MODEL OF GIS-BASED APPLICATION FOR FIRM COMPETITIVENESS ANALYSIS

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Abstract: The use of geographic information systems (GIS) as a tool for data presenting and analyzing in various areas of modern society becomes more and more relevant and aproved. GIS provide rich opportunities for complex analysis of many economic indicators combined with spatial (geographical) data. The competitiveness consolidating such indicators is a complex and multifaceted concept measured by index highly depending on the level of awareness in technological, organizational and managerial aspects. This determines the application of information and communication technologies (ICT), including GIS for data gathering, exchange, processing and storage, for output information, as well as for knowledge generation in order to management decision support in business organizations. The literature review shows a large number of firm competitiveness researches but none of them are related to GIS. The article investigates an innovative model of an online application using GIS for firm competitiveness analysis. The model of the application has a modular structure, including modules of: interface, online GIS, functionality (business logics) and firm database. The interface module contains web pages for queries and results from analysis with spatial localization. The module of functionality covers scripts of the functions for: data entry and support, firm competitiveness index calculation, GIS and firm database connections, index ranking, factor, comparative and trend analysis, and others. A method of firm competitiveness index calculation, developed by the authors in their previous research, is applied. In addition to the methodology, methods are used to: determine user access levels; selection of GIS layers; analysis of firm competitiveness. The GIS module includes spatial and attribute data in layers of: basic administrative map, transport network, urban territories, engineering infrastructure, demography, water resources, and firms for selected region. The firm database contains main firm data and the respective competitiveness indicators. The analysis is consistent with standard classifier of the business sectors and includes firm ranking in accordance with their competitiveness indices for selected business sector and time period. The proposed model is a basis of software application development for diagnostics and analysis intended for business analysts and firm managers, researching the firm positions and bottlenecks, helping management decision making. The article is developed under project НИС-Б-1078/16.03.2020 of the University of Forestry, Sofia, Bulgaria.
Keywords: firm competitiveness, GIS, online application, model, firm competitiveness analysis

1. INTRODUCTION
GIS technology integrates common database operations such as query and statistical analysis with unique visualization and geographic analysis benefits offered by maps (Banes et al. 2010). The advantage of GIS, compared to traditional information systems, lies in the much wider possibilities for statistics, analysis and visualization of the geospatial information maintained and processed in them. This information is significantly richer and more visual than the attribute (textual and numerical) and respectively, more effective to support management decisions in different human activities.

Particularly, the preference of GIS in the firm management consists in primary data processing, analysis and visualization on:

- the territorial distribution of enterprises, firms and organizations by economic sectors;
- operational and strategic planning;
- logistics operations;
- production and employment by territory, year, demography, climate, etc.;
- market research an marketing of products and services;
- competitiveness;

Thereby, utilization of GIS in the firm management improves organizational integration and decision making process because of facilitating the communication and sharing information. Gaining competitive advantage is the main goal of the companies' management which will make company sustainable at the regional, national or international market or all of them (Kranjak, Sikimić, & Tomić 2016).

In view of that, the intentions of the present study are in a research and analysis of the firm competitiveness using GIS. They are based on a preliminary survey of the achievements in the area.

2. LITERATURE OVERVIEW

There are some GIS applications concerning economic management. At the initiative of one of the largest Bulgarian employment website JobTiger[10] an online Industrial Map of Bulgaria has been created to meet the needs of large-scale industry solutions (JobTiger, 2020).

The card helps to improve the education-business relationship by bringing together vocational high schools, universities, career events and industrial enterprises.

In an other study, by smart card data and GIS-based application, the transit competitiveness index in Seoul is calculated which represents actual transit travel times (Lee, Park, Kho, & Kim, 2019).

Other authors propose a new GIS-based model to assess the socio-economic potential of Gran Canaria and Tenerife islands (Santana-Sarmiento, Álamo-Vera, & De Saá-Pérez, 2019). A method for territory competitiveness index calculation is developed using local resource data and multi-criteria analysis by GIS.

A 3D city web platform based on WebVRGIS (Li et al, 2015) is created using 3D building model, residents data, real-time and historical traffic data. The platform offers 3D analysis and visualization of the concerned city massive information.

In his research Sonti (2015) explores the potential application of GIS in forest management in three African countries. Forest management planning involves predictions of future forest growth relative to different management activities affecting its temporal and spatial dimensions. In (Deliyska, & Manoilov, 2009) a GIS of Bulgarian forest industry enterprises is presented.

None GIS-based application of firm competitiveness analysis was found. Given the above conclusions, in the current article a model of GIS-based application for firm competitiveness analysis is proposed.

3. METHODOLOGY OF BUILDING GIS-BASED APPLICATION FOR FIRM COMPETITIVENESS ANALYSIS

The methodology includes the following steps:

3.1. Goal definition

The goal of the GIS-based application of firm competitiveness analysis is: collection, storage and processing of primary data and subsequent analysis of summary information about firm competitiveness in different sectors of the national economics.

3.2. User determination

Users are firm managers, business analysts, database and GIS administrators. The firm managers and the analysts require and have access to the calculated firm competitiveness indices and to analysis results. Database and GIS administrators maintain respective firm data and GIS layers.

3.3. Model building

The model includes four basic interconnected modules: interface, functionality, firm database and online GIS (Figure 1).

Figure 1. Common schema of the model of GIS-based firm competitiveness analysis

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[10] https://www.jobtiger.bg
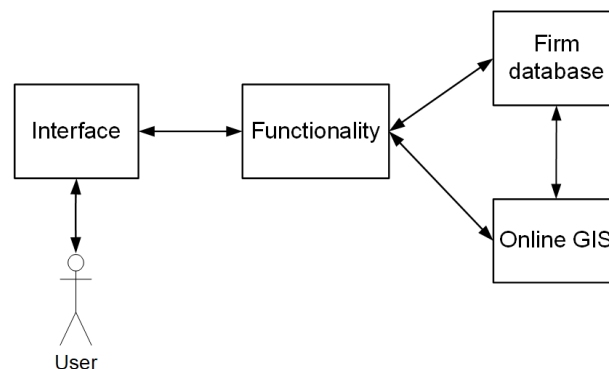
3.3.1. Interface
The interface is a web page for user access. Users submit queries and receive results in the page invoking respective functions of the functionality module.

3.3.2. Functionality
The functionality includes three groups of functions for: firm data support, GIS spatial data support and firm competitiveness analysis (Figure 2).

Firm data support functions include data entry, update and delete, and following firm competitiveness index calculation. It should be pay attention that each change of firm data causes a recalculation of all firm competitiveness indices stored in the table *Annual firm results* of the firm database (see Figure 3). Moreover, an update of GIS firm dot layer is performed. The recalculation is a part of each firm data support function. Separately, there may be queries for a single firm competitiveness index extracted from the above table.

The method of firm competitiveness index calculation is applied developed by the authors in their previous research (Ivanova, 2016; Deliyska, & Ivanova, 2011).

GIS spatial data support functions are about adding or deleting of GIS basic map layers. Particularly, there is a function of firm dot layer generation.

Figure 2. UML activity diagram of the functionality
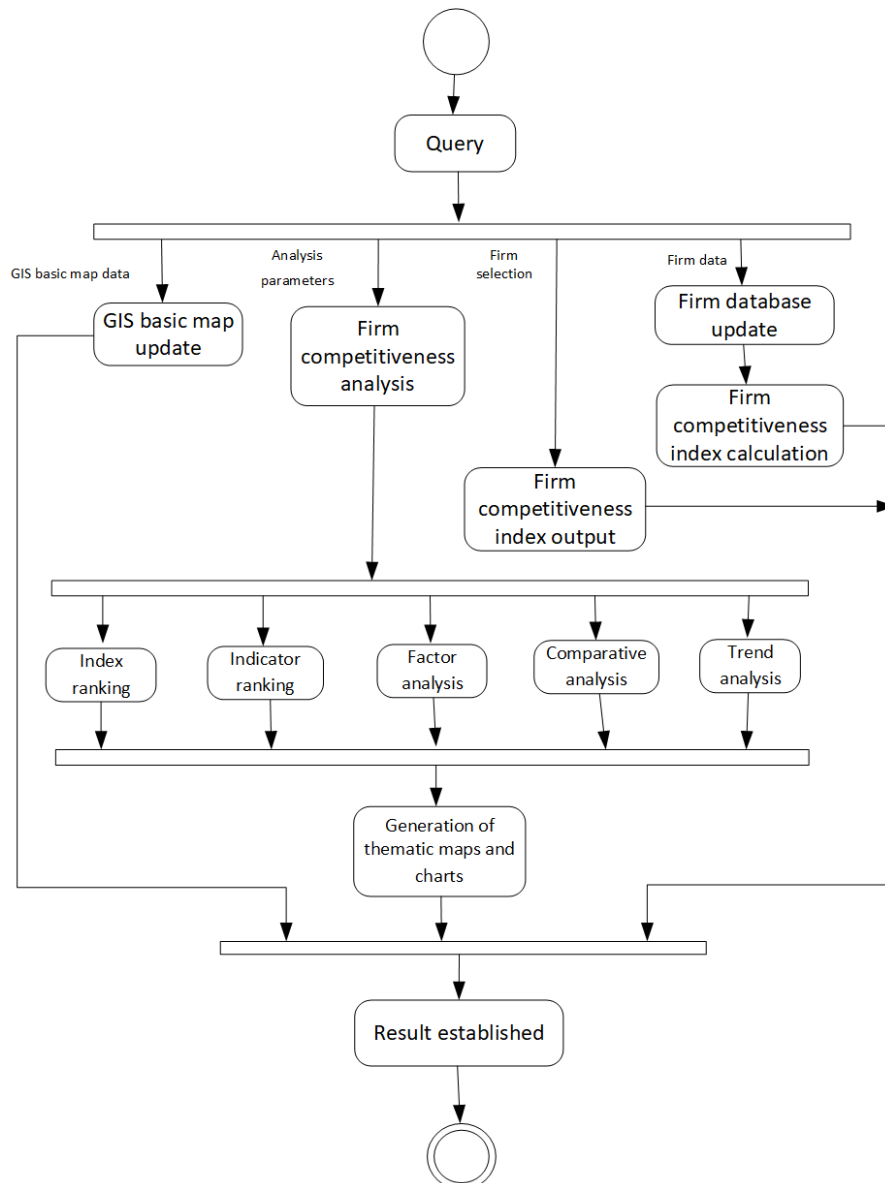
The firm competitiveness analysis functions are consistent with standard classifier of the business sectors and use known methods concerning:

- ranking firms by their competitiveness indices;
- ranking firms by each of indicators of competitiveness index for given year or period of years;
- factor analysis of the dependence of the index value on each indicator value for given year;
- comparative analysis of indices for different years and the dynamics of their change;
- trend analysis of the year index values in view of forecasting firm development.

These functions generate the respective thematic map ad charts in the online GIS environment.

3.3.3. Firm database
The firm database contains main firm data and the respective competitiveness indicators. It is of classic relational type and includes tables shown on Figure 3.

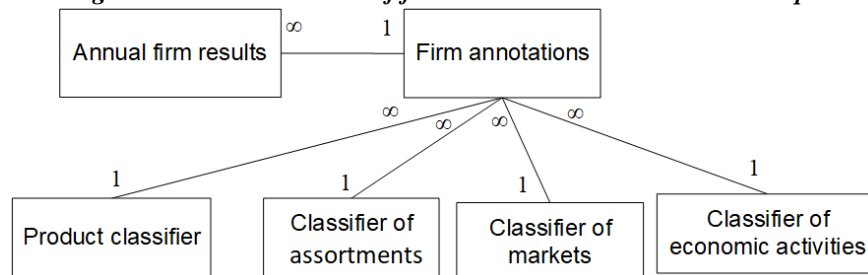*Figure 3. Common schema of firm database tables and relationships*

Table *Annual firm results* contains annual data for the number of employees, labor productivity, fixed assets, profit and calculated index of competitiveness. The main table *Firm annotations* contains basic firm data – name, address, assortments, products, markets and economic sectors. The main table is linked to some classifiers - *Product classifier* (about product groups), *Classifier of assortments* (including data on the totality of all products and their varieties that the manufacturer offers on the market), *Classifier of economic activities* (about all national economic activities in production of goods and services).

3.3.4. Online GIS
The online GIS comprises spatial and attribute data of the basic map layers including: administrative and transport network, urban territories, engineering infrastructure, demography, water resources, and etc. depending of analysis needs. A layer of firm competitiveness indices for selected region is added and updated dynamically by each analysis query and the respective function.

3.4. Implementation of the model
For the implementation of the model must be used approved standard web technologies taking into account the requirements of the selected online GIS. Currently, online GIS platforms are too few. A free online GIS is QGIS Cloud[11]. GIS MapInfo Pro[12] proposes some online services. Most suitable for the model implementation is ArcGIS Online, which enable to build interactive maps which explain digital data, sharing maps with specific groups or everyone, work effectively across organization to build and use maps, analysis tools for reveal relationships, identify prime locations, use optimal routes, and analyze patterns to make predictions (Esri, 2020).

4. CONCLUSION
The proposed model of GIS-based application for firm competitiveness analysis is a foundation of the following development of the respective online software system. The results of the firm competitiveness analysis are important for business analysts and firm managers, researching the firm positions and bottlenecks, helping management decision making.

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[11] https://qgiscloud.com/
[12] https://www.mapbis.com/mapinfo-pro/

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