Six Sigma Green Belt Project Report

Reducing Delivery Delays By Improving The Order Management Process At D Vietnam

Kim-Cuong Nguyen

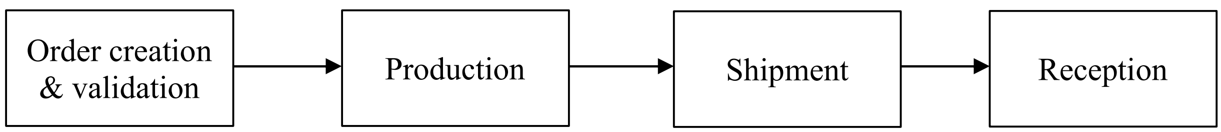
March 25, 2019

1 Background and Introduction

D is the world's largest sporting goods retailer that provides top quality technical sports products at reasonable prices. The products are comprised of apparel, footwear and equipment. The company has its production teams located in various countries, namely Vietnam, China, India, Bangladesh, etc. Production teams oversee outsourcing suppliers to produce and supply for over 1,500 stores worldwide.

As a retailer that has two seasons, Spring/Summer & Autumn/Winter, with a variety of seasonal products and as one that employs the strategy of produce-to-demand, on-time delivery is one of the critical success factors of the company. Also, the company's order management process plays an undeniably important role.

The order management process at D can be summarized as below:



Over the past few years, despite an impressive growth in D's business, delivery-on-time (DOT) rate performance by D production team in Vietnam has been on a downwards trend. However, no official project has been carried out to investigate the root causes and to find out ways to improve the DOT performance. With a view to reducing delivery delays by D Vietnam production team, I choose to work on the problem of order management process that clearly meets the criteria of a repetitive process. By applying DMAIC methodology – Define, Measure, Analyze, Improve, Control, I aim to define the process, identify variations and provide recommendations to reduce delivery delays, enhancing internal customer satisfaction and meeting demands of end users. Because the order management process is standardized in all departments and across all suppliers, I narrow down the project scope and choose to carry out this project at A factory – the largest supplier of W Vietnam category.

2 Define Phase

2.1. Project Charter

Project Name:	Reducing delivery delays by improving the order management process at D Vietnam
Department/Area Name:	W Department – A Factory
High Level Problem Description:	Delivery delays have a negative impact on the financial situation of the department (e.g. cost of air-shipment) and on the whole company (e.g. sales loss)
Project Type:	Six Sigma DMAIC
Problematic Objective:	To decrease delivery delays at A factory of W Department, D Vietnam
Problematic Indicator:	Delivery-on-time rate
Project Scope:	A factory of W Department, D Vietnam
Current Baseline Performance:	81% in FY2018

Project Champion:	Operational Process Manager of W Dept.
Process Owner:	Operational Process Manager of W Dept.

Table 2.1. High level project charter for the project

Business Case:

The process of order management plays an important role in fulfilling customer demands. The aim of the process is to have the demanded product quantity available at the right time, the right place and at the best cost. DOT rate performance by W Vietnam has been decreasing significantly during the past few years while the company's global business is booming. DOT rate dropped to 81% in FY2018. Despite Vietnam's important role in D's global supply chain, the bad performance has made Vietnam a less attractive production country to the company because of an increase in air-shipment cost and sales loss resulting from late delivery. Hence, the project has been initiated; otherwise, the company cannot brighten its financial picture.

Problem Statement:

Delivery delays are putting a financial strain on D and causing frustration to production team members and retail department.

Goal Statement:

To reduce delivery delays caused by A factory – W Dept and increase DOT from the current level to the target DOT of 95% in FY2019.

Scope:

The order management process starts when a retail supplier creates an order on system and ends when the order is received into a retail warehouse and the order status is updated to "close".

Because the number of suppliers in D Vietnam supplier panel is high while all departments and suppliers share the same order management process and have been experiencing the same problem, the scope of the project is narrowed as below:

- Only orders produced at A factory and managed by W Vietnam are part of this project.
- Only replenishment orders are part of this project. Implantation orders are not because the process applied for implantation orders bears some differences.

Stakeholders:

The key customers of the process are retail department who needs the products to be available for sales plans and end users who have demands for the products.

Besides, other stakeholders are:

- Finance department who controls financial losses from delays;
- Production team who implements the changes made to the processes;
- Logistics team who have their transportation plan mixed up due to delays;
- Suppliers who have their production plans mixed up due to delays.

Deliverables:

The project's deliverables include:

- Causes of variations in the order management process
- Improvement of the process to reduce delivery delays
- Reduction in delivery lead-time

Roles and Responsibilities:

The roles and responsibilities of team members are specified and agreed to as below:

- Project Champion & Process Owner: Operational Process Manager of W – support to provide relevant data on order process and FY2018 order information.
- Project leader

2.2. SIPOC Analysis

Process name: Order Management Process at D				
SUPPLIERS	**INPUTS**	**PROCESS**	**OUTPUTS**	**CUSTOMERS**
Retail Suppliers (RS)	Order generation: model, quantity, contractual delivery date, delivery destination	Order creation ↓ Order validation ↓ Production ↓ Shipment ↓ Reception to warehouse	New order record in electronic order management system Order delivery Correct items to be delivered to customers Delivered quantity to be the same as demanded quantity Quality criteria to be met Cancelled orders due to late delivery Finished goods stock to be destroyed/donated due to cancelled orders	End customers Retail Suppliers Finance office Production team Logistics team
Production Team: *Industrialization Production Leader (IPL), Supply Production Leader (SPL), Quality Production Leader (QPL)*	Model validation for mass production Model cost+ validation Model quality specifications			
Finished Goods Suppliers	Production plans Material availability Product Ex works cost validation			
Logistics	Vessel booking Customs clearance			
Retail Warehouse	Order reception status			
Human Resources department	Employees			

Table 2.2. SIPOC analysis

2.3. Voice of the Customer Analysis

Based on the SIPOC analysis in which I defined the customers of the order management process, I chose to interview the following stakeholders to get a better insight into the process:

- Two retail suppliers

- Two SPLs from the production team in charge of A factory
- One production planner from A factory
- One transport planner from logistics team
- The finance management coordinator of W department

Below are the questions designed to ask the stakeholders about the order management process at D Vietnam, W Department:

- What do you think are issues with the order management process that lead to order delays?
- What recommendations do you have to improve DOT rate?
- What do you see as the impacts of delivery delays?

I summarize the responses in the table below.

Selected Market Segment	Raw VoC Data	Affinity Diagram Theme (focus point)	Cognitive Issues	CTQ
Retail Suppliers	DOT rate is getting worse and we have shortage frequently. (1)	Variation in delivery lead-time (1)	Order delays impact sales.	On-time delivery
	It takes them too long to confirm an order. We don't have enough time to react to a delayed order. (2)	Variation in reliability of confirmed dates (2)	Low reliability of confirmed expected delivery dates has widespread negative impacts.	Reliable expected delivery dates
	The confirmed delivery dates are unreliable. Sometimes they change the dates so much. I can't keep track and this causes difficulty for us to plan orders. (2)	Miscellaneous comments (X)		
	The delays negatively impact our warehouse capacity. Many times, when many delayed orders arrive at the same time with on-time orders and there is not enough space in warehouses, we have to delay reception of on-time orders to get the seriously delayed orders first. (1)			
	There is no standard lead-time in accordance with order quantity.			

	Instead, there is only lead-time per order. We do need shorter lead-time for small quantities. (X)			
	We are trying to reduce air-shipment for environmental concerns while on-time delivery has not been improved accordingly. (X)			
SPLs	We depend on suppliers to confirm orders' expected delivery dates. Many orders take suppliers too long to confirm, mainly because of their capacity issues. (2)			
	The order management is conducted on system, but the system is too slow and sometimes it takes so long for order information to synchronize among retail department, production, logistics and suppliers. (X)			
	The initial delays reduce capacity for future orders and hence, cause more delays as a domino effect. (1)			
Production planner	We typically commit a replenishment lead-time of 30 days for orders of almost all types of products; however, we often get orders with shorter lead-time. (X)			
	Our production has had more issues since we tried to take more high-tech products. Productivity is difficult to estimate and hence, more delays have happened. (X)			
	Many orders have quite small quantity and sometimes we forget to produce/ship. (X)			
Transport planner	The expected delivery dates are unreliable and are often changed, which makes it difficult us to plan transportation and leads to vessel capacity shortage or in excess. (2)			

Finance management coordinator	Delays impact our bottom line. (1)			
	Because of unreliable expected delivery dates, it's difficult to pilot monthly P&L correctly. (2)			
	Lots of additional costs are incurred from logistics, production due to delays. (1)			

Table 2.3. VOC summary table

Potential Xs

Some potential Xs have been identified as below. More investigation will be conducted in the Analyze phase.

- Mindset of dependence on air-shipment mode to catch delivery dates.
- Time lags due to unresponsiveness of systems.
- Incorrect requested order lead-time.
- Quality issues due to product technicality.
- Tracking methods for orders with small quantities.

2.4. Definition of CTQ(s)

CTQ	Definition of a Unit	Definition of Opportunity for a Defect	Definition of a Defect
Yearly delivery-on-time rate	An order item	Not-on-time delivery of an item	An item delivered 7 days earlier than or later than the contractual delivery date

Table 2.4. Definition of CTQ for order management project

2.5. Entitlement gap

DOT rate in FY2018 was 81% while the target was 95%. The actual delivery is on average 5 days later than the requested delivery dates while ideally, there should be no gap.

3 Measure Phase

3.1. Operational Definition of the CTQ(s)

The operational definition of the CTQ – the yearly delivery-on-time rate is as below:

Criteria: if an order item is delivered at the time as requested.

Test: Was the order item delivered within +/- 7 days of the contractual delivery date?

Decision: The order item was delivered on time or not on time (late or advance)

3.2. Data collection plan

The data collection plan is summarized in the table below.

Define What to Measure		Define How to Measure			Define Who Will Collect It	Sampling Plan		
Metric	**Type of Metric**	**Measurement Method**	**Data Tags Needed to Stratify the Data**	**Data Collection Method**	**Person(s) Assigned**	**Where?**	**When?**	**How Many?**
CTQ: Yearly delivery-on-time rate	Attribute classification data (on-time or not-on-time). However, an order item is considered on-time if it is delivered within the range of +/- 7 days compared to the contractual delivery date. Therefore, I also use measurement data (actual lead-time vs. requested lead-time).	Automated from the company's database	Order number, order quantity, order creation date, order transfer date, contractual handover date, actual handover date, contractual shipment date, actual shipment date, contractual zone arrival date, actual zone arrival date, last delivery date	Extracted from the company's system into spreadsheet	Project champion	A factory	FY2018	All orders delivered in FY2018

Table 3.1. Data Collection Plan for CTQs

3.3. Validate Measurement System for CTQ(s)

The measurement system is also the order management system. The relevant order dates are reliable. Some dates like order creation date and order transfer date are automatically recorded by the system. Regarding other dates, at each step, the relevant date must be keyed in before the next step can be carried out. For example, the actual handover date needs to be inputted so that an order can be shipped. The real shipment date is requested before customs documents can be extracted so that the goods can be received.

Therefore, it can be concluded that the measurement system can accurately deliver data.

3.3. Collect Baseline Data and Estimate Process Capability

The line chart of weekly DOT in FY2018 is as below.

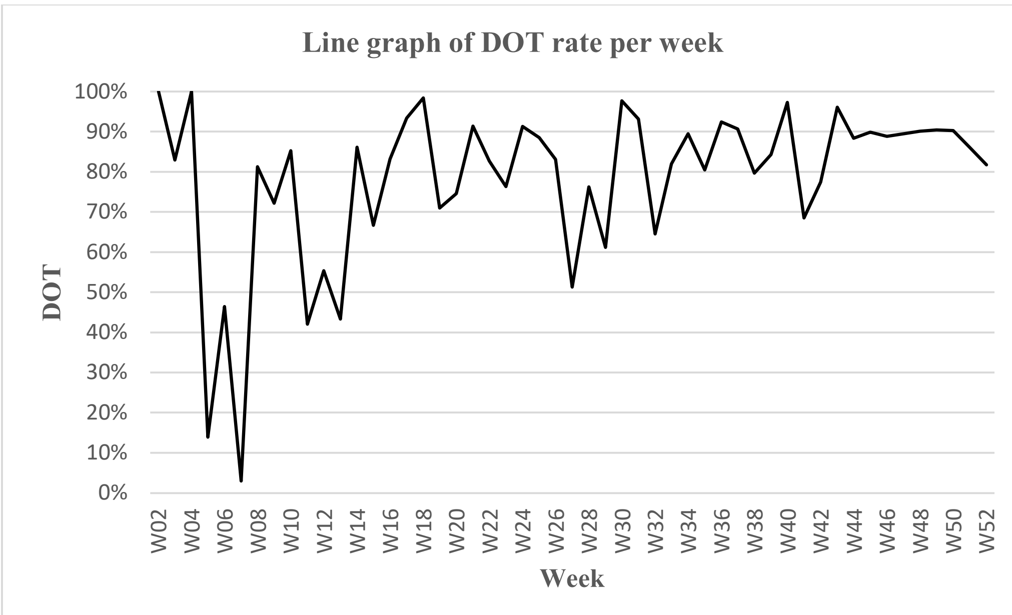


Figure 3.1. Line graph of DOT rate per week

The line chart above reveals that order delays seemingly exhibit no specific trends all the year around. There is a large variation in the percentage of weekly delayed quantities during the year and the on-time delivery rate fluctuates from 3% to 100%.

To assess the stability of the baseline data for the CTQ, I created a P chart based on the weekly on-time quantities, as shown by Figure 3.2. Because of the different subgroup sizes, the upper and lower control limits values vary by each subgroup. As can be clearly seen from the chart, most of the points lie outside the control limits; in other words, it can be concluded that in addition to common variation, there are special causes of variation in the order management process, some of which may relate to productivity of the people of concern in this process. Therefore, any improvement must come from responsibility of both the management and the people who directly get involved in the process.

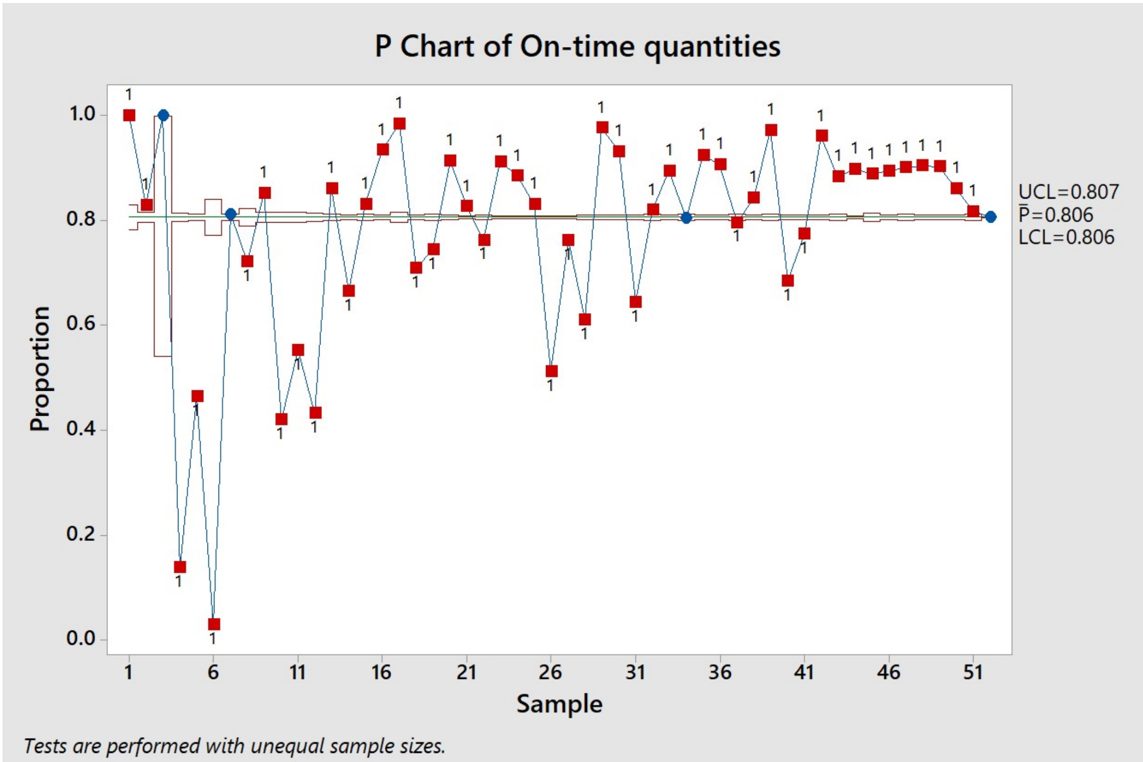


Figure 3.2. P chart of delayed quantities

Because the data on the CTQ is classification attribute data – delivery-on-time rate per week, I do not make histograms to get the data distribution. However, that an order item is delivered on time or not can be measured by the delivery date gaps; delivery is considered on-time if the item is delivered within +/- 7 days compared to contractual delivery date. I created a histogram for the delivery date gaps - the number of days that the real delivery date is different from the contractual delivery date per order item. The histogram shows an approximate Poisson distribution.

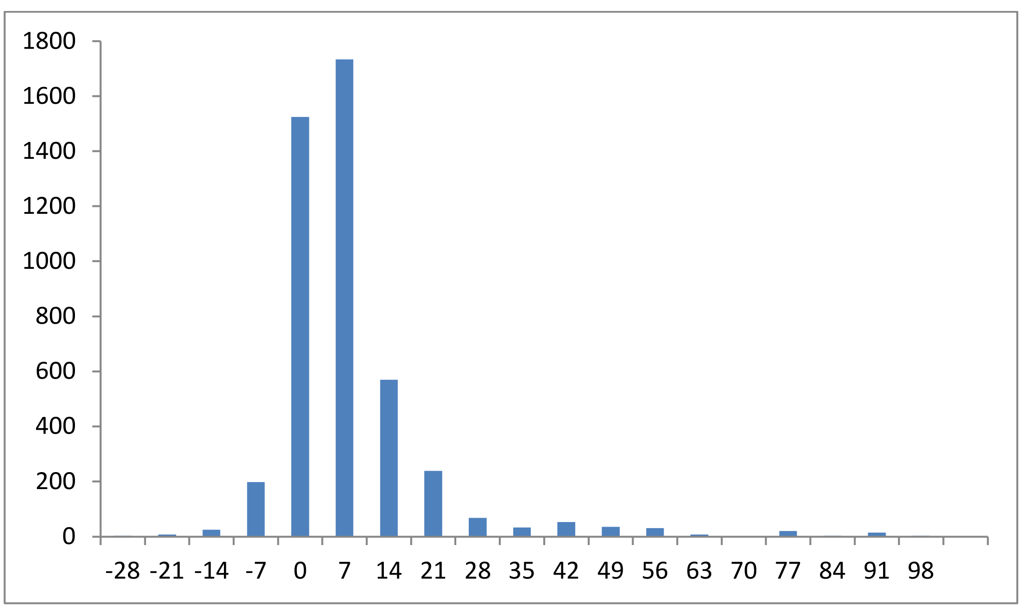


Figure 3.3. Histogram for delivery date gaps

Some basic statistical analysis of the weekly DOT rate is summarized in the table below:

Mean	78.23%
Median	83.19%
Standard deviation	20.22%
Minimum	3.00%
Maximum	100%
Range	97%

Table 3.2. Basic statistical summary

The median is much different from the mean and the standard deviation is high, indicating that there is a large variation in the process.

Because the process is not stable itself, I do not determine its capability.

Concerning the Measure phase, I decided not to use the following tools:

- DPMO/DPU: the tools are frequently used to measure the average number of defects that will be normally observed for each unit or service. In this project, what is measured is the delivery status of an order item, so this tool is not applicable.
- Gauge/Gage R&R: this tool is used to investigate variability in the measurement system caused by the measurement device or by differences between operators. In this project, the measurement system is also the order management system which is implicitly reliable.
- C_p & C_{pk}: this tool is better used when the data follows a normal distribution while in this project, the data is not.

4 Analyze Phase

4.1. Detailed Flowchart of the Process

Figure 4.1. shows the high-level flow chart of the order management process.

4.2. Identification of Potential Xs for the CTQ

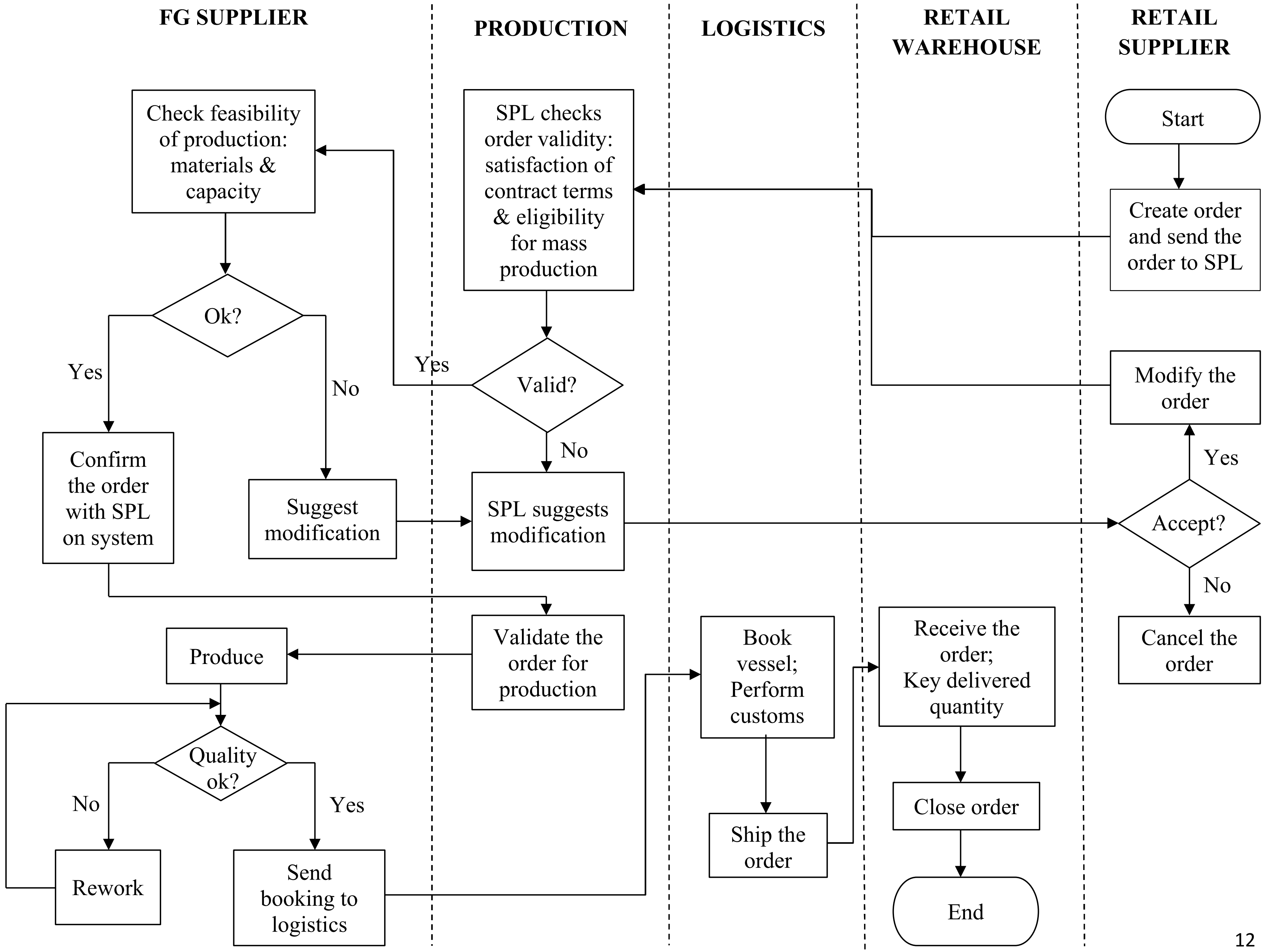
To analyze the causes of delays, I created the cause & effect as shown in Figure 4.2. Based on the analysis, I narrowed down the number of Xs as below:

- X_1: Wrong requested lead-time
- X_2: Order transfer lead-time
- X_3: Small order quantity
- X_4: Vessel issue (Vessel arrives late, is cancelled or skips one port)

The above-mentioned causes seem to be most directly related to the order management process itself and have relevant data available for further investigation. I do not select the remaining causes:

- The causes of materials, machinery and quality issues relate to other processes managed by some other departments. Manpower causes require a different type of analysis, knowledge tests, coaching, for example. Therefore, I just notify the Operational Process Manager in charge about those causes, but do not take more investigation.
- The mindset of production team to depend on air-shipment as a last resort may be one of the reasons for delays; however, this is difficult to assess now when the policy to stop using air-shipment mode by D has not been fully applied.
- Weather is obviously a reason for longer sea transportation lead-time and it is completely out of control. The only solution now is to find alternative transportation modes, by truck,

Figure 4.1. High level flowchart of the current process



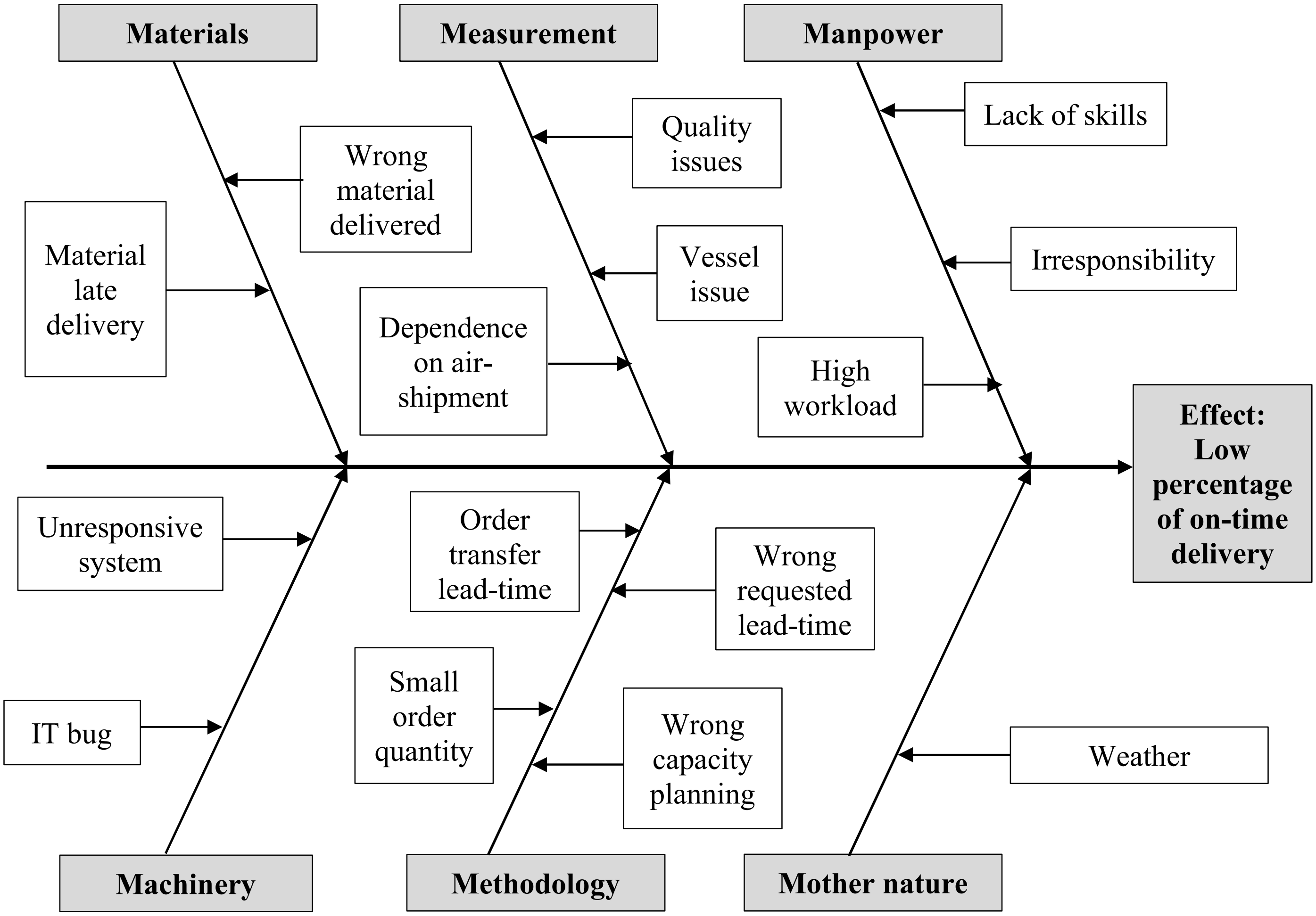


Figure 4.2. Cause & Effect; Fishbone diagram for delivery delays

by train, for example. The project of finding alternatives is being conducted by logistics.

- Wrong capacity planning is definitely an important element and has long been a headache issue to the company. The issue is currently being worked on.

I decided not to use the tools of Pareto analysis and Failure modes and effects analysis (FMEA) to reduce the numbers of Xs because of the small number of Xs identified. I do not use Multi-vari charts because I find that the process is not affected by any of the three types of variation, positional, cyclical and temporal.

4.3. Operational Definitions of Xs

The operational definitions of the Xs are as below:

X_1: Wrong requested lead-time

Criteria: The number of days between the order creation date and contractual delivery date.

Test: Select an order and subtract the Order Creation Date field in the database from the Contractual Delivery Date field in the database. Compare that requested lead-time with the committed lead-time per customs zone.

Decision: If the requested lead-time is equal or higher than the committed lead-time, the requested lead-time is correct. Otherwise, it's wrong.

X_2: Order transfer lead-time

Criteria: The number of days between the order creation date and order transfer date.

Test: Select an order and subtract the Order Creation Date field in the database from the Order Transfer to Supplier Date field in the database.

Decision: The subtraction result is the order transfer lead-time.

X_3: Small order quantity

Criteria: The orders have order quantity lower than 1,000pcs.

Test: Locate the Order Quantity field in the database.

Decision: If the order quantity is lower than 1,000pcs, the order has a small quantity.

X_4: Vessel issue

Criteria: The number of days between the actual handover date and real shipment date.

Test: Select an order and subtract the Actual Handover Date field in the database from the Real Shipment Date field in the database.

Decision: If the subtraction result is larger than 4 days, there is potentially a vessel issue. Otherwise, there is no.

4.4. Data Collection Plan for Xs

The data collection plan is summarized in the Table 4.1.

4.5. Validate Measurement System for Xs

The measurement system is also the order management system. The validity of this system has been discussed in detail in part 3.3.

4.6. Test of Theories to Determine Critical Xs

4.6.1. X_1: Wrong requested lead-time

Theory: I had a theory that retail suppliers made a request of wrong delivery lead-time; therefore, although the orders are delivered in accordance with the committed lead-time, they are still marked as “delayed”.

Analysis: I analyzed data in Table 4.2. below to see whether late orders with wrong requested lead-time account for a large percentage of delayed orders.

Of approximately 4 million replenishment order items delivered in FY2018, over 1 million or 30.41% were ordered with a wrong delivery lead-time, of which almost 837,000 pcs were delivered on time, representing 24.55% of the total order quantity. Regarding those wrong-lead-time quantities, supposing that the relevant retail suppliers had created orders with correct lead-time, nearly 860,000pcs, or 25.21% of the total order quantity would have been delivered on time. This shows little improvement.

Total order quantity	Quantity with wrong lead-time		On-time quantity			
			With wrong lead-time		With correct leadtime	
	Quantity	%	Quantity	%	Quantity	%
3,409,522	1,036,877	30.41%	836,894	24.55%	859,417	25.21%

Table 4.2. Data on Wrong Requested Lead-time

Conclusion: Based on the analysis, it seems that X_1: Wrong requested lead-time is not a critical X that leads to high percentage of delays.

Define What to Measure		Define How to Measure			Define Who Will Collect It	Sampling Plan		
Metric	**Type of Metric**	**Measurement Method**	**Data Tags Needed to Stratify the Data**	**Data Collection Method**	**Person(s) Assigned**	**Where?**	**When?**	**How Many?**
X_1: Wrong requested lead-time	Attribute	Automated from the company's database	Order Creation Date, Contractual Delivery Date, Standard Lead-time	Extracted from the company's system into spreadsheet	Project champion	A factory	FY2018	All orders delivered in FY2018
X_2: Order transfer lead-time	Measurement	Automated from the company's database	Order Creation Date, Order Transfer Date	Extracted from the company's system into spreadsheet	Project champion	A factory	FY2018	All orders delivered in FY2018
X_3: Small order quantity	Attribute	Automated from the company's database	Order Quantity	Extracted from the company's system into spreadsheet	Project champion	A factory	FY2018	All orders delivered in FY2018
X_4: Vessel issue	Attribute	Automated from the company's database	Actual Handover Date, Real Shipment Date	Extracted from the company's system into spreadsheet	Project champion	A factory	FY2018	All orders delivered in FY2018

Table 3.1. Data Collection Plan for Xs

4.6.2. X_2: Order transfer lead-time

Theory: I believed that the later the SPL transfers an order to the supplier, the higher likely the order is to be delivered late. In general, the supplier makes a weekly production plan after receiving orders and tries to minimize delays; however, in case of conflicts, priority is given to orders that are transferred to the supplier earlier without consideration of the actual order creation date by the retail supplier on the SPL's system.

Analysis: I subtracted Order Creation Date from Order Transfer to Supplier Date to get the actual order transfer lead-time. I subtracted Contractual Delivery Date from Last Delivery Date to get delivery date gaps – the number of days that the actual delivery date is different from the contractual delivery date. *(Note: Last Delivery Date on system represents the date when the order is received into the relevant retail warehouse.)*

I ran a regression of delivery date gaps against actual order transfer lead-time and got the result as Table 4.3.

Regression Statistics	
R Square	0.709481
Adjusted R Square	0.709286
Standard Error	12.64874
Observations	4575

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	89947.86	89947.86	562.2067	2.6E-117
Residual	4573	731637.6	159.9907		
Total	4574	821585.5			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-2.53742	0.358384	-7.08017	1.66E-12	-3.24003	-1.83481
Order Transfer Lead-time	1.391473	0.058685	23.7109	2.6E-117	1.276422	1.506523

Table 4.3. Regression Result for Order Transfer Lead-time

Based on this result, p-value is much lower than $\alpha = 0.05$, so the coefficient of Order Transfer Lead-time is statistically significant. There is a linear relationship between order transfer lead-time and delivery date gaps.

Conclusion: Based on the preceding analysis, X_2: Order transfer lead-time is likely to be a critical X that affects delivery delays.

4.6.3. X_3: Small order quantity

Theory: I hypothesized that there is a correlation between small order quantities and delivery delays. Orders with quantities lower than 1,000pcs are considered as small quantities.

Analysis: I analyzed and compared the percentage of delays on orders with small quantities versus those with not-small quantities. Results are shown in Table 4.4.

Criteria	Total order quantity	Late quantity	Delay rate
Order with small quantities	799,226	578,624	72%
Order with not-small quantities	2,610,296	2,178,929	83%

Table 4.4. Data on Small Order Quantity

The percentage of on-time delivery on orders with small quantities is significantly lower than orders with not-small quantities, 72% for the former and 83% for the latter.

Conclusion: As can be seen from the data in Table 4.4., it seems that X_3: Small order quantity is a critical X for on-time delivery.

4.6.4. X_4: Vessel issues

Theory: I came up with a theory that vessel issues, including vessel late arrival, vessel cancellation and port dismissal, are also responsible for delivery delays. Orders that are shipped after 4 days since actual handover date are considered to have vessel issues. 4 days is the number of days that logistics team commit to get on-time shipment.

Analysis: The analysis results are summarized in Table 4.5. There is no significant gap between delay rates on orders with vessel issues and those without vessel issues.

Criteria	Total order quantity	Late quantity	Delay rate
Vessel issues	731,816	574,631	79%
No vessel issues	2,677,706	2,182,922	82%

Table 4.5. Data on Vessel Issues

Conclusion: Based on the preceding analysis, it appears that X_4: Vessel issues is not a critical X that affects on-time delivery rate.

4.7. Develop Hypothesis about the Relationship between the Critical Xs and CTQs

Based on the preceding analysis and testing of different theories, small order quantities and order transfer lead-time are determined to be the critical Xs that affect on-time delivery rate. In other words, I believe that on-time delivery rate is a function of X_2: Order transfer lead-time and X_3: Small order quantities.

5 Improve Phase

5.1. CTQ Solution Equation

As concluded in Analyze phase, two critical Xs that affect the percentage of on-time delivery are determined as below:

- X_2: Order transfer lead-time
- X_3: Small order quantities

5.2. Process Improvement Alternatives

I based on the critical Xs and came up with several change concepts.

5.2.1. X_2: Order transfer lead-time

Based on the analysis in part 4, the longer the order transfer lead-time is, the more likely an order item is to be delivered late. I propose the following alternatives:

1/ Synchronize the systems used by SPLs and suppliers (the system designed by D for suppliers to get orders)

- Pros:

- Suppliers can see order information at the same time as SPLs receive orders from retail suppliers and use that information to make a draft production plan before SPLs confirm the final order information.
- Suppliers can also see the changes made orders or new requests to existing orders and make immediate updates to their production plan.

• Cons:

- There is a risk of miscommunication of the finalized order information.
- The synchronization takes long to get approval and implantation because it requires a change in IT and costs incurred.

2/ SPLs train suppliers on how to check order validity and set automatic order transfer to suppliers on their systems.

• Pros:

- Suppliers can get orders immediately once the orders are created and transferred to SPLs.
- Suppliers can check order validity and feasibility of production at the same time.
- The change can be applied immediately by a change in system settings by SPLs.
- SPLs still can re-check orders upon validation for production.
- Lead-time is shortened.

• Cons: I do not identify any cons associated with this option.

5.2.2. X_3: Small order quantities

Orders with small quantities stand higher risks of being delivered late. A possible underlying cause identified from interviews with suppliers during Define phase is that it is more difficult to keep track of those orders. Suppliers forget to put the orders on their production plan, to produce or to make shipment.

I propose the following solutions:

1/ Adopt control activities - SPLs set a routine to perform the following tasks:

- *Check if weekly production plans include all validated orders.*
- *Check actual production progress against production plans.*
- *Check weekly shipment plans.*

• Pros:

- The routine can eliminate all the risks of orders being missed for production and shipment.
- The routine is easy to be set up and followed.

• Cons:

- The new routine requires more time and efforts dedicated by SPLs to follow.

2/ SPLs create a manual order by combining small orders that have similar contractual handover dates (suppliers work with handover dates only – the date they ship orders to ports) and send to suppliers. SPLs then follow to tell which quantities to be shipped on which dates.

• Pros:

- Suppliers can get an order with large quantities to produce.

• Cons:

- This activity requires SPLs far more time and efforts to perform.

3/ Design a few production lines with fewer workers to run smaller lots, producing orders with small quantities.

- Pros:
- Orders with small quantities are monitored separately, reducing the risk of being forgotten.
- Cons:
- The design of new production with fewer workers needs time for efficiency testing.
- There will be an increase in production costs because the suppliers need to pay more for the workers of those lines to motivate them. Currently, workers wages depend a lot on production line productivity that tends to increase with large quantity production.

4/ SPLs set a routine to send emails reminding suppliers of orders with small quantities weekly or bi-weekly.

- Pros:
- This activity does not take much time and is easy to do.
- Cons:
- It is still difficult to ensure that suppliers follow the reminders.

5/ Synchronize the system used by suppliers to make production plan and shipment plan with the system of D designed for suppliers to get orders.

- Pros:
- The automation of the systems eliminates the risk of missing orders.
- Cons:
- The solution incurs costs.
- The system updates require approval and implementation that are likely to take long.

5.3. Select the best alternative methods.

To assess the impact of proposed solutions, I used the Impact/Effort Matrix below:

<table>
<tr><td rowspan="4">Impact</td><td>High</td><td>Solution 5.2.1.2. Set automatic order transfer</td><td>Solution 5.2.1.1. Synchronize the systems used by SPLs and suppliers
Solution 5.2.2.1. Set a new monitoring routine
Solution 5.2.2.3. Design production lines for small quantities
Solution 5.2.2.5. Synchronize suppliers' systems with the system designed by D for suppliers to get orders</td></tr>
<tr><td>Low</td><td>Solution 5.2.2.4. Send reminding emails of orders with small quantities</td><td>Solution 5.2.2.2. Create manual orders combining small quantities and follow to advise handover dates</td></tr>
<tr><td rowspan="2"></td><td>Low</td><td>High</td></tr>
<tr><td colspan="2">Effort needed to implement</td></tr>
</table>

Figure 5.1. Impact/effort matrix

Based on the matrix, I decided to go with solution 5.2.1.2., set automatic order transfer and not to go with solution 5.2.2.2., create manual orders.

Regarding solution 5.2.1.1, it is expected to have high impact but also requires high effort. Normally, there should be a further study; however, considering the root cause of order transfer lead-time, the option of automatic order transfer can work well already, so I decided not to go with solution 5.2.1.1., synchronize SPLs and suppliers' system.

Concerning remaining solutions with high impact, high effort and those with low impact, low effort, I used a decision matrix to study the solutions further. The cell values are as follows:

0 = no relationship, 1 = weak relationship, 3 = moderate relationship, 9 = strong relationship

Based on the analysis of pros & cons of each solution in 5.2., I had the matrix below.

Criteria	Weight	Alternative Solutions			
		Solution 5.2.2.1.	Solution 5.2.2.3.	Solution 5.2.2.4.	Solution 5.2.2.5.
Root caused addressed	0.4	9	9	1	9
Time needed for implementation	0.2	9	3	9	1
Cost of implementation	0.2	9	3	9	1
Ease of implementation	0.2	3	3	3	3
TOTAL	**1**	**7.8**	**5.4**	**4.6**	**4.6**

Table 5.1. Decision Matrix

From the decision matrix, I found that adopting a new control activity by setting a new routine for SPLs is the best option.

In conclusion, I decided to go with the two solutions below:

1/ SPLs train suppliers on how to check order validity and set automatic order transfer to suppliers on their systems.

2/ Adopt control activities - SPLs set a routine to perform the following tasks:

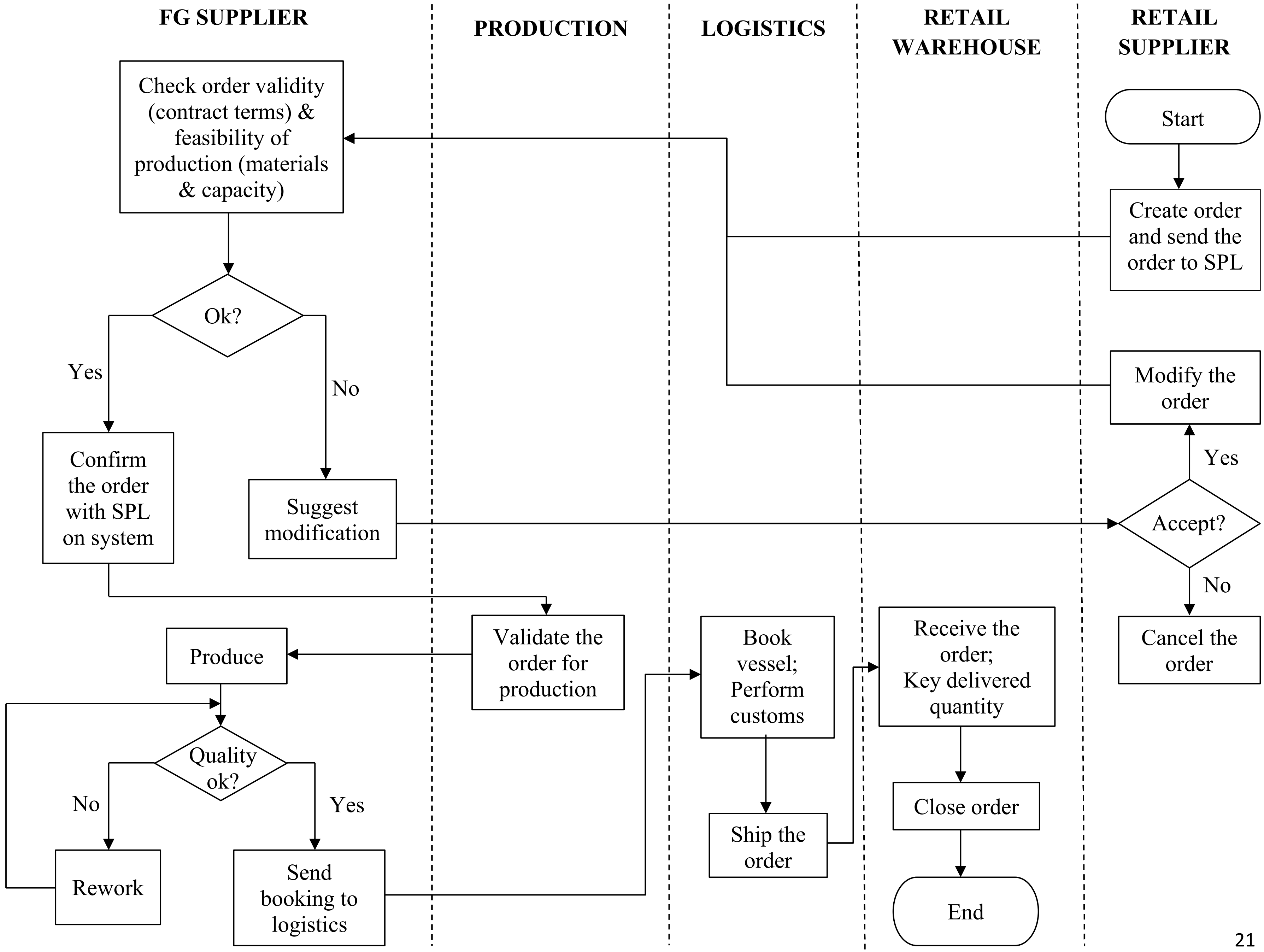
- Check if weekly production plans include all validated orders.
- Check actual production progress against production plans.
- Check weekly shipment plans.

5.4. A Flowchart of the New Improved Process

The first solution, to set automatic order transfer, requires some modifications to the current order management process. The second solution, however, does not. It just improves the control aspect of the order management process and overall, does not change the main process flow.

The flowchart of the new improved process is shown in Figure 5.2.

Figure 5.2. Flowchart of the New Improved Process



6 Control Phase

6.1. Mistake-proofing devices

To avoid missing any steps in the new proposed routine and to avoid the risk of IT bug that may affect the automatic order transfer function, I recommend all the SPLs use a checklist for weekly to-do tasks, including:

- Checking if any orders cannot be automatically transferred. Note that there is no need to check order details. SPLs just need to manually transfer any remaining orders in case of IT bugs.
- Checking if weekly production plans include all validated orders.
- Checking actual production progress against production plans.
- Checking weekly shipment plans to ensure all orders are shipped as requested.

6.2. SPC

P chart can be drawn on weekly delivery-on-time rate to see if the process has become stable or not.

If the process is stable and in control, further steps can be taken to determine the process capability.

6.3. Control Plan

A control is developed as shown in Table 6.1. on the next page.

Process	CTQ or X?	Metric Character-istic	Metric Specification/ Requirement	Measure-ment Method	Where the Data Points for the Metric Will be Collected?	Sample Size	Frequency	Who Measures	Where Recorded	Decision Rule
Order transfer to suppliers	X	Order automatic-ally transferred to suppliers? (Y/N)	Order Transfer Date = Order Creation Date	Extract from database	Electronic order management system	All weekly replen-ishment orders	Weekly	SPLs	Spread-sheet	If any orders are not automatically transferred to suppliers, SPLs need to study the reasons and get support from IT if needed.
Delivery	CTQ	Weekly delivery-on-time rate	USL = 100% LSL = 95%	Extract from database	Electronic order management system	All weekly replen-ishment orders	Weekly	Project Champion	Spread-sheet	If the weekly DOT rate is lower than 95%, use the PDSA cycle until the weekly DOT rate gets higher than or equal 95%.

Table 6.1. Control Plan for Order Management Process