Identification of Supply Chain Performance at Company X: a Case Study

Executive Summary

Every Chief Executive Officer and or manager must always face competition. In today's economy the battlefield is shifting from individual company performance to what we call supply chain performance. Supply chain performance refers to the extended supply chain's activities in meeting end-customer requirements, including product availability, on-time delivery, and all the necessary inventory and capacity in the supply chain to deliver that performance in a responsive manner. Supply chain performance crosses company boundaries since it includes basic materials, components, sub-assemblies and finished products, and distribution through various channels to the end customer. It also crosses traditional functional organization lines such as procurement, manufacturing, distribution, marketing sales, and research development. To win in the new environment, supply chains need continuous improvement. To achieve this we need performance measures which support supply chain performance improvements (Kluwer, 2004). In this empirical research we identify a number of supply chain performance measures that are measured to support and monitor supply chain performance improvements across the organic coated supply chain in company X .

Company X produces around x amount million tons of steel a year. The site produces high-quality cold rolled, hot rolled, and coated (painted or tinned) steel. Company X produces mainly for customers in three different markets:

1. Automotive industry
2. Construction
3. Packaging steel

Steel making process

To produce steel the following raw materials are needed:coal, ore, and additives. Before these materials can be used in the blast furnace to produce pig iron they need to be processed first. Coal is processed in the coke-oven plant and comes out as coke. Ore and additives are processed by either the sinter plant to sinter or the pellet plant to pellets. A combination of coke, sinter, and pellets is entered to the blast furnace which then produces pig iron. At the bottom of the blast furnace the pig iron is tapped into torpedo wagons and then transported to the Basic Oxygen Steel plant. In the Basic Oxygen Steel plant, steel is produced with additives such as O_2 (to reduce the carbon content in the pig iron) and scrap metal. This results in steel. The steel produced in the Basic Oxygen Steel plant can be processed further in two ways. It is either transported to the Direct Sheet Plant which transforms the steel directly into coils, or to the slab casting machine which transforms the liquid steel into slabs. In both cases the coils or slabs can be further processed or sold to customers. The slabs can be further processed by the hot strip mill into coils. Coils can be processed in the pickling line, cold strip mill, galvanizing line, and or Organic Coated Line. The investigation took place at the Coated Products department in Ijmuiden. The Coated Products department consist of several operations at which painting coils on the Organic Coated Line is one of them. The purpose of the Organic Coated Line is to paint coils with one or more organic coating layers (paint layers). After the coil is painted the coils are packed and transported to the customer. The customer will further processes the coils into e.g. roof panels.

Research question

As you can see is that the Organic Coated Line is at the end of the Supply Chain (SC). In the back of our mind we have to take into account that when a customer places an order the production will starts almost at the beginning of the Supply Chain i.e. the Basic Oxygen Steel plant. So the order must follow the whole route before it can be further processed on the Organic Coated Line. During the whole production route many problems occur. So when e.g. a machine is broken down in the Basic Oxygen Steel plant this causes delays in the whole Supply Chain, but mostly on the Organic Coated Line. In other words this result in poor SC performance in the Coated Products department.

The goal of this research is to develop insights on factors influencing poor SC performance on the organic coated SC (by means of a quantitative and qualitative case study). In order to achieve the goal of this research, a main research question is formulated. The is as follows:

> **What are the root causes for poor SC performance in the organic coated SC and how does this relate to benchmarks provided by theory?**

In this empirical research the focus is on construct-, and internal validity. Construct validity was measured as the use of multiple sources of evidence by interviewing specialists at various organizational levels who are involved in the organic coated SC. In this study, various data collection methods were used. The methods include interviews, documents, quantitative data, questionnaires and observations. Use of multiple investigations were carried out by making specialists participate in conducting measurements and analyzing the data. Furthermore, the specialists had their own point of view on the research problem, which provided new information about the subject being studied. Internal validity was measured in grounded analysis and explanation building. Research was also a comparison with conflicting literature. SC performance measurement framework was conducted after sufficient analysis of SC performance measurement literature.

Preliminary findings

An investigation was performed on potential causes of poor supply chain performance in Company Y. The production process in Company Y consists of buying Hot Rolled Coil which is processed in a Cold Mill installation into a full hard coil. This full hard is then transferred into one of the two combined galvanizing/coating lines which adds a layer of zinc and paint on the product. The product exiting the line is the finished product (Organic Coated Coil), which will subsequently be sold to further partners in the supply chain who usually transform the Organic Coated Coil into a finished product to be used in the construction sector (typically in the shape of a panel or profile). Over the past 10 years, supply chain performance, as measured by OTIF (On Time In Full), has been on average 67%, without a sustainable stable performance for a period longer than 3 months. Several hypothesis were tested and based upon these provisional results, focus need to be on increased understanding of the root causes of an arrears position, and what processes were identified to improve this position. Participation of key groups within the company is required to formulate actions. Also it indicates that individual learning on supply chain processes seem to not to have an influence on OTIF performance. Finally it was concluded that despite improvement programs being established, the organization has not been able to institutionalize learnings from these programs as OTIF performance has remained around 67% throughout a longer period.

Further expected results of this research are a clarification between theory and current practice of organizational learning for construction supply chains. Results are that there might be a (causal) relation between an increased understanding of one or more of the 4 processes in organizational learning and the root causes of good supply chain performance. This should result in a best practice recommendation to identify which processes should be embedded in an organization to facilitate improved supply chain performance. The conceptual model developed may serve as a tool for companies to (de)select practices in order to facilitate improved performance. The results from this research might be applicable to industries with comparable supply chains.'

Hypothesis

Currently the SC performance of Coated Product department in company X is very poor. Several improvement programs have been started over the years. This has lead to some successes, but more often it has not changed performance. One of the initiatives is to realize a OTIF performance of 85%. OTIF is the transition of a finished good to the customer that is delivered on time. In this research, the core problem is that it is not clear which variables determine the poor causes for OTIF performance. From the theoretical analysis four indicators were identified. namely: order book analysis, profitability, time and managerial implications. According to the preliminary findings the following four indicators were identified: operational performance of the production lines, increased complexity of the order book, the total amount of material delayed (arrears) and changes in key people. It seems that there is a proper link between the theoretical and practical indicators. Therefore, hypothesis were formulated to analyze the results which are as follows:

1. Hypothesis 1: Lower operational performance of the production lines will result in delays in orders being produced and hence decreased OTIF performance. Operational performance measures how much of time machines are actually operating, the speed at which machines are manufacturing output, and the percentage of the output that is the right quality. Operational performance will be used as an indicator of operational performance of the production lines.

2. Hypothesis 2: Increased complexity in the order book will result in lower OTIF. The goal is to find which indicator define the complexity of the order book on the Organic Coated Line and should therefore be analyzed.
3. Hypothesis 3: Higher amounts of material delayed (arrears) will result in more inability to produce orders on time and thereby lower OTIF.
4. Hypothesis 4: More changes in key people in the supply chain function will result in deteriorating OTIF performance followed by a recovery. In the past 10 years several directors, managers et cetra had a position in the company. The goal is to find out which indicator plays a crucial role in changes in key people.

In this research we set the hypothesis to investigated the relationship between the indicators and the OTIF performance. Further, we were also able to explain or predict the OTIF performance as specific as possible with the identified indicator based on regression analysis.

Operational performance

The indicator that was used for operational performance is Overall Equipment Effectiveness (OEE). OEE itself is a quantitative element of Total Productive Maintenance which is used to benchmark and analyze any production process. The OEE tool provides the ability to measure the efficiency of the machine for improving productivity. OEE was proposed by Nakajima, which is basically a metric to identify potential areas for productivity improvement which would result in increased equipment effectiveness by evaluating three main factors of OEE, namely, availability, performance and quality (Nayak et al., 2013):

OEE= availability $\times$ performance $\times$ quality

OEE focuses on six major losses, namely, breakdown, setup adjustments (waiting), reduced speed, minor stoppages, rework and yield losses (scrap). All these losses lie under the umbrella of availability, performance and quality (Nayak et al., 2013). Availability takes into account equipment unavailability time due to breakdown and setup adjustments. It is defined as (Nayak et al., 2013):

$$\text{Availability} = \frac{\text{loading time} - \text{downtime}}{\text{loading time}}$$

where loading time is the total equipment running time or scheduled production time.

Performance takes into account speed losses due to minor stoppages and equipment idling. Performance is a ratio of the actual operating speed of equipment to its ideal speed. It is defined as (Nayak et al., 2013):

$$\text{Performance} = \frac{\text{ideal cycle time} \times \text{output}}{\text{actual operating time}}$$

Quality is one of the important factors that needs to be determined for the calculation of OEE. Quality is a proportion between good parts produced and total parts produced by that equipment and is calculated as follows:

$$\text{Quality} = \frac{\text{inputvolume of quality defects}}{\text{input}}$$

The net utilisation rate is calculated by the following:

net utilisation = OEE $\times$ Gross utilisation, Gross utilisation is calculated by dividing the scrap by rework

Complexity of the Orderbook

Within the organic coated department, the coils are covered with a layer of paint. The paint types to be applied on the coils can be subdivided into three coatings, namely:

- primer (for both functional and non-functional side)
- backing (for the non-functional side)
- top-coat (for the functional side)

Before a coil can be painted it must meet the technical requirements of the paint line such as the coil diameter, coil width, coil weight, coil length et cetera. If the coils meets all the requirements, production can start.

company X offers a whole range of colors and coats. In this research aspects such as the total production of each color coat over a period of 10 years were analyzed.

Arrears

Arrears are the total amount of orders that are behind in terms of volume. Practically arrears are originated from the term Net Advanced Position (NAP). NAP is the balance of the number of tons of steel that is produced too early (advances) minus the number of tons of steel that is produced too late (arrears) up to and including a certain week. Arrears are the number of tons that have not been produced in a consultancy week. Advances are the number of tons that are produced too early in a consultancy week. In this research the main focus was only on the arrears.The data that was used to analyze the arrears was from November 2014 until October 2018 on monthly basis. Afterwards, the root causes for the arrears were identified via 6 experts. Since there were multiple causes with no data available, the causes were ranked based on experts judgemental decisions. Therefore, the Analytic Hierarchy Process (AHP) was used to determine which of the causes were more important relative to each other. For this weights were given to each cause. With the weight we can determine which cause of the arrears is the most important problem for the arrears.

Changes in key people

For changes in key people, former and current supply chain managers were interviewed to get an overview of the SC from their perspective.

Results and conclusions

Operational performance

Hypothesis 1: Lower operational performance of the production lines will result in delays in orders being produced and hence decreased OTIF performance. Two main indicators for operational performance were Overall Equipment Effectiveness and Operational Overall Equipment Effectiveness. Correlation analysis has shown that there was only a relationship between Operational Overall Equipment Effectiveness and the OTIF performance. Further, the sub indicator, planned ratio, had the highest relation with Operational Overall Equipment Effectiveness. Therefore, this sub indicator was identified as the main cause for low performance. Analysis has showed that the planned ratio has a small correlation of +.213 with the OTIF performance. Further, (theoretical and statistical) regression analysis proved as expected that the OTIF performance was indeed mostly predicted by the planned ratio with the following regression model:

$$Y = 36.819 + 0.452x_1$$

So, we can conclude that the hypothesis is proven to be correct.

Complexity of the order book

Hypothesis 2: Increased complexity in the order book will result in lower OTIF. The complexity of the order book was defined by different types of painted products. Based on data analysis it seemed that production of coils with paint layer x_1 and x_2 have a large correlation with the OTIF and thus results in lower OTIF performance. Next to that, regression analysis proved that x_1, x_2 and x_3 are the variables that explain the OTIF performance, with the following regression model:

$$Y = 82.743 - 0.014x_1 - 0.036x_2 - 0.004x_3$$

Thus, our strongest predictor is x_2: a one point increase in x_2 is associated with a 0.036 point decrease in OTIF performance. Our model doesn't prove that this relation is causal but it seems reasonable that improving on the production level of x_2 will cause slightly higher OTIF performance. Therefore, we can conclude that complexity of the order book is defined by the painted products x_1, x_2 and x_3 and that the hypothesis is proven to be correct.

Arrears

Hypothesis 3: Higher amounts of material delayed (arrears) will result in more inability to produce orders on time and thereby lower OTIF. According to correlation analysis there seems to be a large correlation between the OTIF performance and the arrears. Regression analysis showed that OTIF is mostly explained by the indicator arrears with the following regression model:

$$Y = 87.760 - 5.356x_1$$

Further six root causes were identified i.e. human mistakes, technical malfunction, lack of storage, lack of internal transport capacity, programming rules and paint availability by six experts. Afterwards, a survey was conducted and analyzed with the Analytic Hierarchy Process tool. In the survey, each cause was judged based on the three criterion, namely: importance (how serious is the problem in light of cost, safety, or quality, etc?), urgency (how soon should it be solved to avoid more serious problems?), tendency (is the problem getting worse, staying the same, or getting better?). The results for the overall ranking for the causes were: human mistakes (1^{st} place), technical malfunction (2^{nd} place), programming rules (3^{rd} place), lack of storage (4^{th} place), paint availability (5^{th} place) and lack of internal transport (6^{th} place). These identified causes for the arrears could be used as a starting point for further improvement and can therefore improve the OTIF performance.

Changes in key people
Hypothesis 4: More changes in key people in the supply chain function will result in deteriorating OTIF performance followed by a recovery. Qualitative analysis was executed on two SC managers. Over the past years they have implemented some tools i.e. Do More With Less program, Make-to-Availability, making customer pay a bit more for a better service that resulted in some improvements. Next to that, both managers had their position for more than six years. Let's say if managers would switch position every year, it might affect the OTIF performance because it takes a few months to get insight in a certain function and to know how to cooperate in the whole organic coated SC. Therefore, improving the organic coated SC would not be feasible within a short-term period/ function. One of the goals both managers had was to optimally use the capacity and provide good services to customers. This indicates that they were building up on goals that were already determined in the company by previous managers. In other words, existing / unfinished work is passed on to the following/ future managers. So, based on the qualitative analysis we can conclude that more changes in position does not affect the OTIF performance.

All in all we can conclude that, the indicators arrears and complexity of the order book result in poor SC performance on the Organic Coated Line.

Recommendations

We recommend company X to use the identified indicators for poor performance as a starting point to improve the OTIF performance. Therefore, they have to test the identified indicators on several other similar manufacturing industries in several countries for a certain period before using the identified indicators as performance measurements. When company X observes that the identified indicators are representative, they can decide to use the indicators for further improvements. When deciding to use the indicators for further improvement, company X should update it continuously. This has to be done, because situations that are related to OTIF performance could change over a certain period of time. For, example when a new colorcoat will be used in the future, it could change the SC or production requirements for this type of colorcoat. So, a recommendation to update the indicators is needed a few times per year, when using the indicators definitively.

One aim for further research could be to carry out a multiple case study research in which the cases are selected from various industries. In this way, a more suitable measurement framework could be found for each (steel) industry. In this study, a framework was chosen for manufacturing industry where four different indicators were chosen for a valid framework. Those indicators were selected due to the purpose of measuring SC performance. In different SC's there could be different performance measurement categories. Generally a framework is valid for every industry, but there should be a deep analysis on how to build up practical measures according to the framework. More research regarding the SC and SC performance measurement is needed, especially in traditional industry sectors like the steel industry. Companies that are able to both manage the SC and measure it are the winners. In order to manage a SC efficiently, its performance needs to be measured continuously.