process was also very complex, the sampling could be considered through a “Wonderland”-perspective. “Begin at the beginning ... and go on till you come to the end: then stop”, as the king said to the white rabbit when the rabbit was told to describe a very complex and complicated course of events (Carroll, L., chapter XII). Our beginning was the person receiving the order. We tried to map all information inputs and outputs as well as all activities employed with the information before output according to the protocol in figure 4. Then we chose the next respondents, as the persons supplying input and receiving output, and the end where to stop were when all persons participating in the process had been interviewed. We also analysed the documents connected to each case and the documents regulating process and activities such as ISO 9001 quality documents. The eight cases generated in total interviews with 31 respondents. As most respondents are activated in more than one case, the study has a mean of 11 respondents per case.

To document the exact process from order to delivery in each case we used a process management tool called MS Visio. To make a model, which could be easily understood by all parties involved, we chose to use only a few easily understood shapes to present the flow as depicted in Figure 6.

We made two major types of analyses of the cases. First, the documented models were compared with official documentation as for example ISO 9000 handbook. This gave results indicating whether or not the official documentation was known and used. Second, the problems indicated by the respondents were clustered and compared between the cases. This analysis gave us a briefcase of problems that could be compared with the theoretical framework. The analysis of the documented models of the eight cases also includes a more

qualitative part with ocular inspection of the models and a dialog within the research group and discussion including the respondents.

4.1. Reliability and validity

Using a case study approach in a retro perspective way could make it difficult to determine cause and effect and participants may or may not recall important events. Events may be subjected to bias i.e. particularly post rationalisation.

Cross-case analysis was used as a mean to increase the internal validity of the findings from the study (Voss, Tsikriktsis et al. 2002). The present study cross-case analysis was operationalized by comparing all the eight case, but also by comparing the four cases from the first firm as one group and the four cases from the other firm as a second group. Some findings could be presented as causal relations in the concluding discussion if we could find patterns within each organization.

External validity is whether a study's finding can be generalized beyond the immediate case study (Yin 1994). It could be argued that some generalizations could be made in the concluding discussion if we could find patterns valid for both organizations, as using replication logic in multiple case studies increases external validity.

In the present study reliability was helped by use of multiple data sources or triangulation. Apart from interviews with all respondents we were deliberately seeking answers from multiple data sources which could lead to more reliable results (Voss, Tsikriktsis et al. 2002).

Multiple cases may reduce the depth of the study when resources are constrained, but both increase external validity, and help guard against observer bias.

5. Case studies: Presentation and analysis

We mapped the flow of information and physical materials from receiving an order to the point of delivery i.e. firm A case 1 depicted in Figure 6. The boxes represent a process and the arrows represent information or physical material and are described in Table 2. The methodology presented above was used to map all cases. Some general conclusions will be presented in the next chapter. We choose to present one case more profound to present a picture of the methodology to the reader. Case A1 was chosen due to the facts that it had most disturbances within the integrated supply chain.

Above presented case was not successful due to insufficient communication with customer.

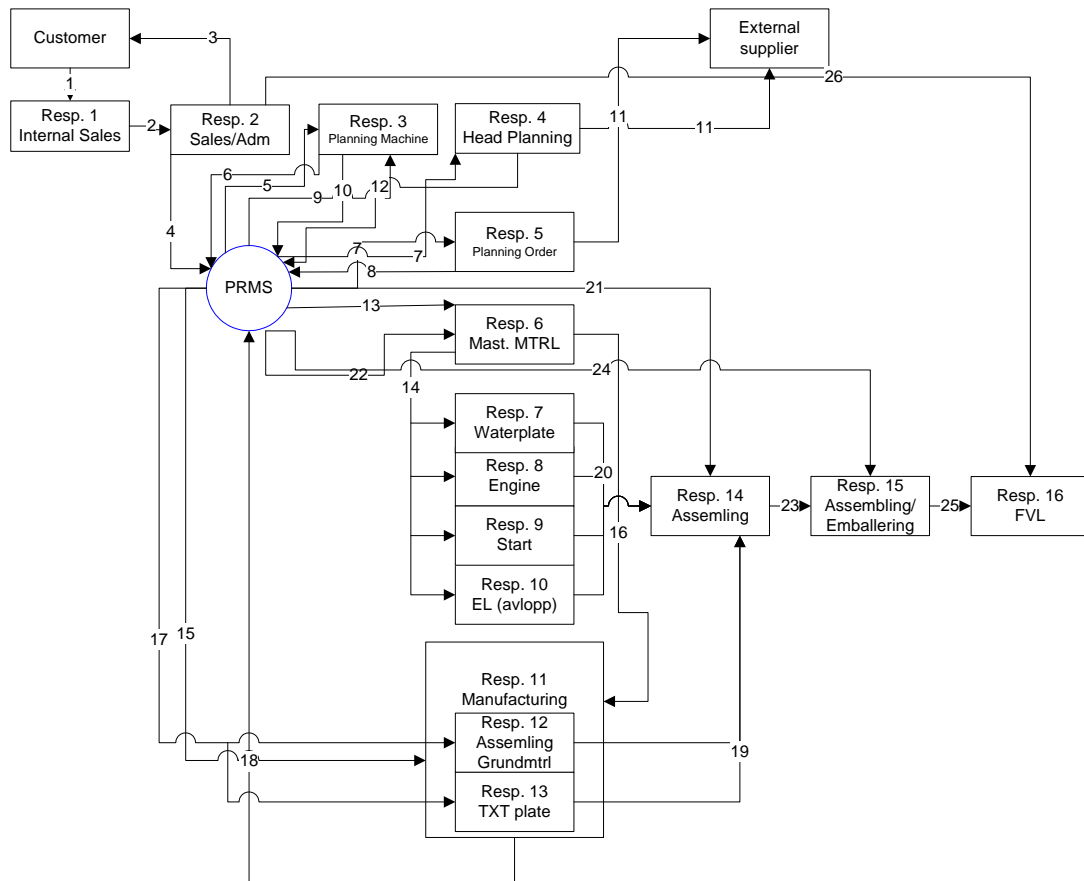


Figure 6 The information and physical flow mapped (case A1)

The goods was forced to a short delivery time even though the products could not be installed at the customer workplace. This caused lower priority for other orders in stock that caused unnecessary irritation with other customers. The diagram (Figure 5) gave us an understanding of the structure in the process. The next step was to analyse each information and physical material flow (arrows). The list below (see Table 2) describes the information flow. Each number represents one delivery of information from Figure 5.

Table 2 Description of the information flow. Arrow no. refers to the numbers in figure 6

Arrow no.	Resp. no.	Respondent action – receives or loading (what and how)	Respondent action – sending (what and how)
1	1	Receives order from customer by phone.	
2	2	Receives order from internal sales by phone.	
3	2		Sends order confirmation to customer by mail.
4	2		Sends information [A] to PRMS.
5	3	Loads information [A] from PRMS.	
6	3		Sends information [B] to PRMS.
7	4 and 5	Loads information [B] from PRMS.	
8	5		Sends information [C] to PRMS.
9	3	Loads information [C] from PRMS.	

10	3		Sends information [D] to PRMS.
11	4 and 5		Sends order to external suppliers by fax/EDI.
12	4		Sends information [E] to PRMS.
13	6	Loads information [D] from PRMS.	
14	6		Sends information [F] to respondent 7, 8, 9 and 10 orally.
15	11	Loads information [E] from PRMS.	
16	11	Receives information [G] from respondent no. 6 orally.	
17	12 and 13	Loads information [E] from PRMS.	
18	11		Sends information [H] to PRMS.
19	14	Receives information [J] from respondents no. 7, 8, 9 and 10 as a paper together with physical goods.	
20	14	Loads information [K] from PRMS.	
21	6	Loads information [H] from PRMS.	
22	15	Receives information [L] from respondent no. 14 together with goods.	
23	15	Loads information [K] from PRMS.	
24	16	Receives information [M] from respondent no 15 together with goods.	
25	16	Loads information [N] from PRMS.	
26	2		Sends information [O] to PRMS.

The example described above is an example of a bad case. At the point of delivery eight machines were missing. A reprioritising was done at the workshop, causing the problem that some other customer had to wait for their products. When products were to be delivered to the customer the driver found out that the customer was not ready to receive the products.

Although we did not present all eight cases as detailed as above, we summarise our findings from all eight cases in Table 3. Some of the phenomena identified in case A1 was similar in the other cases. The table presents the eight cases and the major disturbances, which can be connected to these cases.

Table 3 Results of the analysis of the eight cases

		Disturbances within the supply chain							
		Good or bad case	Lack of information between sales and customer.	Changes in order from customers	Lack of information - internal supply chain.	Internal supply chain - failure.	Information not on time.	Lack of material or wrong material.	
Case	Case A1	bad	X	X	X	X	X	X	
	Case A2	bad		X	X	X	X	X	
	Case A3	bad	X	X					
	Case A4	good							
	Case B1	bad			X			X	
	Case B2	bad		X	X			X	
	Case B3	good							
	Case B4	bad	X	X	X			X	

We found that three disturbances were more frequently represented in the eight analysed cases: 1) Procedures to handle changes in an order from a customer e.g. delivery time, order size. 2) Lack of information in the internal supply chain e.g. information about changed delivery time, information about changed stock information, and information about missing machines. 3) Procedures to handle information about delays in internal production or wrong material delivered e.g. different packages or products. We summarise the three disturbances more in detail below:

1. The major problem in the presented case is that changes in the order are sent to PRMS, but the change does not trigger any action further on in the internal supply chain. Actually all staff acted according to procedures; they received a change from the customer, processed the proper documents and sent the information to PRMS. The problem occurred because staff along the internal supply chain did not know a change had been made and as there were no checkpoint or routines to check whether the present information was correct, the changes was not detected until it was to late even though it existed in the system. After the information is sent to PRMS it loses its connection to an individual, which means that there is actually no one responsible for passing the information further on in the internal supply chain. This in combination with the lack of a trigger to an individual to check the information lead to a situation where the right information existed at the right time, but never reached the right place (right individual).

2. When production fails to complete internal orders in time, there is no feedback to PRMS. PRMS only receives information when an internal order is completed. This of course affects planning, as new schedules are not developed to organize an alternative production plan for the order in progress. This leads to a situation when the right information does not appear in time. This could be explained as a problem in the interface between the older paper-based system and the new electronic system. Because all the routines that the various departments were used to are not present in the electronic system, a complementary system of papers and oral orders according to the older system is needed to secure an order. It appears, however, that it could be problematic when the paper-system and the electronic system are not totally compatible. We found that this led to a confidence that “it is all in the PRMS”, when there is actually a lot of information on paper or even the oral communication between the individuals in action. As director of planning describes:

“Production had not produced as planned. No changes are made after order been delivered out for production – it is better to proceed instead of creating unsure ness in the supply chain. This bad case could be stopped this if the information had reached the head planning before a certain date. It was lack of communication between customer and sales which created the initial problem”

3. The interface between the paper-system and the electronic system also causes insecurity and failure in producing internal standard components and to keep a sufficiently exact record of stock values. Explicitly many respondents claim that there are often products missing in stock or that components needed for assembly are missing. We found that this could be caused of a unclear border between the paper-system and the electronic system; It seems that employees are not totally agree on where the correct information is best found. Information should, according to some respondents, best be found in the papers following the physical goods, while it should, according to other respondents, best be found in the PRMS. It is of course important that information is equal from all sources and that there is a clear priority on which information that is the most rigor source.

All the respondents answered that they only worked with direct information i.e. information directly connected to the physical material flow. None of the 31 respondents could say that they got indirect information.

6. Conclusions

This study makes a contribution to the understanding of mapping and description of the information and physical material flows of the integrated supply chain. The study presents a process oriented mapping tool, which can be used to easily map and describe information flows, and physical material flows.

Many methods frequently used in the industry for mapping information flows are theoretically based. This presumes deductive perspective as the model is already given

when the mapping process starts. Our methodology offers an inductive approach, which takes its base in the interviews and forms the model as a result of the empirical findings.

The results of this study can be used to inform the members in the integrated supply chain about the real world events that affects the chain e.g. the understanding of the need for 1) the right information, 2) at the right time, 3) to the right place.

Both firms have similarities within the information flow – the information flow is more voluminous at the beginning of the integrated supply chain. In the presented case (A1) we found that the respondents were more “sending intensive” in the beginning of the flow than in the end of the flow. Sending intensive means that they rather send information to PRMS than load information from PRMS. The respondents in the end of the flow were more “loading intensive” than in the beginning of the flow. Both firms are highly depending on both computerised and orally communicated information.

We found three factors i.e. disturbances, which could be improved and rationalised to generate a better flow within the integrated supply chain:

- Procedures to handle changes in an order from a customer.
- Lack of information in the internal supply chain.
- Procedures to handle information about delays in internal production or wrong material delivered

These factors could be further tested and could be used to develop supply chain performance measures, which could be appropriate to measure the performance across the total chain i.e. supplier – organisation – customer. Chibba and Hörte (Chibba and Hörte 2003) claims that the least concerned measure are total chain measures, which depict performance across organisational boundaries and measures the performance of the complete supply chain. This includes links to suppliers and customer e.g. total chain costs – the ability to minimise the total cost from supplier to the end customer. It also measures the delivery performance: delivery-to-request date, delivery-to-commit date, and order fill lead-time.

If an organisation use a computerised system as both firm A and B it is important that the system triggers the individual in that sense that the individual is aware of the latest change and prompted to take an action.

Finally, this study will hopefully contribute to better knowledge about the complexity of the integrated supply chain and the need for suitable measures. Even though both organisations have sophisticated information systems there still are disturbances within the supply chain.

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