

TRANSPORT TECHNOLOGIES

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THE TOOLS FOR PROCESSES OPTIMISATION IN MANAGING AN ENTERPRISE –
MULTI-CRITERIA OPTIMISATION**

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Abstract

The concepts of optimization, optimal, are very natural elements of our normal (everyday, colloquial) vocabulary, which are used – and one can even risk a statement overused - in situations when you want to point to the characteristics of a subject, object or phenomenon that significantly differentiate them in a given class, type or kind. This is, in a sense, an over-interpretation, especially in cases when we do not give, or are unable to indicate the criteria that constitute the essence of the space for assessing the distinguished features of the indicated object. Optimization – the method of determining the best (optimal) solution (searching for the extreme of the function) from the point of view of a given criterion (indicator) of quality (eg cost, road, efficiency). Examples of multi-criteria optimization applications could be multiplied indefinitely, hence only a few obvious examples of a quite general nature: product and production process design, financial management, aircraft design, cars (e.g. maximization of the performance indicator when limiting the vehicle's fuel consumption, or lowering the weight of the device while maximizing the strength of its individual components, etc.), maximizing profits, including the one performed by minimizing production costs. The conditions of crisis management are significantly different, with specific characteristics of the application area of multi-criteria optimization in the decision-making process. The very definition of crisis management determines a certain framework that, on the one hand, corresponds legibly with the idea and principles of multi-criteria optimization, on the other hand, they naturally prefer the indicated criteria defined by the function of the goal. The work presents the essence of the optimization problem in the simplest possible way, including in relation to crisis management conditions.

Key words: IT in logistics management; logistics; multi-criteria optimization; optimization tools; technologies and IT systems in logistics.

1. Introduction

The speed of changes taking place in turn forces entrepreneurs to constantly adjust the forms and methods of business management, the only alternative here is the loss of position in an increasingly competitive market. Today, it is not enough to just produce cheaply even with a high quality product. The list of success criteria complements the client - his preferences, cultural conditions, but also the manner and level of his service - and the flow of products and information in the logistics chain beyond the in-house production

system. This inherently dynamic perspective forces entrepreneurs to use modern tools to optimize management processes based on multi-criteria analysis supporting the decision-making process.

Information is one of the pillars of effective functioning of modern economy and business, both on a micro and macroeconomic scale. Information is a resource with the characteristics of a commodity, the management of which is subject to universally binding market laws, constituting a criterion determining the scope and form of this functioning. Its proper flow and synchronization is sometimes an essential factor in the success of the market game,

and thus the efficiency of the entity's operation on the market. The methods and means of computer science are inseparably associated with the concept of mass service systems, the essence, character and structure of which was shaped over the years as a tool for automation and optimization of processes, including repetitive processes. Such a very illustrative example of a typical environment was military logistics, where as early as in the 1930s, solutions to mass service problems were sought in the development and implementation of information technology based on subsequent generations of computational technology.

Currently, logistics departments of production and trade enterprises, which include units that deal with storage, transport, planning and purchases, as well as companies providing external logistics services are increasingly integrating their activities on the basis of the use of information technology. Enormous flows of information about raw materials and materials needed to supply the production department, about orders to be carried, require professional service while maintaining the necessary standards, which becomes an important argument for maintaining full compatibility between individual entities in the field of documents and goods flows. In this area, IT becomes a natural element of supporting the implementation of logistics processes as components of the integrated market structure. It is a natural necessity, allowing for the full use of all possibilities offered by the modern logistics concept. It allows, among other things, minimizing expenditures for the business activity of a given economic entity thanks to the systematic and thus the most efficient resource management of individual processes that take place as a result of actions to accomplish a specific business task.

2. Systems and IT in Logistics

Following The Dictionary of Foreign and Borrowed Terms, **information** can be defined as:

- providing notification about something, communicating something;
- every factor thanks to which people or automatic devices can function in a more efficient, goal-oriented way.

All material flows are accompanied by the flow of information. Information flows play a supportive role in relation to material flows, performing a

supporting function in organizing effective supply chains. The information system includes information resources and elements that enable power, maintenance and provision of these resources to the user. These are the senders and recipients of information as well as technical and organizational means of collecting, communication, processing and protecting information. It is based on the broadly understood ICT infrastructure which is the basis for the implementation and implementation of IT systems supporting the management of logistics processes in the enterprise. This system should include, among others:

- reliability determined as the probability of the system meeting its tasks in a given time,
- flexibility conditioning the maintenance of the required standards of operation with a specific dynamics of changes in the environment and enterprise development opportunities,
- openness in the scope of the possibilities of operation (compatibility) with other systems in other enterprises, which allows for the exchange of information between them, taking into account mutual links in the decision-making process.
- economic efficiency and effectiveness taking into account the cost aspect while maintaining the above features.

The logistics information system is a set of interrelated elements, i.e. people, equipment and procedures, integrated in a way that provides the enterprise logistics management bodies with a package of information necessary for planning, implementing and controlling activities that underpin the functioning of a given business entity (production, commercial, etc.).

Among dominant suppliers of integrated ERP systems, the largest market share is held by: SAP, Oracle, BAAN and JD Edwards. Figure 1 shows the percentage market share of the leading ERP software producers. The products offered by these suppliers differ from one area to another, but they share one common feature. Everyone wants to present a certain set of business practices that can be perceived by the client as an added value that can increase the future benefits it achieves.

Source: own study based on [Mabert, Soni 2001¹, pp. 69-70]

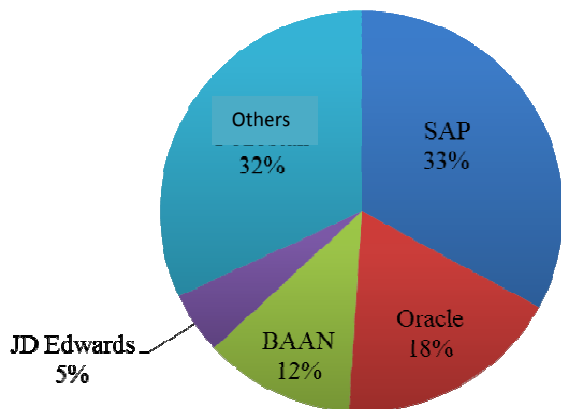


Fig. 1 the Percentage of market share of individual ERP system providers

3. Multi-Criteria Optimisation

The concept of optimization, optimal, is a very natural element of our normal (everyday, colloquial) vocabulary, used - and one can even risk a statement overused - in situations when you want to point to the characteristics of a subject, object or phenomenon that significantly differentiate them in a given class, type or kind. This is, in a sense, over interpretation, especially in cases when we do not give or are unable to indicate the criteria that constitute the essence of the space for assessing the distinguished features of the indicated object. In colloquial terms, this is not a harmful phenomenon (misleading, introducing information noise) as the use of such terms as, for example, "the most optimal".

In the most approximate terms, the concept of optimization can be defined as follows:

Optimization – the method (process) of determining the best (optimal) solution (searching for the extreme of the function) from the point of view of a specific criterion (indicator) of quality (e.g. cost, road, efficiency).

The search for the best solution is not a major problem in the situation of a single type criterion, e.g. quantitative, unambiguously indicating whether something is "better or worse". Usually, however, there is a problem in which a number of factors

(criteria) determine its status and, unfortunately, most often they remain in the antagonistic system.

Therefore, we distinguish the concepts of single- and multi-criteria optimization.

Multi-criteria optimization - an operational research department that deals with determining the optimal decision when there is more than one criterion².

Multi-criteria problem

$$f_k(x) \rightarrow \max \quad (k = 1, \dots, s)$$

$$x \in X$$

where:

x - any solution (decision)

$f_k(x)$ - objective function related to the k -th partial criterion

X - a set of acceptable solutions (decisions)

Examples of multi-criteria optimization applications could be multiplied indefinitely, hence only a few obvious examples of a quite general nature: product and production design, financial management, aircraft design, cars (eg maximization of the performance indicator while limiting the vehicle's fuel consumption or reducing the weight of the device) while maximizing the strength of its individual components, etc.), maximizing profits, including by minimizing production costs.

The conditions of crisis management are significantly different, with specific characteristics of the application area of multi-criteria optimization in the decision-making process. The very definition of crisis management determines a certain framework that, on the one hand, corresponds legibly with the idea and principles of multi-criteria optimization, on the other hand, they naturally prefer the indicated criteria defined by the function of the goal.

Crisis management – the activity of public administration bodies being an element of national security management, which consists in preventing crisis situations, preparing to take control over them through planned actions, reacting in case of crisis

¹ Subsequent publications do not specify the size of the shares while maintaining similar proportions

² Ameliańczyk A., *Wektorowa optymalizacja w modelach decyzyjnych ze szczególnym uwzględnieniem modeli growych*, WAT, Warszawa 1979

situations, removing their consequences and restoring resources and critical infrastructure³.

Crisis situations management is an extremely important field for the proper functioning of the state. In today's socio-economic realities, security turns out to be one of the most important factors that not only stabilizes growth and development processes, but also becomes an element of these processes⁴.

The definition covering the issues of planning and optimization of decisions in the conditions of crisis management is given by prof. Z. Zamiar⁵ in his work *An Outline of the Theory of Crisis Management*, pointing to the determinants and critical elements in the decision-making process, where apart from the multi-criteria **compromise** characteristic for optimization, we are confronted with the essence of priority in relation to the indicated criteria determined by the purpose function. It would seem that such a problem practically eliminates the idea of optimization in crisis conditions. Nothing more wrong. Priority criteria determine the framework and determine the nature of the optimization function in a specific scope, but they do not change the essence and principles of optimizing the use of forces and resources to achieve the purpose function.

In conclusion, wherever optimal decisions must be made in the conditions of a compromise between two or more (sometimes conflicting) criteria (goals) - we encounter the concept of **multi-criteria optimization**.

The above conclusion in a sense imposes a way of proceeding in the process of searching for the optimal solution (optimal decision), which is basically a **mini-max** compromise. The problem of ordering solutions generates the basic goals and principles that this process is subordinated to, the most important of which are:

- organizing the set of elements according to the adopted classification rules

- distinction of the smallest possible subset constituting the basis for making choices

The idea of classification in accordance with the above objectives is characterized by the so-called Hasse diagram

A graph directed $H(Z, R)$, where Z is a set of compared items, and R is a partial order relation defined on the elements of the Z set in the way that:

$$uRw \iff u \text{ "better than"} w$$

Following the definition presented, the following conclusions are drawn:

* the ordering depends on the adopted criteria, but the convergence of criteria (similarity) does not necessarily lead to the indication of the same solutions

* detailed criteria (wording, weights, etc.) are determined by the decision maker and are not always an objective reflection of reality, but rather a reflection of the decision-maker's preferences (element of risk of decision)

* in principle, the orderings show which solution is the best in the sense of the accepted criterion, and not which solution is objectively the best

Here another conceptual space is born, quite difficult to clearly define objectively, which is expressed in the questions: how to compare quantitative and qualitative criteria and how to evaluate the decision-maker's sensitivity to differences in criteria values? Is there the same threshold value for all the criteria, for the change in preferences of the decision maker? Is there full symmetry in assessing diversity?

Here another concept appears which to a certain extent objectifies the idea of ordering solutions (decisions) in the light of the adopted criteria, namely the thresholds of indiscernability. Lack of symmetry means the existence of two thresholds of indiscernability.

Definition! (Formulation of indiscernability thresholds)

- decision $D1$ is better than decision $D2$ in the sense of a given criterion, when the value of this criterion is higher by $p\%$,

- decision $D3$ is worse than decision $D2$ (in the sense of the same criterion), when the value of the criterion is lower by $q\%$.

In the context of the above considerations, it is purposeful to introduce certain ordering principles under the concept of the hierarchy of goals, with the

³The Act of April 26, 2007 on crisis management (Journal of Laws of 2007 No. 89, item 590), with further amendments.

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distinction of the main criterion and the secondary criteria (criterion).

When for a decision maker, one criterion is essential (main) and the other less important (secondary), the search for the best solution is carried out due to the main criterion, while maintaining a certain level of implementation due to the secondary criteria. However, this does not guarantee an objective indication of an unambiguously optimal solution, because in analogous conditions another entity may point to completely different priorities, sometimes even determining the decision-making process (e.g. in the conditions of crisis management).

So, setting a **compromise decision** boils down to solving the task:

$$f_1(x) \rightarrow \max \\ f_k(x) \geq p_k \quad \text{for } k=2\dots s$$

where:

$$x \in X$$

f_1 - main criterion

p_k - satisfactory level of implementation of the k -th secondary criterion

When setting a compromise solution, the established derogation from the maximum values of individual criteria cannot be exceeded. Determining the compromise decision consists in solving the sequence of auxiliary tasks Z_k ($k = 1, \dots, s$). The solution of the final task Z_s sets a compromise decision for the multi-criteria task.

4. Conclusions

The implementation of increasingly complex processes and tasks, including planning tasks, based on the flow of large amounts of information, is practically impossible without system support using information technology that proposes dedicated software packages. The development of information technology allows for an increasingly common use of MRP / ERP class software in broadly understood logistics (including a logistics enterprise), mainly in the field of logistics planning regarding material flows. The ERP system (Enterprise Resource Planning) is an integrated information system (IIS) covering the entire production and distribution

processes that integrate various areas of the company's operations. MRP (Material Requirements Planning) is an active method of inventory management developed at the turn of the 1950s and 60s, whose developed philosophy is MRP II class systems (Manufacturing Resource Planning), additionally taking into account the use of production capacities and technical equipment, integrating manufacturing operations with financial planning. These are modern management support tools that, combined with priorities and constraints (boundary parameters) defined by the crisis management function, are universal tools that allows solving even the most complex tasks in the field of multi-criteria optimization.

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Інформаційні технології в логістиці. Інструменти для оптимізації процесів управління підприємством – багатокритеріальна оптимізація

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Поняття оптимізації, оптимальності, є дуже вживаними елементами нашого звичайного (повсякденного, розмовного) словарного запасу, які використовуються у ситуаціях, коли ви хочете вказати на характеристики суб'єкта, об'єкта або явища, яке істотно розрізняє їх у даному класі, типі або виді. Це, в певному сенсі, є надмірною інтерпретацією, особливо у тих випадках, коли ми не даємо, або не можемо вказати критерії, які складають суть простору для оцінки виділених особливостей зазначеного об'єкта. Оптимізація – це метод визначення найкращого (оптимального) рішення з точки зору даного критерію (показника) якості (наприклад, вартості, дорожнього руху, ефективності). Приклади застосування багатокритеріальної оптимізації можуть бути досить різноманітними, такими як: дизайн продукції, літаків, автомобілів та особливості їх виробництва, фінансовий менеджмент, дизайн (наприклад, максимізація показника ефективності при обмеженні витрати палива на транспортному засобі або зниження ваги пристрою при максимізації сили окремих його компонентів тощо), максимізація прибутку, включаючи таку, що досягається шляхом мінімізації витрат на виробництво. Управління кризовими явищами значно відрізняється особливостями області застосування багатокритеріальної оптимізації у процесі прийняття рішень. Саме визначення кризового менеджменту визначає певну структуру, яка, з одного боку, чітко відповідає ідеї та принципам багатокритеріальної оптимізації, з іншого боку, віддає перевагу зазначеним критеріям, що визначені цільовою функцією. Робота висвітлює суть проблеми оптимізації найпростішим способом, у тому числі з урахуванням умов кризового управління.

Ключові слова: багатокритеріальна оптимізація; інструменти оптимізації; логістика; технології та ІТ-системи в логістиці; ІТ в управлінні логістикою.

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Информационные технологии в логистике. Инструменты для оптимизации процессов управления предприятием – многокритериальная оптимизация

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Понятие оптимизации, оптимальности, являются очень применяемыми элементами нашего обычного (обыденного, разговорного) словарного запаса, используемыми в ситуациях, когда вы хотите указать на характеристики субъекта, объекта или явления, которое существенно различает их в данном классе, типе или виде. Это, в определенном смысле, является избыточной интерпретацией, особенно в тех случаях, когда мы не приводим, или не можем указать критерии, которые составляют суть пространства для оценки выделенных особенностей указанного объекта. Оптимизация – это метод определения наилучшего (оптимального) решения с точки зрения данного критерия (показателя) качества (например, стоимости, дорожного движения, эффективности). Примеры применения многокритериальной оптимизации могут быть весьма разнообразными, такими как: дизайн продукции, самолетов, автомобилей и особенности их производства, финансовый менеджмент, дизайн (например, максимизация показателя эффективности при ограничении расхода топлива на транспортном средстве или снижение веса устройства при максимизации силы отдельных его компонентов и т.д.), максимизация прибыли, в том числе сведения, достигается путем минимизации затрат на производство. Управление кризисными явлениями значительно отличается особенностями области применения многокритериальной оптимизации в процессе принятия решений. Само определение кризисного менеджмента определяет соответствующую структуру, которая, с одной

стороны, четко соответствует идее и принципам многокритериальной оптимизации, с другой стороны, предпочитает указанные критерии, определенные целевой функцией. Работа освещает суть проблемы оптимизации простым способом, в том числе с учетом условий кризисного управления.

Ключевые слова: логистика; технологии и IT-системы в логистике; многокритериальная оптимизация; инструменты оптимизации; IT в управлении логистикой

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