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TIME BASED PERFORMANCE METRICS IN LOGISTICS: A CASE STUDY FROM SAUDI ARABIA

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ABSTRACT

This paper aims to equip logistics management with a comprehensive way to evaluate logistics players' performance including the management itself. This paper presents a systemized flexible mechanism to develop time based logistics performance metrics based on organizations' logistics network structure. The framework will enhance logisticians and practitioners with decision support system to evaluate the effectiveness of the logistics time based performance. Logistics lead time analysis concept is used to break down the total logistics lead time into time windows/intervals enhanced with predefined control time limits. Time windows are generated by change of player, task, and place over the lead time. The number of metrics equals the number of the time windows. The developed metrics are mainly based on comparing the actual performance against the agreed plan for each time window. Pareto Chart will be used as a prioritization system to determine the poorest logistics performance of each path and each player as well. The proposed time based performance system designed in way to enable decision maker precisely identifies opportunities for improvements hence improve the supply chain performance to reach excellence. Data from a company operating in Saudi Arabia is considered as our main case study to testify the proposed performance system.

INTRODUCTION

The system of the performance measurement is described as the complete set of metrics used for performance measurement which is the process that measures effectiveness and efficiency of action. Effectiveness is the extent to which a customer's requirements are met and efficiency measures how economically a firm's resources are utilized when providing a pre-specified level of customer satisfaction [1]. Waters [2] stated that "there is clearly no shortage of measures" but there are a significant amount of possible logistics metrics. Cost is not always the main problem. Lead time was amongst them besides order fulfillment, delivery errors, and damages. Lead time and on time delivery are the two time-related logistics performance out of the ten common measures used by Ferreira. Surprisingly, none of the ten common measures are cost related [2]. Relying solely on financial indicators may cause misleading results or confusion. Financial metrics may show satisfactory results. However, they do not necessarily mean that the supply chain network run in an effective way. Sharahi and Abedian [3] emphasize on the importance to differentiate between financial and non-financial metrics. Waters [2] stated that financial metrics are easy to calculate, general, comparable and sound logic. However, they focus on past performance rather than the current one, thus they are slow to react to inconsistencies. They are purely based on accounting aspects and ignore the real performance of logistics. Financial performance shows that there is a problem but does not show what it is and how to solve it [2]. Moreover, Harrison and Hoek [4] indicated that cost is a more subjective and opened to different interpretation. On the other hand, they described the time it as an "an absolute measure".

Shepherd and Gunter [1] refer to the time as one of the measurements that measure the supply chain capability to meet high level of customer service. The difficulty of measuring specific performance criteria is proportional to the tangibility of the criteria itself. The more tangible the performance criteria are the more easily to measure and vice versa. According to Ritchie and Brindley [5] the timeliness is the more tangible measure that is related to service level. Its ability focused in identifying problems from delayed delivery. Goldsby and Martichenko [6] stated that "of all of the resources found in life and in logistics, none is more important than time. It is the only resource you can never reclaim". Time is also among the most main metrics in logistics and is one of the potential wastes in logistics. Accordingly, lean logistics concept is used to eliminate waste and decrease lead times thus increase supply chain agility and flow. Compatibly, Six Sigma concept tends to reduce deviation and understand the problem sources and defined as "the elimination of wastes through disciplined efforts to understand and reduce variation, while increasing speed and flow in supply chain" [6].

Supply chain event management (SCEM) holds a similar concept of controlling. Its functionalities of tracing, tracking and warning of supply chain processes supports decision making process [7]. SCEM takes care of registering, monitoring and evaluation of events. It is defined as an early alerting system for abnormalities or deviations in the supply chain in a company and between two companies. It employs statistical and technological application to serve as a control solution for standard and nonstandard supply chain events. On the other hand, Branda and Tolujev [8] stated that SCEM concept has different approaches and it is still not yet systemized or standardized. They introduced Logistics Event Management (LEM) indicating that it is used rarely as a separate concept and is usually defined synonymously with SCEM. They stated that "The concepts and functionalities of SCEM are transferable to LEM". In general, LEM refers to event management in logistical systems, whereas SCEM refers to event management in supply chains. Accordingly, logistics event management is understood as "the need for accurate and timely management of information in order to maintain on-time deliveries, reduce inventory levels and ensure that the right product is in the right place at the right time" [8]. Therefore, this study evaluates the time based performance metrics in logistics at multinational company running in Saudi Arabia.

METHODOLOGY

This study proposes a framework for developing time based logistics performance metrics. This framework will enhance logisticians and practitioners with decision support system to evaluate the effectiveness of the logistics time based performance. The framework consists of 4 steps namely logistics lead time analysis, performance measurement, controlling and visualize.

Logistics Lead Time Analysis

Logistics lead time is "the time taken to complete the process from goods inwards to delivered product" [9]. The analysis of the lead time is used to break down the total logistics lead time into time windows/intervals assigned to them the allocated time to perform a certain task. These time windows are generated by change of player, task, and place over the logistics lead time. Each time window should represent one player to facilitate tracing logistics players' performance and avoid recrimination. Accordingly, logistics lead time analysis is used as a flexible comprehensive way to identify the performance of each player in the logistics network. Flexibility is in terms of the number of time windows or intervals that might differ from one network to another. Number of the metrics equals number of the generated time windows.

Performance Measurement

Each metric evaluates the time based performance of the logistics' player against the plan. Additional charges are assigned to each window to monitor the cost deviation from the plan in order to identify the source of ineffectiveness processes. The plan usually should reflect the contract agreements between logistics parties. The best performance is the on track performance and this can be realized in two different ways. The first way can be achieved in the absence of any gaps between time intervals. Gaps are the idle time between the ending of one task and the starting of another. This can be calculated by subtracting the starting date for a time window (x+1) from the ending date of the previous time window Tex. Hence, ideal performance is realized when the difference between one job and another equals 0; the ending of one job is the beginning of another.

$$\sum\triangle = (T_s(x+1), Tex) = \sum(D_x) = 0 \qquad (1)$$

(x+1)= The actual start date of the time window (x+1).
Tex = The actual end date of the time window (x).
Dx= Delay or difference between end of (x) and start of (x+1).
The second way of calculating the best performance is determined when the actual performance divided by the ideal performance equals 1. Greater than 1 exceeds the planned time to perform a certain task and going below 1 means that the task was done in a shorter period than the required time. Similarly, in

terms of cost, the best performance can be realized in the absence of any additional cost or charges from the plan. It can be also calculated when the actual incurred cost divided by the ideal cost equals 1. Ideal cost is the required cost for each logistics path to run in an effective way. Greater than 1 exceeds the required cost. This can be used to show both logistics players' performance and logistics path performance.

$$\frac{Actual\ Performance\ of\ X\ (time\ or\ cost)}{Ideal\ Performance\ of\ X\ (time\ or\ cost)} = 1 \qquad (2)$$

Controlling

In the continuous changing environment, plans are always surrounded by risks of deviation from plan. A risk of deviation from plan in logistics is expected all the time and should be well managed. Some deviations are extremes, requiring revision of the plan and some others are still manageable, requiring prompt actions. The concepts of control limits that are generally used in the control charts to monitor changes in the mean of a process are used in this research to monitor the variation and behavior of logistics player's performance against the plan. The plan represents the center point. Besides, upper and lower control limits are used to monitor deviations from the target for each time window. The value of the LCL and UCL are set by logistics experts based on the plan or contracts. Data on the actual performance of the logistics service providers should be visualized on the control chart to monitor the behavior of the current performance of the players against the plan. These control limits will provide in-depth evaluation; any deviation from the target requires further investigation and any exceeding of one of the control limits requires attention and revision of the plan or the contracts with logistics service providers. By this way, decision maker will be able to track and monitor the movements of material over the logistics lead-time. It will be easier for the decision maker to determine the deviation processes against the plan and the logistics player responsible for this deviation.

Visualize

Along with the control limits, Pareto Chart is one of the basic tools of quality that employed to show the performance into two levels. In particular, Pareto Chart shows the most impactful players in each single logistics path. In general, it will determine the most negative impactful paths on the overall performance logistics network. Consequently, this helps in creating a prioritization system to solve the most important causes of logistics network problems or the most malfunctioning logistics paths in logistics network rather than focusing on obvious or more recent ones. Likewise following these steps, it is much easier for the decision maker to point the source of the problems and solve it or improve it. It enables the decision maker to identify the player who is responsible for each event, at which time and on which place.

A Case from logistics department in Saudi Arabia

This research includes a case from a logistics unit, part of a multinational company running in Saudi Arabia. This unit is responsible for managing the movement of shipments from different destinations among different players. Logistics role is focused on securing the shipments to be delivered to the store at the right time and at the lowest possible cost. The task is very changeable since receiving shipments prior the agreed time are not in favor to the store sometimes because the store may not be ready to physically place the order. Similarly, receiving the shipments after the agreed time may affect the products availability and had a negative impact on the customers' perception on the availability of products. Data is retrieved from the unit in order to assess the performance of the logistics. Performance that will be assessed based on the received data. The only data is available are on (container details, dispatch date, containers arrival date, containers clearance date, and return date). This is in addition to the demurrage and detention cost.

RESULT AND DISCUSSION

Starting from the logistics lead time analysis, Figure 1 shows a breakdown of the lead time into time windows (T) based on the available data. Each time window represents the role of a logistics path's player that has a potential to delay and in turn affect the logistics performance. According to the available information, Table 1 explains each performance metric (M) and the Upper (UCL) and lower (LCL) control time limits to perform a task.

Based on the available data, it would not be possible to break T4 further in a way to assign each player to a single time window. T4 includes 3 players which they are the store, the transporter and the logistics management. Because of the unavailability of data on starting and ending time of each job, it would not be feasible to use the first equation that shows the gaps between the time intervals. Therefore, the second equation will be used in the analysis. The framework application will be applied on seven logistics paths that origin from different countries of the world and end with Jeddah store. The data analysis will be analyzed for 3 consecutive months; September, October and November in 2012.

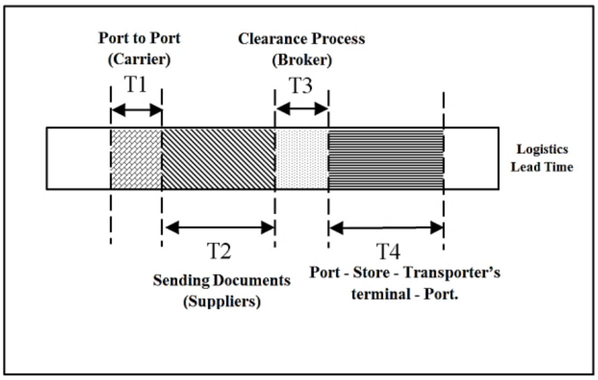

Figure 1: Logistics lead time analysis

Table 1: Metrics Description

M	T	Logistics Service Providers	Performance Metrics Equations	LCL	UCL
1	T1	Carriers	The actual time taken by the carrier to deliver the shipment from port to port / The agreed time taken by the carrier to deliver the shipment from port to port	The agreed time – 2days	The agreed time +2days
2	T2	Suppliers	The actual time taken by the supplier to send necessary document to the logistics management / The agreed time taken by the supplier to send necessary document to the logistics management	Unrestricted	0
3	T3	The broker	The actual time taken by the broker to clear all containers / The agreed time taken by the broker to clear all containers	5	8
4	T4	1. Transporter 2. Store 3. Logistics Management	The actual time to deliver shipment from port to store by the transporter, unload it by the stored then deliver it to the transporter terminal from where the containers are returned to the port / The agreed time to deliver shipment from port to store by the transporter, unload it by the stored then deliver it to the transporter terminal from where the containers are returned to the port	Undefined	10

By comparing Path A's actual logistics lead time and planned logistics lead time, we found out that the total actual time exceeds the planned logistics time by approximately 18 days. As shown in Figure 2, the planned lead time of the "Port to Port" is 10 while the average actual performance is 22.46. This exceeds the target by 12 days. Sending necessary documents are received before the arrival of the container. That is why they do not take a place in the actual logistics lead time. The time required for clearing containers should be done within 8 days. The broker performance almost meets the target with an average 8.16 days. "Port – Store – Transporter Terminal - Port" time window takes longer time than it supposed to be. It is supposed not to exceed 10 days where the actual performance takes 16 days as an average.

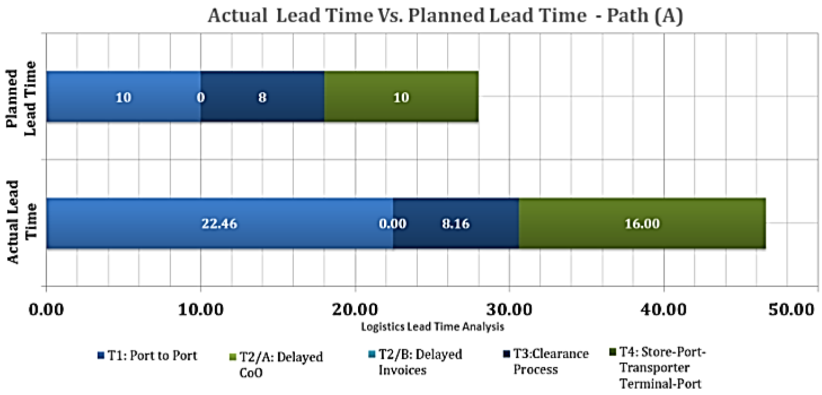

Figure 2: Actual lead time Vs. Planned lead time - Path (A)

By using the control charts in Figure 3, it is clear to determine which player exceeds the limits and which is not. The benefit of the control limits is to distinguish accepted deviation from extreme ones. It is obviously seen that the T1 and T4 performance exceeds the upper control limit which requires a further investigation. T3 slightly exceeds the upper control limit. While the other two performances T2/A and B are within the limits.

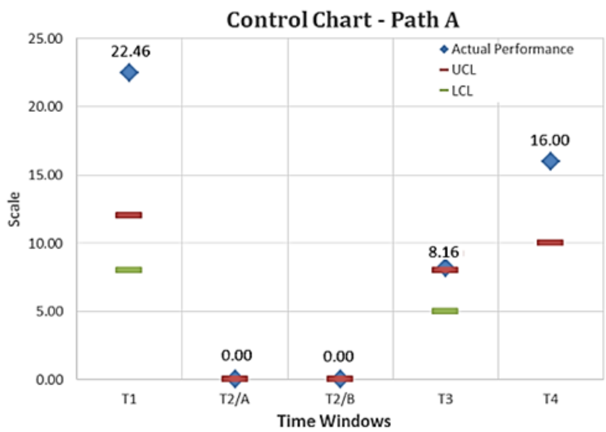

Figure 3: Control Chart - Path (A)

Pareto chart in Figure 4 highlights the most important sources of delays that affect the total logistics lead time of Path A. The horizontal axis shows the logistics players and the left vertical axis shows the delayed performance of the players. Bars represent each player's performance. The right vertical axis is the cumulative percentage of the total delays. It is clearly shown in Figure 4 that the carrier is the main root of the delay on path A, then the 3 Players' performance who are responsible for the time window T4 , then the broker performance which contributes with only 1% to the total delays of the lead time. 67% of delays are intensified in the carrier performance.

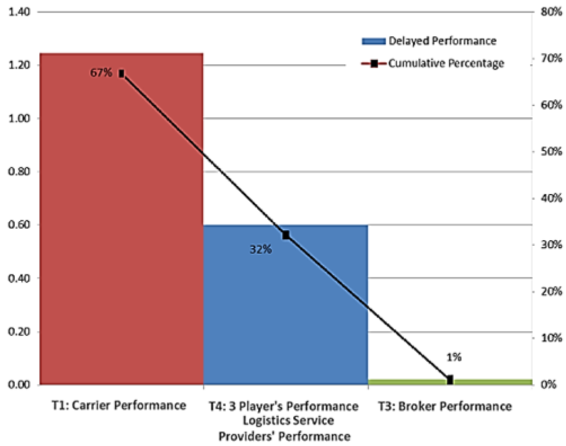

Figure 4: Logistics service provider's performance

Again, Pareto chart in Figure 5 used to highlight the poor time based performance of the logistics paths. The horizontal axis shows the logistics paths and the left vertical axis shows the delayed performance in each path. Bars represent each path's performance. The right vertical axis is the cumulative percentage of the delays in the logistics network. It is clearly shown in Figure 5 that near to 25% of total delays in the logistics network are sourced from Path C. The next Path G and E represent more than 25% of the delays. Greater attention and focus should be directed on paths C, G and E that represents 56% of the total logistics network delays.

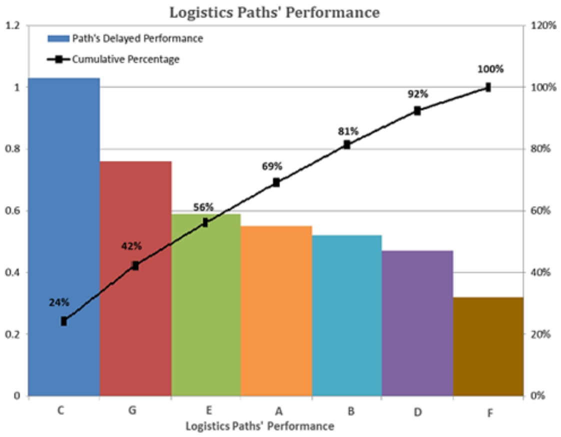

Figure 5: Logistics paths' performance

Table 2 summarizes the final results of the time and cost based performance of the seven paths. The lead time and cost performance of each path was computed as described in equation (2). The cost performance of each path was computed based on the data we received on demurrage cost and detention cost. They are referred to ineffective running of the T3 for the demurrage cost and T4 for the detention cost. Demurrage cost is incurred when the broker exceed the UCL and detention cost is incurred when the T4 exceed UCL. The table shows that all paths are exceeding the plan. Path C has the poorest performance by exceeding the required lead time by approximately 103%. Then, paths G, E, A and B, they are exceeding the time limits by more than 50%. Regarding to the cost based performance, the table shows that the paths C, A, and F have the best cost based performance by exceeding the limit by 10% only. Whereas, high costs were incurred on paths G, D, E, and B. The broker is the responsible for the demurrage cost but it is still unclear to determine who is exactly responsible for the detention cost since T4 is managed by 3 players (the store, the transporter and the transportation management).

Table 2: Time and cost based paths' performance

Path	Total Actual Lead Time	Total planned Lead Time	Total Actual Incurred Cost	Demurrage Cost	Detention Cost	Total Planned Cost	Time Based Performance	Cost Based Performance
C	101.43	50	67,097.02	0	5,893.00	61,204.02	2.03	1.1
G	79.3	45	131,184.71	4,280.00	49,878.00	77,026.71	1.76	1.7
E	72.95	46	80,678.24	1,418.29	22,500.00	56,759.95	1.59	1.42
A	46.62	30	77,748.86	420	8,400.00	68,928.86	1.55	1.13
B	57.94	38	106,672.97	6,124.09	25,010.00	75,538.88	1.52	1.41
D	61.77	42	112,472.21	7,110.00	33,800.00	71,562.21	1.47	1.57
F	61.87	47	56,548.07	384.97	6,200.00	49,963.10	1.32	1.13

Recommendation

These metrics give room to improve the overall performance of the transportation logistics as well as each player’s performance.

First, controlling and claiming system should be activated in order to monitor and claim any loss caused by the logistics’ players. Prompt response to the deficiencies caused by logistics’ players will add more seriousness to the players’ relationships. It will help also logistics parties to abide the terms and conditions written in the contracts.

Second, indicate the lead time parameter is used in many ways including planning, updating systems’ parameters, etc. Therefore, it should be updated based on reality and not on what is agreed on in the contracts. Updating this parameter based on agreements and not reality, it may drive the availability of products to disasters and impact the service level of products. This especially occurs when the gap between the agreed/planned and actual performance is noteworthy or is observed frequently.

Third, participation of different logistics parties to preform one task at the same time at the same place complicates the process, weakens the performance and increases the dependency. Dependency occurs when each player is waiting for other player's order to do a required task. As lower dependencies as better performance is realized. In this case, the transportation management waits for the broker information about the cleared containers. The management then should manage the communication between the store and the transporter to direct shipments movements and return them to the port. This poor performance of T4 may refer to the lack of open communication channels where information is promptly updated and shared with all transportation logistics players. Receiving information prior the time will help each player be prepared for the next step and next action without the need to any external order from any external parties.

CONCLUSION

Deviation from plans costs companies not only in terms of money but in terms of the quality of service provided to the customers through the availability of products on shelves. This in turn will affect the customers trust. If the customer loses the trust they will simply switch to the competitors. Logistics is one of the main reasons that affect the availability of products. Each logistics' player involved in the process plays a very critical role in securing the availability of products on shelves. Any delay from one player will affect the whole logistics performance. Hence, logistics performance should be well managed but not at the expense of the availability of products. Without performance measurements, there is no room for improvements to reach excellence in logistics management. The suggested flexible mechanism to generate time based logistics metrics aims to equip logistics management with a comprehensive way to evaluate each player's performance including the management itself. Logistics lead-time analysis in turn will provide a fair and constant tool for evaluating logistics players' performance, as well as each single path. With this mechanism, logisticians, practitioners and decision maker will able to identify problems and take necessary actions and decisions for corrections.

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