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Core: A decision support system for regional competitiveness analysis based on multi-criteria sorting

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ABSTRACT

If regional competitiveness is equated to the capacity to attract and preserve investments, then the perception investors have of the region's characteristic is fundamental. This perception is a result of a complex integration of multiple criteria. This paper approaches the analysis of regional competitiveness by techniques of multi-criteria sorting. An ELECTRE-based preference model is used in the framework of the new THESEUS multi-criteria evaluation method for making competitiveness assignments. The model's parameters are inferred from a set of assignment examples. This model is implemented in the CORE decision support system, which satisfies a requirement of Sinaloa State Government in Mexico. CORE performs very well analyzing the competitiveness of Mexican regional entities. This will allow governments to better define their policies by placing financial resources more efficiently. The model and the system are conceived to easily emigrate towards other regional contexts.

1. Introduction

Through centuries economists have identified in academic literature different factors and mechanisms which, when interrelated, allow economic development of a country or region and, in synthesis, can be defined as the capacity to maintain sustained increase in product per capita and its fair distribution [17]. These elements comprise, among others, prior historical conditions, natural resources available, geographic location, efficient application of resources in a competitive market with an increasing division of labor, physical and human capital accumulation, technological progress and diffusion combined with legal, cultural and institutional elements that allow them to be displayed [17,21]. Globalization has increased the opportunities of countries and regions to reach the economic growth faster thanks to the possibility of attracting capitals, capability for innovation and capacity for faster and greater access to growing markets. At the same time, however, the countries are becoming more fragile and may be suddenly sanctioned for bad performance, experiencing the opposite (capital flight, drain of highly qualified human resources, loss of markets), thereby affecting the income of the population.

Papers on territorial competitiveness are strongly influenced by the work of Michael Porter [22], who provided an important conceptual framework and notably stimulated an interest of the international community in this topic. Territorial competitiveness is based on the capacity of one geographic unit to maintain its medium and long term economic growth, sustained increase in capital investment, product per capita and exportations in order to improve the income and welfare of its population. However, the evaluation of its economic performance must also take into account the quality of its regulatory framework, governmental institutions and actions that favor or hinder the performance of companies, resource availability, infrastructure, innovation capabilities, and all the facilities available to the productive units so they can compete in the best markets of their sector and region. For the companies, the ideal conditions for competing are the existence of a market economy governed by the rule of law, respect for intellectual property, and transparency with no government-protected monopolies. Therefore, it is assumed that prevalence of modern institutions and democratic systems favoring free market will provide territories with strong competitive capabilities that help companies located in such economic space succeed.

It is not so important for public policies to measure competitiveness as to find a suitable way to influence its enhancement. Considering that the level of competitiveness is an effect of multiple factors, detection of causal relationships between them is necessary to find out its determinants, and this should be done beyond a mere qualitative description. Only a more or less precise quantitative description will allow the evaluation of the public action impact on competitiveness. It is necessary to characterize a mathematical function (in its most general sense) that allows evaluating changes in competitiveness with regard to changes in attributes of the social object that have influence on it and are modifiable by the action of public policies. On the basis of such model, a "competitiveness simulator" could be created as an instrument for the assessment of policies aimed at its enhancement.

In [24], Sala-I-Martin et al. pointed out the popularization, in economic literature, of partially correlating the rate of economic growth

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to a substantial number of variables with this kind of regression models:

$$\gamma = \alpha + \beta_1 \cdot x_1 + \beta_2 \cdot x_2 + \ldots + \beta_n \cdot x_n + \varepsilon$$

where γ is the dependent variable and x_i are the explanatory or causal variables; α and β_i are constants to be determined; and ε represents the magnitude of error.

If the assessment of competitiveness is seen as a multicriteria decision problem, and if γ is a "proxy" variable reflecting competitiveness, the above model can be seen as a weighted-sum value function. This kind of models requires mutual preference independence and constant compensation ratio, which are quite severe mathematical conditions. Interaction among criteria is not modeled. In order to reflect such interaction, a non-additive value functional model based on the Choquet Integral should be used (cf. [2,14,18]). As the above model is totally compensatory, the extremely negative evaluation of some causal variables can be compensated with positive evaluations of other attributes. A partially compensatory model, including capability to exercise the veto when the status of some attributes is very unfavorable, could reflect better the perception of competitiveness.

To the best of our knowledge, this work approaches the analysis of regional competitiveness for the first time by modern techniques of multicriteria decision analysis (MCDA). The aim of MCDA is to assist a decision maker (DM) in choosing, ranking and sorting alternatives (actions, objects) according to multiple criteria [4]. Many decision support systems (DSSs) have been designed using MCDA to help DMs in analyzing problems and making easier decisions (e.g. [3–5,8,20]). Here, we propose an assessment of competitiveness by using a fuzzy outranking relation model. Fuzzy relations are an excellent alternative to the functional approach, since they are more general, have greater expressive capacity and are capable of modeling situations of intransitivity and incomparability [13].

The main aim of this paper is to present a "what if" analyzer, which is in fact a "competitiveness simulator". It uses certain reference information about competitiveness in order to construct a causal model in terms of many explanatory variables. Thus, a DM can explore the effect of changes on some causal variables, performing "what if" analyses on which public policies for competitiveness improvements can be designed. This model is implemented in a decision support system which satisfies a need of Sinaloa State Government in Mexico.

This paper is structured as follows: some theoretical background is presented in Sections 2 and 3. The main models are described in Section 4. The CORE system implementation is discussed in Section 5, and some experimental results are given in Section 6. Final conclusions are presented in Section 7.

2. Background

The World Competitiveness Report 2009–10 defines competitiveness as a set of institutions, policies and factors that determine the level of productivity of a country (cf. [25]). Hence the *Global Competitiveness Index* (*GCI*) measures the set of institutions, policies and factors that make possible the real growth and medium-term economic prosperity [25]. According to the *GCI* methodology, countries are divided according to their historical stage of development at the present, in three categories: economies whose growth rests on the exploitation of their resources (*Factor-driven stage*), those progressing due to more efficient performance of their productive activities and institutional processes (*Efficiency-driven stage*) and the mature ones, whose growth rests on the innovation (*Innovation-driven stage*). The differentiation between these categories is based on the use of the Gross Domestic Product (*GDP*) per capita variable (at exchange rate prices). Twelve subfactors of competitiveness, grouped into three higher hierarchical factors are considered at present: *Basic Requirements*, *Efficiency Enhancers*, *Innovation* and *Sophistication Factors*. Each of these factors is itself an index. The *GCI* is the result of a weighted sum of these factors, but the "weights" of each factor are different according to the respective type of economy (see Fig. 1 and Table 1). At the same time, each of the twelve factors at the second hierarchical level contains numerous explanatory variables in a linear regression model.

A mandatory reference in Mexico is the Mexican Institute for Competitiveness (IMCO). It is a private institution that sells index evaluation and construction services at different levels of the Mexican government. Institute's reports define synthetically competitiveness as a capacity of a territory to bring investments, since the rest of variables, such as growth, income, access to markets, etc. depends on this one. This institution characterizes the social object (as far as competitiveness is concerned) in terms of ten factors, which at the second hierarchical level are disaggregated into 122 causal variables. The IMCO uses the Gross Domestic Product as "proxy" measure of competitiveness *CP*. Every region is characterized by a pair ($\mathbf{x}$, *CP*); $\mathbf{x}$ is a vector of $\mathfrak{R}^N$, whose dimensions are measures of causal variables; and *CP* is the measure of competitiveness. Reference information is composed of a set $T = \{\mathbf{x}_1, \mathbf{x}_2, \ldots \mathbf{x}_M\}$, where M is the number of characterized regions. A functional model $U(\mathbf{x}) = w_0 + w_1x_1 + \ldots. w_Nx_N$ (x_i is the i-th component of the vector $\mathbf{x}$) that approaches the *CP* measure is obtained from T by employing regression techniques [16].

3. Analysis of competitiveness: different perspectives

With regard to competitiveness and its analysis, three different problems can be distinguished:

a) Estimation. If competitiveness is defined as an index composed of several measures, the problem of estimating competitiveness consists of assigning a value to this index for a potential stage of the social object (that might be the present one) under analysis.
b) Ranking. Given a set of regions in a similar context (countries, states, provinces, municipalities, cities), this problem consists of establishing an order within the set in the sense of decreasing competitiveness.
c) Sorting. In general, classification means assigning objects to preexisting categories. A special case of this process appears when there is an order of preference between categories, i.e., it is possible to associate them with an assessment. Then classifying turns into evaluating, assigning a qualitative evaluation to each object. Competitiveness could be evaluated, for instance, on the scale {*Very low*, *Low*, *Below average*, *Average*, *Above average*, *High*, *Very high*}. These categories imply relative judgments, however, well defined in the context of a set of regions that are being compared.

To the best of our knowledge, the existing competitiveness analysis methods are oriented to estimation and ranking, mainly by constructing an index that is calculated from a weighted-sum model of several factors, which, at the same time, are modeled as weighted-sum functions of several causal variables (cf. [16,25]). A competitiveness index like *GCI* arises from that model. It is a real number, useful for estimation and ranking. This can be seen as an efficient way to synthesize information. But such information is needed for making decisions, so competitiveness analysis should be considered an instance of more general multi-criteria decision problems. However, seen as a tool for multi-criteria analysis, weighted-sum models suffer important criticisms: i) the model is totally compensatory, the extremely negative evaluation of some causal variables can be compensated with positive evaluations of other attributes; ii) mutual preference independence and constant compensation ratio are necessary conditions for model's validity; iii) the model cannot handle ordinal and qualitative information (hence, ordinal or qualitative causal variables must become cardinal in order to keep meaningfulness of the results); and iv) the model cannot handle imprecise information.