Physical Distribution Flexibility in Logistics Systems and Its Impact on Productivity

Ömür Tosun and Fahriye Uysal
Ayşe Sak School of Applied Sciences, Department of Internaional Trade and Logistics, Akdeniz University, Antalya, Turkey
E-mail: {omurtosun, fahriyeuysal}@akdeniz.edu.tr

Abstract—**This paper aims to develop the construct of physical distribution flexibility within the context of logistics system. This is important that the role of flexibility in satisfying competitive opportunities while accommodating logistics uncertainties. Therefore, the role of different physical distribution flexibility types in delivering strategic outcomes is determined. The construct of physical distribution flexibility is via review of existing literature focus on the role of operational flexibility for both competitive advantage as a response to coping logistics uncertainty. The application part of this study is improved to model the effects of physical distribution flexibility on productivity in courier companies. Competitive firms are ranked due to their perception on the customers using grey approach.**

Index Terms—**supply chain, flexibility, logistics, grey approach**

I. Introduction

To succeed in an uncertain and competitive environment, firms must respond to changing customer needs faster than before, and logistics flexibility is an important part of this response. Customer loyalty can be changed easily if the firms cannot satisfy any of their needs. Each customer is looking for special treatment in design, production, and delivery, which is the main reason for the firms must view flexibility from a supply chain perspective instead of equipment or process perspective.

Upton [1] defines flexibility as increasing the range of products available, improving the firm's ability to respond quickly, and achieving good performance over a wide range of products. From the customers' perspective, cross-functional as well as cross-company efforts are needed to eliminate bottlenecks, increase responsiveness, and create a level of performance that builds competitive advantage [2].

II. Logistics Flexibility

Logistics flexibility is the ability of a firm to respond quickly and efficiently to continuously changing customer needs in inbound and outbound delivery, support, and services. It enables firms to satisfy demand as it occurs rather than forecast sales and react to future orders. Logistics flexibility includes many activities such as organizing inbound and outbound shipments, providing manufacturing support, and supplying information to coordinate these efforts. With logistics flexibility, a firm can delay commitment, embrace change, and fine tune delivery to meet specific customer needs. Logistics flexibility is supported by a market-oriented strategy where all parties work together to create a fast, efficient, and reliable supply chain [3].

Quick response was the main goal of a logistic system. To ensure quick response in highly competitive situations, as demanded by the time-based strategy, suppliers resorted to increased service levels, thereby increasing costs. Flexibility in logistic systems may well represent a potential source of improved efficiency [4].

Flexibility becomes particularly relevant when the whole supply chain is considered, consisting of a network of supply, production, and delivering firms. In this case, many sources of uncertainty have to be handled, such as market demand, supplier lead time, product quality, and information delay. Flexibility allows switching production among different plants and suppliers, so that management can cope with internal and external variability [5].

In a global scenario, not only manufacturing, but also logistics can be an important source of competitive advantage, since material flows strongly affect business performance. Different logistics channels of the supply chain can be activated in order to face emergencies such as demand peaks. The production order assignments to the plants and the organization of transports are then critical decisional factors that can decrease the performance of a wide range of products [5].

Flexibility seeks to increase range/variety, improve mobility/responsiveness, and achieve uniform performance. Range is the firm's ability to design, make, and distribute different products. Range is high when the number of products is large and the degree of difference among the products is great. Mobility is the speed at which a firm can change from one product to another. So, flexibility is even greater when a firm can switch quickly among a large number of different products. Uniformity is the ability to maintain performance standards as a firm switches among products. For example, high uniformity implies the ability to maintain high quality as the product

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is changed. The greatest level of flexibility is achieved when a firm can quickly change between a large number of very different products and maintain uniformly high performance [3].

The logistics performance of a supply chain is also affected by the supply strategy: for instance, components can be delivered to a production plant from a local and/or from a distant supplier, as well as by single, double, or multiple sourcing. The choice of a supply strategy depends, for instance, either on the critical role of the component or on the logistics complexity (for instance, commodity parts and big components are usually provided by local suppliers). Different distribution and procurement policies are considered in the paper. In particular, each assembler can purchase the needed components from (according to an increasing value of flexibility): one (local), more than one (limited), all the available suppliers (global), respectively. Similarly, different distribution policies are considered: each assembler can deliver its products to the close market (local), to more than one market (limited), and/or to all the markets (global) [5].

Physical distribution flexibility is the ability of a firm to adjust the inventory, packaging, warehousing, and transportation of physical products to meet customer needs, quickly and effectively. It's also called as outbound logistics flexibility. Physical distribution flexibility involves material and information flow, and it demands agility in activities such as packaging, warehousing, and outgoing transportation.

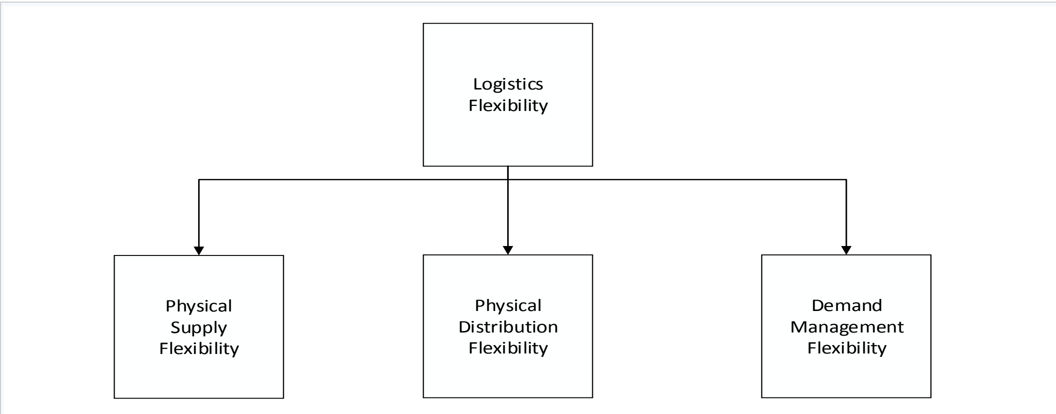

Figure 1. Basic model of the flexibility

These capabilities are important to strategic responses because they are visible to customers. The types of packaging and the number of transportation modes capture the range attribute of physical distribution flexibility. Mobility can be assessed by the time and cost to use different transportation modes and different packages. Uniformity can be examined by quality and delivery dependability across the various outgoing products. Physical distribution is a capability because it impacts the customer directly through delivery speed and quality. Customers experience firsthand the performance of the distribution system [5].

III. Application

In the courier business, different firms try to gain advantage over each other to satisfy their customers and even to obtain another's customer. Distribution flexibility becomes the main actor in this survival strategy.

To measure the effect of distribution flexibility, a basic model is developed according to the literature survey. Simple questionnaires are developed and asked to the customers of the courier firms to identify the competitive advantage points for the customers and rank the different firms on the business. The basic study model is given in Fig. 1.

Customers are asked to evaluate the three properties of the logistics flexibility for each company. Courier alternatives are ranked according to the importance value of the obtained logistic flexibility. For this evaluation, the Grey approach [6], [7] is used.

In the Grey approach, there are m possible warehouse alternatives given as $W = \{W_1, W_2, \dots, W_m\}$. $A = \{A_1, A_2, \dots, A_n\}$ is the set of n independent criteria. $\Theta w\ \{\Theta w_1, \Theta w_2, \dots, \Theta w_n\}$ is the vector of criteria weights. In this study, criteria weights and ratings of the warehouses are taken as linguistic variables. These values are given in Table I and Table II. In Table I, linguistic criteria weights whereas in Table II criteria rating values ΘG in Grey numbers are given. A Grey number is shown as $\Theta \mathrm{G} = [\underline{G}, \overline{G}]$. The detailed procedure is given below [6].

TABLE I. Scale of Attribute Weights

Scale	W
Very low (VL)	[0.0, 0.1]
Low (L)	[0.1, 0.3]
Medium Low (ML)	[0.3, 0.4]
Medium (M)	[0.4, 0.5]
Medium High (MH)	[0.5, 0.6]
High (H)	[0.6, 0.9]
Very High (VH)	[0.9, 1.0]

TABLE II. SCALE OF ATTRIBUTE RATINGS

Scale	W
Very poor (VP)	[0, 1]
Poor (P)	[1, 3]
Medium Poor (MP)	[3, 4]
Fair (F)	[4, 5]
Medium Good (MG)	[5, 6]
Good (G)	[6, 9]
Very Good (VG)	[9, 10]

Step 1: Criteria weight identification

A group of decision makers (DM) identifies the criteria weights. If there is *K* number of decision maker, then the criteria weight is calculated as

$$\Theta w_j = \frac{1}{K}\left[\Theta w_j^1 + \Theta w_j^2 + \cdots + \Theta w_j^K\right] \quad (1)$$

where Θw_j^K $(j = 1, 2, \dots, n)$ is the criteria weight of the *K*th DM.

Step 2: Criteria rating value in linguistic variables

Criteria rating values in linguistic variables are calculated using

$$\Theta G_{ij} = \frac{1}{K}\left[\Theta G_{ij}^1 + \Theta G_{ij}^2 + \cdots + \Theta G_{ij}^K\right] \quad (2)$$

where ΘG_{ij}^K $(i = 1, 2, \dots, m;\ j = 1, 2, \dots, n)$ is the criteria rating value of the *K*th DM.

Step 3: Establish the Grey decision matrix

ΘGij are linguistic variables based on the grey number. Grey decision matrix is:

$$\begin{bmatrix} \Theta G11 & \Theta G12 & \cdots & \Theta G1n \\ \Theta G21 & \Theta G22 & & \Theta G2n \\ \vdots & & \ddots & \vdots \\ \Theta Gm1 & \Theta Gm2 & \cdots & \Theta Gmn \end{bmatrix} \quad (3)$$

Step 4: Normalize the Grey decision matrix

In the normalization process, the ranges of the Grey numbers are limited to [0, 1]. Normalization depends on either minimization (cost) or maximization (benefit) of the criteria. Maximization criteria ΘG_{ij}^* is given as

$$\Theta G_{ij}^* = \left[\frac{\underline{Gij}}{G_j^{max}}, \frac{\overline{Gij}}{G_j^{max}}\right], G_j^{max} = max_{1\le i \le m\{\overline{Gij}\}} \quad (4)$$

Minimization criteria ΘG_{ij}^* is given as below

$$\Theta G_{ij}^* = \left[\frac{G_j^{min}}{\overline{Gij}}, \frac{G_j^{min}}{\underline{Gij}}\right], G_j^{min} = min_{1\le i \le m\{\underline{Gij}\}} \quad (5)$$

Step 5: Establish the weighted normalized Grey decision matrix

The weighted normalized Grey decision matrix is the product of normalized Grey decision matrix and criteria weights $(\Theta Vij = \Theta G_{ij}^* * \Theta w_j)$.

Step 6: Set ideal warehouse alternative as referential warehouse alternative

From *m* possible warehouse alternative set (S = {S_1, S_2, …,S_m}) the ideal referential warehouse alternative ($S^{max} = \{G_1^{max}, G_2^{max}, \dots, G_n^{max}\}$) by using

$$S^{max} = \left\{ \begin{matrix} \left[\underset{1 \le i \le m}{max}\underline{Vi1}, \underset{1 \le i \le m}{max}\overline{Vi1}\right], \dots, \\ \left[\underset{\le i \le m}{max}\underline{Vin}, \underset{1 \le i \le m}{max}\overline{Vin}\right] \end{matrix} \right\} \quad (6)$$

Step 7: Calculate the Grey possibilities

Compare warehouse alternatives set S = {S_1, S_2, …,S_m} with ideal referential warehouse alternative S^{max};

$$P\{S_i \le S^{max}\} = \frac{1}{n}\sum_{j=1}^{n}\{\Theta Vij \le \Theta G_{ij}^{max}\} \quad (7)$$

Step 8: Prioritize warehouses

Rank the order of warehouse alternatives based on the comparison given in (7). If S_i value is smaller, the ranking order of S_i is better. Otherwise, the ranking order is worse.

In this study, five alternatives firms (S) are selected according to their marketing share in Turkey. Four decision makers (DM) are selected from different companies using these couriers heavily in their business life. Each of them is evaluated according to the criteria physical supply flexibility (C_1), physical distribution flexibility (C_2) and demand management flexibility (C_3). The calculation procedure is given below:

Step 1

By using (1), criteria weights are calculated.

Step 2

Criteria ratings values for six warehouse alternatives are calculated by using (2).

Step 3

Using (3), establish the grey decision matrix.

Step 4

Establish the grey normalized decision table.

Step 5

Establish the grey weighted normalized decision table.

Step 6

Make the ideal warehouse S^{max} a referential alternative, using (6).

S^{max} = {[0.436, 0.675], [0.700, 0.975], [0.365, 0.650]}

Step 7

Calculate the grey possibility degrees, using (7). Grey possibility degree results are given below:

$P\{S_1 \le S^{max}\}$ = 0.737

$P\{S_3 \le S^{max}\}$ = 0.632

$P\{S_5 \le S^{max}\}$ = 0.542

$P\{S_2 \le S^{max}\}$ = 0.698

$P\{S_4 \le S^{max}\}$ = 0.546

Step 8

Rank the order of six warehouses, according to the results given in Step 7.

$S_5 > S_4 > S_3 > S_2 > S_1$

From the results, it's seen that S_5 is the most suitable alternative for the companies when flexibility is in the foreground.

IV. Results and Discussion

Courier company selection with the focus point of flexibility for the customer is applied in this study. Selection process is a multi-criteria decision-making problem including both quantitative and qualitative criteria. A basic flexibility structural model with three criteria is designed and expert are asked to evaluate the alternative firms based on this model. In this paper, a multi-criteria decision making approach for sustainable warehouse location selection is given. Physical supply flexibility, physical distribution flexibility and demand management flexibility are selected as the indicators of the physical distribution flexibility. The proposed method is applied to select the proper company which has the advantage of flexibility from the point of its customers. By using Grey approach, alternative 5 can be selected as the most flexible company.

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References

[1] D. M. Upton, "Management of manufacturing flexibility," *California Management*, vol. 36, no. 2, pp. 72-89, 1994.

[2] G. Hamel and C. K. Prahalad, "Strategic intent," *Harvard Business Review*, pp. 63-76, May-June 1989.

[3] Q. Zhang, M. A. Vonderembse, and J. S. Lim, "Logistics flexibility and its impact on customer satisfaction," *The International Journal of Logistics Management*, vol. 16, no. 1, pp. 71-95, 2005.

[4] M. Barad and D. E. Sapir, "Flexibility in logistic systems-modeling and performance evaluation," *International Journal of Production Economics*, vol. 85, pp. 155-170, 2003.

[5] A. C. Garavelli, "Flexibility configurations for the supply chain management," *International Journal of Production Economics*, vol. 85, pp. 141-153, 2003.

[6] G. Li, D. Yamaguchi, and M. Nagai, "A grey-based decision-making approach to the supplier selection problem," *Mathematical and Computer Modeling*, vol. 46, no. 3–4, pp. 573–571, 2007.

[7] J. J. Zhang, D. S. Wu, and D. L. Olso, "The method of grey related analysis to multiple attribute decision making problems with interval numbers," *Mathematical and Computer Modeling*, vol. 42, no. 9–10, pp. 991–998, 2005.

Ömür TOSUN has a Ph.D. degree of Business Administration in the department Production Management, University of Akdeniz, Antalya-Turkey. He received the BS in industrial engineering in 2002 from Dokuz Eylül University (Turkey), and MBA in 2005 in from University of Akdeniz. Her research interests include operation research, metaheuristics and scheduling.

Fahriye UYSAL has a Ph.D. degree of Business Administration in the department Production Management, University of Akdeniz, Antalya-Turkey. She received the BS in industrial engineering in 1991 from Dokuz Eylül University (Turkey), and MBA in 2000 in Food Economics and Administration from University of Akdeniz. Her research interests include operation research, logistics and supply chain management.