Application of the QFD Technique Method in Logistics Strategy

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Abstract: One of the most significant corporate challenges today is to meet customer expectations. In order for customer satisfaction to be achieved, it is necessary to review the entire corporate system and related processes and coordinate the various corporate strategies. In the recent past, it was widely regarded as sufficient by managers to develop the right marketing strategy in order to sell a product. However, there is currently a discussion as to whether a marketing logistics strategy as a well-designed logistics environment is needed to sell the product and thereby gain customer satisfaction. In this article, we present the Quality Function Deployment (QFD) technique, an effective tool for transforming consumer needs into technical, quality characteristics. The method of QFD technique can also be successfully applied in the field of logistics. Utilizing it ensures the possibility of examining the impact of the sub-areas and processes of marketing and logistics services on the basis of customer needs. In addition, visual control can be used to illustrate that whilst two products require the same logistics strategy, lead times already cause significant differences in the interaction of logistics processes and technological parameters. The analysis also highlights the shortcomings of the logistics environment, thereby supporting the decision-making of the company management in both marketing and logistics strategy planning.

Keywords: logistics; marketing; logistics strategy; 6R; Quality Function Deployment (QFD); visual control

1 Introduction

The life and decision-making structure of companies have undergone significant changes in recent decades. Due to the competitive nature of the market, meeting customer expectations at the highest possible level has come to the forefront, and marketing has also gained significant ground.

As a result, expert groups specializing in marketing strategy are constantly formed to deal with the analysis of various effects on consumer decisions and define advertising strategies and campaigns for the sale of goods.

When defining a marketing strategy, it is necessary to define the logistics strategy at the same time, as customer service requires a well-established logistics system. In order to map the logistics environment required for a given product, the Quality Function Deployment (QFD) technique method was used [1]. After the presentation of the QFD technique, the applicability of this method in the field of logistics is described.

The adequacy of logistics processes depends to a large extent on choosing the right processes for the right logistics strategy. The appropriate logistics solution depends on what strategic decisions are made, such as Push or Pull, centralized or decentralized, single-stage or multi-stage in distribution, single-channel, or multi-channel.

Different logistics strategies can be well supported by different methods, for which the QFD technique is an excellent analogy [2]. But it is not only beneficial to plan things but also to recognize the real difference between each logistics strategy and possibly to explore new strategic considerations.

Therefore, in this article, as a working hypothesis, we also included the issue of the obvious short and long lead times in the study, which resulted in an interesting finding.

For our analysis, we constructed a relationship matrix that forms the core of the QFD technique for four different products: examples with short and long lead times in Push and Pull systems. At the intersections of the matrix, we use the values according to the relevance of the given relationship.

From the values obtained here, we show through visualization what differences are caused by different logistics strategies and nonidentical lead times.

With our research, we would like to explain that, taking into account the specifics of a given product, the same system is implemented through different logistics processes.

After evaluating the relationship matrix, it can be clearly decided what logistics strategy the product requires, and this can also be used to develop the company's marketing logistics strategy [3].

2 The Impact of Marketing on Logistics Strategy

To raise the issue, we first describe, through an example, what happens when a marketing strategy is not aligned with the logistics system.

The case in point is when a product suddenly gains popularity as a result of advertisements, but the associated supply chain is insufficiently prepared for this increased demand.

The customer enters the store with the intention of purchasing the product that has caught everyone’s attention as a result of the marketing strategy. After serving the first few customers, the store runs out of stock, meaning only a portion of the increased demand is met, causing in turn dissatisfaction in the customers. The customer either has to then wait for a new supply of the product or look for another point of sale where the product is in stock, but perhaps not for the same price.

Such an example clearly shows that for a product to succeed, the needs for logistics services (6R) must also be met. Indeed, meeting customer expectations not only means that the right product is available of the right quality and at the right cost, but also in the right place, at the right time and in the right quantity, since each product is sold together with the associated logistics service.

In order to analyze the current state of the logistics system and its possible shortcomings, it is necessary to examine the following areas:

- Check product availability and stock available at the depot.

- Consideration should be given to whether storage capacity is available when purchasing larger stocks, or whether customers can be served by intermittent delivery.

- It is necessary to map whether there is a supplier who ensures regular, scheduled delivery and is able to respond appropriately to suddenly increased demands.

If we examine a product in the light of the entire supply chain, then an analysis of the production parameters is also necessary, as the capacity of the factory and the availability of the raw material also significantly influence the satisfaction of customer needs. [4].

Based on the examination of the elements of the supply chain, it can be suggested that it is not enough to only discuss marketing or logistics. In the case of a well-functioning company, it becomes necessary to define a marketing logistics strategy, since the product is sold together with the related services Therefore, the efficiency of a company's logistics system is reflected in the quality of customer service [5].

In order to quantify customer needs, it is necessary to choose a technique, the application of which not only deals with one sub-process but also connects customer expectations in a targeted way with various company activities and technical parameters.

One of today’s forgotten quality techniques is the Quality Function Deployment (QFD) technique, the use of which has declined significantly in Europe, but is still used in the Far East as a key element of engineering design [6].

3 Application of QFD Technique

The QFD philosophy originated in Japan, and its concept was developed by Professor Yoji Akao in 1966.

According to Akao, QFD is a technique for developing a quality product for customer satisfaction and translating consumer requirements into design goals throughout the manufacturing process, ensuring the realization of a quality product at the design stage, and extending quality control to the stage where there is not a finished product, just a concept or plan [7].

Shortly after the introduction of this technology significant cost reductions were seen, and its application spread rapidly among manufacturing companies.

The QFD technique is basically a design process that takes a qualitative approach to new products. Design, development, and implementation are also driven by customer needs and values [8].

It aims to meet the highest possible level of consumer needs through the design of manufacture and production planning processes developed by engineers, taking into account customer expectations. It can also be used as a documentation tool, as it provides an overview of each step of the design [9].

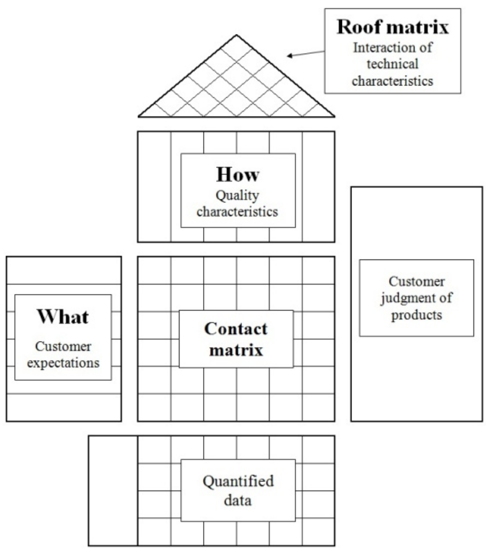

Figure 1
Structure of the House of Quality (HOQ) with the functions of each area [13]

A practical formalism of transforming consumer needs into technical, quality features is the House of Quality (HOQ) [10], as shown in Figure 1. It works as an aid to examine the expectations of the market, the technical factors influencing satisfaction, the quality of competitor products, and it also helps in determining the technical parameters.

The quality house matrix of the QFD technique can be used effectively to design logistics strategies [11]. The needs of the customer can be examined both in the design of the new logistics environment and in relation to the existing logistics system.

This clarifies the logistics strategy applicable to the introduction of a given product, thus avoiding a potentially erroneous corporate decision. [12].

As described in the previous chapter, QFD is a systematic design preparation method that seeks to more fully meet customer needs, a technique used by manufacturers and service providers to gather requirements, expectations, and customer purchasing decision factors [14].

It is essential to realize customer needs thoroughly and to translate these needs into the professional, technical language of product design so that customer expectations are met [15].

To apply the method, a marketing and technical survey must first be prepared. In the first round, the customer needs and the priorities set for the product are collected. The survey is prepared on the customer side using the interview and questionnaire technique, and on the corporate side using the brainstorming method.

The parameters of the competing products and their suitability for the customer must be examined, including niche markets. If available, product compliance can also be supported by analyzing previous product development experience. Part of the preparation of the survey is also the cost estimate of the production process.

The practical tool for the implementation of the method is the previously mentioned quality house, in which data is processed by matrix technology.

The data needed to complete the matrix is collected and made available by different disciplines.

The task of marketers is to map the needs of the customer, by asking the "What does the customer want?" question, and filling the answers in the rows of the matrix.

The data required for the columns of the matrix is compiled by the product or service designers, based on the technical, quality characteristics, and product parameters suitable for satisfying the customer's expectations, by answering the "How is it implemented?" question.

At the intersections of the rows and columns, symbols or numbers are placed according to the relevance of the given relationship, which expresses the correlation between customer needs and the characteristics taken into account during the design.

Quantified data is collected in the continuation of the columns, and in the extension of the rows, customer opinions of the products are included. The roof matrix provides space for the interrelationships of the designed product characteristics.

During the practical implementation of the QFD, the planning can be further divided into 4 stages: product and component design, process, and production planning. Accordingly, we can apply a four-phase QFD procedure with the construction of 4 different quality housings, which creates an analysis based on customer specifics, taking into account the specifics of the fields [16].

Throughout the four-phase QFD process, product parameters can be determined from the conceptual characteristics of the product, and process characteristics can be determined in turn from them. Due to the transparency of the design, they provide a firm basis for the preparation of complete product documentation, which can be presented during an audit or when the product is approved, if required.

4 Use of Multiphases QFD Method in Logistics

By applying the QFD method in the field of logistics, the target values of the design and production process can be determined through the derivation of primary customer needs.

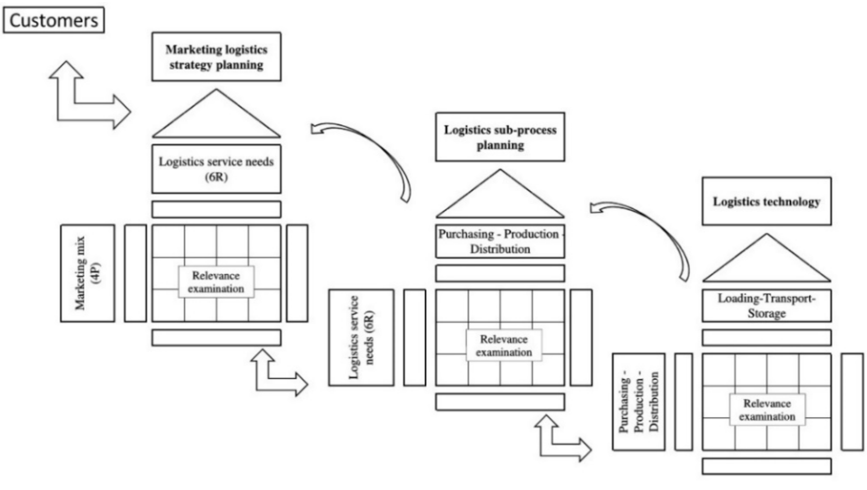

Figure 2
Three phases in the process used to design logistics strategies strategies

The use of the matrix and the study of the interaction of processes and parameters support the selection of the appropriate logistics strategy for a given product.

One of the main differences from the original four-step process is that when designing logistics systems, we can discuss a three-phase process (Figure 2), as the component design is already integrated into the process as an element of logistics systems.

Another difference between the quality houses of the QFD technique and the houses used in logistics is that we perform a relevance test of the indicated sub-processes, thus clarifying the effect of the processes on each other by examining a given product.

The elements of the relationship matrix for examining the relevance of the three-phase logistics procedure have been elaborated in detail. The starting point of the study is in each case the marketing mix elements are defined by customer expectations. These are compared through three steps to the needs related to the logistics service, then to the logistics sub-processes and technological parameters.

In the following, the elements of the relationship matrix are detailed for each phase.

				Logistics service					
				R_1	R_2	R_3	R_4	R_5	R_6
				λ_1	λ_2	λ_3	λ_4	λ_5	λ_6
				The right product	In the right quantity	Of the right quality	At the right time	In the right place	For the right cost
Marketing mix (4P)	**P_1**	γ_1	Quality						
		γ_2	Physical appearance (design)						
		γ_3	Product availability						
		γ_4	Manufacturing technology						
		γ_5	Customer service						
		γ_6	Logistics resilience *						
	P_2	γ_6	Price						
		γ_7	Discounted price						
	P_3	γ_8	Product life cycle						
		γ_9	Number of distribution channels						
		γ_{10}	Product location						
		γ_{11}	Assortment						
		γ_{12}	Stock						
	P_4	γ_{13}	Advertisement						
		γ_{14}	Sales promotion						

Figure 3
The first phase: the marketing-logistics strategic planning

The first house (Figure 3) is designed to support marketing-logistics strategy planning. Therefore, among the elements of the marketing mix, we introduced a new concept called “logistics resilience”. This is necessary as a product may be suitable in all respects, but if it is unsuitable for storage and transport, it will not reach the buyer.

The product alone does not represent value in use, only if we add both the space value and the time value produced by logistics. Thus, the characteristics of the product related to its traditional value in use should not contradict its logistics parameters (e.g., an excellent product but not deliverable). For this reason, even at the design stage, it is necessary to examine how suitable the product is for logistics, i.e., whether it can be transported and stored properly.

Logistical resilience, therefore, means that we have to produce a product with a value in use on which we can still place the logistical burdens needed to produce place value and time value.

				Procurement					**Manufacturing**					**Distribution**				
				I_1	I_2	I_3	I_4	I_5	M_1	M_2	M_3	M_4	M_5	O_1	O_2	O_3	O_4	O_5
				Procurement planning	Price and cost analysis	Selection of suppliers	Track orders	Determining material requirements plans	Production schedule	Lead time	Constant production volume	Inventory level	Fast, low-cost transition	Delivery item sizes	Number of goods handling	Fast and reliable delivery method	Inventory costs	Strong IT relationship between manufacturer and customer
Logistics service needs (6R)	**R_1**	λ_1	The right product															
	R_2	λ_2	In the right quantity															
	R_3	λ_3	Of the right quality															
	R_4	λ_4	At the right time															
	R_5	λ_5	In the right place															
	R_6	λ_6	For the right cost															

Figure 4
The second phase: the logistics sub-process planning

The second phase (Figure 4) is the logistics sub-process design, where we examine logistics service needs (6R) in relation to procurement, production, and distribution processes.

In this relationship matrix, the levels of relevance between 6R and logistics sub-processes can be mapped to help clarify the relevance of logistics sub-processes to the expectations for logistics services when examining a given product.

The third phase (Figure 5) is to examine the components of logistics technology, where the elements of procurement, production, and distribution are compared with the parameters of loading – transport - storage.

In this relationship matrix, the relevance of the previously formulated logistics sub-processes with technological elements is examined. It can be used to clarify how logistics sub-processes and technological parameters interact for a given product, thus clarifying the applicable logistics strategy.

			Loading			**Transport**					**Storage**				**IT**
			L_1	L_2	L_3	T_1	T_2	T_3	T_4	T_5	W_1	W_2	W_3	W_4	β_1
			Number of distribution channels	Documentation of incoming goods	Quality control	Shipping distance	Delivery frequency	Delivery unit	Distance of depots	Order item size	Storage costs	The size of the stock to be stored	Warehouse administration	Number of types of goods	IT support
Procurement	I_1	Procurement planning													
	I_2	Price and cost analysis													
	I_3	Selection of suppliers													
	I_4	Track orders													
	I_5	Determining material requirements plans													
Manufacturing	M_1	Production schedule													
	M_2	Lead time													
	M_3	Constant production volume													
	M_4	Inventory level													
	M_5	Fast, low-cost transition													
Distribution	O_1	Delivery item sizes													
	O_2	Number of goods handling													
	O_3	Fast and reliable delivery method													
	O_4	Inventory costs													
	O_5	Strong IT relationship between manufacturer and customer													

Figure 5

The third phase: the logistics technology

4.1 Practical Application of the Method to Select the Appropriate Logistics Strategy

In order to be able to properly illustrate the application of the QFD technique method in the field of logistics, we created a relationship matrix that forms the “trunk” of the first, second, and third houses for 4 products. For each product tested, a relevance study was performed using the three-phase logistics procedure, which can be found in Appendices 1, 2, 3, and 4.

The relationship matrices included the parameters compiled on the principle from the previous chapter. Our decision was based on the fact that we can see the relevance of the processes in context through the application of the three-phase logistics procedure. In this way, it can be clarified what differences can be discovered during strategic decisions.

The starting point for defining the products is the Push and Pull systems used in logistics, which already assume a logistics strategy of sorts. For this, we examine products with different lead times. In the present study, we selected the examples that form the basis of the relevance study based on these parameters. The exemplary products in Appendices 1, 2, 3, and 4 represent our present decision and can be modified as needed during further studies.

During the completion of the relationship matrices, we analyze the effect of the listed, previously known expectations and the different sub-processes on each other.

In the relationship matrices in Appendices 1, 2, 3, and 4, the relevance assessment is examined in the range 0, 1, and 2, to which a meaning is also associated in the legend (Table 1). These values can be normalized later with Fuzzy [17]. Since the use of Fuzzy sets in logistics is often closer to the practical approach, it is necessary to convert the crisp numbers in the results into Fuzzy sets, that is, to properly evaluate the results, it is necessary to use the Fuzzy QFD technique [21].

Table 1

Legend for Appendices 1, 2, 3, 4

Legend	
2	Significantly relevant
1	Relevant
0	Neutral /not relevant

On the relationship matrices of the product tests in the appendix, it clearly seems that the Push and Pull strategy already fundamentally defines the logistics sub-processes of the product.

Products manufactured in the Push principle system are made based on forecasted order data, in larger quantities. In contrast, the products of the Pull system are made to a specific order, an express customer demand [18].

Lead time is a parameter that affects all logistics processes, as one of the important “milestones” of customer satisfaction is when the customer receives the product [19].

As can be clearly seen from the prepared contact matrices, lead time and customer expectations related to the product already cause significant differences in terms of logistics sub-processes as well as the marketing concept to be developed.

The examination of the four different products (Appendices 1, 2, 3, 4) clearly confirms that, given the specificities of a given product, the same system is implemented through different logistical processes.

Applying the method of QFD technique in the field of logistics clarifies what kind of logistics strategy a given product or service requires.

4.2 Impact of Push and Pull Logistics Strategy and Lead Time on Logistics Sub-Processes and Logistics Technology

The product-specific relevance studies in the appendix were based on the Push and Pull strategies and the different lead times. Using visual control techniques, we illustrate:

- differences in the relevance of products with the same logistics strategy but different lead times,

- and the difference in relevance between products with a defined logistics strategy and the same lead time.

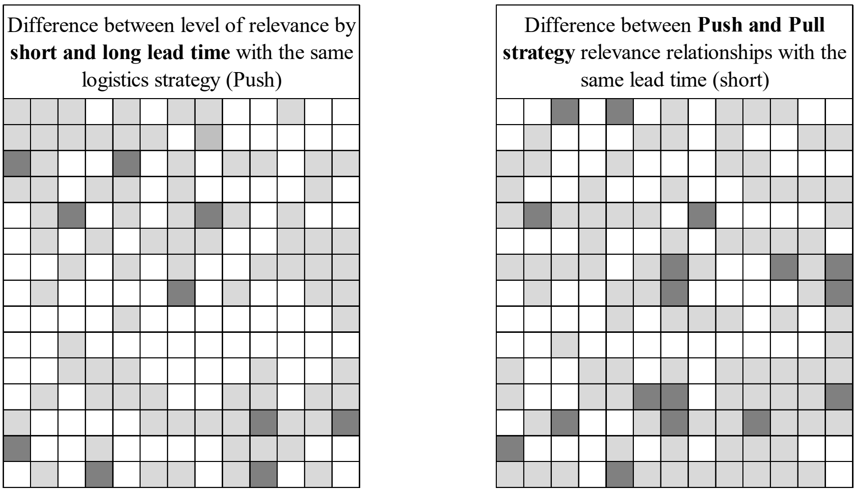

Figure 6

Using visual control technique to display the difference in relevance level between appendices 1 and 2 (left) and between appendices 1 and 3 (right)

Table 2

Legend for comparison with visual control technique (Figures 6 and 7)

Legend	
(white)	Same level of relevance
(light grey)	Relevance slightly different
(dark grey)	Relevance significantly different

Table 3
Data for the analysis of Figure 6

Legend	Level of difference	Difference between level of relevance by short and long lead time with the same logistics strategy (Pull)		Difference between Push and Pull strategy relevance relationships with the same lead time (long)	
		Number of deviations	%	Number of deviations	%
	2	17	0,09	6	0,03
	1	83	0,42	77	0,40
	0	95	0,49	112	0,57

The visual control technique helps make the differences clear (Figures 6 and 7; Table 2). If everything in the figures were white, it would mean that a uniform logistics system could be applied to all products. As different customer expectations emerge, so do increasing differences in product-related logistics processes. The visualizations are produced to highlight the tendency for dissimilar products to require different logistics strategies.

Legend	Level of difference	Difference between level of relevance by short and long lead time with the same logistics strategy (Push)		Difference between Push and Pull strategy relevance relationships with the same lead time (short)	
		Number of deviations	%	Number of deviations	%
	2	10	0,05	17	0,09
	1	82	0,42	91	0,47
	0	103	0,53	87	0,44

Figure 7
Using visual control technique to display the difference in relevance level between appendices 3 and 4 (left) and between appendices 2 and 4 (right)

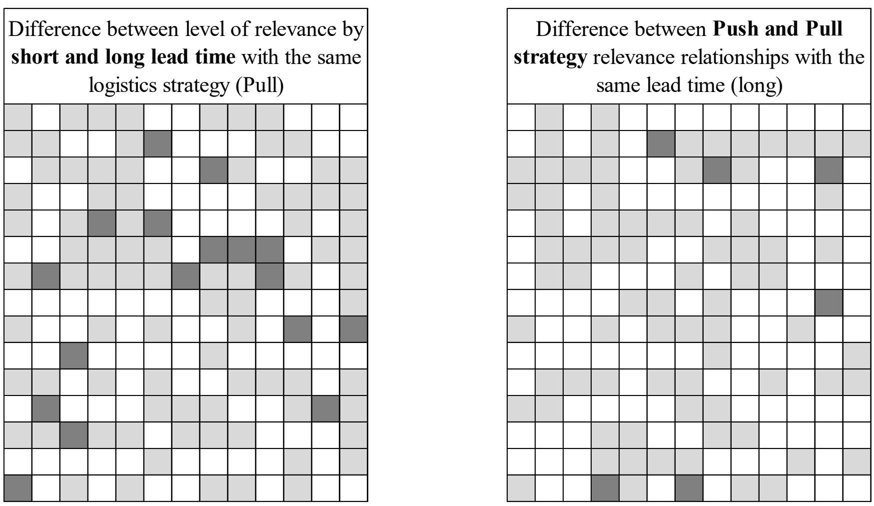

Table 4
Data for the analysis of Figure 7

In our present study, the visual control technique shows how changing the lead time and logistics strategy changes the interaction of product logistics processes and technological parameters. As can be seen in the legend, the darker the area, the more significant the difference. For the test, we used the third matrix of the relevance tests filled out with example products in appendices 1, 2, 3, and 4 called "Logistics technology", where the relevance level of logistics sub-processes was examined from the perspective of logistics technology elements. During the examination carried out with the help of visual control, we examined the differences between the relevance levels determined for the example products shown in Appendices 1, 2, 3, and 4. Dark gray refers to a significant difference between the examined products, which in this case takes the value “2”. Light gray represents minor deviations, which in this case takes the value “1”. White indicates that the relevance of the examined products shows no difference. The numbers show - based on the example products in Appendices 1, 2, 3, and 4 - how products with different logistics strategies and different lead times differ in terms of the logistics environment. As can be seen in Tables 3 and 4, the degree of deviations show similar percentages when examining the same logistics strategy with different lead times and when examining different logistics strategies with the same lead time.

The relevance studies of the example products with the Push - short lead time, Push - long lead time, Pull - short lead time, and Pull - long lead time logistics strategies in Appendices 1, 2, 3, and 4 also clearly show the significant differences between the distinct strategic decisions.

Examined in its context, it can clearly be seen through the prepared visualizations that a change in the applied logistics strategy or lead time already generates significant differences in the logistics sub-processes and the applied logistics technology.

Most of the available literature suggests strategic decisions to decide whether to use a Push or Pull logistics strategy for a particular product [20]. However, based on our analysis, it appears that at least as strategically important a decision or aptitude is whether a product has a long or short lead time. In our present study, the difference between short and long lead times based on the patch effect is larger than between the Push and Pull strategies.

The differences show that the choice between short and long lead times is of the same or sometimes greater strategic importance from a logistical point of view than when using a Push or Pull logistics strategy.

The conversion of the QFD method to logistics use and the preparation of a relevance study for a specific product provides a new scientific approach to the selection of a logistics strategy related to a specific product and to the further development of the already existing logistics environment.

Conclusions

There has been a significant recent increase in the importance of the marketing and logistics specialties, yet companies still fail to address the two areas together when developing strategies. As the market has a growing number of products with increasingly more choices, the marketing-logistics strategy has progressively gained more space.

In order to properly understand the importance of collaboration between the two areas, a technique must be used that helps meet the needs expressed by customers and the processes of engineering design. The QFD technique is used by a few, although it is one of the best methods for translating customer needs into engineering design parameters.

We found that the application of the QFD technique in the field of logistics can be used to examine the impact of each sub-area on each other, and the analysis also highlights the shortcomings of the logistics environment, thus supporting the design of logistics strategies.

In this article, we have used 4 different examples to show how this method can be used to analyze the logistics environment. We performed a relevance study, which can be used to determine the marketing-logistics strategy of a given product, through the logistics sub-processes and the applied logistics technology. In addition, we introduced the concept of logistics resilience as an element of the marketing mix, which is a new approach to product examination. It can be used to analyze whether a given product is suitable for logistics.

The analysis of the prepared connection matrices and the diagrams illustrated with the visual control technique clearly demonstrate that the logistics sub-processes and logistics technology parameters of a given product are significantly influenced by the applied logistics strategy and lead time. Therefore, it is not possible to apply a uniform logistics strategy to all companies; the specifics of the product must also be taken into account. The visual control technique provides an opportunity to subject the presented data to further, more detailed numerical analysis.

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Appendix

Appendix 1

PUSH System with short lead time. Example product: soft drink, self-service vending machine.

Marketing logistics strategic planning

Marketing mix (4P)				Logistics service R_1 λ_1 The right product	R_2 λ_2 In the right quantity	R_3 λ_3 Of the right quality	R_4 λ_4 At the right time	R_5 λ_5 In the right place	R_6 λ_6 For the right cost
	P_1	γ_1	Quality	1	0	2	0	0	1
		γ_2	Physical appearance (design)	2	1	0	0	0	2
		γ_3	Product availability	2	2	0	2	2	1
		γ_4	Manufacturing technology	0	0	2	0	0	1
		γ_5	Customer service	1	0	1	1	1	1
		γ_6	Logistics resilience *	1	0	1	0	0	1
	P_2	γ_6	Price	1	1	2	0	2	2
		γ_7	Discounted price	1	2	1	0	2	1
	P_3	γ_8	Product life cycle	1	0	2	0	2	1
		γ_9	Number of distribution channels	2	2	0	2	2	1
		γ_{10}	Product location	2	2	0	2	2	2
		γ_{11}	Assortment	1	0	0	0	1	2
		γ_{12}	Stock	2	2	0	2	2	2
	P_4	γ_{13}	Advertisement	2	2	1	2	2	2
		γ_{14}	Sales promotion	2	2	1	2	2	2

Logistics sub-process planning

Logistics service needs (6R)				Procurement I_1 Procurement planning	I_2 Price and cost analysis	I_3 Selection of suppliers	I_4 Track orders	I_5 Determining material requirements plans	Manufacturing M_1 Production schedule	M_2 Lead time	M_3 Constant production volume	M_4 Inventory level	M_5 Fast, low-cost transition	Distribution O_1 Delivery item sizes	O_2 Number of goods handling	O_3 Fast and reliable delivery method	O_4 Inventory costs	O_5 Strong IT relationship between manufacturer and customer
	R_1	λ_1	The right product	1	1	2	0	1	2	2	2	2	1	2	1	2	1	2
	R_2	λ_2	In the right quantity	2	2	2	1	2	2	1	2	2	1	1	1	2	1	2
	R_3	λ_3	Of the right quality	2	1	1	0	2	0	0	0	0	0	0	0	1	0	0
	R_4	λ_4	At the right time	2	1	2	2	2	2	2	1	1	1	0	1	2	1	2
	R_5	λ_5	In the right place	2	0	2	2	2	1	1	1	2	1	1	2	2	1	2
	R_6	λ_6	For the right cost	2	2	2	1	1	1	0	0	1	1	1	1	1	2	1

Legend	
2	Significantly relevant
1	Relevant
0	Neutral /not relevant

Logistics technology

			Loading L_1 Number of distribution channels	L_2 Documentation of incoming goods	L_3 Quality control	Transport T_1 Shipping distance	T_2 Delivery frequency	T_3 Delivery unit	T_4 Distance of depots	T_5 Order item size	Storage W_1 Storage costs	W_2 The size of the stock to be stored	W_3 Warehouse administration	W_4 Number of types of goods	IT β_1 IT support
Procurement	I_1	Procurement planning	0	2	2	1	0	1	1	1	1	1	1	2	2
	I_2	Price and cost analysis	0	0	0	1	0	1	1	2	2	1	0	1	1
	I_3	Selection of suppliers	2	1	1	2	0	1	0	2	0	2	1	1	2
	I_4	Track orders	1	1	1	0	0	0	1	0	0	0	1	0	2
	I_5	Determining material requirements plans	0	2	2	1	0	1	0	0	1	2	1	2	2
Manufacturing	M_1	Production schedule	1	0	1	2	2	1	1	2	1	1	1	1	1
	M_2	Lead time	1	1	1	2	2	0	2	1	1	2	2	0	2
	M_3	Constant production volume	0	1	0	0	2	1	2	1	0	1	0	1	2
	M_4	Inventory level	1	0	0	1	2	1	1	1	2	2	1	2	1
	M_5	Fast, low-cost transition	0	0	1	0	0	0	0	1	0	0	0	2	0
Distribution	O_1	Delivery item sizes	0	0	0	1	1	2	1	2	1	2	1	1	1
	O_2	Number of goods handling	2	0	1	2	2	2	2	2	1	1	1	1	2
	O_3	Fast and reliable delivery method	2	0	0	2	2	2	2	2	0	2	1	1	2
	O_4	Inventory costs	2	0	0	0	1	1	1	1	1	1	1	1	0
	O_5	Strong IT relationship between manufacturer and customer	1	0	0	0	2	1	1	1	0	2	2	1	2

Appendix 2

PUSH System with long lead time. Example product: socks.

Marketing logistics strategic planning

Marketing mix (4P)				Logistics service					
				R_1	R_2	R_3	R_4	R_5	R_6
				λ_1	λ_2	λ_3	λ_4	λ_5	λ_6
				The right product	In the right quantity	Of the right quality	At the right time	In the right place	For the right cost
Marketing mix (4P)	P_1	γ_1	Quality	2	0	2	1	0	2
		γ_2	Physical appearance (design)	2	1	0	1	0	1
		γ_3	Product availability	1	0	0	2	1	2
		γ_4	Manufacturing technology	1	1	2	1	0	1
		γ_5	Customer service	1	0	1	1	1	0
		γ_6	Logistics resilience *	1	0	0	0	0	1
	P_2	γ_6	Price	1	1	1	0	0	2
		γ_7	Discounted price	1	1	0	0	0	2
	P_3	γ_8	Product life cycle	1	1	0	0	0	1
		γ_9	Number of distribution channels	0	0	0	1	2	2
		γ_{10}	Product location	0	0	0	1	2	0
		γ_{11}	Assortment	1	2	0	0	0	2
		γ_{12}	Stock	1	0	0	1	1	1
	P_4	γ_{13}	Advertisement	1	1	1	1	1	2
		γ_{14}	Sales promotion	0	1	0	1	1	2

Logistics sub-process planning

Logistics service needs (6R)			Procurement					Manufacturing					Distribution				
			I_1	I_2	I_3	I_4	I_5	M_1	M_2	M_3	M_4	M_5	O_1	O_2	O_3	O_4	O_5
			Procurement planning	Price and cost analysis	Selection of suppliers	Track orders	Determining material requirements plans	Production schedule	Lead time	Constant production volume	Inventory level	Fast, low-cost transition	Delivery item sizes	Number of goods handling	Fast and reliable delivery method	Inventory costs	Strong IT relationship between manufacturer and customer
R_1	λ_1	The right product	2	1	2	0	0	0	0	2	0	0	0	0	0	0	1
R_2	λ_2	In the right quantity	2	1	2	0	2	0	0	2	2	0	1	0	1	1	1
R_3	λ_3	Of the right quality	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0
R_4	λ_4	At the right time	0	0	1	0	2	1	1	1	2	0	1	1	0	0	0
R_5	λ_5	In the right place	0	0	1	0	0	1	1	1	2	0	1	0	2	0	0
R_6	λ_6	For the right cost	2	2	2	1	0	0	0	1	1	1	1	1	1	2	1

Legend	
2	Significantly relevant
1	Relevant
0	Neutral /not relevant

Logistics technology

			Loading			Transport					Storage				IT
			L_1	L_2	L_3	T_1	T_2	T_3	T_4	T_5	W_1	W_2	W_3	W_4	β_1
			Number of distribution channels	Documentation of incoming goods	Quality control	Shipping distance	Delivery frequency	Delivery unit	Distance of depots	Order item size	Storage costs	The size of the stock to be stored	Warehouse administration	Number of types of goods	IT support
Procurement	I_1	Procurement planning	1	1	1	1	1	1	0	2	1	1	0	2	2
	I_2	Price and cost analysis	1	1	1	2	1	2	1	1	2	1	0	1	1
	I_3	Selection of suppliers	0	2	1	2	2	1	1	2	1	1	1	2	1
	I_4	Track orders	0	2	1	1	1	0	0	0	0	0	1	1	2
	I_5	Determining material requirements plans	0	1	0	1	1	1	1	2	2	2	0	2	2
Manufacturing	M_1	Production schedule	1	1	1	1	2	0	0	1	1	1	0	2	2
	M_2	Lead time	1	1	0	0	1	0	1	1	1	1	1	1	1
	M_3	Constant production volume	0	0	0	0	2	1	0	1	1	1	0	2	1
	M_4	Inventory level	1	0	0	1	1	1	1	1	2	2	1	2	2
	M_5	Fast, low-cost transition	0	0	0	0	0	0	0	1	0	0	0	2	0
Distribution	O_1	Delivery item sizes	0	0	1	2	2	2	1	2	1	1	1	1	0
	O_2	Number of goods handling	2	1	1	1	1	1	2	2	0	0	1	2	1
	O_3	Fast and reliable delivery method	1	0	0	2	2	1	1	1	1	0	0	0	0
	O_4	Inventory costs	0	0	0	1	1	1	1	1	2	2	0	1	0
	O_5	Strong IT relationship between manufacturer and customer	1	1	0	2	2	0	2	1	1	0	2	2	2

Appendix 3

PULL System with short lead time. Example product: pizza.

Marketing logistics strategic planning

				Logistics service					
				R_1	R_2	R_3	R_4	R_5	R_6
				λ_1	λ_2	λ_3	λ_4	λ_5	λ_6
				The right product	In the right quantity	Of the right quality	At the right time	In the right place	For the right cost
Marketing mix (4P)	P_1	γ_1	Quality	1	0	2	2	2	2
		γ_2	Physical appearance (design)	2	0	2	0	0	1
		γ_3	Product availability	1	2	0	2	2	1
		γ_4	Manufacturing technology	2	2	2	2	2	2
		γ_5	Customer service	2	0	2	2	2	2
		γ_6	Logistics resilience *	2	0	2	1	1	1
	P_2	γ_6	Price	0	2	0	1	1	2
		γ_7	Discounted price	0	2	0	0	0	2
	P_3	γ_8	Product life cycle	0	0	0	0	0	0
		γ_9	Number of distribution channels	2	0	1	1	2	1
		γ_{10}	Product location	1	0	0	2	2	0
		γ_{11}	Assortment	2	2	2	0	0	1
		γ_{12}	Stock	1	0	0	2	2	2
	P_4	γ_{13}	Advertisement	1	0	2	2	2	2
		γ_{14}	Sales promotion	1	0	2	2	2	2

Legend	
2	Significantly relevant
1	Relevant
0	Neutral /not relevant

Logistics sub-process planning

				Procurement					Manufacturing					Distribution				
				I_1	I_2	I_3	I_4	I_5	M_1	M_2	M_3	M_4	M_5	O_1	O_2	O_3	O_4	O_5
				Procurement planning	Price and cost analysis	Selection of suppliers	Track orders	Determining material requirements plans	Production schedule	Lead time	Constant production volume	Inventory level	Fast, low-cost transition	Delivery item sizes	Number of goods handling	Fast and reliable delivery method	Inventory costs	Strong IT relationship between manufacturer and customer
Logistics service needs (6R)	**R_1**	λ_1	The right product	1	1	1	1	2	2	2	0	0	2	0	0	2	0	2
	R_2	λ_2	In the right quantity	2	1	1	2	2	2	0	0	0	2	2	0	1	0	2
	R_3	λ_3	Of the right quality	1	1	2	2	0	0	2	0	0	1	1	1	1	0	0
	R_4	λ_4	At the right time	2	0	1	1	0	2	2	0	1	2	2	1	2	0	1
	R_5	λ_5	In the right place	2	0	1	1	0	1	0	0	1	1	1	0	2	0	2
	R_6	λ_6	For the right cost	1	2	1	0	2	0	1	1	1	2	1	0	1	0	1

Logistics technology

			Loading			Transport					Storage				IT
			L_1	L_2	L_3	T_1	T_2	T_3	T_4	T_5	W_1	W_2	W_3	W_4	β_1
			Number of distribution channels	Documentation of incoming goods	Quality control	Shipping distance	Delivery frequency	Delivery unit	Distance of depots	Order item size	Storage costs	The size of the stock to be stored	Warehouse administration	Number of types of goods	IT support
Procurement	I_1	Procurement planning	0	2	0	1	2	1	0	1	2	2	0	2	2
	I_2	Price and cost analysis	0	1	0	1	0	2	0	2	1	1	0	2	2
	I_3	Selection of suppliers	1	2	1	2	1	1	0	2	1	1	1	1	2
	I_4	Track orders	0	1	1	1	0	0	0	0	0	1	0	1	1
	I_5	Determining material requirements plans	1	0	1	2	1	2	0	2	1	2	1	2	1
Manufacturing	M_1	Production schedule	1	0	1	1	2	1	0	2	2	2	0	2	1
	M_2	Lead time	0	0	0	1	2	1	0	2	1	2	0	1	0
	M_3	Constant production volume	0	0	0	0	1	0	0	1	0	1	0	0	0
	M_4	Inventory level	1	0	0	1	1	1	0	0	1	2	0	2	0
	M_5	Fast, low-cost transition	0	0	2	0	0	0	0	1	0	0	0	2	1
Distribution	O_1	Delivery item sizes	1	0	0	2	2	2	0	2	0	1	0	0	0
	O_2	Number of goods handling	1	0	1	1	1	0	0	2	0	0	0	0	0
	O_3	Fast and reliable delivery method	2	1	2	2	2	1	0	1	1	0	0	0	1
	O_4	Inventory costs	0	0	0	0	0	1	0	1	2	2	0	1	0
	O_5	Strong IT relationship between manufacturer and customer	0	1	1	0	0	0	0	0	1	1	1	2	2

Appendix 4

PULL System with long lead time. Example product: custom made car.

Marketing logistics strategic planning

				Logistics service					
				R_1	R_2	R_3	R_4	R_5	R_6
				λ_1	λ_2	λ_3	λ_4	λ_5	λ_6
				The right product	In the right quantity	Of the right quality	At the right time	In the right place	For the right cost
Marketing mix (4P)	P_1	γ_1	Quality	2	0	2	0	0	1
		γ_2	Physical appearance (design)	1	0	2	0	0	1
		γ_3	Product availability	0	0	0	0	0	0
		γ_4	Manufacturing technology	1	1	2	1	0	2
		γ_5	Customer service	0	0	1	1	1	2
		γ_6	Logistics resilience *	2	0	2	1	0	2
	P_2	γ_6	Price	1	0	1	1	0	2
		γ_7	Discounted price	0	0	0	0	0	1
	P_3	γ_8	Product life cycle	1	0	1	0	0	2
		γ_9	Number of distribution channels	0	0	0	2	0	1
		γ_{10}	Product location	0	0	0	1	0	0
		γ_{11}	Assortment	0	0	0	0	0	0
		γ_{12}	Stock	0	0	0	0	0	0
	P_4	γ_{13}	Advertisement	1	0	0	0	0	1
		γ_{14}	Sales promotion	1	0	1	0	0	1

Logistics sub-process planning

				Procurement					Manufacturing					Distribution				
				I_1	I_2	I_3	I_4	I_5	M_1	M_2	M_3	M_4	M_5	O_1	O_2	O_3	O_4	O_5
				Procurement planning	Price and cost analysis	Selection of suppliers	Track orders	Determining material requirements plans	Production schedule	Lead time	Constant production volume	Inventory level	Fast, low-cost transition	Delivery item sizes	Number of goods handling	Fast and reliable delivery method	Inventory costs	Strong IT relationship between manufacturer and customer
Logistics service needs (6R)	**R_1**	λ_1	The right product	0	0	1	0	1	0	0	0	0	0	0	0	1	0	2
	R_2	λ_2	In the right quantity	1	0	1	1	2	1	1	1	1	1	1	0	0	1	0
	R_3	λ_3	Of the right quality	0	1	2	0	1	0	0	0	0	0	0	0	1	0	0
	R_4	λ_4	At the right time	2	0	1	1	2	2	2	1	1	1	0	1	2	0	2
	R_5	λ_5	In the right place	1	0	0	0	1	0	0	1	0	0	0	1	2	0	2
	R_6	λ_6	For the right cost	2	2	1	1	1	2	0	2	2	2	1	1	1	2	1

Legend	
2	Significantly relevant
1	Relevant
0	Neutral /not relevant

Logistics technology

			Loading			Transport					Storage				IT
			L_1	L_2	L_3	T_1	T_2	T_3	T_4	T_5	W_1	W_2	W_3	W_4	β_1
			Number of distribution channels	Documentation of incoming goods	Quality control	Shipping distance	Delivery frequency	Delivery unit	Distance of depots	Order item size	Storage costs	The size of the stock to be stored	Warehouse administration	Number of types of goods	IT support
Procurement	I_1	Procurement planning	1	2	1	2	1	1	0	2	1	1	0	2	2
	I_2	Price and cost analysis	1	0	0	1	1	0	0	2	1	0	1	2	2
	I_3	Selection of suppliers	1	1	0	1	2	1	0	0	0	1	1	0	1
	I_4	Track orders	1	1	1	2	1	0	0	0	0	0	1	0	2
	I_5	Determining material requirements plans	0	0	0	0	0	0	0	2	1	2	0	2	2
Manufacturing	M_1	Production schedule	1	0	0	0	1	0	0	0	0	0	0	1	2
	M_2	Lead time	1	2	1	0	1	0	2	1	0	0	1	1	1
	M_3	Constant production volume	0	0	0	0	1	0	0	0	1	1	0	0	1
	M_4	Inventory level	0	0	0	0	1	0	0	0	2	2	2	2	2
	M_5	Fast, low-cost transition	0	0	0	0	0	0	0	0	0	0	0	2	1
Distribution	O_1	Delivery item sizes	0	1	0	1	2	1	0	2	1	2	1	0	1
	O_2	Number of goods handling	1	2	1	1	1	1	1	1	0	0	1	2	1
	O_3	Fast and reliable delivery method	1	0	0	1	1	1	1	0	0	0	0	0	0
	O_4	Inventory costs	0	0	0	0	0	0	0	1	2	2	1	1	1
	O_5	Strong IT relationship between manufacturer and customer	2	1	0	0	1	0	0	1	0	1	2	2	2