Multiple Criteria Analysis in Facilities Management

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Abstract. The research’s object of this paper is facilities management process, interested parties striving to attain their goals and micro and macro environment that make up an integral whole. A comprehensive research into the above object required the development of new methods of multiple criteria analysis enabling to thoroughly assess variable micro (labour skill level, innovation, software, expert and decision support systems, education and training, types of contracts, etc.) and macro (technological, legislative, political, social, economic and other aspects) environment of a facilities management sector. All these variable factors can be optimised. In order to demonstrate the optimisation of the above variable factors a determination of rational housing investment instruments is considered in this paper as an example.

Keywords: Facilities Management, Multiple Criteria Analysis, Micro and Macro Environment.

1. FACILITIES MANAGEMENT IN DIFFERENT ECONOMIES

Facilities management has different priorities in different countries. It is not surprising that there are divergent views and interpretations among various countries, with marked differences between countries with developed market economies, those with transition economies and developing countries. Not all countries with one of the three development levels, in practice uses facilities management in the same way and so have different strategies. Legislative, political, social, economic, technological, culture, traditions and other reasons determine these different strategies. As an example, further on we shall briefly discuss some of the above factors.

New workplaces are emerging in the world and are driven by organizational change, information and Internet technology. Companies are experimenting with workplace innovation that involves moving workplaces out of the office into homes or a client’s office. Management of these “virtual workers” is based on trust rather than on control. Trust is largely determined by culture and traditions, etc.

Duffy (1992) points out that the way the office market is organized heavily influences the type of office building built in a country. In his opinion, user dominated markets, as in Northern Europe, tend to provide office buildings of higher standards rather than developer dominated markets.

A survey by Andersen (1995) among a group of large European corporations showed that the attitude to real estate varies from country to country. For example, facilities management in Central and Eastern Europe that are facing so many problems, there is hardly any will to invest time and money in to the professional management of a workplace.
As Steiner (1995) describes, Scandinavian architects tend to be more user-orientated by creating comfortable, healthy workplaces and architects of some other countries tend to be more art-orientated by creating aesthetic buildings.

Generally, in all countries, economic information on facilities management includes the finances and depreciation, taxes, insurances and large maintenance and administrative works, etc. These economic indicators are related to a country’s economical and political situation. The relationship of economy and politics in developing countries is usually connected. Poor economic conditions of a country may lead to political changes; on the other hand, a politically unstable country is usually related to a severe economic condition. Such situations could affect the efficiency of facilities management activities. The major, factors of economic impacts in developing countries are inflation, interest rate variations, currency revaluation and devaluation, differences between escalation clauses and current market prices and other conditions that could affect facilities management. Forecasting these economic indicators require great attention and is particularly useful for planning facilities management.

At present, in transition countries some low-income group inhabitants (i.e. pensioners, unemployed and large families) cannot afford the payment of bills for heating their premises. The thermal renovation of a building would reduce heating costs and save state expenditures on social allowances. In addition, the political party in power that cannot solve this urgent problem in a rational way will not be selected in the coming elections. Therefore, the problem appears to be not only a social one but also a political one.

A successful strategy for facilities management should be more-or-less compatible with legislative, political, social, economic, culture, technical, technological and other factors. A varied spectrum of strategies can be launched, while keeping in mind that the mix of influencing factors and relative emphasis is on one or other of those factors and overall will depend on local conditions.

2. EFFECT OF CHANGING THE BUSINESS ENVIRONMENT ON THE EFFICIENCY OF FACILITIES MANAGEMENT SECTOR

One of the major tasks of facilities management organizations is to carry out its activities under the most favourable micro and macro-level conditions. Efforts are made to ensure that the structure, goals, output, efficiency and quality of services of the facilities management organization will be at maximum conformity with the existing business environmental conditions. The pursuit of impracticable goals, for instance, trying to realize projects which surpass the organization’s capabilities or the environment (economical, social, legal, political, competitive, technical and technological conditions) is adverse and may cause undesirable consequences.

In order to assure the efficiency of facilities management activities, it should be executed within certain boundaries that are determined by micro and macro-level factors.
2.1. Macro Efficiency Level Factors

The highest level at which efficiency factors may be considered are the macro efficiency level factors. The level of efficiency and the scope of activities of the facilities management sector depend on the following macro-level variable factors:

- Key economic indicators for the country as a whole,
- Legislation,
- Demand and supply,
- Market,
- Culture,
- Intervention of government,
- Politics,
- Interest rates,
- Environment issues,
- Unemployment,
- Wage levels,
- Insurance,
- Inflation,
- Climate,
- Unofficial economy, etc.

The efficiency level will, therefore, vary depending on the aggregate effect of these macro level factors.

As an example, further on we shall briefly discuss some of the above mentioned macro efficiency level factors.

Buildings may be private, state-owned or rented and determine whether the users are interested in effective facilities management or not. Another aspect of legislation that influences facilities management is regulations on an employee’s participation. According to Duffy (1992), in northern Europe workers’ councils and labour unions have greater power and this is reflected by extremely high standards of space, amenity and comfort for office workers.

Hofstede (1996) describes how, in the hierarchy of culture, such as France, Italy and Germany relations between a position in the hierarchy and his/her workplace is well illustrated by the workplace’s allocation. In Central and Eastern Europe countries people at the top of the company will have workplaces with more space, better view and more privacy.

The demand for a facilities management sector to a large extent depends on the overall rate of a country. The demand for facilities management sector tends to fluctuate particularly according to the state of the government’s economy and the social and economic policies, with consequent effects on facilities management services.

Also, social problems affect facilities management and some facilities management problems go beyond the physical structure of buildings. The problems in various...
districts are those of street crime, burglary, vandalism, unemployment and lack of education.

Natural conditions in terms of location and climate affect facilities management. The facilities manager should investigate the climate conditions related to solar radiation, temperature, humidity, rainfall, wind, dust storms, changing ground water level and permafrost.

The government or local authorities stimulate the interest of some private companies that invest in some particular areas. The financial assistance may be in the form of subsidies, grants, benefits and preferential credits, government guarantees of a loan. This economical States policy is aimed at reducing unemployment, and restoring, developing or improving certain buildings and districts, etc.

The government by changing taxation as well as the structure and volume of its own expenditure (expanding of town reconstruction programmes, housing subsidies and benefits etc.), affects the demand for construction and facilities management, inflation and other factors. An increase in taxation and a curtailment of government expenditure usually tends to lower the demand for construction and facilities management, and vice versa. Often measures of both types i.e. taxes and government expenditure go hand-in-hand, so, the efficiency of the facilities management relies on the Government’s fiscal and monetary policy.

Many countries have a policy of subsidizing various forms of energy conservation measures in buildings, through grants and tax incentives. In Hillebrandt’s (1988) opinion, the social cost or costs to the community of consuming energy (too rapid consumption of non-replaceable energy reserves, that affect future generations but not indirectly the existing householders; the adverse effect on the balance of payments of large oil imports or a reduction in the amount available for export and the high capital costs of investment to increase energy availability) are higher than the private costs of doing the same.

2.2. Micro Efficiency Level Factors

The second level of factors may be considered as the micro level and these depend on those at the macro level. The level of efficiency and the scope of activities of the facilities management sector depend on the following micro variable factors:

- Infrastructure,
- Labour skill’s level,
- Innovation,
- Sources of company finance,
- Software, expert and decision support systems,
- Facilities management associations,
- Education and training,
- Types of contracts,
- Equipment, etc.

Some of the above factors depend on the influence of the macro level factors. For instance, the system of taxation that is set at the macro level (following the fiscal policy of the government) exerts a direct influence on wages and salaries (and
thereby disposable incomes) and on prices of services at the micro level. The standpoint of the State (various laws and decrees, working of State institutions, etc.) regarding certain activities exerts considerable influence on the organizations efficiency. The law directly governs relations of the various interested parties, for instance, between occupier and owner.

As an example, further on we will briefly discuss some of the mentioned micro efficiency level factors.

A number of interested parties to a various extent are involved in the facilities management process of buildings. Some of the interested parties directly take part in the facilities management process while others belong to the category of users. Still others are “spiritually” affected by the outward qualities of a building. Architectural, aesthetic, and urban aspects of the building generate different feelings in the owner, his/her associates, neighbours, tourists and regular passers-by. The interested parties pursue different aims and objectives such as:

- The building owner invests, takes financial risks, develops capital assets and charges capital cost;
- The facilities manager lets built space, provide services, optimizes space use, maintains facilities and, provides technical competence;
- The user/tenant formulates space and service requirements, pays rent, acquires and maintains production equipment, etc.

Efforts are taken to gain a maximum at a minimum cost.

Goals of employees and employers not always coincide. Employees want to receive a higher salary while employers try to save money by seeking to increase viability and profit for the facilities management firm. Nevertheless, there are many common interests. Facilities management sector becomes more mechanized and technically complicated and qualifications of the staff have to grow. Therefore, firms need to employ highly skilled, reliable workers, which understand modern and techniques and are able to work with the latest equipment. Salaries of employees, the possibility of permanent employment greatly depend on the effective performance of the facilities management firm; therefore the majority of workers are interested in constructive collaboration with employers.

Insufficient personnel skills may adversely affect the utility of a facilities management process. Resources are lost on personnel training and workers have to use this additional time to complete their work. Trained employees work more effectively and because of this they themselves will earn more and the firm will obtain a greater profit. Lack of skills increase costs of performed works and the difficulties with the implementation of new techniques will reduce the facilities management’s quality. Firms offering higher salaries encourage workers to improve their skills. But higher salaries increase prices and the demand for work performed by the firm tends to decrease. With an increase in salaries a supply of skilled labour increases, after a reduction of salaries the best workers leave the firm and the competitive possibilities of the firm decrease. Therefore, it is feasible to discuss the possibilities of employing personnel with various skill levels and to train them.
A facilities management firm having selected a concrete market and nomenclature for its offered services has to analyze how to organize its work effectively. This depends on the decisions made on services, personnel and equipment. A firm’s competitive level depends greatly on the decisions taken.

3. DETERMINATION OF RATIONAL FACILITIES MANAGEMENT PROCESSES

3.1. Determination of Rational Facilities Management Processes

A facilities management process consists of closely interrelated stages: i.e. consultation, planning, procurement, implementation and monitoring. A facilities management process may have many alternative versions. These variants are based on alternative consultation, planning, procurement, implementation and controlling stages and their constituent parts. The above solutions and processes will be considered in more detail later. For instance, alternative space management variants can be developed by varying its space organisation, removals, inventory compilation/updating and main services solutions (building security, reception, telephone switchboard, cleaning, snow-clearing service, upkeep of outdoor facilities, garden care, plant care in the building, post room, travel office, office service, central secretariat, canteen management, removals service, central archive, courier services, office supplies and safety specialist). Therefore, thousands of facilities management process alternative versions can be obtained. The diversity of available solutions contribute to a more accurate evaluation of climatic conditions, risk exposure, maintenance services, as well as making the project cheaper and results in a better way of satisfying a client’s aesthetic, comfort, technological and other requirements. This also leads to a better satisfaction of the needs of all the involved parties in the facilities management process.

Various interested parties (e.g. users, owners, and facilities managers, etc.) are involved in the facilities management process, and trying to satisfy their needs and affecting its efficiency.

The above needs or objectives include the expected cost of facilities management services, occupier, owner and building support, building inspection, budgeting, cost optimization, coordination of services; accounting; It also includes contract management; leasing management; technical operations management; maintenance, inspection and, repair of equipment and systems (gas, water, wastewater, heating, ventilation, cooling, electrical systems, lifts, warehousing systems, automatic door and gate, communication, cable and network, security, laundry and dry-cleaning systems, general building equipment, other equipment and systems), etc. Facilities management companies should be able to offer a range of services that can be flexibly extended or reduced.

The problem is how to define an efficient facilities management process when many various parties are involved because the alternative versions come to thousands and the efficiency changes with the alterations in the business environment conditions and the constituent parts of the process. Moreover, the realization of some objectives seems more rational from the economic perspective though from other perspectives (i.e. technological, comfort, space, administrative, technical, etc.) they have various
significances. Therefore, it is considered that the efficiency of a facilities management process depends on the rationality of its stages as well as on the ability to satisfy the needs of the interested parties and the rational character of micro and macro-level environment conditions.

A formalized presentation of the research shows how changes in the business environment and the extent to which the goals pursued by various interested parties are satisfied, cause corresponding changes in the value and utility degree of the facilities management process. With this in mind, it is possible to solve the problem of optimisation concerning the satisfaction of the needs with reasonable expenditures. This requires an analysis of the facilities management process versions allowing one to find an optimal combination of pursued goals and available finances.

The determination of the utility degree and value of the facilities management alternatives under investigation and an establishment of the priority order for its implementation does not present much difficulty if the criteria numerical values and weights have been obtained and the multiple criteria decision making methods are used.

By way of an illustration, we provide a short analysis of a criteria system of some facilities management constituent parts. They include computer-aided facilities management systems, service of a facility, and equipment.

Cormier (2000) described the process and elements for comparison and the selection when considering various computer-aided facilities management systems. Cormier (2000) considered the following criteria system: modules and tools (lease management, move management, strategic space planning, maintenance management, accounting/charge-back, communication/cable management, personnel management, etc.) the also considered cost information (cost of software, cost of training, cost and ease of software integration, cost of software maintenance, and after-sale support) technical information (platform, network access, native database support, database connectivity, user interface, security, reports, file formats, and interoperability) and key features.

The service of a facility can be evaluated as: operational productivity, aesthetic value or public image, comfort (noise, colour, air quality, thermal comfort, working conditions) flexibility, and cost (design, construction, indirect expenses, operating and maintenance expenses, renovation costs, the interest paid on loan).

Effectiveness of equipment can be evaluated by the following criteria system:

- Price,
- Expenses for use,
- Expenses for repair (maintenance, capital),
- Capacity,
- Number of operations performed,
- Reliability,
- Comfort,
- Physical and technical durability,
- Weight.
One of the main tasks of the efficient implementation of facilities management is multiple criteria optimisation of its life cycle process with the aim of maximum purpose satisfaction of all interested parties in the process. The interested parties and their aspired goals make up one entity. However, there are some potential conflicts among interested parties: e.g. speed versus waste, cost versus quality, capital cost now versus after operational efficiency, aesthetics and comfort versus cost, environment versus user needs, etc. The greater the scope of the realization of pursued goals (taking into account their significance) the greater (in the opinion of interested parties) the total efficiency of the project. In other words, the total efficiency of a project is directly proportional to the entity of its realized goals.

The level of efficiency and the scope of activities of the facilities management sector depend on the many micro and macro-level variable factors. All these variable factors can be optimised. In order to demonstrate the optimisation of the above variable factors a determination of rational housing investment instruments will be considered below as a an example.

3.2. Determining Rational Housing Investment Instruments

Medium and long-term credits are used for housing investment and certain factors and interested parties have an impact on the efficiency of alternatives of housing investment instruments.

3.2.1. Factors and interested parties affecting the efficiency of housing investment instruments

A great number of effective housing investment instruments have been developed and successfully used in advanced industrial economies. The economic, legislative, political, social, technical and cultural situations and traditions are different in every country. Also market economies have been developed in a variety of levels. Often the efforts to introduce housing investment instruments, which proved to be efficient in some countries, were not successful in others.

The same housing investment instruments when applied to various economies yield various results as far as efficiency is concerned. Researchers and practical workers use diverse criteria when analysing the efficiency of housing investment instruments. Based on the above mentioned expertise, the efficiency of housing investment instruments may be approached. Efficiency of housing investment instruments also depends on interested parties (see Fig. 1).
Compatibility of investment instruments with an available market system; the availability of interested parties in using an instrument; compatibility of an investment instrument with a State legislative system; interest rates, period of maturity, down payments, subsidies, sweat equity, loan-to-value ratios, administration, marketability, loan repayment and payment of interests, risk and guarantee, source of financial means, waivers of closing costs, delinquency on loan, etc.

Interested parties affecting the efficiency of an investment instrument: homeowners, State government, local government, financial institutions, landlords, builders and developers, speculators and real estate agents, etc.

Fig. 1. Some factors and interested parties affecting the efficiency of housing investment instruments

3.2.2. Development of quantitative and conceptual databases of housing investment instruments

In order to find the most efficient housing investment instruments for a particular country, the country’s exhaustive conceptual and quantitative description should formed. The data then obtained should be subject to multiple criteria analysis, so as to help to choose the most rational variants.

Conceptual descriptions of an investment instrument life cycle presents textual, graphical, numerical, mathematical and other forms of information about the investment instruments. The criteria used for their definition, as well as giving the reason for the choice of this particular system of criteria, their values and weight is also essential. Conceptual information is needed to make a complete and accurate evaluation of the alternatives considered. More useful information and the development a system and subsystems of criteria and defining their values and weight (see Fig. 2) illustrates the development of a conceptual database fragment containing the information on housing investment instruments.

Quantitative information is based on the criteria systems and subsystems, units of measure, values and initial weight. The determination of the utility degree and value of the investment instruments and the establishment of the priority order for its implementation does not present much difficulty if the criteria numerical values and weight are obtained and the multiple criteria decision making methods are used.

The process of determining the above the system of criteria, qualitative criteria initial weight and numerical values of the investment instruments under investigation is based on the use of various expert methods, on the Internet, etc. Quantitative criteria numerical values are obtained by analysing the data on investment instruments and different documents, Internet, etc. The magnitude of weight indicates how many times one criterion is more/less significant than another in the multiple criteria evaluation of investment instruments. The results of the comparative analysis of the
investment instruments are presented as a grouped decision, forming matrix where columns contain \( n \) alternative investment instruments, while all quantitative information pertaining to them is found in \( m \) lines.

<table>
<thead>
<tr>
<th>Criteria describing the investment instruments</th>
<th>Significance</th>
<th>Measuring units</th>
<th>Alternative investment instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest rates</td>
<td>( q_1 )</td>
<td>( m_1 )</td>
<td>( x_{11} ) ( x_{12} ) ( \ldots ) ( x_{1j} ) ( \ldots ) ( x_{1n} )</td>
</tr>
<tr>
<td>Period of maturity</td>
<td>( q_2 )</td>
<td>( m_2 )</td>
<td>( x_{21} ) ( x_{22} ) ( \ldots ) ( x_{2j} ) ( \ldots ) ( x_{2n} )</td>
</tr>
<tr>
<td>Down payments</td>
<td>( q_i )</td>
<td>( m_i )</td>
<td>( x_{i1} ) ( x_{i2} ) ( \ldots ) ( x_{ij} ) ( \ldots ) ( x_{in} )</td>
</tr>
<tr>
<td>Loan repayment and payment of interest</td>
<td>( q_l )</td>
<td>( m_l )</td>
<td>( x_{l1} ) ( x_{l2} ) ( \ldots ) ( x_{lj} ) ( \ldots ) ( x_{ln} )</td>
</tr>
<tr>
<td>Source of the financial means</td>
<td>( q_{i+1} )</td>
<td>( m_{i+1} )</td>
<td>( x_{i+11} ) ( x_{i+12} ) ( \ldots ) ( x_{i+j} ) ( \ldots ) ( x_{i+1n} )</td>
</tr>
<tr>
<td>Subsidies</td>
<td>( q_{i+2} )</td>
<td>( m_{i+2} )</td>
<td>( x_{i+21} ) ( x_{i+22} ) ( \ldots ) ( x_{i+j} ) ( \ldots ) ( x_{i+2n} )</td>
</tr>
<tr>
<td>Risk and guarantee</td>
<td>( q_i )</td>
<td>( m_i )</td>
<td>( x_{i1} ) ( x_{i2} ) ( \ldots ) ( x_{ij} ) ( \ldots ) ( x_{in} )</td>
</tr>
<tr>
<td>Delinquency on loan</td>
<td>( q_m )</td>
<td>( m_m )</td>
<td>( x_{m1} ) ( x_{m2} ) ( \ldots ) ( x_{mj} ) ( \ldots ) ( x_{mn} )</td>
</tr>
</tbody>
</table>

Table 1 A fragment of developing housing investment instruments quantitative database.

Fig. 2. A fragment of developing housing investment instruments conceptual database.
3.2.3. Search for rational housing investment instruments

The quantitative and conceptual databases, which are being developed now, give an exhaustive description of housing investment instruments and allow for their multiple criteria analysis. This helps to determine the investment instruments efficiency of the country in question. Moreover, the databases and multiple criteria analysis offered could be used in the search for efficient lenders.

Since the efficiency of alternatives of a housing investment instrument is determined by taking into account much varied information, a multiple criteria analysis should include methods enabling a decision maker to implement a comprehensive analysis of the variants, leading to and making a proper choice.

The following methods developed by authors are aimed at performing this function:
- Method for determining the initial weight of the criteria (using experts’ methods),
- Method for the criteria weight establishment,
- Method for multiple criteria analysis and setting priorities,
- Method for determining alternatives utility degree.

4. Conclusions

Facilities management companies should be well informed of the micro and macro environment levels in which the companies operate. A business environment can create or eliminate opportunities and threats. Facilities management companies analyse the micro and macro environment levels and distribute the company resources to take advantage of opportunities and to minimize threats to the company’s activities. Micro and macro level factors can be optimised. These questions have been analysed in this paper.

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