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The Supply Chain Value Stream Model

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Abstract

Current demands on companies regarding the flexibility of production and logistics, as well as the digitalization of processes, are extremely high. To handle all the relationships within a Supply Chain, it is appropriate to implement Supply Chain Management between the involved companies. Every single company has its own processes, whether it is production or logistic processes, to monitor and analyze. Supply Chain Management for all members of the Supply Chain is more complex than the single company analyses. To meet the ever more complex requirements, there must be a new way to describe all attributes in conjunction with every process. For this reason, the Supply Chain Operations Model (SCOR) and the Supply Chain Value Stream model were developed. Both models try to describe and give advice to optimize the Supply Chain. “The SCOR model has been developed to describe the business activities associated with all phases of satisfying a customer’s demand,” according to the Supply-Chain Council (SCC) (2006). For the Supply Chain Value Stream model, it is important to show all information whether physical or related flows of material and information. To display these different flows, there is a uniform presentation, which is based on special symbols for Value Stream modeling. Depending on the focused details, there can be a “macro” or “micro” view on the production or logistics processes. These also allow a closer look at the problems inside a process or within the Supply Chain. The aim of this publication is to show the opportunities of Value Stream modeling in different ways, but especially the benefits of the Supply Chain Value Stream model.

Keywords: SCOR; Stream model, Supply Chain Management; Supply Chain Value.

Introduction

In view of the increasing numbers of international co-operations and vertical integrations, along with the focus on core competencies, organizations are under pressure to see themselves as part of a Supply Chain (SC). This constitutes a connection between companies, which take part in producing a product. A Supply Chain includes every single company, which contributes to this production from the suppliers of unmachined parts through logistics service providers, until the distributor, and even customer. Within this Supply Chain, there are many processes related to and influencing each other. It is no longer possible to consider every company individually in its processes. Every occurring problem influences the following processes of the supply chain.

In modern management, Supply Chains are coming to the fore because of growing competition in global markets, short life cycles at the product launch and high expectations from customers. To satisfy all these requirements, the process configuration of all companies within the Supply Chain must become more effective. The reduction of the delivery time and moreover the reduction of costs for non-value-added services are two of the focal points from which to observe the Supply Chain as a whole. It is also important to take a look at every single company and its processes to find the unsolved problems. The optimal design of production processes and the optimization of logistic processes as well as the cost savings coming along with them are important for the competitiveness of enterprises. To reap the full benefits of saving, it is necessary to get a full overview of all processes all over the whole SC. It stands to reason, that the visible representation is the best way to give an excellent overview of all processes and connections between the participants in the SC. The description in written form quickly becomes incomprehensible by continually growing size of members within a SC. Visualization has the advantage of showing the processes and their problems at a glance. If, however, the production and information flows are very complex, it is necessary to take care that all the important information is visible.

Currently, some models subsist to display these Supply Chains, which does not represent a SC perfectly. One of the better models to describe the value stream is the SCOR model. In the next chapter, it will be briefly presented. However, regarding these limited modeling methods, this present issue describes a new model, the so-called Supply Chain Value Stream model.

Supply Chain Management and its Modeling

The function of Supply Chain Management (SCM) is to describe and display the movement of materials and information, as well as finances within a company and its partners along the value stream. This means in effect it measures the whole flow of goods and information from a supplier to a consumer (Chopra and Meindl, 2014). The flow of goods mostly runs in one direction, namely from the producer to the customer, while the flow of information circulates in both directions. Supply Chain Management provides an opportunity of the optimization of planning, design and management of operations over the entire delivery chain (Piontek, 2013).

For enterprises, it is important to control every part of production and delivery. The fourth industrial revolution and the opportunity to collect every kind of data make it possible to show all processes and flows of information and goods over the whole Supply Chain in real time. However, it also makes things very complex and not easy to comprehend. In the digital age, the tracking of each component part from the production start to the final delivery to the end customer is possible and necessary. Here it is important for optimization to share and analyze all key information and find apparent problems as soon as possible.

Attention should not only be paid to the point of view from these enterprises and companies. Much more important is the point of view from the customer. All requirements imposed for the production and logistics processes are geared on the customer wishes. Every plan for optimization should be focused on the customer requirements (Erlach, 2010).

Thus, it is required to model the production processes within the company and additional the whole Supply Chain from supplier to consumer to display an overall view of the Value Stream. In fact, within the high complexity of Supply Chains there is a need of options for visualization. On the one hand, it is necessary to show the overall view for the Supply Chain but on the other hand, it is required to focus the problems at the place where they begin. For this purpose, there are various possibilities, for example, the SCOR model or the Value Stream model.

SCOR Model

The Supply Chain Operations Reference model (SCOR) serves as an example for the successful implementation of the theoretical concept of Supply Chain Management. In 1996, the Supply-Chain Council aimed to establish standardized procedures within a SC. SCOR contains all steps of the entire logistics chain – from incoming orders to the bill payment (Werner, 2013). The core of the model is an ideal typical and a cross-divisional approach, which describes the processes inside the SC of the associates uniformly. With the help of a system of indicators there can be drawn a comparison. The reference model has a hierarchically structure and includes four different levels. These representing the top level, the configuration level, the design level and the implementation level. These levels include the following properties:

Level 1 (top level): Within this level, the Supply Chain and its content are displayed. For this, the SCOR model distinguishes between five upper-level processes: plan, source, make, deliver and return. The plan considers the offers and the demand for the production. The sector source view all processes related to the procurement. All processes relational to the production are included in the range make. Logistics procedures are combined within the sector deliver and the sector return includes all processes related to the restitution of goods. These categories describe all processes within a Supply Chain. Therefore, the highest level within a company defines the scope and content. A combination of these processes defines the function of a company within a SC.

Level 2 (configuration level): Since the top level is defined, the configuration level put the implementation potentials in concrete terms. The five top-level-processes (plan, source, make, deliver and return) are compared to three process types. These are the planning process, the execution process and the enable process. The interaction of these categories with the process types forms a matrix. The execution process is further subdividing for differentiation and for better allocation to the product.

Level 3 (design level): here, the configuration level is more exactly specified. Every single process is viewed and analyzed. Due to this observation, the key figures and the performance of the processes within the company can be evaluated.

Level 4 (implementation level): at this point, there is no precise specification. Every company implements his own processes. Depending on the focus of the urgent problems, the company specified the individual process elements (Werner 2013).

Unfortunately, the SCOR model is highly complex and hard to comprehend. It requires a very intensive training and is still under development. Not all the important aspects for a SC can be realized, for example, the SCOR model does not provide any transportation processes. The involvement of new associates within the Supply Chain results in a renewed complete analysis of all processes and SCOR levels. In daily dealings, it is extremely difficult to operate.

Therefore, there is a demand to develop an additional model, which has the priority for visual design and display processes within a SC at macro and micro levels. The Supply Chain Value Stream model can represent this additional model.

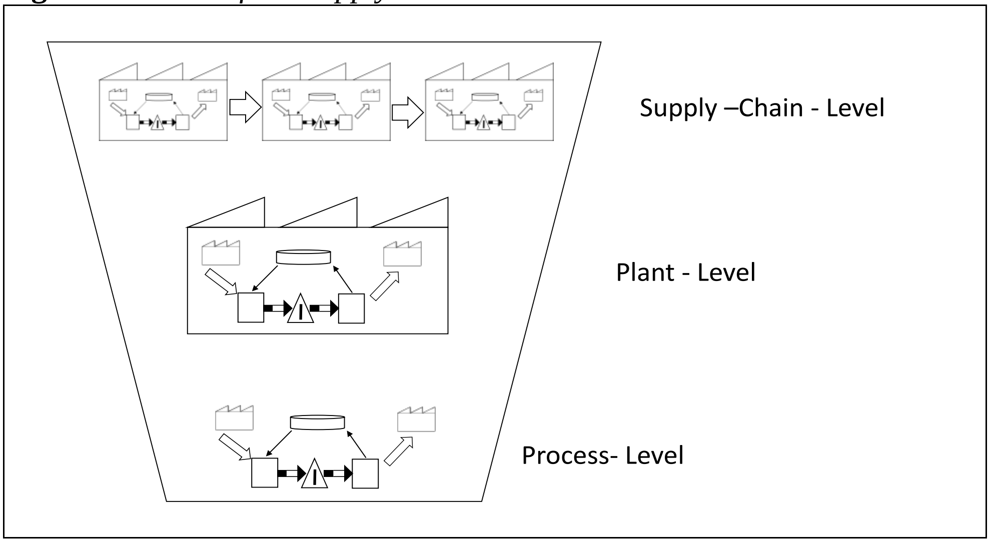
Supply Chain Value Stream Model

Supply Chain modeling is also possible with the Supply Chain Value Stream model. This is the result for linking several Value Stream models. It builds on a Value Stream model, which was developed by Mike Rother (Rother and Shook, 2015) and the Lean Enterprise Institute, USA and based on ideas with which the Toyota Production System was developed and documented. A Value Stream includes all activities, value adding as well as non-value adding, which are necessary to bring a product through the entire production flow from raw material to the hand of the customer (Klevers, 2007; Rother and Shook, 2015). The advantage of this modeling method is that it aligns with the flow direction of goods. The Value Stream is related to the customer and is exclusive defined on the requirements of the customer, the value adding and waste. The presentation of the Value Stream includes the physical flow of materials as well as the related flow of information. In this regard, the flow can go beyond the company boundaries.

The Value Stream can be implemented on several levels, which begins on the “Process-Level”, followed by the consideration of only one plant

("Plant-Level") and in the next step the consideration of several plants within the group until the "Supply-Chain-Level" (Figure 1).

Figure 1. *Levels of the Supply Chain Value Stream Model*

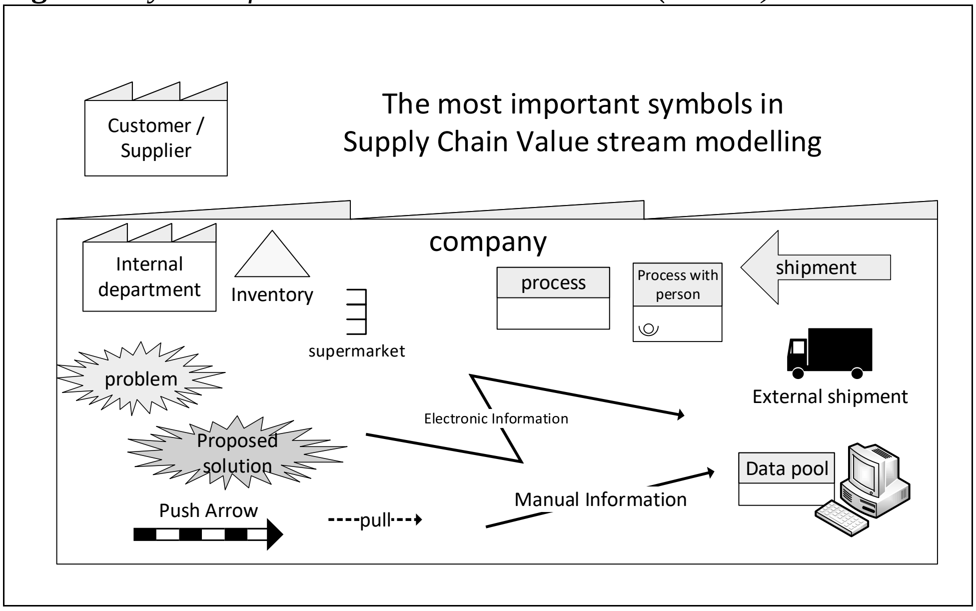


The "Process-Level" shows all subsections within the production process of a company. Like the design level in SCOR, every process can be considered and analyzed. Therefore, every problem can be evidence at the point of its creation. The whole plant is contemplated in the "Plant-Level". Here, the relationship between the different processes is focused. It involves every single consideration from the process level but is not any longer in detail. It is a matter of the problems within the flow of goods between the single production processes. In this case, the transportation of goods and information between the processes are illuminated more exactly. Within the "Supply-Chain-Level", the connection between every participant of the SC is considered. It is important that every single connection be displayed in this view. The Supply-Chain-Level presentation consists of each single view, every process and every plant level. A new member of the Supply Chain, for example a new manufacturer of unmachined goods, can be inserted into this overall view of the Supply Chain without great effort.

Unlike the SCOR model, the foundation of the Value Stream model is the visualization of the status quo and a target status with simple symbols and aids. Problems are visualized in the status quo view and for the target status, another similar view shows a possible solution for every problem. Based on standardized symbols there are good ways to differentiate between the actual state and the target state. The base for the understanding of the Supply Chain Value Stream model is a good incorporation in the symbolism of this model (Lindner and Becker, 2010).

For representation of the value flows, various symbols are used that are split in material flow symbols and information flow symbols. It is conceivable to fall back on the most important symbols for the Supply Chain Value Stream model because focusing the superordinate modeling of the whole Supply Chain. The following illustration shows an extract of the used symbols.

Figure 1. *Symbols for the SC Value Stream Model (Extract)*



With these symbols, every flow of information and material can be pictured. The flow direction is displayed with arrows. In Figure 2 there are five different depictions of arrows. For one thing, an arrow for electronic information is not as straight as the arrow for manual information. These two arrows mark the flow of information within the Supply Chain. For example, the start of electronic information and this matched arrow is the symbol of the data pool. Alternatively, the start can be an internal department or a customer who sends a request to a central server.

Another arrow is the one labeled with the lettering ‘shipment’. This arrow shows the direction of logistic processes. In production processes there are material movements from one process to the other. To display this movement or ‘push’ of material, a striped arrow is used. A dotted arrow is utilized for the ‘pull’ direction.

Problems and proposed solutions are highlighted, for example in yellow and green for a good visibility. The form of a cloud with jagged outlines highlighted the importance of these symbols. Every problem can be viewed on the first sight.

The symbol for external or internal departments looks like a depiction of a factory building. It is often the starting point for the Value Stream visualization. The big symbol for a company includes all symbols that are important to show the processes within this company.

A simple box is the symbol for all processes. There can be an expansion label for a process including persons. These boxes are interconnected by means of the different arrows.

The stock of a company can be displayed with two different symbols, depending on the use of it. On the one hand, there is the symbol of a triangle, which marks the inventory. In this context, it is possible to make a note of the stock range under this symbol. On the other hand, there is a symbol for supermarket, which marks the controlled stock for production.

To show the distribution services between several plants or companies, there is used a symbol, which looks like a truck. These symbols are the foundation of the Supply Chain Value Stream modeling. Depend on the processes within a company or a Supply Chain, they can be extended with more symbols (Rother and Shook, 2015).

The overview, in relation to highly complex Supply Chains, and the overview of itemization may look overloaded and confusing. This can be avoided by presenting the Supply Chain Value Stream model aggregated over different levels of aggregation. Those responsible can choose the level of aggregation depending on the optimization goal.

To document several pieces of information in relation to the processes, it can be useful to implement a data panel under these symbols. This allows a good view of the current conditions. With all these information in this Value Stream model, it is possible to see all important things within the Supply Chain.

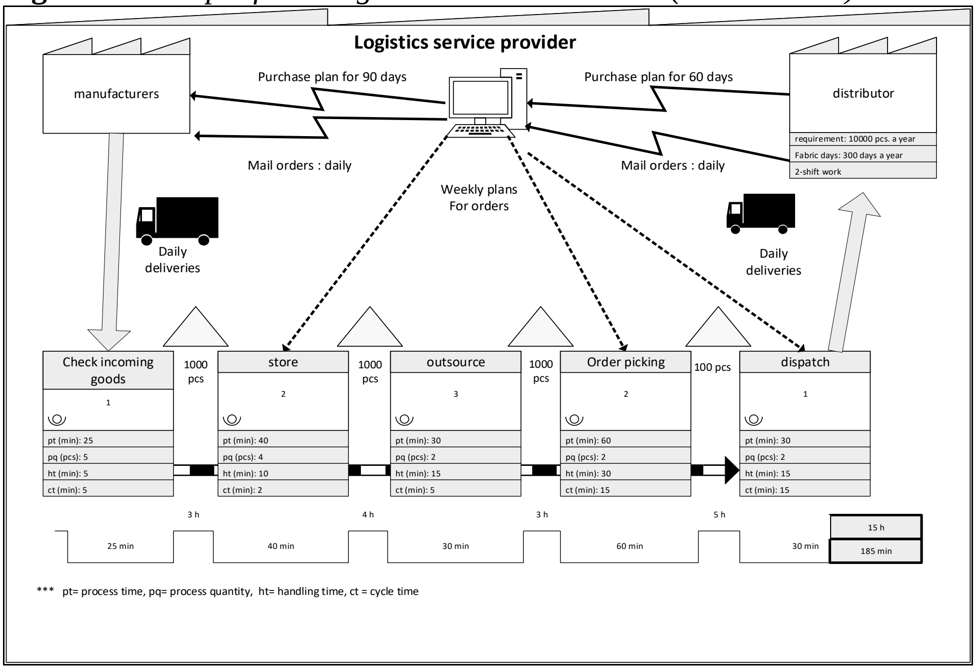
The Supply Chain Value Stream model gives itself an edge towards other models with the opportunity to model finance, information and material flows separately. Moreover, it contains transport processes. Though it focused on companies, it is possible to widen it on networks.

The Connection of Different Classical Value Stream Models

The ‘micro’ view (classical detailed view) shows only the four levels out of the view of a company. Only the chain of the individual ‘micro’ views build the ‘macro’ view (the connection of ‘micro’ views) in the form of a SC Value Stream model.

Figure 3 shows a ‘micro’ view for a logistics service provider. This depiction includes a distributor who makes a purchase plan for 60 days and transfers the information virtually to the logistics service provider. A purchase plan for 90 days is sent from the logistics service provider to the distributor. The mail orders occur daily. Deliveries from the distributor to logistics service provider also take place every day. From the receipt of the goods to the dispatch for a distributor, there are five steps including receipt and dispatch. Between each of these steps there are inventories implemented. Below the data panels of all processes there is a timeline for the process time.

Figure 2. *Example for a Logistics Service Provider ('Micro' View)*



In this example, the estimated needs of a logistics provider stand at 100,000 pieces every year. The provider works in 300 days a year in 2-shift operations. This information is documented in the data panel under the symbol for the distributor. For the process mapping the handling time is the most important indicator. It is a unit-related explicit date that shows how long a good need to be processed. The following formula shows the calculation of the handling time. It is the result of the process time divided by the process quantity:

$$handling\ time\ (ht) = \frac{process\ time\ (pt)}{process\ quantity\ (pq)}$$

In Figure 3, the handling time required is five minutes for the first process, 10 min. for the store process and 15 min. for the outsource process, 30 min for the order picking process and 15 min for the dispatching process, which were executed from the logistics service provider.

Another important key figure is the cycle time. It represents the performance of a process within the production. This key figure results from the output of handling time divided by the number of producing resources that can be employees or machines. For example, four employees should handle two producing machines so the quantity of resources is two. If the working place is a single workstation, the quantity is only one.

$$cycle\ time\ (ct) = \frac{handling\ time\ (ht)}{quantity\ of\ resources}$$

In the next step, the handling time must be multiplied by the number of pieces, if the process extends through more than one piece.

$$cycle\ time\ (ct) = number\ of\ pieces * \frac{handling\ time\ (ht)}{quantity\ of\ resources}$$

In Figure 3, the cycle time is five minutes for the first process of checking the incoming goods. The next process, store, has a cycle time of two minutes. The inventory before the processes are rated by their range. It describes how long the stored good is available. The following formula shows the calculation of the range:

$$range\ (r) = \frac{stock\ quantity\ (sq) * workdays}{quantity\ of\ identical\ parts * annual\ sales}$$

The sum of all cycle times will yield the straightforward time of added value, through which an end product passed during development. The amount of all ranges resulted in the rough lead-time for passing through the process according to the principle “First In, First out” (FIFO).

In Figure 3, we have waiting times (wt) between the processes based on stocking the product. In summary, we have an amount of 15 hours waiting time. This index is important for the Value Stream Quotient.

Under the process boxes, there is a timeline. It includes the values for the process time and the time for creation of value.

The Value Stream Quotient (VQ) is an index which describes the quality of a value stream. It describes the relationship between the process time and the waiting time.

VQ =∑ wt +pt /∑pt

The greater this Value Stream Quotient (VQ) is, the worse is the whole value stream.

In Figure 3, we received the following Value Stream Quotient: 15 hours waiting times and 185 min. process time.

VQ =∑ wt +pt /∑pt = 900min+185 min/185 min = 5.86

The interpretation of the value stream quotient is very easy, if we know that the best value is a VQ of nearly one, achieved by having no waiting time.

This means we have some waiting time in our scenario. It will be noticed that there are some possibilities to optimize all processes. A good process chain would have no or little waiting time, especially storage time.

Figure 3 shows an example for the ‘micro’ view of a logistics service provider, this is only one section of the whole modeling of a Supply Chain. The ‘macro’ view combines all ‘micro’ views to an overall view of all members of the Supply Chain. The next chapter presents the ‘macro’ view.

Supply Chain Value Stream Model as 'Macro' View of the Value Stream Model

As already mentioned, the chain of the single 'micro' views forms the 'macro' view. After all members of the Supply Chain has created a 'micro' view for their processes and has generated a Value Stream model for the company itself, these different views can be merged together for one 'macro' view of the whole Supply Chain. This point of view does not deal with the single process problems, but rather with their influence on the entire process. The following figure shows the 'micro' view related in a customer-supplier relationship. Information planning and management take place locally. Moreover, the 'macro' view depict the local process times.

Figure 3. *Example for the Supply Chain Value Stream Model ('Macro' View)*

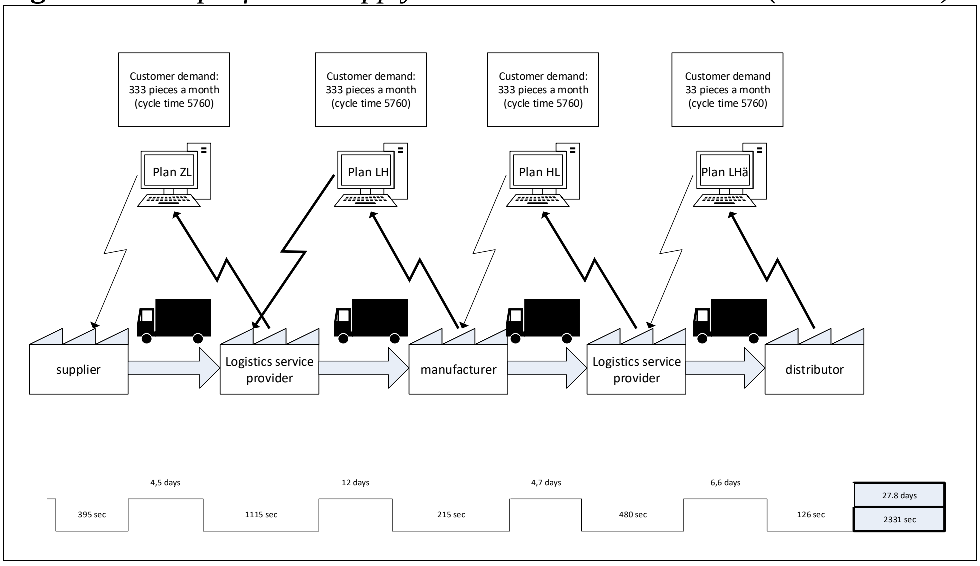


Figure 4 shows that the 'macro' view includes every member of the Supply Chain. From the supplier to the distributor are all stations for the product mentioned. The accumulated single times from every local planning, which are displayed in the 'micro' view, will yield the total times, so that, with help of the SC Value Stream model, the times of the whole chain can be presented clear and mathematically easily traceable.

The lead times of a Supply Chain can be calculated easily by add up the single times like handling time, storage time and transportation times etc..

This 'macro' view, which is presented in Figure 4, is not very suitable to optimizing the processes that connect the members of the Supply Chain. It is more appropriate for taking a more detailed look at the connected processes for the modeling of the target status.

After the current status is modeled with the symbols from Figure 2 and looks similar to Figures 3 and 4, the identified problems may be plotted. Depending on the observed sector, a view is selected and converted in the target state view. Problems related to a single process within one company of the Supply Chain should be considered in the 'micro' view of this company, but could also be contemplated as a reference in the 'macro' view.

The following chapter gives an example for modeling with the Supply Chain Value Stream model.

The Value Stream Model for a Detergent Supply Chain

To validate the main idea of the Value Stream model, it is meaningful to describe the basic facts with the help of an easy example (Figure 5).

To develop the Supply Chain processes for detergent uses different resources, chemistry and synthetics. The packaging for detergent mainly uses paperboard from the paper industry, which has its resources from forestry. All products of those companies use special logistics service providers in the Supply Chain. The detergent industry uses additional logistics service providers for the demand side, which distribute the final products to the wholesaler and to the retailer. These suppliers are the "Logistics Services Supply side" (LSSs) and the "Logistics Services Demand side" (LSDs). In our scenario only the retailer supports the customers. All these processes are described in Figure 5. Here also the transport quantities and the transport times of the vans are visualized.

In this example, the Value Stream model gives an expedient overview of the whole scenario. All independent companies are visualized with a "Supply Chain Value Stream company symbol" (Figure 2).

The Supply Chain for detergent has the following production quantities and production times:

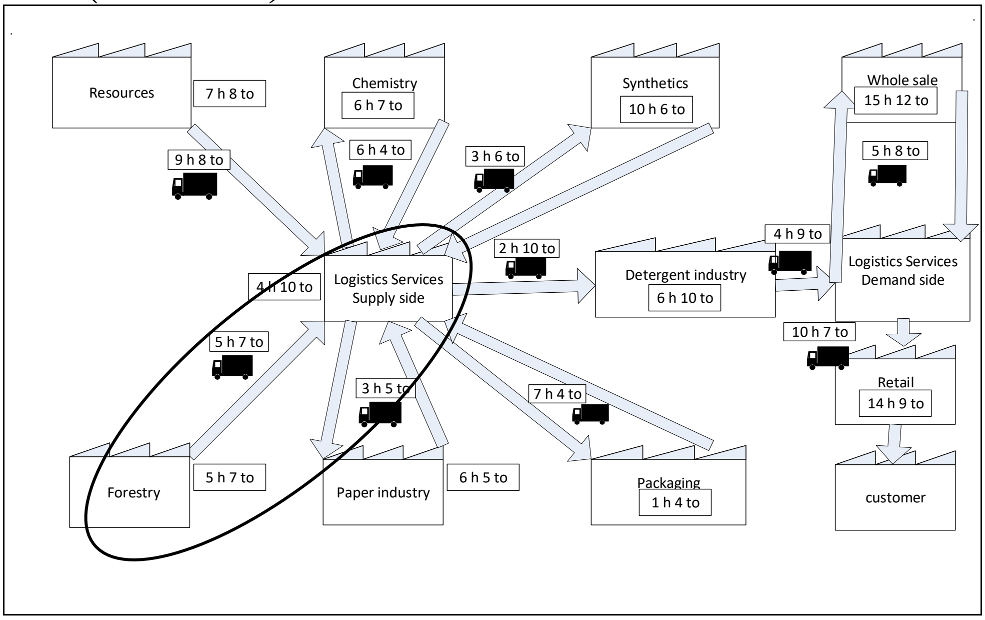
Company	***production time/h***	***production quantity/to***
Resources	7	8
Chemistry	6	7
Synthetics	10	6
Detergent	6	10
Forestry	5	7
Paper industry	6	5
Packaging	1	4
Whole sale	15	12
Retail	14	9

The Supply Chain for detergent has the following transport quantities and transport times:

From	*To*	*Transport time/h*	*Transport quantity/to*
Resources	LSSs	9	8
Chemistry	LSSs	6	4
Synthetics	LSSs	3	6
LSSs	Detergent	2	10
Forestry	LSSs	5	7
Paper indust.	LSSs	6	5
Packaging	LSSs	1	4
Detergent	LSDs	4	9
LSDs	Whole sale	5	8
LSDs	Retail	10	7

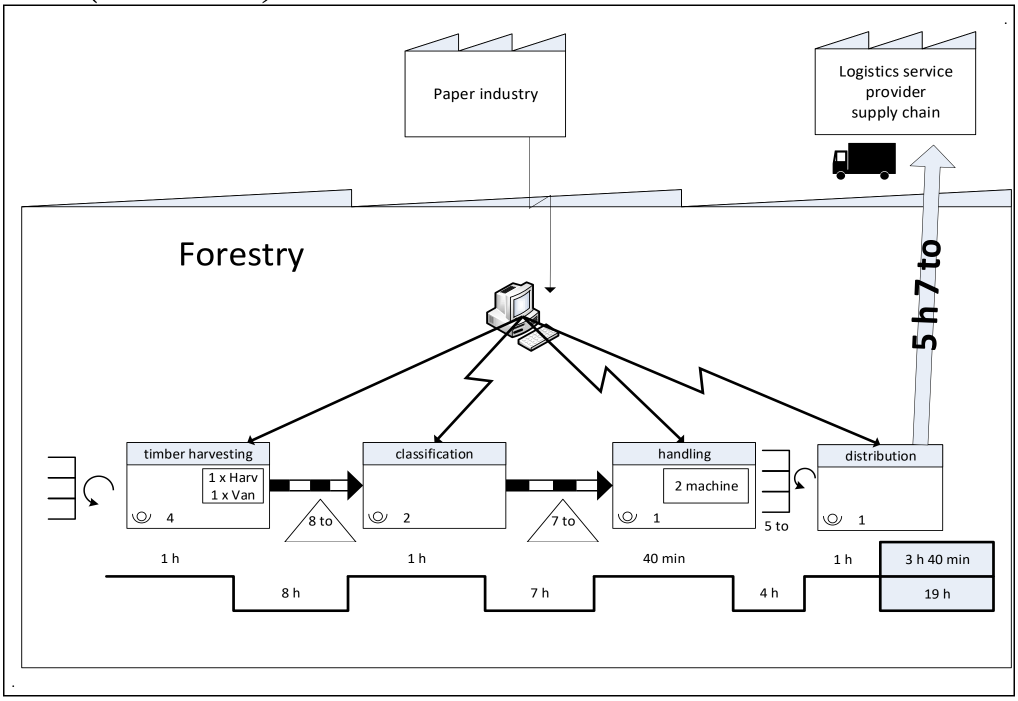
The aim of the overview, seen in Figure 5, is to visualize the whole Supply Chain in only one figure. The connection to the Value Stream model is that a “customer” in one part of the figure can be the “supplier” in a connected other part of the figure. This fact should be described by using the oval marking in Figure 5. The oval marking is the area which should be visualized in Figure 6. It helps to understand the ‘micro’ view of that chosen detail. Here the customer of the forestry is the supplier of the “Logistics Services Supply side” (LSSs).

Figure 4. *Example for the Value Stream Model for a Detergent Supply Chain ('Macro' View)*



The distribution process in Forestry serves the transportation process of the “Logistics Services Demand side” (LSDs), as seen in Figure 6.

Figure 5. *Example for the Value Stream Model for a Detergent Supply Chain ('Micro' View)*



The forestry process starts with the harvest of timber in a fixed defined quantity. For this timber harvesting a so-called Harvester and a van are needed. Four workers support this process. It has a process time of one hour. The following push-process brings the harvested number of 8,000 kg (8 to) timber to a classification process. Here we need two persons. The time between these two processes take 8 hours. The classification process takes also one hour. Again, we need a push-process with a waiting time of 7 hours. After the classification process, we only have 7,000 kg (7 to) of timber for finishing. The following handling process takes 40 minutes with one person and two machines. At the end of this process, we have a structured quantity of timber. This is visualized by a *supermarket* symbol (Figure 2). The following distribution process uses a so-called *pull-access* to the *supermarket* and uses one person. The waiting time in the supermarket is four hours and the process time for the distribution process takes one hour. In summary, we have used three hours and 40 minutes for the process time and 19 hours for the waiting time.

Thus, we have the following Value stream quotient with 19 hours waiting times and 220 min processing time:

VQ =∑ wt+pt /∑pt = 1140 min+ 220min /220min = 6,18

This results in five hours total transportation time. The result also has 7,000 kg (7 to) timber for a following transportation process. As described before, the customer of the forestry is the “Logistics Services Supply side” (LSSs). Otherwise the supplier of the “Logistics Services Supply side” is the forestry.

Here we see the main meaning of the value stream model. We have the opportunity to select an individual aggregation level. This aggregation level was described before as a 'macro' and a 'micro' view. In our example, the 'macro' view is the overview in Figure 5, and the micro view is the detailed visualization in Figure 6.

Conclusions

The overall analysis shows that the linking of value streams beyond corporate boundaries and the overall consideration of lead times are appropriate tools to realize a company-wide Supply Chain Management. Optimization potential over the whole Supply Chain can be presented with linked value streams showing temporal reduction potential. New members of the Supply Chain, for example a new supplier, can be integrated easily in present structures. There is no need to start with the whole modeling process all over again in order to consider the new member.

The Supply Chain Value Stream model is an appropriate method with which to describe and visualize complex Supply Chains. Depending on the optimization goal, those responsible can choose the specific view, which represents the exact range of work. This observation shows the problems that arise on the point where they begin, and so adequate countermeasures can be taken.

The standardized symbols make it possible to gain an understanding of these visualizations quickly and thereby allow for a close cooperation across the individual departments and plants, as well as between the whole Supply Chain Value Stream. One major advantage here is the possibility to extend this model. Every new participant can be included in the existing plan with the same symbols, and it is a way to see the connection between the new member and the other parts of the Supply Chain quickly.

A view into the future tells us that the value stream, in which each company is located, will be enlarged, and there will be more and more relationships to handle. In this case, it needs an easy-to-follow tool for visualizing these complex Supply Chains. The Supply Chain Value Stream model meets these requirements in order to be able to succeed in the future.

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