

СИСТЕМНИЙ АНАЛІЗ І ТЕОРІЯ ПРИЙНЯТТЯ РІШЕНЬ

СИСТЕМНЫЙ АНАЛИЗ И ТЕОРИЯ ПРИНЯТИЯ РЕШЕНИЙ

SYSTEM ANALYSIS AND DECISION-MAKING THEORY

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ALGORITHMIC SUPPORT FOR MULTICRITERIA ASSESSMENT OF RETAIL INFORMATION SYSTEMS

This article is devoted to the issues of assessing the effectiveness of information systems for enterprises engaged in retail trade in consumer goods. This article describes the tasks that the retail FMCG trade, as well as the functions of the retail trade, solve. The features of the subject area were considered, which will form the basis for the formation of scales for assessing the effectiveness of information systems. The priorities, tasks, and features of the business model of enterprises engaged in retail trade in consumer goods, depending on the market segment they occupy. Various types of corporate information systems that can be used in retail trade are considered. The analysis of the subject area made it possible not only to determine important metrics for assessing the effectiveness of information systems but also to determine the priority of the requirements for the availability of certain functionality in the information system from each business segment, large, medium and small. Also, the existing standards in the subject areas of software development and enterprise organization were considered. This article proposes a methodology for evaluating information systems for enterprises engaged in consumer goods retail trade that belong to different market segments. The proposed methodology is based on the approach of multi-criteria expert assessment. An example of linguistic variables for one of the questions of the questionnaire for experts is given. The order of operation of the expert system is also presented in the form of an activity diagram. The developed expert information system can be monetized by providing referral links to the products of companies supplying information systems for retail. In the future, it is planned to add the ability for qualified experts to select combination of metrics for assessment, as well as change the assessment scale to increase accuracy.

Keywords: information system, retail trade, consumer goods, performance assessment, expert assessments.

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АЛГОРИТМІЧНЕ ЗАБЕЗПЕЧЕННЯ ДЛЯ БАГАТОКРИТЕРІАЛЬНОЇ ОЦІНКИ ІНФОРМАЦІЙНИХ СИСТЕМ ДЛЯ РОЗДРІБНОЇ ТОРГІВЛІ

Дана стаття присвячена питанням оцінки ефективності інформаційних систем для підприємств, що займаються роздрібною торгівлею товарами масового попиту. В даній статті наведені завдання, які вирішує роздрібна торгівля товарами масового попиту, а також функції роздрібною торгівлі. Були розглянуті особливості предметної області, які ляжуть в основу формування шкал оцінювання ефективності інформаційних систем. Також виділені пріоритети, завдання та особливості бізнес-моделі підприємств, що займаються роздрібною торгівлею товарами масового попиту в залежності від займаного ними сегмента ринку. Розглянуто різні типи корпоративних інформаційних систем, які можуть використовуватися в роздрібній торгівлі. Аналіз предметної області дозволив не тільки визначити важливі метрики для оцінки ефективності інформаційних систем, а й визначити пріоритет вимог щодо наявності певного функціоналу у інформаційної системи від кожного сегмента бізнесу - великого, середнього і малого. Також були розглянуті існуючі стандарти в предметних областях розробки програмного забезпечення та організації підприємства. У даній статті запропонована методика оцінки інформаційних систем для підприємств, що займаються роздрібною торгівлею товарами масового попиту, які належать до різних сегментів ринку. В основу запропонованої методики покладено підхід багатокритеріального експертного оцінювання. Наведено приклад лінгвістичних змінних по одному з питань анкети для експертів. Порядок роботи експертної системи також представлений у вигляді діаграми діяльності. Розроблена експертна інформаційна система може бути монетизована шляхом надання реферальних посилань на продукти компаній-постачальників інформаційних систем для роздрібною торгівлі. Надалі планується додавання можливості для кваліфікованих експертів здійснювати підбір комбінації метрик для оцінювання, а також змінювати шкалу оцінки для збільшення точності.

Ключові слова: інформаційна система, роздрібна торгівля, товари масового попиту, оцінка ефективності, експертні оцінки.

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АЛГОРИТМИЧЕСКОЕ ОБЕСПЕЧЕНИЕ ДЛЯ МНОГОКРИТЕРИАЛЬНОЙ ОЦЕНКИ ИНФОРМАЦИОННЫХ СИСТЕМ ДЛЯ РОЗНИЧНОЙ ТОРГОВЛИ

Данная статья посвящена вопросам оценки эффективности информационных систем для предприятий, занимающихся розничной торговлей товарами массового спроса. В данной статье приведены задачи, которые решает розничная торговля товарами массового спроса, а также функции розничной торговли. Были рассмотрены особенности предметной области, которые лягут в основу формирования шкал оценивания эффективности информационных систем. Также выделены приоритеты, задачи и особенности бизнес-модели предприятий, занимающихся розничной торговлей товарами массового спроса в зависимости от занимаемого ими сегмента рынка. Рассмотрены различные типы корпоративных информационных систем, которые могут использоваться в розничной торговле. Анализ предметной области позволил не только определить важные метрики для оценки эффективности информационных систем, но и определить приоритет требований по наличию определенного функционала у информационной системы от каждого сегмента бизнеса – крупного, среднего и малого. Также были

рассмотрены существующие стандарты в предметных областях разработки программного обеспечения и организации предприятия. В данной статье были предложены методика оценки информационных систем для предприятий, занимающихся розничной торговлей товарами массового спроса, которые принадлежат к различным сегментам рынка. В основу предлагаемой методики положен подход многокритериального экспертного оценивания. Алгоритм опроса пользователей, которые могут выступать в роли экспертов, представлен в форме диаграммы деятельности. Приведен пример лингвистических переменных по одному из вопросов анкеты для экспертов. Разработанная экспертная система может быть монетизирована путем предоставления реферальных ссылок на продукты компаний-поставщиков информационных систем для розничной торговли. В дальнейшем планируется добавление возможности для квалифицированных экспертов осуществлять подбор комбинации метрик оценивания, а также изменять шкалу оценки для увеличения точности.

Ключевые слова: информационная система, розничная торговля, товары массового спроса, оценка эффективности, экспертные оценки.

Introduction. At the present moment, it is impossible to imagine a modern enterprise that would refuse to use information systems for the automation of its business processes. Information systems can reduce the time spent on analytical tasks, simplify customer and supplier relationship management, receive the necessary reporting in the shortest possible time, and much more. Automation and implementation of an information system is an important and necessary step for any enterprise that wants to be competitive in the twenty-first century. However, the management of the enterprise does not always give sufficient attention to the process of formulating requirements for the desired information system, which makes it difficult or even impossible to choose the information system that will help to solve enterprise problems efficiently as possible. The decision can be made by omitting the process of creating a requirements specification (or any other similar document), without involving experts who work with these systems, but simply by studying Internet sources. Understandably, with such an informal approach to making an important decision for the company, the probability of choosing a system that does not fully meet the needs of the customer is quite high. Inconsistency of the software being introduced or available at the enterprise with the requirements emanating from the statute or business model of the company leads to loss of revenue, gradual loss of competitiveness, and as a result leads to bankruptcy.

FMCG retailers are not an exception. (By FMCG we mean food, light industry products, as well as household chemicals.) This subject area has its own specific features, which translate into requirements for the functionality of the information system. These requirements can be used as metrics for assessing the quality of information systems. The presence, absence, or completeness of the implementation of these requirements will form the basis of expert assessments, the announced combination of which will describe the degree of compliance of a certain system with the requirements of an enterprise belonging to a certain market segment (small, medium or large business).

This work is devoted to the subject area of FMCG retail. This paper will consider the features of the subject area and the requirements for the functionality of information systems for retail FMCG, which are formed depending on the affiliation of a trading enterprise to a certain market segment.

The purpose of this work is to improve and formalize the process of evaluating the effectiveness of information systems for FMCG retail.

Retail trade specifics. Retail trade is an economic activity in the field of commodity circulation, covering the sale and purchase of goods to the end consumer and the

provision of trade services to him.[1] Retail trade matches the seller's interests in earning income and the buyer's needs for high-quality goods and services.

The retail business is always customer-oriented and follows socio-economic trends in order to remain competitive. Retail is based on the theory of individual choice, which is based on the principle of consumer priority. Therefore, retail trade is a social expression of the quality of life of a society.

Manufacturing firms make goods and sell them to wholesalers or retailers. Wholesalers resell these products to retailers, who resell to end consumers.

Retail trade realizes the produced consumer value, that links production with consumption and maintains a balance between offer and demand. At the same time, it does not matter who and where sells goods and through what distribution channels they are brought to end consumers [2].

Retail trade common activities:

- purchasing goods from a wholesaler and offer them for sale to anyone who wishes unchanged or after some processing;
- formation of a wide range of goods and a list of services that satisfy customers' needs;
- receiving and processing orders from customers;
- creation and continuous optimization of a product stand in order to maximize revenue. (For example, products with the highest margins are located at eye or chest level, while products with lower margins are usually located on the lowest or highest shelves.);
- organization of the process of delivery of ordered products to the client;
- studying the demand for goods and their market supply, maintaining a balance between supply and demand;
- working on logistics, optimization of warehouse stocks, in order to reduce the volume of product losses, is especially important for the trade of rapidly perishable products, for example, food.
- advertising and information work of retail trade enterprises;
- providing customers with a range of services that facilitate the process of not only buying but also using the goods (accepting pre-orders, selling individual goods on credit, delivering purchased goods to the buyer, assembling and installing purchased goods on scrap from the buyer, teaching the buyer how to operate technically complex goods, gift wrapping of purchased goods, etc.);
- stimulation of sales by increasing the identification of products and holding promotions;
- any independent systematic commercial activity is considered to be entrepreneurship. This means that it is initially aimed at making a profit from the sale of its goods;

- the size of the enterprise is a universal criterion for its work organization. Small firms are traditionally supported by the state by lowering taxes and other mandatory payments, while large firms have a lot of demands, they bring huge income.

Small business is by far the most common case. It is easier to organize, even with little or no work experience. Gradually, the size can increase to medium, due to an increase in annual turnover and attracting more resources. An enterprise can only be called a large business that covers several countries or has entered the international level. It always has a large number of end consumers. [2]

Small businesses include sole proprietorships, as well as microenterprise businesses and cooperatives with up to 50 employees. The main features of this form are:

- Lack of territorial distribution.
- Limited list of activities. Shops, travel agencies, small industries, dental or other small clinics, private educational institutions specializing in courses can work on this principle.
- The minimum set of checks. Supervisory authorities provide small companies with supervisory holidays, and when they end, the period for conducting inspection activities does not exceed 50 hours per year.
- The status does not need to be confirmed by special means. It is determined by the annual turnover, a certain number of employees, and the share ratio to the authorized capital.

Thus, we can distinguish the following requirements for information systems from small retail businesses:

- Low price.
- Moderate increase in the price of licenses and services by an increase in the number of workplaces or customers.
- Minimum requirements for accounting and reporting functions.
- No need for high-level analytical and customer relationship management tools.

Medium enterprises differ from small ones in terms of coverage. They usually include an entire network that is capable of serving a large customer audience. They can conduct their work in different areas within a state or country. The retail network can affect an entire region, but at the same time not enter the market of a neighboring region.

There are some characteristics of medium enterprises:

- Slow adaptation to changing market conditions.
- Orientation to improve the quality of goods or services to consumers.

Medium-sized businesses have net income - from 8 to 40 million euros, assets – 4–20 million euros, employees - from 50 to 250 [2].

As for the spheres of activity, this form of entrepreneurship is characteristic of network trading companies, construction firms, and large medical centers. In the global economy, it is medium-sized organizations that play the largest role, bringing about a third of all revenues to the state. At the same time, no tax breaks or other supportive measures are taken in relation to them.

Thus, we can distinguish the following requirements for information systems on the part of medium-sized businesses:

- Availability of functionality for notifying customers about new products and ongoing promotions.
- Availability of tools for supplier relationship management.
- Availability of tools for customer relationship management.
- Availability of analytical tools for sales analytics and demand forecasting.

Large companies are businesses that produce a substantial portion of all goods or services in their industry. Their volumes are noticeable in everything: the number of employees, the number of sales, the annual turnover. But most importantly, they do not work within the framework of one specific territorial market, but in several regions of the country or at the international level. The signs of such enterprises can be considered:

According to Ukrainian legislation, large enterprises are considered to be enterprises with an annual income from the sale of goods, works, and services over 40 million euros (in equivalent), a book value of assets of more than 20 million euros, and an average number of employees of more than 250 people [2].

- Strict observance of the order about inventory.
- Large retail space.

The most popular representatives of a large entity can be considered such venerable giants as Apple, Bosch, Samsung, Coca Cola, BMW. Since they have to work in many countries at once, they must adhere to global legislation and take into account the norms of each specific market. In addition, the number of shareholders in a firm may include not only businessmen but also the state. This gives some indulgence in work, but at the same time imposes additional obligations.

Thus, we can distinguish the following requirements for information systems on the part of the large business:

- All the requirements of medium-sized businesses.
- The widest range of analytical devices, including devices for analyzing global demand trends on the Internet.

Types of information systems for retail. Now that the requirements for information systems for retail businesses have been clarified, it is time to consider the types of business information systems that are presented on the modern market.

Having considered the types of systems existing on the market, we can make a conclusion that CRM systems are most suitable for retail enterprises. The use of ERP systems can also be justified, but these systems are more suitable for resource (or production) enterprises, rather than trade ones.

Also, in addition to ERM / CRM, a large business can use other information systems that are listed in the list to achieve their high-level goals. BPM systems serve to formalize business processes in an enterprise HRM systems can also be used to monitor the performance of personnel and collect important statistical information, which in the future can be used to restructure the staff of employees, recruit a team to implement a project or estimate the time it

will take to implementation of a project by a specific team of employees.

However, our task is to select the system that best suits the requirements of a particular enterprise, therefore, only CRM systems will act as instances for evaluation.

Types of corporate information systems that are present at the market and their description provided in table 1.

Table 1 – Types of corporate information systems

Name	Characteristic
ERP (Enterprise Resource Planning)	System for planning (managing) of enterprise resources.
CRM (Customer relationship management)	information system for an interaction model that believes that the center of the entire business philosophy is the customer, and the main areas of activity are measures to support effective marketing, sales and customer service.[3]
ECM (Enterprise Content Management)	An information system for the implementation of control over the strategic infrastructure and technical architecture to support a single life cycle of unstructured information (content) of various types and formats.[4]
CPM (Corporate Performance Management)	An information system for monitoring and managing business performance, covering the entire range of tasks in the field of strategic and financial management of a company.[5]
HRM (Human Resource Management)	An information system for the automation of activities, aimed at timely provision of the organization and management of personnel and its optimal use.[6]
EAM (Enterprise Asset Management)	This is an information system designed mainly for the automation of processes related to the maintenance of equipment, its repair, as well as aftersales service of this equipment.[7]
EDMS (Electronic Document Management)	Information system for enterprise document management.[8]
Workflow	A system that is responsible for the document flow of the enterprise in a complex, ranging from a simple order to the final routes and versions of the documents used.
Collaboration	A system responsible for the electronic interaction of people, but not as formalized as workflow.

Standards within the subject area. ISO 9000 is a series of international standards containing terms and definitions, basic principles of quality management, requirements for the quality management system of organizations and enterprises, as well as guidelines for achieving sustainable results. The standards of this group have subsections aimed at quality management, resources,

workflow, planning, personnel management and other activities at the enterprise. [9]

These standards are based on the process approach to the organization of labor in the enterprise and the implementation of the PDCA cycle.

ISO/IEC 25000:2014 clarifies the use of the new series of International Standards named Systems and software Quality Requirements and Evaluation (SQuaRE). The main aim of ISO/IEC 25000:2014 is to provide a comprehensive overview of SQuaRE contents, common reference models and definitions, as well as the link between the documents, allowing users to understand series of standards, based on their intended application. It also explains the transition from the old ISO/IEC 9126 to the new ISO/IEC 14598 standard [10].

TCO is a concept of calculating the costs associated with the purchase of a product. During calculation of the TCO, not only direct costs are calculated such as product price, support and depreciation prices, but also indirect costs. Examples of indirect costs are user training costs, loss of efficiency during staff training, and the similar.

In order to assess the system as objectively as possible, it is necessary that the assessment algorithm covers the following attributes of the system quality:

- The degree of compliance with the user's requirements.
- The quality of the software, especially the quality of UI / UX execution.
- The cost of the license, support, expansion of the service package.

Algorithm for assessing the effectiveness of information systems. Genetic algorithm for multi-criteria assessment of the efficiency of information systems can be given in the following form:

- Form a set of indicators of employees to assess the degree of compliance of the information system functionality with the requirements presented by experts and the general business model of the enterprise $Y_1, \dots, Y_n$.
- Form assessment scales $X_q = \{x_q^1, \dots, x_q^{S^q}\}$, $q = 1, \dots, n$ of indicators, where S^q is a sign of the scale.
- Form a set of criteria $K_1, \dots, K_m$, $m < n$ for the aggregation of indicators $Y_1, \dots, Y_n$.
- Generate scales $L_i = \{l_i^1, \dots, l_i^{D^i}\}$, $i = 1, \dots, n$, $q = 1, \dots, n$ for aggregated indicators, where D^i is a scale sign.
- Choose a method for constructing scales of aggregated indicators.
- Build scales of aggregated indicators of all hierarchical levels using a combination of aggregation methods.
- Solve the problem of assessing the economic efficiency of the implementation of the information system at the enterprise [11].

The systems will be rated on a ten-point scale according to the following metrics:

- The cost of the license.
- The rate of change in the cost of licenses and support services with the same growth in the number of jobs and clients.

- Availability of basic analytical tools for trading (sales funnel, demand forecasting, integration with Google analytics).

- Availability of tax reporting.
- Ability to connect a fiscal registrar.
- Availability of Email-mailing.
- Availability and quality of performance of the personnel management monitoring tool.
- Availability of data export to XLS, XLSX, CSV.
- Quality UI / UX.
- Optimization and robustness.

Further, expert assessments for each of the metrics will be multiplied by the corresponding weight coefficient. The weighting factor will be formed based on the client's enterprise belonging to a certain market segment, as well as the client's requirements for the functionality of the information system (table 2). Algorithm of calculating score in fig. 1.

Table 2 – Calculating score for multicriteria assessment

	Wages (user priorities)	Exp. marks for system "A"	Exp. marks for system "B"
Metric 1	0.3	10.0	6.0
Metric 2	0.1	10.0	10.0
Metric 3	0.1	6.0	10.0
Metric 4	0.3	8.0	8.0
Metric 5	0.2	6.0	10.0
Score	1.0	8.1	8.6

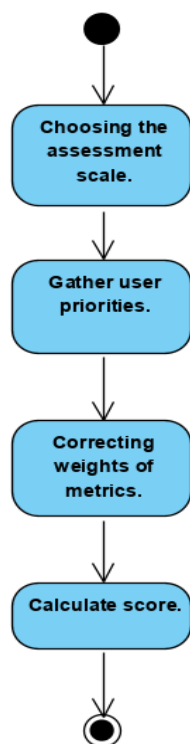


Fig. 1. Algorithm of calculating score

Algorithm for collecting user requirements. For the survey of business representatives in the field of retail trade

in consumer goods, it was decided to use a questionnaire, and linguistic variables [12] will be used to set priorities (fig. 2). Example: "Should an information system build a sales funnel based on statistical data?"

- "Yes, I do need it."
- "Yes, most likely I need it."
- "I might need it."
- "I probably won't need it."
- "Most likely I won't need it."
- "I definitely won't need it."

This approach was chosen because it will provide maximum coverage of the target audience, since unqualified users can work with it, and it also reduces the time spent by the user, which will increase the likelihood that the user will complete the survey.

It should also be noted that in the absence of functionality in the system, marked by the user as unambiguously or most likely necessary, this system will not be included in the list of recommended systems for the user, even if its final score will be sufficient to get into the top three systems.

	A	B	C	D
1 User answer		Weight before	Weight after	Weight corrected
2 "Yes, I definitely need it"		0.3	0.45	0.45/($\sum$ all marks)
3 "Yes, most likely I need it."		0.3	0.36	0.36/($\sum$ all marks)
4 "I might need it."		0.3	0.30	0.30/($\sum$ all marks)
5 "I probably won't need it."		0.3	0.21	0.21/($\sum$ all marks)
6 "Most likely I won't need it."		0.3	0.09	0.09/($\sum$ all marks)
7 "I definitely won't need it."		0.3	0.00	0.00

Fig. 2. Linguistic variables and their impact on weights

Possible software implementation. The web application will be the most relevant option for implementing an expert system for assessing the effectiveness of information systems for retail enterprises. The expert system can be implemented using C#.NET or Java Spring technologies. This implementation option was chosen because:

- It provides maximum audience reach.
- Convenient to use.
- No download required.
- Allows the owner of the expert system to track page traffic and other important metrics for the product.
- More opportunities to monetize the system in the future.

The fig. 3 below shows the algorithm of the expert system.

Prospects of the project. The expert system can be monetized by providing referral links to the products of companies that supply information systems for retail.

In the future, the expert system can be improved by:

- adding a more complex algorithm for qualified experts;
- adding an opportunity for qualified experts to select a combination of metrics for assessment;
- adding the ability for qualified experts to give their expert assessments of information systems;
- changing the scale for expert assessments from 10 points to 100 points to improve accuracy.

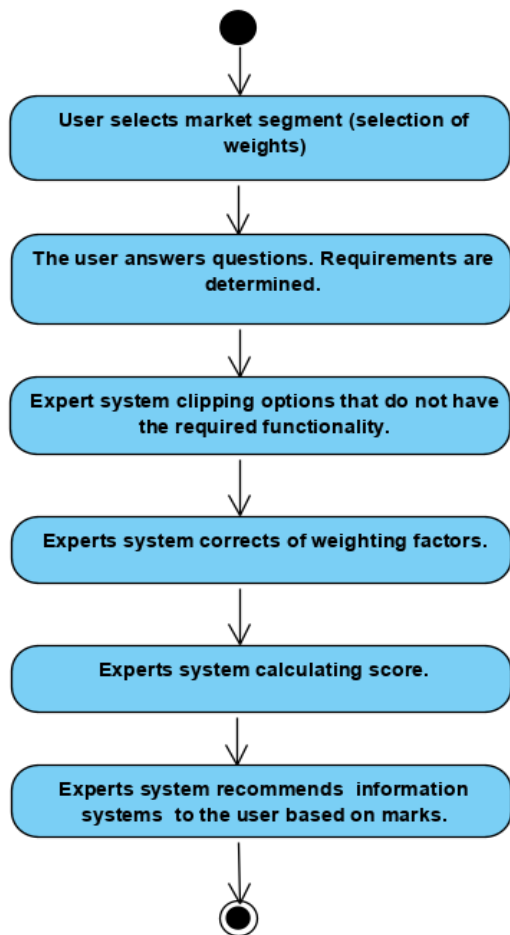


Fig. 3. Algorithm of user interaction with the expert system

Conclusion. As a result of the research, an algorithm that formalizes the process of assessing the effectiveness of information systems for FMCG retail enterprises was proposed. An algorithm for evaluating the effectiveness of systems and its possible software implementation in the form of an expert system was proposed. Potential future improvements to the expert system were also suggested.

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