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Performance measurement in cargo distribution center: a case study

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Abstract

Cargo transportation is a key element for an effective and properly functioning logistics chain. Due to the role it plays in overall logistics chain performance, it is important for cargo firms to be at their peak level in terms of provided service quality and implementation. Continuous performance evaluation is critical for diagnosing and preventing any problems that might disrupt the firms' ability to keep providing their services and further prevent customer dissatisfaction. Therefore, the aim of this paper is identifying the problems that cause the performance of Company X's distribution center located in İzmir to stay below desired levels, which consequently lead to customer dissatisfaction, and to offer a feasible solution for the identified problems. In order to identify underlying problems, performances of two distribution centers located in different cities are compared and improvements for worker performance, workload distribution, and processes are suggested.

1. Introduction

Focusing on supply chain management (SCM) has pushed companies to reconsider their business strategies. The concept of SCM requires coordination, communication and cooperation within the supply chain with other businesses. Many of the businesses known for mastering SCM, such as Walmart, Toyota, and Cisco, are large firms that dominate their supply chains. Companies need to focus on using best SCM practices, sharing information with their suppliers, reducing inventory, and investing in new technologies because of their sheer size.

Third-party logistics companies (3PLs) have grown into such a leadership role, acting as a key "orchestrator" within the supply chain to assist in promoting best SCM practices. 3PLs use different performance measurement tools to keep on enhancing their activities and improve their competitiveness. Working in today's challenging market forces companies to design an effective procurement process to gain competitive advantage. Mathematical models and certain performance measurement tools provide critical data that can be utilized by managers in settling on strategic and operational choices.

Managers that have access to important data regarding their operations can utilize them in order to overcome the challenges that may be faced during processes. In order to remain competitive and provide value to consumers, it is crucial for business to be effective and efficient in all business processes, focus on core competencies and outsource functions that third parties can perform more efficiently (Zacharia, Sanders, & Nix, 2011).

3PLs use performance measurement tools to enhance their activities where needed and improve their competitiveness. The quality of service is vital for the survival of any organization. It is the intuitive procedure by which the association comprehends the service and satisfies their necessities. The quality of logistics service performance is a key marketing component that helps create customer satisfaction.

Company X is one of the globe's leading companies in logistics business; therefore, it must keep track several aspects of its businesses in every country they are currently operating. As measuring the performances of all of their DCs can prove to be a highly complex, time and resource demanding issue due to the vast number of

employees and facilities owned, Company X uses its own calculation method specifically designed for their operations in order to measure the performance of their DCs.

In this study, primary data was collected from the Company X, calculated, and used to compare the performance values of the Company X's DCs in two largest and most populous cities in Turkey. The main purpose of this study is to understand the factors which could be causing this lower level performance seen in İzmir DC in comparison to İstanbul DC and propose different solution options in order to achieve an increase in performance. For performance measurement a multi-criteria decision making method implemented by the company, "Package Per Hour (PPH)", will be used.

This study consists of literature review, methodology, data collection and analysis, findings, conclusion and limitations and further research sections respectively.

2. Literature review

Performance measurement acts as a tool to identify possible weakness to eliminate them and strengths to further improve them in order to meet customer expectations and strategic goals.

Many performance criteria are objective and can be easily identified. They are easy to understand as they are typically numerically depicted, such as costs. In most situations, a lower cost would be preferred. Some specific factors such as expenses and resource usage are the first ones to come to the minds of many people as the most significant performance indicators. Further affecting the results are contextual factors such as confidence and exposure, which are more subjective. No defined concept of qualitative criteria is available and when it can be applied properly to the supply chain (Chan, 2003).

Compared to performance measurement implementations, there are very few academically proven performance measurement structures in existence. Most of the performance measurement structures built in organizations are a series of best practices included into specific performance measurement frameworks. Two structures are the basic requirements for an effective performance measurement system are: one systemic and one procedural; In contrast of a range of other performance management tools, such as calculate lists, etc. (Folan & Browne, 2005).

In today's competitive era, it has been shown that many businesses have failed to maximize the potential of their supply chain as they have also failed to develop effective the performance measures and metrics needed to fully integrate their supply chain in order to improve efficiency. The following are listed as the main performance measurement issues (Akyuz & Erkan, 2010);

- Incompleteness and differences in measuring performance and metrics
- Failing to show the set of measures in a balanced system
- Disconnection of calculations from strategy implementations (Akyuz & Erkan, 2010)

The method of performance management is the mechanism through which the company manages its success according to its organizational and functional objectives and goals. The performance measurement system is the information system at the center of the performance management process and it is of critical importance for the performance management system to function effectively. There are two critical elements about the performance assessment system's content and structure: reliability and implementation (Bititci, Carrie, & McDevitt, 1997). There is a basic business demand to boost manufacturing efficiency in the face of current global competition and rising stakeholder demands. Manufacturing companies' efficiency and profitability rely on their production facilities' reliability and productivity.

Multiple Criteria Decision Making (MCDM) is a subsidiary of operational research dealing with finding optimal results in complex situations including different indicators, conflicting goals, and criteria. There are no boundaries to limit application areas for MCDM. Because of this attribute of MCDM, there is extensive research conducted on the topic and so many techniques invented. Some methods for MCDM follow as; Multi-Attribute Utility Theory (MAUT), Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Case-Based Reasoning (CBR), Data Envelopment Analysis (DEA), Simple Multi-Attribute Rating Technique (SMART), Goal Programming (GP), ELECTRE, Measuring Attractiveness by a categorical Based Evaluation Technique (MACBETH), VIKOR method, Weighted sum model (Mangla, Sah, Singh, Deng, He, Kumar, & Bansal, 2017) As shown in Table 1, performance measurements tools are used in different sectors using many different variables and measurement methods.

Table 1. Usage areas of MCDM methods

Author	Usage Area
Bousofiane, A., Dyson, R.G., & Thanassoulis, E (1991)	Banking
Valdmanis, V. (1992)	Hospital
Murphy, D.J., Pearson, J.N., & Siferd, S.P. (1996)	Purchasing Decisions
Talluri, S., Hug, F., & Pinney, W.E. (1997)	Cellular Manufacturing
Nozick, L.K., Borderas, H., & Meyburg, A.H. (1998)	Travel Demand
Poli, P.M. & Scheraga, C.A. (2000)	Customer Service
Shafer, S.M. & Byrd, T.A. (2000)	Information Technology Investments
Min, H. & Joo, S.J. (2006)	3PLs

As in every other sector, performance measurement is also of great importance in the logistics sector. Logistics operations often deal with high uncertainty, multiple actors at every step of the supply chain, and goods with values ranging from low to high. Existence of all these factors makes performance measurement in logistics sector especially challenging. Third-party logistics service providers face increasing pressure as their customers become increasingly demanding (Panayides et al., 2018). According to Mentzer et al. (2001), strategic and systemic coordination between supply chain partners for the execution of operational functions with the purpose of establishing long term-term performance improvement for all participating firms is called supply chain management. What this definition of supply chain management means is supply chain requires collaboration from all of it is members to perform well. However, a supply chain's performance is only as strong as its weakest member. This is why individual companies that exist within a supply chain need to measure their performances to ensure they are indeed providing the level of service required by their stakeholders. Due to the complexity of logistics operations and the environment surrounding them, Mishra et al. (2018) points out a need for a comprehensive and holistic performance measurement system tailored for logistics sector. Over the years numerous models and approaches has have been suggested for performance measurement in supply chains, there still exists many challenges that need to be dealt with. These challenges consist of the need to evaluate large amount of data, misalignment between strategic and operational objectives, and lack of an approach that focus on multiple performance expectations imposed by different supply chain actors (Bai & Sarkis, 2012; Katiyar et al., 2018)

3. Methodology

3.1. Case Study and Problem Definition

Case study is variously defined as a method, methodology, or research design (Bassegy, 1999; Yin, 1994; Yin, 2004) which provide deep understanding of a related topic. This method allows researchers to obtain comprehensive sample-based information about an event or situation. The case study approach is an important research method for developing theory, evaluating processes or making same assumptions about the topics (VanWynsberghe & Khan, 2007). The case study method helps in better understanding processes or situations. For this reason, the case study method was used in order to take a real picture of the logistics industry, to observe the events and processes simultaneously to obtain real results by making real measurements.

Company X was selected as the study's case, because, as it was previously stated, the company is one of the world's largest package delivery companies and conducting a research on the operations of company this large could provide us an insight regarding the package delivery industry as well as a better understanding of the factors that can affect the performances of these companies. Due to Company X's size, findings of this study can also be generalized to give hints to smaller companies, which operate in the same sector, to improve their own performances.

Company X is a 3PL logistics provider, which has a huge number of industrial and individual customers to provide logistics services mostly within country. This 3PL company is one of the largest delivery companies in the world and the company is having performance related issues in its distribution center (DC) located in İzmir, the third most populated city in Turkey with a population of almost 4.4 million. The company's distribution center with the best performance according to their own calculations is located in İstanbul which is the country's biggest city in

terms of population as well as one of the World's most densely populated cities with a population of almost 15.5 million.

Company X calculates the hourly rate per employee according to the types of packages and handling types. The company divides its packages into 3 basic groups according to the shipments it receives from its customers (as shown Table 2.). These can be listed as follows.

1. Regular packages: These cargos are carton boxes that contain the cargo itself, they can be in different sizes usually from small carton boxes to medium carton boxes.
2. Irregular Packages: Cargo that can be different from one another in terms of shape, size, and weight, size of the cargo are consists of medium small and big cargo.
3. Small packages: Very small size cargo and mostly documents.

İzmir is a hub for Company X's operations and the operations within the distribution center divide into two categories. The first part of the operations takes place between 6.00 A.M and 5.00 P.M with the second part taking place between 5.30 P.M to 10.30 P.M. Company X states that, İzmir DC operates 2.27 hours less daily on average compared to İstanbul DC. Number of workers are 45 for both DCs whereas the daily average of total packages received is 35.219 for İstanbul DC and 12.949 for İzmir DC.

3.2. Data Collection and Analysis

A six-month data set including total working hours, daily worker numbers, and daily volume of packages was provided by the company. The company was also visited on certain days to observe the packages and handling processes with the intention of better understanding the flow of handling operations and identifying the causes of potential disruptions to this flow. The observations were primarily focused on the night shift, which is between 6.20 PM- 8.30 PM, as according to the data set, this is the time interval with the highest volume.

First station to be inspected was "Irregular" sorting station which deals with medium to high sizes of cargo. Second station was direct packages, which deals with small to medium size of carton boxes. Finally, the third station was "small sort" which mostly deals with documents and small deliveries. This station takes the cargo with bags, then workers measure cargo weights one by one then workers sort these cargos to correct destinations.

Table 2. Number of packages sorted per minute for different package types between 6:20 PM-8:30 PM within Company X's İzmir Distribution Center

Timeline\Stations	Small sort	Irregular	Direct packages
6:20 PM	16/min.	10/min.	18/min.
6:30 PM	8/min.	1/min.	13/min.
6:40 PM	6/min.	1/min.	14/min.
6:50 PM	21/min	2/min.	21/min.
7:00 PM	32/min	1/min.	16/min.
7:10 PM	34/min.	2/min.	22/min.
7:20 PM	14/min.	6/min.	26/min.
7:30 PM	22/min.	10/min.	23/min.
7:40 PM	25/min.	4/min.	18/min.
7:50 PM	27/min.	7/min.	12/min.
8:00 PM	31/min.	-	16/min.
8:10 PM	27/min.	-	12/min.
8:20 PM	18/min.	-	14/min.
8:30 PM	17/min.	-	15/min.
Limitations	Very small cargo or documents	Medium to large size	Small to Med. boxes

Working Times: The distribution center has a working hour scheduling problem. Due to frequently occurring interruptions at conveyor belts and workloads from the weekend distribution center, handling cannot be done properly during the night shift, which causes the distribution center to finish 2 hours late, which is expected to result in overnight labor for employees and extra cost for the company.

Work Plan: Inside the distribution center, the staff is often switching between loading and unloading docks without a delivery schedule or information regarding the packages included in an arriving truck.

Efficiency of Sorting Station: There are also several issues in the sorting stations. Packages are the most common cargo type in the distribution center and its volume starts to increase after 8.00 P.M, it causes stops at the conveyor belt, which then delays the whole operation because other parts of the belt must stop as well. In the small sort station, there are huge amounts of small items that need to be measured and sorted, again around 8:00 P.M, volume

of the small cargo increases and measuring their weights becomes time consuming for the workers in small sort. In the “Irregular” cargo, however, efficiency of the worker becomes important because these big cargos must be handled by a worker and picked one by one to the pallets after cargo arrives to the end of the conveyor belt.

Barcode Device Issues: When we inspect each auto barcode reader, we understand that these readers cannot read the all dimensions of the cargo because of deformed and inappropriate barcodes. If that is the case, conveyor belt stops and worker that monitors the process must be read it with a hand terminal manually which again delays the whole operation for a short time.

After various visits and observations to İzmir DC, we decided to focus on productivity of İzmir DC and compare it to İstanbul DC, which has a high level of performance according to the data provided by the company, in order to determine İzmir DC’s relative performance levels.

As the data set provided by the company is limited in terms of both size and content, MCDM methods commonly used in other studies could not be implemented for this research. Instead, another MCDM method called “PPH”, which is implemented by the company and used in all of their distribution centers, was used for the performance measurement of İzmir and İstanbul distribution centers. The variables used as inputs for PPH calculations are number of packages processed, number of workers, and finally total hours worked. Based on the daily worker numbers and hours, the efficiency of package handling processes was calculated. Package handling efficiency or as it is referred by the company, PPH, is the output of this calculation.

The company wants to measure the effectiveness of distribution centers when the number of employees in Izmir and Istanbul is analyzed in terms of stop number, total delivery, delivery hours, number of packages and working hours. The threshold value in PPH, which is used by the company to measure the performance of its distribution centers, is accepted as 85. Therefore, the efficiency values obtained from the PPH calculation are then needs to be compared to this critical value in order to determine the daily effectiveness of İzmir and İstanbul distribution centers.

5. Findings

When conducting an analysis to measure performance, a particular measure offers little value by itself unless it is comparable to something. Therefore, it is important to have a reference value to be able to draw meaningful conclusions from analysis results (White, 1996). The reference value that is used in this study is 85, which is a self-referenced value provided by Company X.

According to the data set, İzmir and İstanbul DCs’ PPH values are evaluated and compared with each other according to critical value which sets the minimum PPH value DCs should reach. Company X sets critical value as 85 for its DCs. Calculations performed between 2nd September 2019 and 28th February 2020.

The following parameters were used in the performance measurement:

- Stop Number
- Total Delivery
- Delivery Hours
- Number of Packages
- Working Hours

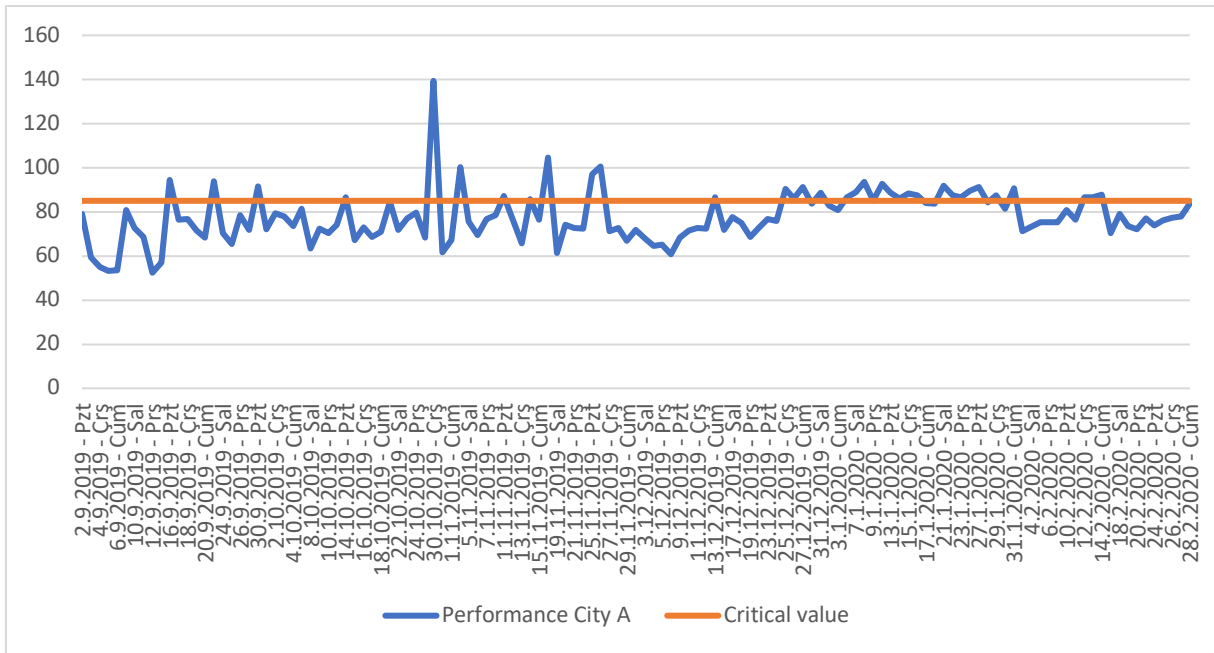


Figure 1. Performance Measurement and critical values of İzmir between September 2019 and February 2020

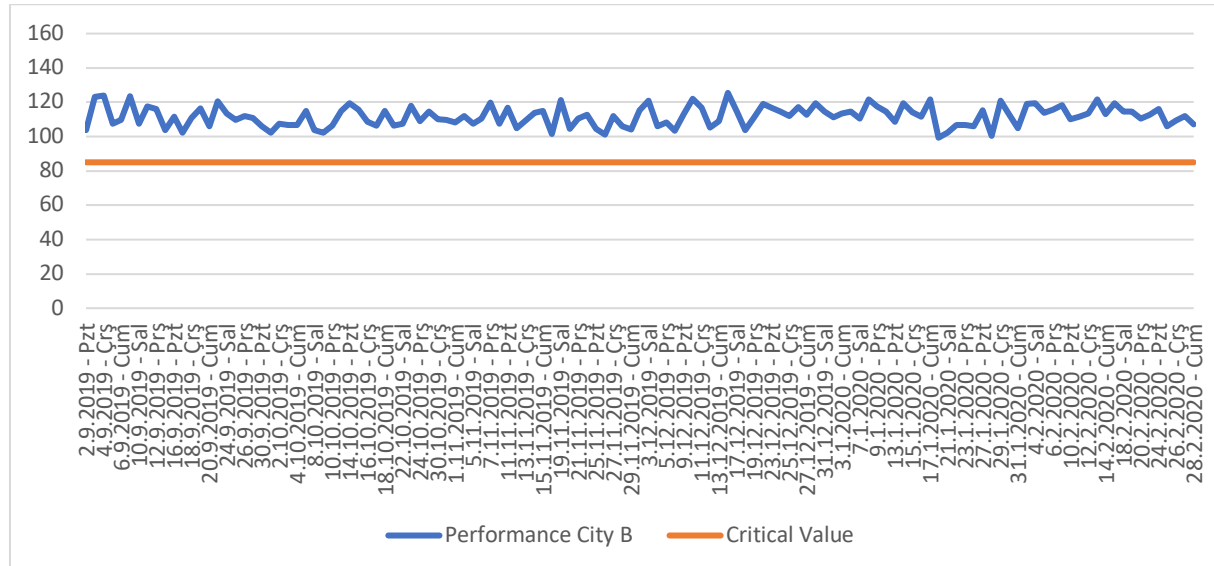


Figure 2. Performance Measurement and critical values of İstanbul between September 2019 and February 2020

In October – 2019, İzmir PPH values are most of the time, below the critical value except Mondays. In Mondays, PPH value of İzmir DC satisfies the critical value. Extra volume from weekends could be the reason for this increase. Another increase is on 30th October 2019. Unexpected increase in volume could be the reason for this. İstanbul DC’s PPH values are slightly lower than previous months but still above the critical value.

In November – 2019, İzmir PPH values are above the critical value on Mondays. Extra volume from previous weekends could be the reason for this. Except for 26th November, İzmir DC’s critical values are below the critical value.

Result from December – 2019 graph shows that PPH value of İzmir DC stays below the critical value for Mondays. Unlike other Mondays, lower volume from previous weekend could be the reason for this decrease in PPH values. At the last week of December, however, PPH value increased to 85 which satisfy critical value. For other weekdays of December, graphs show that PPH value of İzmir DC increased at the last week of December. In İstanbul DC, however, PPH value stays above the critical value and never falls below the critical value.

In January – 2020, İzmir DC’s PPH values most of the time are above the critical value but PPH values are close to critical value. Reason behind this increase in PPH could be New Year celebrations and extra volume from holidays. İstanbul DC’s PPH values are always above the critical value.

For February – 2020, İzmir DC's PPH values most of the time are below the critical value which means there is no extra volume from previous weeks. There are increases in 2nd week of February and from Wednesday to Friday, PPH value of İzmir DC slightly above the critical value. İstanbul DC's PPH values are all above the critical value.

6. Conclusion

According to PPH graphs of İzmir DC, most of the time PPH of the İzmir DC stays below the critical value which is 85 determined by Company X. However, there are some dates where İzmir DC's PPH value increases unexpectedly. For example, on 30th of October, İzmir DC's PPH value is 140 which is highest PPH value for İzmir DC while İstanbul DC's PPH value is 109 at the same date.

On the other hand, İstanbul DC manages to keep its PPH value above the critical value and never falls below the critical value and İstanbul DC's PPH values are more stable on the graphics while İzmir DC's PPH values are more fluctuated and most of the time below the critical value. These unexpected increases for İzmir DC, usually occurs in Mondays. Closing DC in weekends could be the reason for increases PPH values in Mondays.

It is concluded that the low performance of İzmir DC in terms of PPH is caused by lower volume of daily package flow in comparison to İstanbul DC. In this situation, Company X can either try to increase their daily average of packages received through promotions, discounts, and other marketing activities, or they can decrease the number of workers or give day offs to some of workers. If the company chooses the second option, they need to invest in information technologies to be able to effectively forecast package volume to avoid possible work force shortages as the Company X experiences difficulties in receiving accurate information from its customers because of uncertainty factor. Information technologies play a crucial role in a company's success because they help them capture and create value and consequently, make profit (Drnevich & Croson, 2013). Positive effects of information technologies on logistics sectors were also shown by Choy et al. (2014). As a third option, Company X can lower the critical value set for İzmir DC taking the city population and the daily average of packages received by facility into consideration. For İstanbul DC, Company X should be focusing on working hours which are too high compared to the İzmir DC to increase their PPH value even further. Alternatives for İzmir DC can apply to İstanbul DC as well, with both advantages and disadvantages.

The validity of the 85 critical value as a performance indicator is can also be questioned. As it was shown in this study, performance of a distribution center can be affected by different factors, therefore, applying a generalized performance indicator to every distribution center might not always accurately reflect how well a facility is performing. As Panayides et al. (2018) also states, decision makers can have difficulties in understanding what really causes performance issues if the performance indicators are ineffective or inaccurate. Kuo et al. (1999) believe that, a good measurement of performance should also measure quality and safety in addition to efficiency to provide reliable, timely, and high-quality information to the decision makers. However, in this case it can be seen that efficiency is the sole performance indicator for Company X. This is also something that needs to change in their performance measurement process. It has also been shown that the problems seen in the period observed by the company's operations, such as work plan, efficiency of sorting station, and employee related problems due to the extra workload have been analyzed and proved to reduce the efficiency.

There are many theory-based performance measurement methods in the literature, but in practice, developing methods which are easy for companies to use and measure performance in their processes will contribute for companies to be more successful in their industry. This case study is important in terms of showing us the parameters that companies can use for performance measurement in order to be successful in the logistics sector and that these parameters guide the logistics companies operating in our country.

7. Limitations and Further Research

This study was conducted on a single company using a limited data set covering only a 6-month time period due to confidentiality reasons. The reference value of 85 is self-referenced by the company, thus, it does not provide an insight on how the company's performance compares to their competitors'.

Future researchers can apply the parameters that were used in this study to conduct a performance measurement analysis on other companies.

Contribution of Authors

Both Burak Çetiner and Pervin Ersoy contributed to literature review, data collection, problem definition, data analysis, and conclusion.

Conflicts of Interest

The authors declared that there is no conflict of interest.

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