A Fuzzy Approach for Finding an Ideal Location of Industrial Park Area

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Abstract: The volume of the development of the industrial areas is highly influenced by the country, the region, the area and the city. The investment, the settlement and infrastructure are basic conditions, but the qualification, the developing ability and the enterprise of the labour are also essential in the long run. The aim of the model presented in this paper is to determined how to investigate the potential of a given area. The developed model can be a decision-making tool, which can be applied in a given urban planning. This tool applies multi-criteria evaluation in order to analyze the suitability of different areas to locate a new industrial area. The question is what kind of strategy, calculations and decision-supporting models help the business enterprises to designate their park or settling in an industrial area. The asymmetric representation of fuzzy exponents is able to handle the human thinking driven uncertainty like loss aversion and other possibilistic features of socio-economic decisions

Keywords: facility location, decision making, fuzzy objective function

1. Introduction

The word „region" is generally used for geometrical impoundment of earthly space, and it doesn't matter whether the region has any common homogeneity. On the other hand the expression of region refers to a territorial unit, which has something in common in the field of cohesion. Regions classified by one or more characteristics can be separated mainly in three groups:

- region set on the basis of a single characteristic
- region determined on the basis of several characteristics
- complex region

Further grouping made by geographers:

- homogeneous region
- nodal region
- planning or programming region

Homogeneous regions have the feature that their parts are very similar in regards of some different criteria. The planning regions are mostly separated by administrative, planning and information collecting criteria. A region is called nodal region when it is concentrated around something due to the spatial density, create a spatial intersection and become an agglomeration. Further separation of nodal regions can be made if the agglomeration until the administrative borders are examined as well, or in other case if the borders are not taken into consideration. The definition of regions is very flexible and there is no commonly accepted version among representatives of scientist.

In the regional science and analysis the benefits of localization and concentration are often emphasized, they also affects the decision about the premises by considering the economy of the territorial concentration, the source of the local benefits of the industry, the innovation clusters, the expanding poles etc.

The local advantages could mean the global effects and the long-term competitive advantage for companies [3]. On the basis of the regions and the regional science effects it is not accidental that Industrial Parks become mostly next to cities, proper infrastructural facilities and other suitable conditions.

2. Definition of Industrial Parks

It is not clear what the exact definition is for an industrial park. There are many different terminologies known (innovation park, business park, Eco-park, industrial park) in the literature. The Industrial Parks has the characteristic that comes from global-local paradox of regional knowledge of advantages from local concentration. Companies which cluster to Industrial Parks are grouped in one place, usually next to cities and good infrastructural facilities.

The plants within a specific area can utilize infrastructure systems.The transport links and some common facilities (e.g. storage, service units) are usually solved and also more and more services joined to the cooperation within the industrial area (e.g. security services, surveillance, financial services, restaurant, social, health care etc.).

„At the same time the industrial areas are well isolated from the settlements, they formed separate parts (of the settlements), because there is not the resident rather the productive functions dominated" [6].

The areas for commercial utilization, zones, regions means the widest category of the Industrial Park's definition. In several cases these are synonyms but the purpose to make it clear is being noticeable. Distinct from the industrial zone or area, in UNIDO (Industrial Development Organization of UN)'s most documents shows industrial estates, which has distinguish features such as (UNEP 2001):

- is located on relatively large area (this is typically 40-80 ha)
- the established companies could also access to public facilities (water, electricity, etc.) or other public services. The basic technological infrastructure is also available.
- development is correspond with other development plans (especially regional- and settlement development).
- you can find different kind of common (centered) and administrative function in this area, in addition many type of business services – so as managerial, technical and financial - are also available [6]

The industrial areas are expected – not only by the firms, but even by the society and community – today to save energy and not to pollute the air and the water. Sustainable development is supposed to be the aim of their actions. They try to decline exhaust fumes by the means of well-organized logistics and transportation. As the tendency shows, the industrial parks (eco-parks) are highly needed. On the whole they can be energy-saver, since the companies aggregate at a certain area, thus – supposing good infrastructural conditions and well-organized logistics – they can contribute to maintainable development.

The volume of the development of the industrial areas is highly influenced by the country, the region, the area and the city. The investment, the settlement and infrastructure are basic conditions, but the qualification, the developing ability and the enterprise of the labour are also essential in the long run. Measuring this is a hard work, however certain indicators are available.

The question is what kind of strategy, calculations and decision-supporting models help the business enterprises to designate their park or settling in an industrial area. This paper finds a new answer to these tasks.

3. Location decision or location potential

In the last years lot of experiences have been gathered all over world on the development of industrial parks. In spite of the existence of these industrial park areas, in the literatures we can find just few common strategy and methodology for their evolvement.

The scientist mainly deal with this process form the side of companies, namely as a location problem. They are interested in that how to choose a location of company for itself. We call it as a location decision problem. In the literatures we can find very similar way to approach this situation. Here we have to mention some strategies, which can be applied to all the phases: selection, design and planning of location, design the physical structure.

These decision methods are mainly based on the micro- and macro-economical and social factors of a given area. Nowadays proximity to markets and infrastructure or labour availability are still the main factors of industrial location and industrial park selection. The only one has been changed is the analysis, which is also extended for

environmental impacts [1]. The selection of the most suitable emplacement to locate an industrial park through an integrated planning is a complex decision problem. This decision problem has to consider different criteria that help to achieve the objectives of industrial parks.

There were some experimentation in connection with looking for a chance that where an industrial park would be established. These were not academic studies, but simply expectations without any correct information about its verification.

On the one hand more criteria should be existed than we usually have to consider, for instance social, economy, infrastructure, planning, Furthermore these subjective factors can be modeled analytically by fuzzy sets. Therefore, the aim of this study is to show that if there is a geographical area, for example as a region area, which has got a potential from objective factors, than we can enlarge this factor with subjective factors. In this way the potential indicates the possibility of establishing an industrial park in this area.

4. The model

The aim of this model is to determined how to investigate the potential of a given area. The developed model can be a decision-making tool, which can be applied in a given urban planning. This tool applies multi-criteria evaluation in order to analyze the suitability of different areas to locate a new industrial area.

First the model has been divided into three levels. Phase 1 is the geographic area selection, the evaluation and selection of the areas and evaluation of specific zones. Initially an analysis is done to regional scale. This analysis studies a wide area. The aim of this phase is to evaluate the necessity of the development of new industrial areas in which emplacements would be the most suitable to locate them. These process determines the evolvement potential for industrial park of a given area (P_i), where *(i)* denotes the number of area, which are analyzed.

The second phase (Phase 2) delimits the objective factors, which must be influenced by the potential of the areas and which area would be the best to locate a new industrial area. Once the hierarchic levels have been established the following step is to define several variables, which are grouped in categories and subcategories. These categories and subcategories represent intermediate levels, which affect the decision. The variables begin analyzing the existence of requirements that are necessary for the industrial development and these variables finish evaluating if there are enough resources. The categories, subcategories and indicators must be clearly defined within each main group. We call this basic potential.

The main categories are the social (S_i), the economical (E_i), the infrastructure (I_i) and rules (R_i) (Table 1). All factors can be evaluated by any parameters, if there is not, we would decide about the existence of them by yes or not.

Table 1. Categories and subcategories

Categories	Subcategories and its indicators
Social	- Demography (birth and death rate, migratory balance, etc…) - Education (percentage of person with different education, etc…) - Labour (unemployed ratepercentage of person with different education, etc…) - etc.
Economy	- Economic activity (efficiency of sectors, existence of industrial branches, etc….) - costs (resources, labour, waste, etc…) - etc.
Infrastructures	- Transport (land-, rail-, air transports, etc…..) - Energy, water (drinking and waste water, electrical energy, etc…..) - Recycling (recovery facilities, waste management, etc…..) - Communication, IT (internet, phone network, etc….) - etc.
Rules	- Legal and law frame - Taxes - Subsidy

It is evident, that the potential can be defined as a function of these variables. We have to naturally complete the categories with subcategories as well. If necessary it can be extended the suitable categories. It is reasonable, that $P_i = f(S_i, E_i, I_i, R_i)$.

A possible form to evaluate the potential of an area can be given with the following formula (Equation 1). We give the way how to add the independent variables.

$$P_i = a_S S_i + a_E E_i + a_I I_i + a_R I_i \tag{1}$$

The (a) shows the weights of a given objective parameters in a given area. Naturally is reasonable, that the equation can be extended further parameters which are needed to compare the potentials of two or more areas. Here we have to mention that this equation only contains the possible objective parameters. It does not give suitable information about the effect of subjective parameters of a given area.

The third phase of the model (Phase 3) delimits the subjective factors, which must be influenced the potential of the areas that which subjective factor modifies to the potential of an area. In this study we have chosen the inclination to establish business, as a parameter, which modifies our basic potential (also the basic function).

To analyze this subjective factor we can use the fuzzy logic, which is an extension of the classic logic, which recognizes more than real and false values [4]. Therefore, a proposition can be represented by different degrees of veracity, which permit a mathematical formalization in order to handle and analyze information, whose interpretation needs subjective and imprecise concepts, so the fuzzy logic is very useful to treat phenomenon of the real world that is characterized by its complexity and uncertainty [2].

For instance, if there is a subjective factor, which is influenced on the potential, we can analyze as an power function on the basic potential. This is called Pi*, where (*) signs the modified potential, which has got a fuzzy exponent. This exponent varies the slope

and the shape of the potential function (see Fig. 1.). The value of (*b*) is higher than 0, and less, equal or higher than *1*.

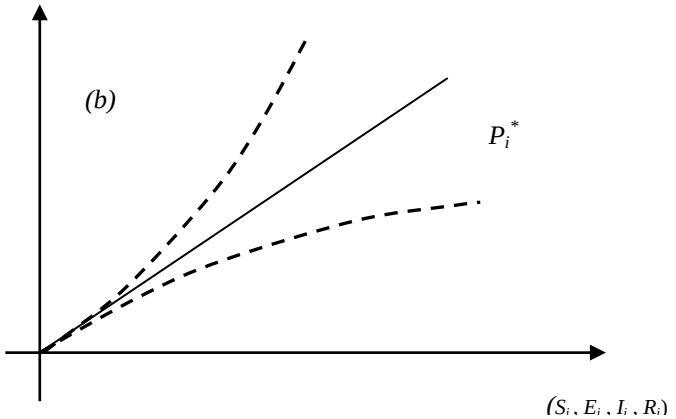

Figure 1. The curve of evolvement potential with fuzzy exponent

If we extend the Equation 1 with the represented fuzzy index, we could define the following step. Let P_i is equal to 100, then the modified potential (P_i*) will show the real potential with subjective parameters. So we can find an area, where a higher or less chance can be found for establishing an industrial park.

$$P_i^* = (a_S S_i)^{b_S} + (a_E E_i)^{b_E} + (a_I I_i)^{b_I} + (a_R I_i)^{b_R} \tag{2}$$

In practical the fuzzy exponent can be determined by the inclination to establish a business in a given area as we have already mentioned above. If we want to collect suitable information about it, for instance it is a good method if we turn to the registry court. By means of the data about the new and cancelled enterprises the above fuzzy exponent can be defined. Naturally we have to give a suitable value/weight for each category like private entrepreneur, small size enterprise, middle size enterprise or multinational enterprise in the area. The weight can be the absolute value of being established enterprise in a given area in the last few years.

5. Application of fuzzy exponents

In our paper an asymmetric fuzzy solution for unvaried function $y = b + aX^{\beta}$ (where *a*, *b*, $\in \boldsymbol{R}$) is applied [3].

The asymmetric representation is able to handle the human thinking driven uncertainty like loss aversion and other possibilistic features of socio-economic decisions (see Fig. 2. and Fig. 3.).

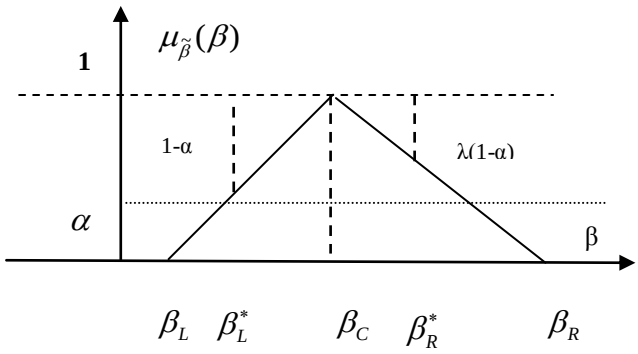

Figure 2. Asymmetric representation of exponents based on different 1-(α-cuts) [3]

$$y=\frac{1}{1+(1+\lambda)(1-\alpha)}(b+ax^{\beta_C})+\frac{1-\alpha}{1+(1+\lambda)(1-\alpha)}(b+ax^{\beta_C-(1-\alpha)(\beta_C-\beta_L)})+\frac{(1-\alpha)\lambda}{1+(1+\lambda)(1-\alpha)}(b+ax^{\beta_C+(1-\alpha)\lambda(\beta_R-\beta_C)})$$

Where: $0 \le \lambda \le 1$ (3)

The continuous formula is:

$$y=\frac{\int_{\beta_L}^{\beta_R}(1-\mu(\beta))(b+a\,x^{\beta})\lambda(\beta)d\beta}{(\beta_R-\beta_L)-\int_{\beta_L}^{\beta_R}\mu(\beta)\lambda(\beta)d\beta} \quad (4)$$

where $\lambda(\beta)=\begin{cases}1 & \beta \le \beta_C \\ \lambda & \beta \ge \beta_C\end{cases}$

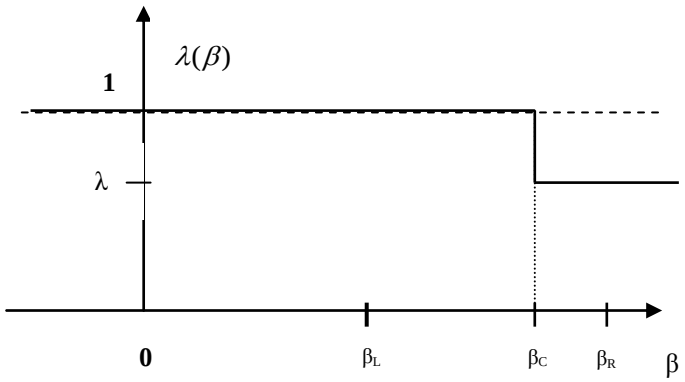

Figure 3. Characteristic function for λ(β) [3]

References

[1] Fernández, I., Ruiz, M.C.: *Descriptive model and evaluation system to locate sustainable industrial areas*, Journal of Cleaner Production 17 (2009) pp. 87–100

[2] Boclin Campos, A.S., de Mello, R.: *A decision support method for environmental impact assessment using a fuzzy logic approach*, Ecological Economics 58 (2006) pp.170–81.

[3] Földesi, P., Botzheim,J., Kóczy, L.T.: *Fuzzy Exponents for Heuristic Based Applications*, Acta Technica Jaurinensis Series Intelligentia Computatorica Vol.1. No.3. (2008) pp.423-435

[4] Bojadziev, G., Bojadziev, M.: *Fuzzy logic for business, finance and management*, World Science, (1997)

[5] Hagett, P.: *Geography*. A Global Synthesis, Harlow (2001) pp. 367

[6] Lengyel, I., Rechnitzer, J.: *Regionális gazdaságtan (in Hungarian)* , Dialóg Campus Kiadó. Budapest-Pécs. (2004) pp. 23-34; pp. 167