Design, Development and Use of Decision Support Systems in the Study of Economic Disciplines in Higher Education

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Abstract. *Research goals and objectives*: to describe the experience of the design, development and use of decision support systems (DSS) in the study of economic disciplines in higher education.
Subject of research: design, development and use of decision support systems in the study of economic disciplines in higher education.
Research methods used: comparative analysis, business analytics, design of software module, interactive decision making, analytical methods.
Results of the research: The quality of a decision depends on the input information and a set of relevant economic indicators. Decision making support systems with calculation algorithms containing endogenous economic indicators, as well as the precedent knowledge base are designed to facilitate selection of alternatives in decision making using exogenous parameters. Automation of economic indicators' calculations has a didactic purpose for students of economic specialties. The DSS developed will facilitate decision-making in semi-structured and unstructured situations at micro and macro levels.

Keywords. decision support systems, calculation algorithms, economic indicators.

Key Terms. DecisionSupportSystems, TeachingMethodology, IntegratedIndicators

1 Introduction

The rapid development of new systems and the creation, storage and handling of information flow caused the active dissemination of information and computer systems in various spheres of human activity [12], including the economy. One of the ways of improving the quality of training and education, according to the Concept of the State program of education development, is the introduction of new pedagogical and information technologies [1].

The need for computer support of decision-making in economics and business today is due to the influence of a number of objective reasons, such as: increase in body of information coming to management and executives directly; complexity of problems solved every day and for the prospect; the need to account and consider a large

number of rapidly changing interrelated factors and requirements; increasing importance of the consequences of the decisions made, and so on. All these caused rapid development and wide use of decision support systems and predefined the objectives and functions of computer systems.

DSS are widely used in the advanced economies of the world, and their number is constantly growing. A number of DSS are used at the level of strategic management particularly for long-, medium- and short-term and financial planning, including the capital investment distribution system. Oriented operational management DSS are applied in marketing (for forecasting and analysis of sales, market research and price).

Therefore, to improve the process of education, it also makes sense to use such powerful technologies as DSS, which is a new step in the development of education, an effective way to meet the needs of students in acquiring new knowledge.

The purpose of the paper is to describe the experience of the design, development and use of DSS in the study of economic disciplines in higher education.

The paper is organized as follows: part 2 describes related works on DSS; part 3 demonstrates classification of DSS; part 4 reveals decision making based on economic information and decision support system; part 5 demonstrates design and development of decision support systems in economics; part 6 considers interface for DSS in the study of economic disciplines in higher education; the last part concludes.

2 Related Work

The presence of a large array of input data, different tasks and restricted time for decision makers requires the creation of expert decision support system (EDSS), which will determine the need for necessary information and facilitate the choice of the appropriate integrated economic indicators for calculation.

The decision making implies determining of various integrated economic parameters which can be calculated in different ways. Patterns of these indicators should be clearly classified according to levels of the economy, such as microeconomics, industrial economics or macroeconomics [7]. It creates a possibility to choose the desired indicator and expand the base of these parameters according to the responsibilities of decision maker, level of economics and specificity of public policy.

Software development of DSS module will allow automating the calculation of integrated economic indicators using the developed algorithms, which will be the base of decision making. This will save valuable time for the construction of new indicators based on input information.

The stated purpose suggests the following tasks:

- to classify and review the existing DSS economics;
- to design and develop new DSS for use in the study of economic disciplines in higher education;
- to describe the technique of using DSS in the study of economic disciplines in higher education;
- to automate the calculation of integrated economic indicators based on input information at micro and macro levels;

- to provide an opportunity to expand the base of integrated economic parameters for increasing flexibility of DSS in decision-making process according to industry specificity or level of responsibility of decision maker.

DSS will reduce economic resources for computation of integrated economic indicators which will increase its allocation and social efficiency. Saved resources of time and budget will provide reserves for expanding and economic growth of SME. Simulations which can be done via EDSS will enhance the economic competence of decision makers. Rational decisions will allow decreasing the deadweight loss of society and increasing its welfare.

Decision theory was born in the XVIII century. The fundamental problems of this theory are the questions of formal basis of choice and the genesis of optimality criterion. Scientific bases of decision theory were laid during the Second World War. Its authors are J. Von Neumann and O.Morhenshtern who published their book on game theory in 1944 [8].

DSS emerged in early seventies of the twentieth century due to development of management information systems. Their development was also significantly influenced by achievements in the field of information technology, especially the emergence of telecommunications networks, personal computers, expert systems, the Internet etc [2, 4, 5]. The term DSS emerged in 1971 and belongs to professors Anthony Horry and Michael Morton (MIT).

There is still no uniform definition of DSS. Some researchers understand it as 'interactive system that provides ultimate users who make decisions an easy and convenient access to data and models for decision making in semi-structured and unstructured situations from different fields of human activity' [8]. Other definitions of DSS are 'interactive computerized systems that help individuals who make decisions, to use data and models to solve unstructured and weak-structured problems' [9], 'DSS is computer information system which is aimed to support various activities during the decision-making in situations where it is impossible or undesirable to have an automated system that completely fulfills the whole process of making' [10]. Such variety of definitions is caused by a wide range of different shapes, sizes and types of DSS.

Structure of almost all computer systems contains the following main components:

- UI subsystem;
- DMS - database management system;
- CSBM - control system of base models.

Specific features of DSS [12] provide important properties for the construction of information systems:

- DSS interactivity is the system responding to various types of actions performed by a person and affecting the computational process, including interactive regime;
- DSS integrating is compatibility of system components for managing data and means of communication with users in the process of decision making support;
- DSS power is the ability of systems to respond to the most essential questions;

- DSS availability is the ability to ensure the issuance of responses to user's requests in the right form at the right time;
- DSS flexibility is a possibility of system to adapt to changes in needs and situations;
- DSS reliability is the system's ability to perform the required functions for a given long period;
- DSS ability to recover is the system's ability to recover in case of erroneous situations both of external and internal origin;
- DSS controllability means the user's ability to control the actions of the system, stepping in the process of solving the problem.

The most important objectives of DSS are [9]:

- improving decisions: managers solve more problems during same time and choose the best solution with regard to time, cognitive limitations and economic restrictions;
- increasing productivity: the ability to create higher quality decisions within shorter period;
- complementing the decision makers' set of tools by the new opportunities concerning extraction and the creation of new knowledge through analysis and identification of problems;
- facilitating the implementation of one or more stages of decision making (information gathering, planning, selection of alternatives);
- streamlining and facilitating the analysis of possible ways of problems solving;
- helping in solving unstructured or semi-structured problems.

The realization of these goals provides DSS users with the following potential benefits [11]:

- increasing the ability of people who make decisions, for processing relevant information and knowledge;
- the possibility of solving the problems insoluble for one person, or requiring a huge amount of time due to the problem complexity;
- solving relatively simple problems faster and /or more effectively;
- providing decision makers with more arguments.

Also the benefits of DSS include intensification of competitive advantage through increased profits, expansion and support of customers, acceleration of decision making. DSS can improve communication of customers and suppliers through Internet and web-based technologies. DSS has an opportunity 24/7 for interactions between staff and customers.

Decision support system is applied under uncertainty, risk, heuristics research etc [4]. Emphasis on practical recommendations about DSS in organizational processes and decision-making activities for seniors and top management is proposed by Teylor [13]. Such DSS suggest deep data conversion in useful form for decision making. An integral component of this type is DSS decision rules which enable managers to make

their decisions based on sustainable business growth and reduce risks. Strategic DSS are based on the principles of multi-dimensional presentation and data analysis (OLAP). The following table 1 provides an overview of well-known decision support systems.

Table 1. Comparative analysis of DSS

Specifications	Expert Choice	Decision Lens	Super Decisions
Developer	Expert Choice, Inc.	Decision Lens Inc.	Creative Decisions Foundation
Link	http://expertchoice.com/	http://decisionlens.com/	http://www.superdecisions.com/
Method of decision-making	Analytic Hierarchy Process	Analytic Hierarchy Process, Analytic Network Process	Analytic Hierarchy Process, Analytic Network Process
Application of pairwise comparisons	+	+	+
Support of team work	+	+	-
Different users roles	+	-	-
Sensitivity analysis application	+	+	+
Web-based	+	+	+
Customers	NASA, Bank of America, WorleyParsons, Washington Gas, Medtronic	Johnson & Johnson, Washington Gas, Federal Aviation Administration, Genentech	

Taking into account different types of large companies which use DSS we can conclude about necessity of these instruments for decision making.

3 Classification of Decision Support Systems

Today there is no single classification of DSS, so let us consider some basic classifications taking into account their different characteristics. At the user level we can distinguish the following DSS types [14]:

- **active** can suggest a solution to be chosen;
- **passive** helps in decision-making process, but cannot make a choice which decision to take;

- **cooperative** allows decision maker to change, replenish or enhance decision offered by the system, and then the user can send these changes to the system to test.

At the technical level are distinguished [15]:

- enterprise level DSS (corporate, enterprise-wide, large-scale) is connected to large data warehouses and serves many managers of firms;
- table (personal, desktop) is a small system that serves only one user's computer.

At the conceptual level are considered [11]:

- Communication-Driven DSS supports groups of users working on the implementation of a general problem;
- Data-Driven DSS, or Data-oriented DSS is mainly focused on the access and manipulation of data;
- Document-Driven DSS searches and manipulates unstructured information given in different formats;
- Knowledge-Driven DSS provides the solution of problems in the form of facts, rules and procedures;
- Model-Driven DSS provides access and manipulation of mathematical models (statistical, financial, optimization, simulation).

Some OLAP-systems which can be treated as hybrid DSS analyze complex data that provide modeling, search and processing of information. Depending on the data types, DSS can be divided into operative and strategic DSS [9].

Operative DSS (or Executive Information System) is assigned for immediate response to changes in the current situation in the management of financial and economic process of a firm, industry or country. These systems have a finite set of reports built on the basis of data from transactional information system of firms' business accounting. They provide an adequate reflection of real-time key aspects of industrial and financial activity. Such DSS are characterized by the following features:

- Reports are based on the standard request for the organization, whose number is relatively small;
- DSS presents reports in most convenient form, including tables, business graphics, multimedia and so on;
- DSS are usually focused on a specific sector, such as finance, marketing, management resources.

Strategic DSS are oriented on analysis of large volume of diversified information collected from various sources. The most important aim of DSS is to search for the most efficient variants of business development, taking into account the influence of factors such as the situation of target markets for the company, changes in financial markets and capital markets, changes in legislation and so on.

4 Decision Making Based on Economic Information and Decision Support System

Setting of each economic problem implies the presence of exogenous and endogenous variables. The task of decision-maker is to identify endogenous variables using exogenous ones. Endogenous variables can be defined using various combinations of exogenous variables. If the subject area is new to decision maker (student), decision support system will offer all database patterns to calculate necessary endogenous indicator. Thus, the presentation of endogenous y indicator will look as follows (table 2):

Table 2. Presentation of endogeneous indexes in database of support system

Index	Designation	Formula	Note	Definition
Total cost	$TC(q)$	$TC(q) = FC + VC(q)$ $TC(q) = AC \cdot q$ $TC(q) = TR(q) - \pi(q)$ $TC(q) = w \cdot l + r \cdot k$ $TC(q) = \sum_{i=1}^{n} p_i \cdot x_i$ $TC(q) = \int_0^q MC(q)dq$	FC - fixed cost $VC(q)$ - variable cost q - quantity AC - average cost $TR(q)$ - total cost $\pi(q)$ - profit w - wage r - rent l - labor k - capitaly p_i - price of resource i x_i - quantity of resource i $MC(q)$ - marginal cost	sum of fixed and variable cost in short-run period

To calculate such economic indicator as 'total cost', presented in table 1, there are 6 basic patterns from which the decision maker will select the one with all exogenous known variables. If none of these formulas allows calculating the endogenous indicator, you must either (i) add a new database pattern that will calculate for given exogenous variables; or (ii) identify all unknown variables, and realize the calculations using the DSS. If the index is calculated in the latter way, it becomes integrated as it requires additional calculations of necessary variables.

The novelty of the software module for calculation of integrated economic indicators is the ability to:

1) reduce the time to choose the desired integrated economic indicator for the decision;

2) adapt an indicator to input information held by decision maker;
3) identify alternative ways of decision making grounded on database of integrated economic indicators of DSS;
4) find out the missing information to make a decision;
5) adapt the economic indexes to software modules of DSS;
6) improve development methodology of integrated economic indicators.

5 Design and Development Of Decision Support Systems in Economics

Higher education system to a greater extent applies information technology [12], due to development of the Internet and supplying educational institutions with powerful computer equipment. Thus, DSS can also be used as a component of higher education. Our DSS developed for economic decision making is a web application [3, 14, 15], which contains a database of integrated economic indicators divided into sections and topics.

Developing DSS for economics we used REST-architecture:

- backend - Platform - WebAPI ASP.NET + SharedLibrary with all services and business logic for use as containers WebApi business logic;
- database - PostgreSQL;
- frontend - AngularJSтаBootstrap.

Platform Web Api ASP.NET allows to create easily HTTP service for a wide range of clients including browsers and mobile devices. Web Api ASP.NET is used for developing RESTful-platform applications on .NET Framework.

To interact with the server standard HTTP methods (GET, POST, PUT, DELETE - simple HTTP-requests) are used, which allows us to manipulate data. Most API calls are directed to use basic CRUD-operations.

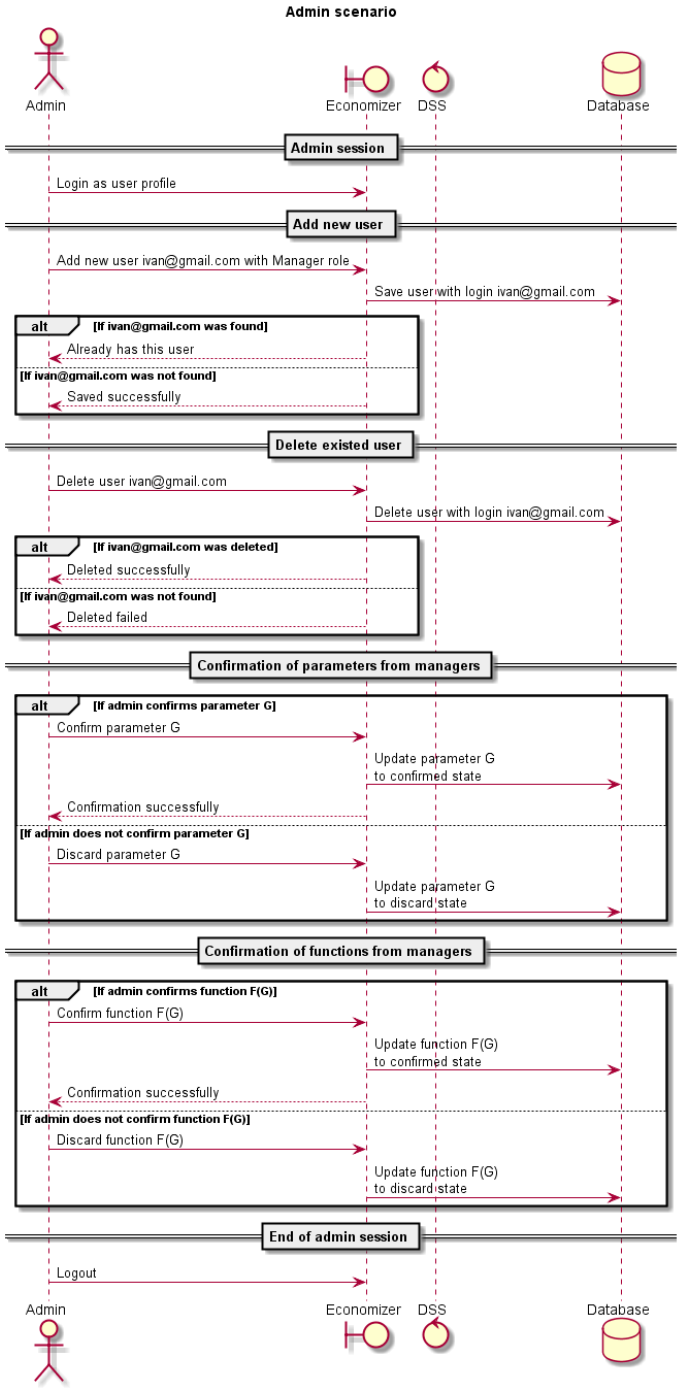

Fig. 1. Administrator Use Case Diagram

For elegant work with the database Entity Framework is used, which is recommended by Microsoft's data access technology. It is an ORM that enables .NET developers to work with relational data using domain-specific objects. They don't have towrite the data-access code.

In DSS developing Unity - IoC-container for dependencies determination is applied. Dependency injection (DI) is a mechanism which allows us to weaken connections between objects interacting in application. Such objects are linked through abstraction, e.g., through interfaces. It makes the whole system more flexible, more adaptable and extensible.

Frontend of DSS for economics is realized by AngularJS and Bootstrap. AngularJS is a JavaScript-framework from Google. It is designed for single-page application development. Its purpose is to expand browser applications on the basis of pattern MVC. Bootstrap is the most popular HTML, CSS, and JS framework for developing responsive web projects. This design allows to separate the main objects from secondary ones, to focus user's attention on the desired item.

Structure of program module DSS is described by following fig. 2 as in [6]

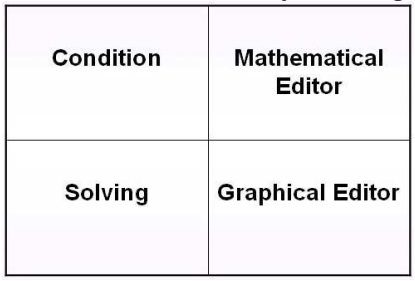

Fig. 2. Structure of 'Solving environment'

It also enables the user to distribute variables into exogenous and endogenous factors, the process solution and tools (calculator) (fig. 3)

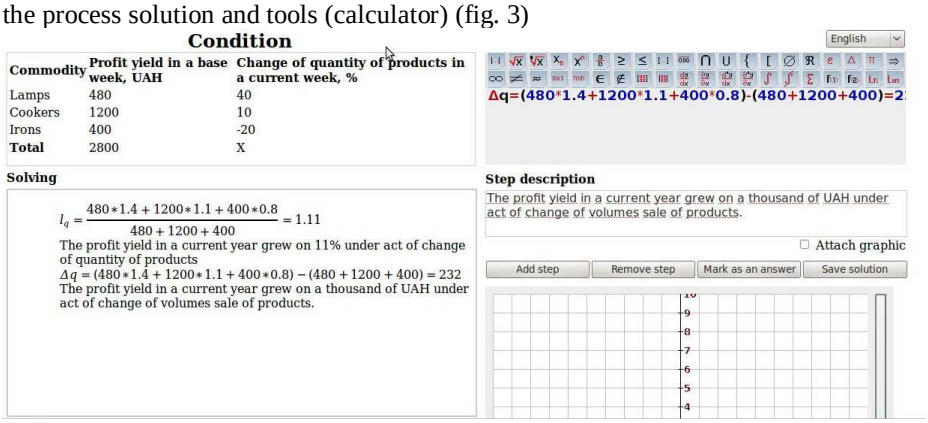

Fig. 3. The software module 'Solving environment'

Module 'Solving environment' consists of two columns, where the left is problem statement, below is decision field, the right is math editor and calculator:

1) Mathematical editor - for special mathematical symbols (fig. 4);

2) Calculator - for calculations (fig. 5).

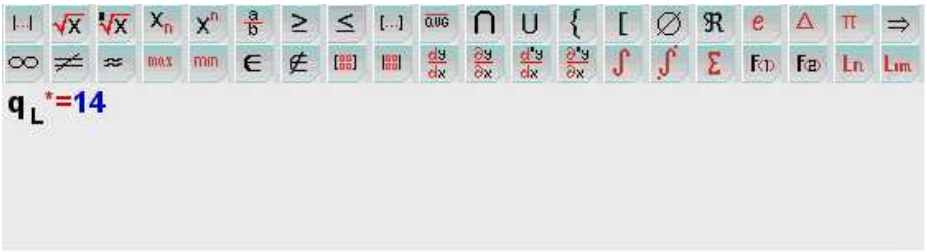

Fig. 4. Math editor

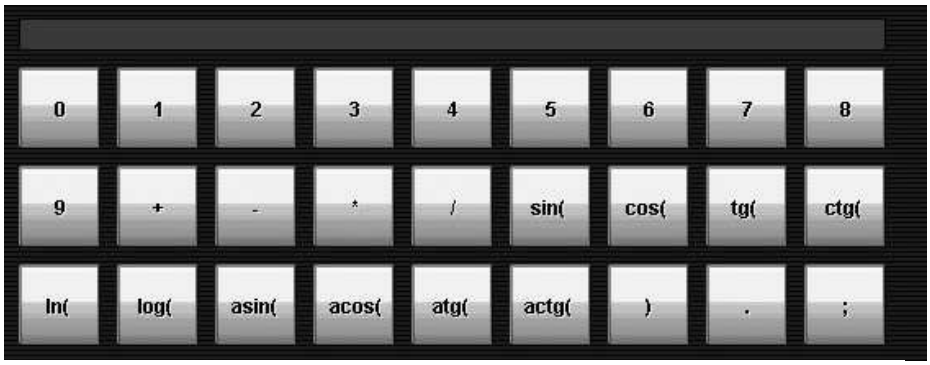

Fig. 5. Calculator module

Once the user has completed the task solution, he or she must select "Save solution" (fig. 6).

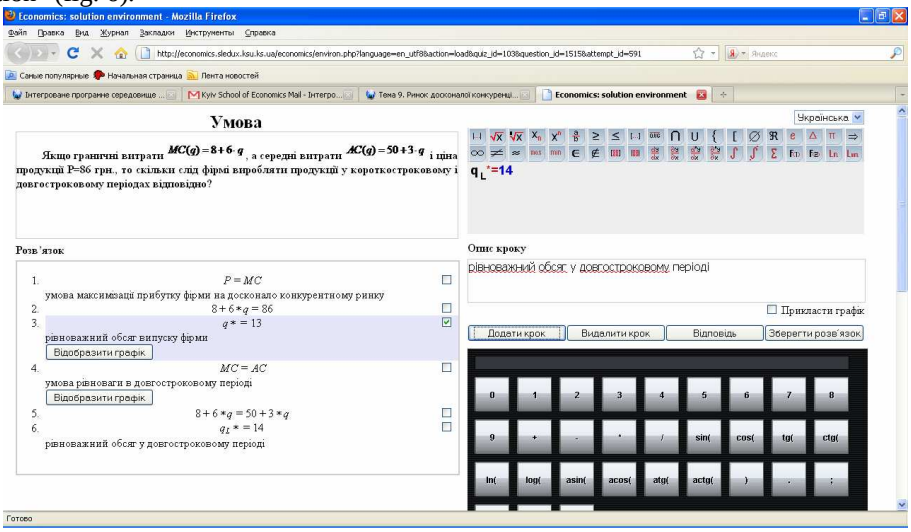

Fig. 6. Sequence of economic indicator calculation

Further you can move to the next problem using the same algorithm. Example of calculation of economic indexes is demonstrated in following fig. 7.

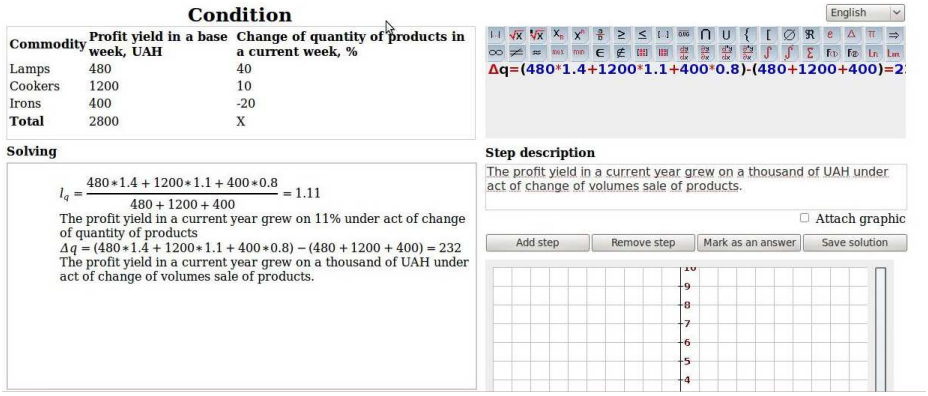

Fig. 7. Example of economic indicator calculation

6 Interface for DSS in the Study of Economic Disciplines in Higher Education

DSS automates the calculation of integrated economic indicators based on input information for decision makers at micro and macro levels [7]. DSS developed for economics foresee the ability to expand the base of integrated economic indicators for increased flexibility in decision-making on specific industry and the level of responsibility of decision makers. The system provides three roles based on the analysis of potential user groups:

- administrator;
- editor (teacher, tutor, student);
- guest (teacher, tutor, student).

Depending on the role, users have different permission.

Guest has the following permission rights: to review all sections and indicators topics; to view topics section; to search option on indicators, patterns and additional performance parameters; to carry out calculations using formulas suggested by the system; to use graphing.

Editor, in addition to the above, can perform the following functions: to add sections to the system: to add topics, patterns and parameters to sections of the system.

Administrator can perform all the functions listed above as well as and additional functions (Administrator Use case diagram is shown in fig. 1): to check and edit the sections, topics, options, functions, patterns proposed by system editors to approve or reject; to add (remove) system users, identify the role of system users (fig. 8).

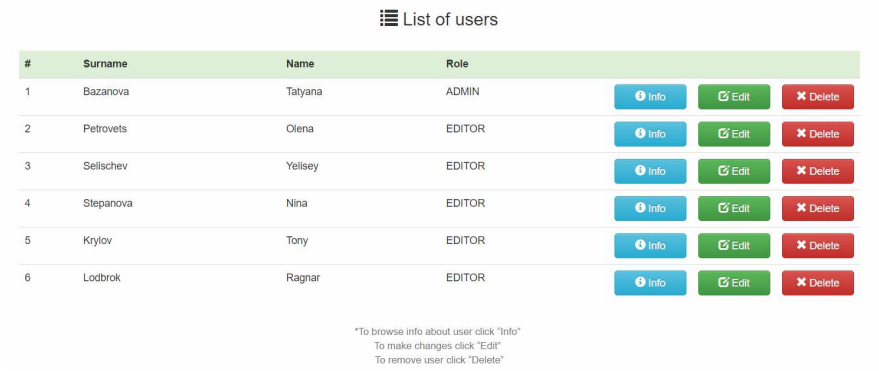

Fig. 8. List of users for consideration of Administrator

If a user wants needs to change his/her role from guest to editor he/she has to register through on-line form and administrator should approve this new role. Editor can propose new section, subsection, pattern or parameters for DSS (fig. 9).

Users have to choose the set of exogenous variables to calculate endogenous variable via search procedure. After pressing the 'Search formula' button the user can see all patterns which include all indicated variables and choose one of them (fig. 9).

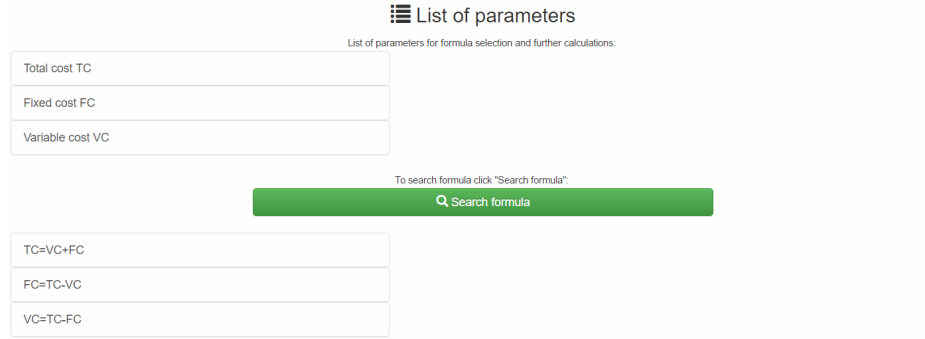

Fig. 9. List of parameters at DSS

To calculate unknown variable after choosing necessary pattern the user has to put known constants for exogenous variables and parameters. Then he/she can press 'Calculate' button to get the answer (fig. 10).

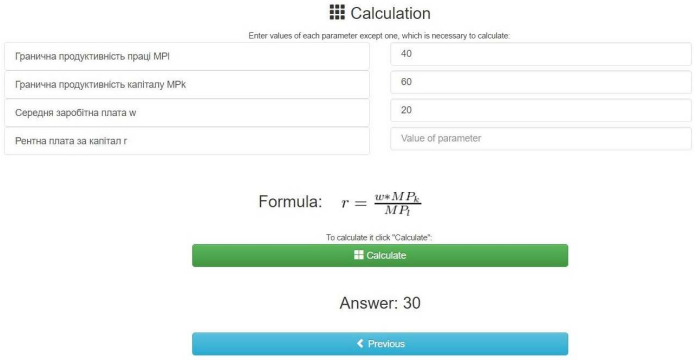

Fig. 10. DSS calculation procedure

If users know other patterns to calculate economic indexes, they can send request to administrator (fig. 11). After administrator has accepted the new pattern by, the data base will expand and the next user can get access to renewed list of economic patterns.

Thus, DSS for the economics is based on the principle of interactive solving problems. The user is able to maintain a dialogue with DSS in continuous mode. DSS increases the efficiency of decision-making.

DSS performs integration of models and analytical methods with standard access to data and sample from them. One or more models will activate to assist in decision making. Database content covers the history of current, past operations and external information about the environment. DSS focuses on flexibility and adaptability to environmental changes or approaches modifications for solving the problems chosen by users. DSS is intended for use in the module, mid-term control and evaluation of knowledge for full-time and distance students. The users of this software are:

1) students of economic specialties;

2) teachers of economic disciplines.

The **advantage** of the software for *students* is the ability to identify endogenous variables using exogenous ones for problem statement using the formulas from database of DSS and built-in calculator.

The **advantage** of the software for *teachers* is the possibility to enrich/supplement the formulas base with new formulas suggested by students in the form of integrated economic indicators. This reduces the time to study well-known formulas and saves time to solve creative problems.

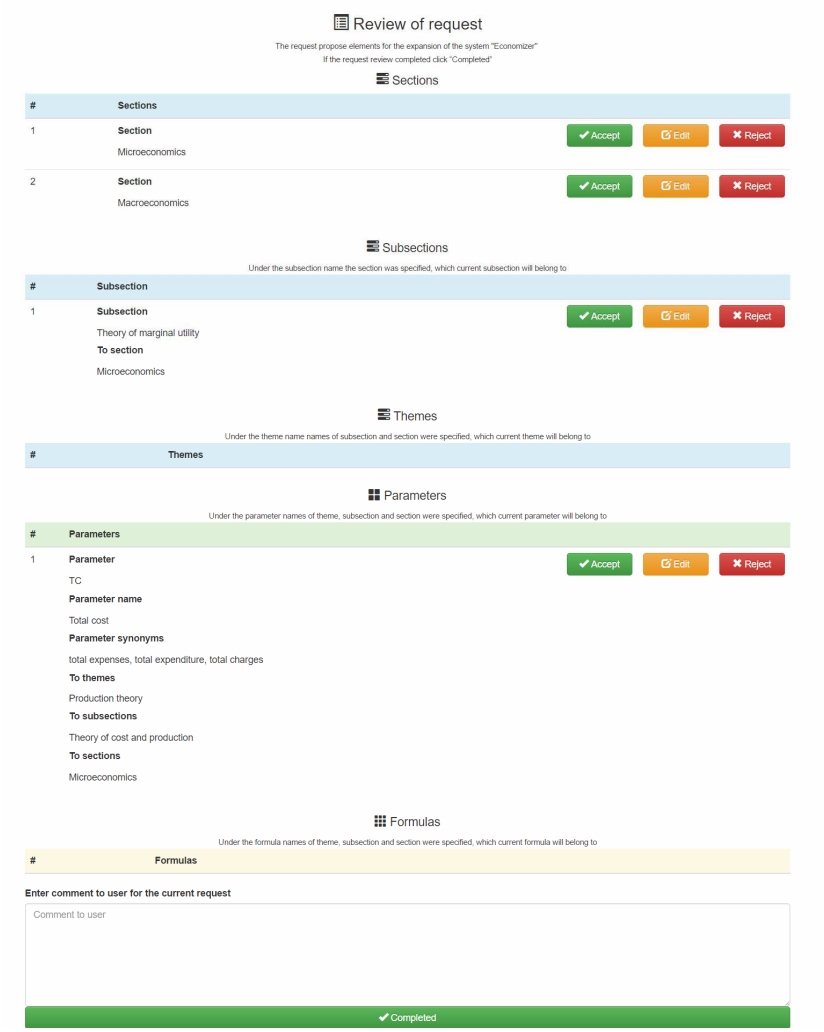

Fig. 11. Review of request from Editor at DSS

7 Conclusions and Outlook

The novelty of the study is developing a unique software module Decision making of support system intended for didactic purposes, enabling the calculation of integrated economic indicators, expanding its base through formalization input precedents. Didactic value of developed DSS is the integration of scientific efforts of experts in economic forecasting, management, modern economic cybernetics and programming.

Decision Support System is an interactive system that provides users easy access to models and data to support decision-making in relation to semi- and unstructured tasks. So, the DSS is interacting with other computerized systems to assist managers

in decision-making. DSS helps managers to find, to calculate and to analyze data concerning the search of solutions. DSS can potentially help the company create an economic advantage saving time for other tasks.

Designed software is fully functional and can be modified in different ways for managers and for students of economic specialties.

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