# Design Vulnerability as the Key Element of the Logistics Efficiency of a Product

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The article highlights the importance of the influence a product itself has on the broadly understood logistics-related issues, referred to as the logistical efficiency of a product. It constitutes the foundation for the concept of design vulnerability of a product, along with its determinants. The paper shows the impact these determinants have on logistics processes on selected examples from the market. The authors of the article also suggest what actions might be undertaken in the strategic and operational sphere of the company logistics, depending on the design vulnerability of a product.

**Keywords:** design, vulnerability, efficiency, product.

## 1. INTRODUCTION

Management, especially in the age of crisis, obligates businesses to search for and implement solutions that would rationalize the costs of enterprise functioning. In this situation, every functioning area of an enterprise, along with the processes that occur there, is re-analysed and re-assessed in terms of the ability to bring any specific value to an organization. Most of the unprofitable operations or organizational units are then subject to deep re-structuring that transforms or – in extreme cases – eliminates the operations or departments that are unnecessary in the enterprise structure.

One of the more significant functional elements of each enterprise becomes logistics. Effective and efficient management of material and information flows is subject to rationalization processes and, what follows, also to assessment and analysis. However, the range of conditions analysed in the sphere of logistics remains varied and depends much on the specificity of an enterprise. Still, this does not change the general tendency where comprehensive operations that rationalize logistics aim at the fulfilment of the 7R principle.

In the course of their research work, the authors of this article noticed the high importance of a product itself in the activities aiming to improve the functioning of logistics of an enterprise. The relevance of understanding the significance of a product for the selection of the adequate way to rationalize logistics is therefore an important element that directly impacts whatever course of action is taken. This forms itself into the concept of the logistics efficiency of a product which assumes the occurrence of one of four types of vulnerability: design, transport, storage or organization-related. Since papers on transport vulnerability and its place in the logistics efficiency of a product have already been published [4,5] this publication will in a way continue the discourse and address design vulnerability in the context of logistics efficiency of a product.

## 2. LOGISTICS EFFICIENCY OF A PRODUCT

The concept of the logistics efficiency of a product has emerged in the course of research on the functioning of logistics management in manufacturing enterprises, as it turned out that there are companies on the market which, already at the stage of the conceptual preparation of their product, include certain logistics-related conceptual aspects. This way, the concept of a logistically efficient product has been defined,

meaning a manufactured item with a number of features and characteristics that facilitate or support logistics management of this product, thus bringing benefit to both the manufacturer and the customer [2]. A product as such may be viewed from the perspective of its features, i.e. elements that differentiate or characterize in an explicit way, as well as through its characteristics, not visible at first sight [8], so logistics efficiency of products should be aiming at identification of possibly biggest number of logistics-friendly product features at the design stage, taking advantage of particular favourable characteristics. This way, a product may emerge, in which the necessity to participate in logistics processes at various stages, both inside and outside of the company, would be taken into consideration already in the conceptual sphere.

The idea of the logistics efficiency of a product is based on a very significant assumption. Namely, an enterprise wishing to use this concept needs to perform a strategic analysis of its activity, including a products it owns, and thus answer the question whether their logistics and supply chain management may be the source of competitive advantage for the company, or not.

The concept of logistics efficiency of a product in its principle uses the notion of vulnerability, however significantly extended. In literature, one may frequently find the notion of transport vulnerability of a product, while logistics efficiency of a product requires a kind of complementation to the issue, by the design, storage and organizational aspect.

Design vulnerability, being the core in the concept of logistics efficiency of a product may in short be characterized as a group of features and characteristics of a product that may be altered by the designer. One needs to notice that there are products with certain features and characteristics that cannot be modified, as well as those that might be subject to certain changes. This way, some products will be vulnerable in terms of design (easily subject to design work), while others will not.

Transport, storage and organization vulnerability derive in some part from design vulnerability. Besides, they inherit these features and characteristics of a product that will not be able to be subject to design modification.

Much as the issue of transport vulnerability may be found in literature [8], and even more – it may be, to a large extent, be the base allowing describing storage vulnerability, organization vulnerability is a new concept, not used so far – in this matter research work is on-going, carried out by the authors of this article. This, the logistics efficiency of a product may be influenced by certain natural features and characteristics of a product and may be the effect of an advanced approach to logistical problems in the enterprise, this area being a carefully thought-out, already at a product design stage.

At this point, it is worth noting that the idea of the logistics efficiency of a product, or more precisely, of the company's approach to logistics issues, implies the necessity to apply a given group of actions – the strategies. Obviously, the selection of a particular strategy will be also dependent on the degree to which a given product is saturated with features and characteristics that would be design-vulnerable or not. The selection of appropriate company functioning strategy in the context of the logistics efficiency of a product will therefore result to a large extent from its design vulnerability. There are items which, due to their range of features and characteristics that impact on design vulnerability on a product itself have narrower or wider range of possible acceptable changes in a product. This in turn translates itself onto the possibility to apply a particular strategy variant – conceptual or adaptive – Table 1., along with the accompanying operational variants. Within each strategy variant it is possible to apply a particular corrective or improvement operational approach, which fully complements the model approach to logistics within the concept of the logistical efficiency of a product.

Table 1. Model approach to logistics in the strategic and operational context within the concept of the logistical efficiency of a product [3].

| | | *Operational approach* | |
|---|---|---|---|
| | | **Corrective logistics** | **Improvement logistics** |
| *Strategic approach* | **Conceptual logistics** | CC model | CI model |
| | **Adaptive logistics** | IC model | II model |

Within the strategic approach, conceptual logistics would be based on defining the most fundamental conditioning of logistics management functioning in an enterprise that would allow competitive advantage of the company on the market. The identified conditions will be, in the next stage, included in a product design process and translated into the features and characteristics of the item. This philosophy is aiming at designing

the project so that it would be able to manage it effectively along the entire supply chain. The objective of adaptive logistics will in many cases be to match possibly effective logistics activity to a product which for many reasons cannot be subject to design changes. This strategy also takes place when the company decides not to identify logistics as the main factor of competitiveness.

The operational character of the strategic approach translates itself onto the choice between two variants: The first of them, corrective logistics, deals with the correction of irregularities and errors in particular areas of logistics and generally is the result of the company having logistics management at low level of development. Improvement logistics is to improve logistics processes, by means of internal, external, functional and other comparisons to the market leaders, thus creating a new value on the market.

The presented strategies allow creating four basic models of logistics in strategic and operational context within the concept of logistics efficiency of a product.

## 3. DESIGN VULNERABILITY

One of the key challenges of modern logistics is to create and implement the awareness of joint management and operations along the supply chain [1]. If such postulate is to be fulfilled, the activity related to product design process becomes the key element allowing effective implementation of the mentioned direction of operations. It so happens because, in many cases, it is a product that that prevents efficient and effective functioning of the entire supply chain. This raises a legitimate question about the features and characteristics of a product that could be modifiable already at the design stage, so that this product could efficiently and effectively function in the entire supply chain – i.e. so that it could be logistically efficient.

Considering the concept of design vulnerability, it is worth noting that it needs in its essence to refer to the issues related to a wide range of conceptual areas: materials, commodities, quality, marketing issues and other. However, in order not to make the problem more complicated, this part of the paper will only present certain general assumptions of design vulnerability in the context of the logistics efficiency of a product.

Each product has certain natural and acquired characteristics [8] Both the natural and acquired characteristics may be to a different extent subject to design processes. Obviously, the natural ones would be much more difficult to modify, as basically, in some circumstances, they cannot be modified at all, while the acquired characteristics are the ones prevailing as subject to the designer's work which is subsequently implemented in production. Thus the key question becomes in what direction the design works should go so as to make a product logistically efficient. A need arises to identify certain particular factors which determine if the features and characteristics a product has are design vulnerable or not. In order to be able to use some structured naming, these factors were named key design elements, and are priority when it comes to particular design-related actions.

The problem of identification of key design elements should be associated with the selection of particular logistics condition of a product that will impact logistics management along the entire supply chain – important logistics factors. The foundation for this kind of a concept are the processes functioning in logistics of management, transport, packaging, inventory management or order handling for a given product. Of course, the issue of assessment and analysis of conditions, criteria and other factors related to significant logistics issues such as key product elements will become the further part of research work. For the time being, the basic processes resulting from the functional classification of logistics have been adopted as a certain kind of a base, being the starting point to the general presentation of the problem. The significant logistics factor will therefore be one or several more important logistic areas related to logistics management of a product along the entire supply chain and determining its logistics efficiency. Thus, each product should be first analysed in terms of singling out the significant logistics factor and in the analysis that follows the possibilities of changes to be made in the key design elements should be indicated.

In order to be able to analyse a product in the context of key design elements, the authors of this work have identified the change areas for the features and characteristics of a product which would at the same time determine the area of design vulnerability. They include:

- the ability to change shape (to change the basic dimensions of a product),
- the ability to change the weight,
- the ability to change the material or physiochemical properties,
- the ability to change the technology of production,

- the ability to use substitute components in a production process,
- the ability to use different packaging.

Generally, the above-presented possibilities may be called the extent to which one may interfere in a product, i.e. modifying it to enhance its logistical efficiency.

Basing on the Sheffi and Rice model [14], concerning the susceptibility of an organization to interference (as regards interference probability and circumstances), it is possible to build-up a similar dependence, in which one of the discussed areas will be the range of possible design changes related to the features and characteristics of the particular product; the other area will concern the consequences for the logistics system. This way, products with high design vulnerability will be characterized by a wide range of possible changes in their features and characteristics that will have a significant influence on the logistics system. On the other hand, products with narrow range of change possibility and low influence on the logistics system, will be products of low design vulnerability – Fig. 1.

The ability to change shape means a change made to one of its main construction parameters, i.e. width, height and depth. From the perspective of transport or storage vulnerability, it often is an important element that would rationalize particular areas of the logistics system– consequences for the logistics system. It goes without saying that adapting these traits to, for instance, means of transport that are available or the existing storage infrastructure directly contributes to an improvement of the results of transport or storage use.

It is similar with the ability to change the weight of a product, which is related to the increase or reduction of the subsystems or other elements in a product. This change may often be correlated with the possibility to change the material or with the possibility to use substitute materials in production of the components that will also impact the overall weight of a product – e.g. a bicycle frame made of steel, aluminium, composite. However, the change of material, just as the change of substitute components may also impact such parameters as resistance, brittleness or fragility which are of significance to the end user of a product as well as for the logistics processes that are planned for this product.

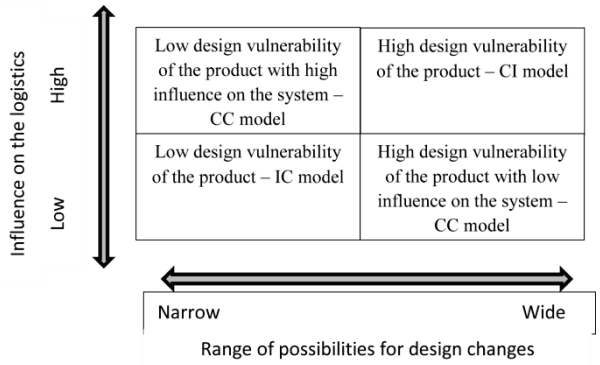


Fig.1. The degree of design vulnerability of a product depending on the capabilities of the scope of design changes and the impact on logistics system
Source: own study

The ability to change technology is mainly related to the notion of standardization and customization. Design vulnerability in this area may influence production logistics (moving towards batch or mass production) as well as on the logistics of order handling and inventory management, which along with the growing personalization of a product become increasingly more or increasingly less complicated. Of course a great importance lies in the possibility to use various kinds of packaging for the project, which obviously can effectively influence the efficiency of logistics.

Establishing the significant logistics factor for the enterprise and in the next stage the key design element, i.e. the range of possibilities for implementation of changes is therefore the starting point in the entire concept of the logistics efficiency of a product. The next stage is to translate the guidelines which stem from the most essential elements of logistics onto design-related activities. Obviously, the nature of a products and their features and characteristics may openly increase or decrease the range of possibilities in design works. They may also often lead to a kind of a conflict between the significant logistics factor and the concept of a product itself. This is why it is so important to introduce the notion of design vulnerability of a product and continue further research work in this area. A properly designed product should include such aspects as transport, storage and organizational vulnerability, which in turn should correspond with the effectiveness of logistic processes (storage, transport, packaging, order handling and inventory rationalization) in all areas of logistics (supply, production, distribution and utilization & returns).

## 4. EXAMPLES OF PRELIMINARY DESIGN VULNERABILITY ANALYSIS OF CHOSEN PRODUCTS

The presented theoretical assumptions served the authors to carry out a short analysis of chosen, deliberately selected products. They were characterized by a specific set of features and characteristics which would, in varying degrees, affect the efficiency of logistics of particular solutions. In the first instance, a significant logistics factor was presented, and the subsequent stage presented change possibilities for the key design elements. Of course, each of the examples has a short summary concerning the possible impact of the proposed solutions on chosen areas of company functioning.

The first of the described examples is the Styrofoam - expanded polystyrene, used in the manufacture of disposable trays, plates, cups and packaging for heated or chilled food. It is also used for insulation in the form of plates or loose beads injected into wall voids of buildings in the construction industry [13]. In case of polystyrene, a significant logistics factor is its transport and storage. This results from the ratio of mass and weight which in case of a product in question are quite specific. The specificity of Styrofoam is that it takes a large space despite small weight, which clearly affects the processes of transportation and storage (it takes much of cargo area, where at the same time the capacities of tonnage remain of no use). Thus the design processes should evidently concentrate on the possibility to change its physiochemical characteristics increasing its thermal conductivity, while maintaining the same volume. This kind of a change would positively influence the improvement of its vulnerability both as regards the aspects of storage and transport. Therefore, during the design process special attention should be drawn to the technological possibilities of production and on ways to improve the process. Of course, such changes are made by the manufacturers and one may find among the offers items such as polystyrene plates with different coefficients of thermal conductivity (from 0.031 to 0.045) [13], but it has direct impact on a product price. Besides, a polystyrene board itself is only one component of the thermal insulation of buildings. The remaining factors are professionalism and quality of work, the type of glue used to attach polystyrene to a given surface, and the type of plaster. The construction of the building itself does not remain without significance either, where the use of more thermally resistant solutions (i.e. plates with lower coefficients of thermal conductivity) may not bring the expected result, as the building will have many more other areas more vulnerable to heat loss.

A product of a similar kind is glass wool [15], which due to its properties is more suitable for transport and storage as it can be easily compressed before final packing. As a result, a block of glass wool with dimensions 50cm x 100cm x 5cm will take less space than an identical block of Styrofoam.

It is worth mentioning that with products like glass wool and Styrofoam design vulnerability is low; thus in many cases the only strategy that can be used, in the context of logistics product efficiency, is the adaptive strategy. This is due to the fact that manufacturing a product with better parameters, for the client and the company, without changing the price would not be possible. It determines the necessity of adapting the logistic solutions to the challenges of the market through improving (improvement logistics) or adapting (adaptive logistics).

A slightly different example is one of the world's biggest furniture companies [14]. The mentioned company focused on including logistics as an important factor that helps competitiveness. While designing their products, special attention is paid so that a product can be then packed into possibly flattest boxes while still maintaining to provide the client with functional furniture as cheap as possible. It means that transport, storage and packing play important roles in logistics. What is interesting is that at the same time the mentioned significant logistics factor should not have negative effects on the quality of a product and drastically increase the price.

It needs to be mentioned that if one was to take a closer look at the furniture companies, the level of design vulnerability is very high. Practically every key logistics element can be modified influencing the logistics efficiency of a product.

A good example that proves this thesis are the foldable corner sofas. The analysed models have de-attachable covers making it possible to keep them clean and to change its colour very quickly as well as allows to keep every colour of the given piece of furniture with low costs – the storage keeps a certain pallet of colours as a sales offer. The sofa was designed in a way so that the client can choose the fabric himself without making the purchase process any longer. Currently there are 9

colours of fabric on sale. This action results in that every sofa frame is identical.

The authors analysed how the mentioned sofa changed over the years. Analysing the current (2010) and the previous (2001) model of the sofa, it is worth noticing the design actions leading to improvements in the logistics efficiency of a product. The current model of the sofa has a different assembly system because of the way it was packed. The previous model was almost fully assembled needing only the cover to be attached. The current model requires much more assembly but at the same time the way it was packed allows for easier collection of a product from a self-service warehouse – the previous one needed to be prepared by a special customer service. The sofa used to be transported in 3 large pieces, now the customer receives four packages that can be easily transported home. In the 2001 version the sofa was assembled by the client from 3 elements. It had clinches attached. The assembly itself only consisted of screwing in 2 studs and 8 legs The new version of the corner sofa is sold in 4 packages. The seats are transported as folded with the cushions (minimalized by vacuum packing) inside. Wanting to assure the correct assembly by the client, the company uses very precise but coherent assembly instructions with such information as the number of screws need provided.

The presented features and characteristics of a product, along with the changes that appear in subsequent versions of a product have an unquestionable impact on the customer service is provide. Most furniture is adapted to a self-service sales system, which eliminates redundant logistics processes. This change allows to obtain lower production costs which is reflected in the price of the ready product (it may be observed on the example of a sofa introduced into sales in 1996, at a price of 599 Euro; in 2001 – the price would fall to 399 Euro, and in 2003 – due to the popularity of the item among families with little children, the company decided to introduce removable and easily-washable covers. In 2008, the sofa received the "Quality granted daily" award, thanks to its strong frame, a comfortable seat and a removable cover. This same year, its price was reduced to 349 Euro, and in the year 2010 the sofa was re-designed to be adequate for self-assembly by customers, which led to another reduction in its price to 299 Euro). The provided example pictures the changes that have taken place in the company in 14 years. The price of the flagship product fell as much as by 300 Euro, which amounts to 50% of the initial cost.

The presented example clearly shows that it is possible to design products that would increase the efficiency and effectiveness of logistics – logistically efficient products can be created. Moreover, the presented company makes evident use of the conceptual strategy, creating new logistics and supply chain-friendly solutions, as the design vulnerability of a product is high. Moreover, the company continuously keeps improving the existing designs, creating new value for the customer.

## 5. SUMMARY

The problem of the logistics efficiency of a product covers a wide range of knowledge. It combines not only the problems of management and logistics, but also of materials, commodities design, etc. However, it seems very useful for logistics and supply chain management to present examples of best practice and prepare certain theoretical base for the concept under discussion.

The concept of the logistics efficiency of a product is strongly correlated with the logistics management development phase in the company. It is difficult to require of the companies with internal isolation of the basic logistics functions, to have conceptual approach to logistics and product design vulnerability analysis. On the other hand, it seems appropriate to prepare certain ready-made solutions for all groups of entrepreneurs, allowing for better evaluation of their product for their logistical efficiency, a significant element of which is design vulnerability. Unquestionably, selected problems already described in literature, should also be included here, such as e.g. methods of vulnerability analysis or assessment, presented by Kroger and Zio [12].

The identification of the significant logistics factor that would translate itself onto particular changes in key design elements should be the base of product design vulnerability analysis. The analysis should not only result in the identification of design elements, which are subject to change, but also determine the choice of a specific strategy for the company.

The sooner the company becomes aware of what product they manage the faster the right path of development as regards logistics management will be found for it. Whether this will be the path of creative and conceptual manner of creating new logistics ideas in a product or if it is going to be the

path of adaptation to the changing demand of the market should be decided by the analysis of design vulnerability of a product.

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