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Evaluation of Key Performance Indicators of Logistics Firms

Nazlıcan GÖZAÇAN[1*] and Çisem LAFCI[2]
[1]Yaşar University/ International Logistics Management, Izmir, Turkey
[2]Yaşar University/ International Logistics Management, Izmir, Turkey

[Corresponding Author indicated by an asterisk *]

***Abstract*— Key Performance Indicators (KPI) has been outlined for implementing total quality management (TQM) across logistics sector. This study constituted on the quality values of logistics firms in the logistics sector, which is examined with key performance indicators through the integrated method of Analytic Hierarchy Process (AHP) and SMART Goal Setting. The calculations were performed for logistics firms. The method used in this study is the integrated method of the AHP Method and SMART Goal Setting. The results highlight the most mentioned key performance indicators in the literature in a prioritized version also during the prioritizing process via AHP Method, the SMART Goal Setting approach also is applied.**

***Key words* - Analytic Hierarchy Process (AHP), Key performance indicators (KPI), SMART Goal Setting, Total Quality Management.**

I. INTRODUCTION

The significance of logistics is growing in this era of continuous growth. The industry demonstrates ongoing growth in many fields. Furthermore, in response to these radical adjustments influencing the logistics industry, the performance word with which the logistics companies are involved is becoming more crucial. The performance knowledge of the logistics process must, therefore, accommodate itself to these latest adjustments.

The Council of Logistics Management describes Logistics as "…is part of the supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods, services, and related information from the point of origin to the point of consumption in order to meet customers' requirements". With this definition, companies have recognized that logistics management plays a vital role in previous decades. Another important point regarding the concepts of logistics performance state is the transportation of the products to the receiver on time with the quality of the logistics services and competence of it. In addition, the logistic performance of the logistics operations is a measure of success and effectiveness [14]. Therefore, quality control in logistics has a high value [4]. There is a significant amount of KPIs for logistics services in the literature, and this surplus is highly dispersed. This disorganization makes quality control difficult. KPIs should be prioritized to solve this problem and to comply with changing quality criteria. The objective of this research is to evaluate the KPIs for Total Quality Management (TQM) of Logistics. An extended literature review is conducted to find the KPIs of logistics in several fields. And, a table of all KPIs found is designed to choose the most mentioned ones. The method used to prioritize the most mentioned KPIs is the integrated method of the AHP and SMART Goal Setting proposed by Shain and Mahbod in 2007. AHP is used as a multi-criteria decision-making method to analyze the literature data with the help of SMART (Specific, Measurement, Attainable, Realistic, and Time-Sensitive) goal-setting method.

This paper is organized as follows. The KPIs in logistics are summarized in Section 2. The methodology is explained in Section 3. The analysis is presented in Section 4. Results and conclusions are summarized in Section 5.

II. KPI IN LOGISTICS

KPIs are excellent indicators to monitor the performance. Key performance indicators vary following nature, and strategy and contribute to calculating the success in achieving long -term goals, also take into account the difficult-to-measure criteria [7]. Databases such as Science Direct, Taylor & Francis, Emerald Insight, and Google Scholar have been used for the research. In this research, a broad literature review is performed. As a result of the literature review, 116 KPIs have been observed, and the first five the most mentioned ones are used as the KPIs in this study. KPIs found throughout the research can be seen in Table 1.

Table 1 KPIs observed throughout the Literature Review

Ability to deal with returns	Flexibility to changes	Product configuration
Accounts receivable turnover	Geographical location	Purchase order cycle time
Accuracy of forecasting	Government satisfaction	Quality of delivery documentation
Accurate billing	Interest coverage ratio	Quality system certifications
Accurate documentation	Inventory accuracy	Quality when receiving goods in the warehouse
Advance notice on shipping delays	Inventory days of supply	Receiving and assessing of return shipments
Advance shipment notification	Inventory management and registration	Relationships with other stakeholders
Asset turns	Inventory turn-around times	Research and development capability
Available stock level	Investor (financier) satisfaction	Response accuracy
Backorder/stock-outs	IT Infrastructure	Response time to inquiries
Building product displays	Labor cost	Responsiveness to changes
Cash flow	Labor efficiency	Return on investments
Cash-to-cash cycle time	Lead time	Return processing cost
Circumstance of delivery	Loss/damage experience	Revenue growth
Community satisfaction	Management accounting techniques	Right equipment supplied
Complete orders	Managerial skills	Sales force complaints
Cost	Market share	Sales force feedback
Cost of returned goods	Non-government organization satisfaction	Sales growth
Cultural match	Number of customer complaints	Shipping error
Customer complaints handling	Number of customer returns	Shipping/transportation Cost
Customer inquiry response	Number of dollars shipped	Social media usage for brand building
Customer satisfaction	Number of dollars/unit shipped	Stock-holding cost
Customer service level	Number of kilos/units shipped	Supplier base size
Delivery defect	Number of shipments per vehicle-mile	Supplier reliability
Delivery reliability	On-time pick-up	Supplier satisfaction
Delivery security	On-time shipment-delivery	The transport and warehouse capacity utilization
Educated employee	Order accuracy	Timeliness
Effectiveness in distribution operations	Order entry methods	Total / overall satisfaction
Effectiveness of delivery invoice methods	Order procedure convenience	Total logistics management costs
Emergency shipping	Overhead cost	Total order cycle time
Employee satisfaction	Packaging activities	Total Supply chain cycle time
Environmental awareness/understanding	Past performance	Transport capacity
Environmental group satisfaction	Perceived quality	Value added cost
Equipment cleanliness	Perceived value of product	Value-added activities
Equity ratio	Personnel attitude	Warehouse capacity
Ethical responsibility	Picking/shipping accuracy	Warehouse cycle time
Fill rates	Process cycle time	Warehouse labor productivity
Financial perspective-profitability	Product and service variety	Warranty cost
	Product clarity	Willingness for information sharing

The on-time shipment, lead time, backorder or stock-outs, shipping error, and fill rate are top five KPIs mentioned according to the literature research of KPIs in international logistics firms (See Table 2).

Table 2 the Most Mentioned First Five KPIs of Logistics Literature

KPIs	Mention Ratio (%)
On-time Shipment/delivery	52
Lead Time	32
Backorder/Stock-outs	32
Shipping error	28
Fill Rates	24

On-time shipment/delivery: The right products are delivered correctly at the right time.
Lead time: The time between the orders initiated and the right product delivered without damage.
Backorder/stock-out: the order cannot be delivered due to the lack of adequate products available in stock.
Shipping error: the number related to shipping mistakes such as mislabeled packaging, neglecting package dimension, etc.
Fill rates: the ratio of the volume of the vehicle utilized to the total volume.

III. METHODOLOGY

Shain and Mahbod proposed the combined method of the AHP and SMART Goal Setting. The combined method is used in this research to prioritize the most cited KPIs. AHP is used as a multi - criteria decision-making approach to prioritize the top five KPIs mentioned in the literature with the help of SMART (Specific, Measurement, Attainable, Realistic, and Time-Sensitive) goal-setting method. The KPIs should be consistent with the SMART acronym. The integration of the AHP and SMART Goal Setting will be an assistant to determine the consistent KPIs in the logistics firms. The process starts with prioritizing the goals with AHP. After all of the goals are prioritized, the following steps can be seen in Fig. 1. (a) First of all, all of the KPIs are defined; as the second stage The AHP Hierarchy based on SMART characteristics is built; pairwise comparison matrices are generated between alternatives however in this case which are the KPIs defined; global weights are calculated; (b) the KPIs that are more relevant to the goals are selected.

A. Analytical Hierarchy Process (AHP)

AHP, a multi-criteria decision-making method is a great way to evaluate KPIs due to all the risks participating [1]. AHP can be a convincing technique when it is applied for complicated decision - making problem for TQM implementation [3]. One of the advantages of AHP is to make both qualitative and quantitative decision qualities consistent, and to be flexible in terms of determining objectives [5].

AHP which is the decision-making tool proposed to effectively aid in making the best solution of complex multiple criteria problems by handling combining both tangible and intangible factors and sub-factors to weight and prioritize is introduced by Thomas L. Saaty [10]. Decomposition of structural hierarchy, pair wise comparative judgments, and synthesis of priorities and the measurement of consistency are the three steps of the AHP [9]. The first step is to decompose the structural hierarchy of the problem into a hierarchical framework such as goal, criteria, and alternatives. AHP problems are defined in at least three levels for complex decisions to be structured as a hierarchy from the general goal to various "criteria", "sub-criteria", and so on. The main purpose is placed at the top of the hierarchy. Criteria follow the main purpose as in intermediate level. Sub-criteria may occupy as a level between criteria and alternatives in some cases. Finally, the decision alternatives are found on the lowest level of the hierarchy. As a creative task of the process, to establish a structural hierarchy problem may require creative thinking depending on the nature or type of managerial decision using different perspectives [10]. Pair wise comparison matrices are created to each element to determine the priorities of the elements in the hierarchical framework in Equation (1);

$$A= [a_{ij}]nxn\ i=1,...,n\ j=1,...,n \quad (1)$$

For each element in each level of the hierarchy, a set of matrices of relative rankings is obtained for the element of the immediately higher level to conduct pairwise comparisons. Such

pairwise comparison matrices are structured to prioritize and transform individual comparative assessments between the elements via ratio scale measurements. The significance of each criterion is subjective. The significance values are given by the decision-maker, such as supervisors or experts, and written on the matrices [10]. The scale that is used to determine the importance is a nine- point scale (See Table 3).

Table 3 the Nine- Point Scale [10]

Intensity of Importance	**Definition**	**Explanation**
1	Equal importance	Two activities contribute equally to the objective
3	Moderately preferred	Experience and judgment slightly favor one activity over another
5	Strongly preferred	Experience and judgment strongly or essentially favour one activity over another
7	Very strongly preferred	An activity is strongly favored over another and its dominance demonstrated in practice
9	Extremely preferred	The evidence favoring one activity over another is of the highest degree possible of affirmation
2, 4, 6,8	Intermediates values	Used to represent compromise between the preferences listed above
Reciprocals	Reciprocals for inverse comparison	

After the pair wise comparison matrices are obtained, eigenvectors or in other word, the relative weights (the relative importance of the elements compared to each other) as in Equation (2), global weights in Equation (3), and the maximum eigenvalue that is also known as λ_{max} for each matrix are calculated in Equation (4) by solving the matrices of order n and a new matrix is created as a result;

$$B_i=[b_{ij}]_{nx1} \quad i=1,...,n \quad b_{ij}=\frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \tag{2}$$

$$C_i=[b_{ij}]_{nxn} \quad i=1,...,n \quad j=1,...,n \tag{3}$$

$$W_i=\frac{\sum_{j=1}^{n} c_{ij}}{n} \qquad W_i=[w_i]_{nx1}$$

$$D=[a_{ij}]_{nxn} \times [w_i]_{nx1} = [d_i]_{nx1} \tag{4}$$

$$E_i=\frac{d_i}{w_i} \quad i=1,...,n \quad \lambda_{max}=\frac{\sum_{i=1}^{n} E_i}{n}$$

When the eigenvectors (the relative weights), global weights and the λ_{max} are achieved, the consistency index is calculated for the matrices of order n by the formula in Equation (5);

$$CI = (\lambda_{max} - n)/(n-1) \tag{5}$$

The value of the random consistency index (RI) based on matrix size from 1 to 10 obtained by approximating random indices using a sample size of 500 (See Table 4) [10].

Table 4 Average Random Index (RI) based on matrix size [10]

n	1	2	3	4	5	6	7	8	9	10

RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

The consistency ratio is then calculated using the Equation (6);

$$CR = CI/RI \quad (6)$$

The acceptable CR range is different depending on the size of matrix i.e. 0.05 for a 3 by 3 matrix, 0.08 for a 4 by 4 matrix and 0.1 for all larger matrices, n≥ 5 [12]. If the value of the CR is more than the acceptable range, the evaluation is inconsistent. The process should be reviewed.

B. SMART Goal Setting

Goal setting is one of the key points to take "right" steps on the way of success, and it is one of the first steps that should be held. The most significant advantage of goal setting is that it is a great tool to guarantee that work is completed on the correct intention, at the accurate time, by the proper staff, in the right utilization of assets [1].

The SMART acronym was first introduced by Doran in 1981. Doran said that "The establishment of objectives of the development of their respective action plans is the most critical step in a company's management process." The acronym that is effective to be associated with setting the ideal goal is SMART. The acronym should be specific on the target area to improve, measurable to be an indicator of progress, assignable to specify who is in charge to manage the process, realistic to see if the goal is achievable within the current resources, time-based to see the due date. The acronym is not limited with the five criteria; also SMARTER acronym is used [8]. KPIs reveal the success level on the way to achieve the goal/s. The goal/s should be clear and concrete. Table 5 displays the words associated with each letter of the SMART acronym that is taken into consideration while determining the KPIs in the paper with the reasons.

Table 5 Smart Goal Setting for Logistics Sector

SPECIFIC	Each criterion in terms of clear and detailed feasibility (which must be able to response such questions as who, where, when, how) and will be evaluated in comparison with the corresponding criteria.
MEASURABLE	Each criterion will be evaluated in comparison with the criteria in terms of concrete measurability by defining the physical manifestations of the goal to make it easier to reach.
ATTAINABLE	Each criterion in terms of being reasonable and achievable, and will be evaluated in comparison with the corresponding criteria.
REALISTIC	Each criterion will be assessed in terms of its realism and the availability of its resources in comparison with the corresponding criteria.
TIME-SENSITIVE	Each criterion will be evaluated in comparison with the corresponding criteria by having a time interval. KPI should provide the structure and depend on this time interval so the analyst is able to monitor the progress.

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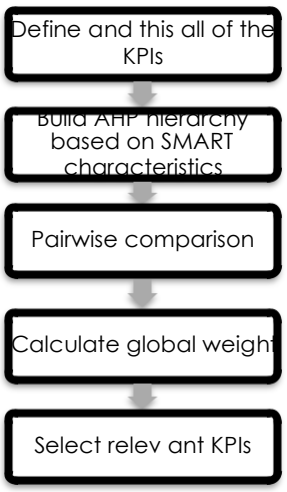
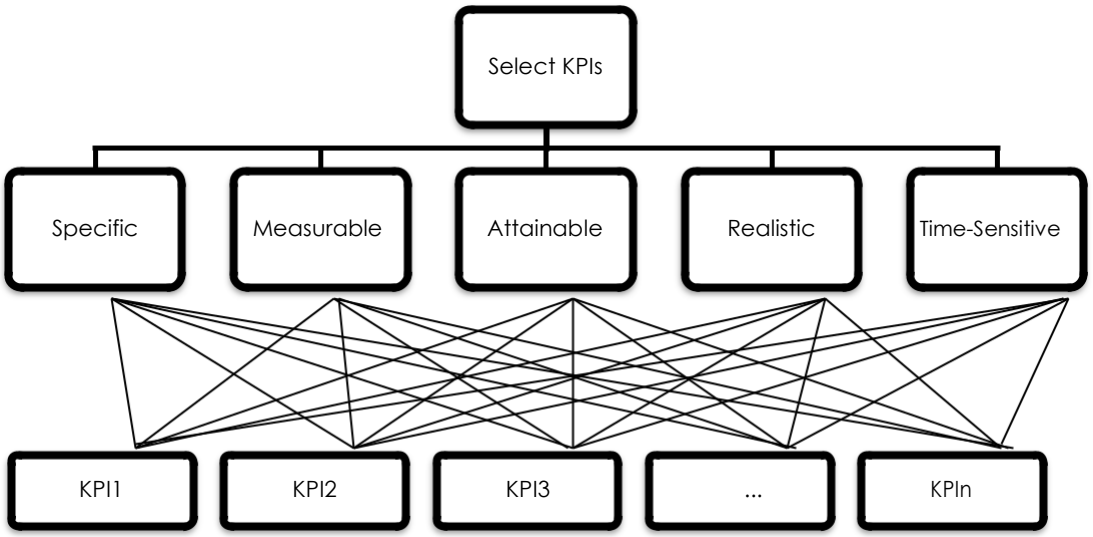
Fig. 1 Integration of The AHP Method and SMART Goal Setting [1]



a)



b)

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IV. ANALYSIS OF THE MODEL

Table 6 The Pair wise Comparison Matrices of KPIs With Relative Importance Weights

	On-time Shipment-delivery	*Lead Time*	*Backorder /Stock-outs*	*Shipping error*	*Fill Rates*	*Relative Importance*
Specific:						
On-time delivery-shipment	**1.000**	**0.497**	**0.446**	**0.735**	**0.393**	**0.106**
Lead Time	**2.010**	**1.000**	**0.378**	**0.633**	**0.218**	**0.118**
Backorder/Stock-outs	**2.241**	**2.646**	**1.000**	**0.699**	**0.523**	**0.205**
Shipping error	**1.361**	**1.579**	**1.432**	**1.000**	**0.398**	**0.183**
Fill Rates	**2.546**	**4.583**	**1.911**	**2.515**	**1.000**	**0.388**
Measurable:						
On-time delivery-shipment	**1.000**	**0.498**	**0.386**	**0.664**	**0.369**	**0.093**
Lead Time	**2.006**	**1.000**	**0.218**	**0.622**	**0.198**	**0.098**
Backorder/Stock-outs	**2.590**	**4.583**	**1.000**	**0.751**	**0.467**	**0.224**
Shipping error	**1.506**	**1.607**	**1.332**	**1.000**	**0.188**	**0.149**
Fill Rates	**2.711**	**5.045**	**2.141**	**5.318**	**1.000**	**0.436**
Attainable:						
On-time delivery-shipment	**1.000**	**0.244**	**0.225**	**0.386**	**0.237**	**0.061**
Lead Time	**4.091**	**1.000**	**0.293**	**0.595**	**0.440**	**0.142**
Backorder/Stock-outs	**4.450**	**3.409**	**1.000**	**0.633**	**0.565**	**0.243**
Shipping error	**2.590**	**1.682**	**1.579**	**1.000**	**0.427**	**0.208**
Fill Rates	**4.213**	**2.272**	**1.769**	**2.340**	**1.000**	**0.346**
Realistic:						
On-time delivery-shipment	**1.000**	**0.298**	**0.481**	**0.790**	**0.595**	**0.111**
Lead Time	**3.350**	**1.000**	**0.435**	**0.841**	**0.595**	**0.183**
Backorder/Stock-outs	**2.079**	**2.300**	**1.000**	**0.773**	**0.523**	**0.211**
Shipping error	**1.266**	**1.189**	**1.294**	**1.000**	**0.263**	**0.160**
Fill Rates	**1.682**	**1.682**	**1.911**	**3.807**	**1.000**	**0.335**
Time-Sensitive:						
On-time delivery-shipment	**1.000**	**0.485**	**0.485**	**1.189**	**1.012**	**0.153**
Lead Time	**2.060**	**1.000**	**0.355**	**0.849**	**0.816**	**0.172**
Backorder/Stock-outs	**2.060**	**2.817**	**1.000**	**1.027**	**0.726**	**0.258**
Shipping error	**0.841**	**1.178**	**0.974**	**1.000**	**0.355**	**0.153**
Fill Rates	**0.988**	**1.225**	**1.377**	**2.817**	**1.000**	**0.264**

The analysis starts with pair wise comparison matrices (see Table 6). The importance of each selected KPI is evaluated in terms of their conformity to SMART characteristics by experts. The evaluations of each logistics expert were obtained by taking geometric means, and pairwise comparison matrices were created. Eigenvectors or relative importance values are calculated as the next step after obtaining the pairwise comparison matrices by summing up each. Later, each element is divided by the sum of its column. The same process is implemented for the SMART acronym, as can be seen in Table 7. Time-Sensitivity is the most significant criterion for logistics companies.

Table 7 The Pair wise Comparison Matrices of SMART Acronym With Relative Importance Weights

	Specific	Measurable	Attainable	Realistic	Time-Sensitive	*Relative Importance*
Specific	**1.000**	**0.261**	**0.411**	**0.863**	**0.411**	**0.098**
Measurable	**3.834**	**1.000**	**0.809**	**0.719**	**0.439**	**0.190**
Attainable	**2.432**	**1.236**	**1.000**	**1.158**	**0.695**	**0.210**
Realistic	**1.158**	**1.390**	**0.863**	**1.000**	**0.293**	**0.153**
Time-Sensitive	**2.432**	**2.280**	**1.439**	**3.409**	**1.000**	**0.348**

The final weights for each KPI are calculated as:

0.098*0.106+0.190*0.089+0.210*0.61+0.153*0.106+0.348*0.153

The results of the calculation of final weights of each KPI are seen in Table 8.

V. RESULTS AND CONCLUSION

In this study, Microsoft Excel is utilized for the computations. Consistency rates of each comparison matrix are therefore below 0.1 in the calculations of pairwise comparison matrices, so that all the comparison matrices are consistent. The results show that the most important KPI, which is compatible with SMART criteria, are fill rates, backorder/stock -outs, shipping error, lead time, and on-time delivery, as seen in Table 8.

Table 8 The Final Weights

KPIs	Final Weights	Ranking
On-time delivery-shipment	0.109	**5**
Lead Time	0.146	**4**
Backorder/Stockouts	0.234	**2**
Shipping error	0.169	**3**
Fill Rates	0.341	**1**

AHP/SMART Method is used because of its advantage of being able to consider both qualitative and quantitative factors. The hierarchy applied at the beginning of the method describes the general situation more clearly and also explains the possible communication between the criteria and the alternatives better. In this case, KPIs are considered as alternatives. As conclusion, the five most important KPIs of logistics are ranked in Table 8. As mentioned at the beginning of the paper, KPIs are essential for TQM. In the logistics sector, Logistics 4.0 has become even more critical in today's conditions and technology. Accordingly, the preferences of the logistics companies, depending on the preferences of quality perception, and KPIs change and develop depending on the understanding of quality. This research provides the basis for the next study. The next research should concentrate on the evolving concept of performance along with the requirements of the ever-evolving idea of Logistics 4.0 and how the present circumstances will evolve.

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AUTHORS

A. Nazlıcan GÖZAÇAN is with Yaşar University/ International Logistics Management, Izmir, Turkey (e-mail: nazlicangozacan@outlook.com).

B. Çisem LAFCI is with Yaşar University/ International Logistics Management, Izmir, Turkey (e-mail: cisemlafci@gmail.com).

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