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Analysis and Visualization of Marketing, Statistical and Macroeconomic Data With GIS

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The most common way to analyze economics data is to use statistics software and spreadsheets.The paper presents opportunities of modern Geographical Information System (GIS) for analysis of marketing, statistical, and macroeconomic data. It considers existing tools and models and their applications in various sectors. The advantage is that the statistical data could be combined with geographic views, maps and also additional data derived from the GIS. As a result, a programming system is developed, using GIS for analysis of marketing, statistical, macroeconomic data, and risk assessment in real time and prevention. The system has been successfully implemented as web-based software application designed for use with a variety of hardware platforms (mobile devices, laptops, and desktop computers). The software is mainly written in the programming language Python, which offers a better structure and supports for the development of large applications. Optimization of the analysis, visualization of macroeconomic, and statistical data by region for different business research are achieved. The system is designed with Geographical Information System for settlements in their respective countries and regions. Information system integration with external software packages for statistical calculations and analysis is implemented in order to share data analyzing, processing, and forecasting. Technologies and processes for loading data from different sources and tools for data analysis are developed. The successfully developed system allows implementation of qualitative data analysis.

Keywords: GIS, statistical analysis, marketing data analysis, location analytics, WEB business software application, management information systems

Introduction

There are various approaches/methodologies for analysis, visualization of marketing, statistical and macroeconomic data. One approach is to use specialized statistical software packages such as SPSS, Eviews, and even Excel. Another approach is to apply the tools of information technology (IT). This IT approach with its features and tools is widely applicable in various business sectors. The components of IT approach include development of information system with components of GIS, data warehouse, and location analysis. So the information system combines the power of the statistical analysis with the visualization tools, power of GIS, and access to big amount of data stored in Data Warehouse. The research analyses the components and shows the main components of a working information system designed for visualization and analysis of macroeconomic data.

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Basic Notions and Components

Geographic Information System (GIS): Definitions

Different definitions of GIS depending on their possibilities and purposes (Raju, 2003):

- GIS is computer system for collecting, keeping, retrieving, and visualization of spatial data (Stillwell & Clarke, 1987);
- GIS is computer system for processing of geo referential information: Input, data management (store and retrieving of data), data processing, and analysis (Aronoff, 1989);
- GIS has three main components—data, analysis, and visualization (Burrough, 1987);
- GIS enables people to easilier view, analyze, and understand geographic patterns and relationships. Through them, people can compare the locations of various objects to discover how they are related to each other or are geographically allocated to other objects in space;
- GIS aims to achieve maximal effectiveness of planning and taking decisions, to deliver effective tools for dissemination of data and analysis, to decrease the data duplication, to integrate data from many sources, and to produce complex analysis including geographical component for retrieving of new information. For each application there are five key questions that GIS can answer (Raju, 2003):

(1) Location—What exists at a particular location?

(2) Condition—Where are certain conditions (identifying locations)?

(3) Trends—What has changed since then?

(4) Models—What spatial pattern exists?

(5) Modeling—What would happen if?

GIS Components

According to some authors, the main components of GIS are four—hardware, software, data, and users. The hardware is a device, with which a user interacts directly in the implementation of GIS operations, which return information directly on the screen of the device. The software is used locally on the user's computer, and it can be a standard web browser or a complex software application. The third component is the database, which is a digital representation of selected aspects of some areas of the Earth's surface. GIS is useless without the people who design, program, support, supply data, and interpret their results (Longley, Goodchild, Maguire, & Rhind, 2005).

GIS Software

At the beginning of the development of GIS, it was a tool with set of commands that can be applied to a range of spatial data to create a new set of data. It consists of a collection of computer procedures that only an experienced programmer can use to build operational GIS. But with the development of the software engineering and the marketing growth of GIS in 1970 and 1980, the demand for high-level applications with standard user interface increases (Longley, Goodchild, Maguire, & Rhind, 2005). The ability for customization was added, which allows applications with specific purpose to be established by common tools.

In recent years a new method was developed which allows software systems to communicate across the network using the paradigm of web services. Web services are applications that disclose their functions through well-designed interface that can be accessed on the internet from another application or web service. This new paradigm allows to link together many GIS functions to create more complex and customized applications.

GIS Applications

Many organizations from both the public and private sector use GIS mapping and data analysis. These organizations are in the transport sector, financial services, insurance, health, environment, marketing, and advertising real estate. Government organizations and NGOs are more open about their GIS operations and data due to the nature of the environment in which they work, while private sector companies provide access to less information on their technology systems fearing that their competitors can copy their technology systems, and thus the company will lose competitive advantages (Amos, 2009).

GIS in transport sector. GIS makes it possible to improve delivery schedules and reduce costs associated with delivering products. Tracking of vehicles GIS technology provides network algorithms to calculate optimal routes for the transport network, which saves time and money. The exact details of the transport network are important to maintain geocoding and functionality for route planning (Bowman & Lewis, 2006).

GIS in finance. GIS is used in finance services for business processes: Localization, establishment of bank branches, and targeted marketing of particular financial products for the customers. Organizations for financial services differ from a company to retail, as they often have large databases of customers with geographic elements. Financial services companies such as Visa and Mastercard are among the first companies to develop web-based GIS applications for locating ATMs for its customers (MapInfo, 2004).

GIS in the insurance business. GIS is used for geospatial analysis and detailed modelling of actives for strategical resources. The insurance companies use GIS through all stages of the insurance process—from quote their policy customers to support recovery after a catastrophic natural disaster (MapInfo, 2005).

GIS in health institutions. GIS is used for enhancement of the process of decision making, for geocoding the location of the patients, for tracking and computing of the optimal way. Ambulances can also be equipped with mobile GIS that will provide the fastest route for the place of emergency (Amos, 2009).

GIS in invironment. GIS is becoming an essential tool for resolving territorial disputes in the field of environment. Researchers and environmentalists use GIS to analyze the environmental pollution and determine possible violation of the ecological balance (Galati, 2006).

GIS in the real properties business. This is the sector where the localization of the real estate plays the key factor. Restaurant business and retail are using GIS for market analysis, for investigating the best location of a new store and cannibalization of the market, and for investigating the optimization of the market. Market analysis is a study of the geographical areas to determine whether there is a large concentration of potential customers and little competition to identify sites for expansion. The study of the location of the object is the process of identifying the ideal plot where to build a new one. Market optimization is the process of identifying gaps in the market, where a new store can serve a population that the retailer does not serve now (MapInfo, 2005).

GIS gives possibility to analyze the markets on macro- and microeconomics level. On a macro level, GIS can prioritize markets and sectors based on demographic, competitive and traditional economic factors. Data generated from GIS analysis could expose the factors that influence positively or negatively on sales of a store (Amos, 2009).

GIS in marketing analysis can investigate the factors which have a positive or negative influence on sellings of particular merchandize in a given store. GIS is used in marketing and advertising by combining GIS software with demographic databases and systems for segmenting the lifestyle of consumers, to analyze the

distribution of the population. Consumers with similar incomes, lifestyles, and tastes, tend to live near each other and have similar buying habits. This segmentation helps analysts understand their users better in terms of their income, tastes, and costs (MapInfo, 2008).

GIS and Marketing Information Systems

Marketing Information Systems

GIS technology is considered as a major component of marketing information systems whose major role is to combine technology with elements of the marketing mix. The concept of marketing information system (MIS) comes from 1960 as a technique for applying the new (at that time) technologies for data processing and making marketing decisions (Hes, Rubin, & West, 2004).

Kotler (1997) defines an MIS as a structure consisting of people, equipment, and procedures, which aims to collect, sort, analyze, evaluate, and disseminate relevant, timely, and accurate information to assist in making marketing decisions.

MIS uses marketing information, which includes information about the environment of the organization, its activities and the extent to which various aspects of the marketing plan are adopted. There are two types of sources of information for MIS—internal (in-house statistics, turnover, analyzes, & reports) and external (industry analyzes, trends, departmental statistics, reports, & analyzes of public institutions).

MIS is the general term which covers both marketing information systems and decision-supporting systems (Longley, Goodchild, Maguire, & Rhind, 2005).

The failure in the use of MIS in organizations is caused most often due to either lack of efficiency or high costs. For this reason MIS should provide effective cost and accurate support for the marketing decision makers. GIS is a system that has these features and are available at relatively low cost. One of the most expensive components of an effective MIS is converted and applied in GIS together with the integration of data from different sources using relatively inexpensive desktop GIS software.

GIS as the main component of marketing information systems, is used as a tool for:

- investigation of new markets and identifying of markets with biggest potential;
- development of marketing strategies to guarantee the optimal development of the expansion;
- survey of the store in the existing markets in order to figure out the possibility of opening of additional stores;
- prognosing of future trends in order to estimate the results of concurrent and demographic changes in the existing markets (Francica, 2006).

GIS in the Marketing Analysis

GIS market analysis is not so often used, but its popularity has been growing in recent years, with the development of web and then of cloud technologies. GIS is integrated and connected directly with more and more other information systems in the companies (Burns, 2000). Emerging technologies such as location intelligence (business intelligence + location) and location analytics, which enable this integration and make GIS functionalities available to a growing number of consumers who are aware of the need for spatial analysis of the data they work with. For the purpose of marketing the most common applications of GIS are related more to consumer marketing, and they play a manifest role in the analysis of processes and operational and strategic level.

GIS contributes to the taking of marketing decisions with two mechanisms:

- ensures a way for analyzing the internal or external marketing data in a appropriated format for taking of decisions;
- gives the possibility to integrate external and internal data in order to significantly enhance the effectiveness of the marketing decisions (Sprague & Carlson, 1982).

The analysis of all marketing data, stored in data base, can be made based on qualitative or quantative analysis, statistical methods, procedures for collecting and dissemination of marketing information, and data analysis models.

Specialized maps such as topographic, soil, and maps showing population density, etc., contribute to decision making. Most functions depicted on the map, have attribute information and descriptive data to each function. Paper maps, however, may show only a limited amount of attribute information by the symbols on the map.

Unlike paper maps, GIS can store, manipulate, and display much richer set of attribute information that connects in sets of items and stores them in units called topics (Harder, 1997). A theme contains a set of similar items, such as all roads in a given area. Another topic may contain all shopping centers with the attributes of those characteristics. Map of the city, for example, can contain many topics, such as highways, roads, political boundaries, public buildings, schools, parks, and more. GIS can create cards "on the fly" based on the characteristics and attributes that are of interest to decision makers. For example, if a decision requires location information of customers, demographic data from the census, the location of stores, and other topics, information about airports may be omitted on the map.

GIS as Component of Marketing Information Systems (MIS)

Twelve of the most widespread possibilities of GIS in marketing are to carry out a market analysis to identify the best customers, their places of residence, and the concentration of potential customers with similar characteristics. Internal data can help with this task. The system of internal reports collects information generated by internal systems for processing transactions of the company. An important element of the internal reporting system of a company is transactional data for consumers during sale (Hess, Rubin, & West, 2004).

GIS in the area of the marketing fulfills analysis of the market, to identify the best clients, their location of residence, as well the concentration of the potential clients with such characteristics. Internal company data can help with this task. The system of internal reports collects information generated by internal systems for processing transactions of the company. An important element of the internal reporting system of a company is transactional data for consumers during sale (Hess, Rubin, & West, 2004).

If the transaction includes information on the location of customers (addresses & postal codes), the location of customers can be easily mapped. If residential addresses are complete and accessible, exact location of the customers can be mapped. If there is information about postal codes of customers, map can be created on which region of the responsible postal code is colored in a different color, and that can generate the number of customers or the volume of sales in the region. By using mapped data, customers can fulfill two main aspects of the marketing campaign. On the one hand, to analyze the amount of sales by presenting customers in concentric circles on a given area, and identifying how many percent are customers in different radius around the store. On the other hand, the marketing company may use the customer's data to set up customer groups to be targeted by campaigns using direct mail, newspapers, or billboards. Mapping the retail space is also an excellent tool for

identifying problems and opportunities in the market. Internal data address and postcode of customers can be used to determine the size and amount of sales from commercial objects. When areas overlap, this is the indication of cannibalization problem because different stores within the same area are competing for the same customers. On the other hand, areas that remain outside the area of the business premises, provide an opportunity to create new commercial objects.

GIS as a Tool for Decision Support of Marketing Decisions

Support systems for making marketing decisions do not create new information by themselves, and instead comprise information which was restructured in a way that helps to retrieve solutions easily and a set of tools which are able to analyze the decisions. These opportunities are consistent with two subjects in research related to marketing information systems: decision support systems (DSS) and data warehouses (DW) (Hess, Rubin, & West, 2004).

GIS as a tool for decision support of marketing decisions includes the possibility for programming of models, which use either internal programming or scripting languages.

The modern GIS includes integrated analytical models for:

- to the activities connected with the distribution via computing the shortest route from support center to the location of the customer with the help of special algorithm;
- to point the different locations of the clients and to update the maps every day;
- to analyze the zone of service via computing the travel time on the existing street net;
- to support the control of the connections with the clients via delivering the possibility for navigating from the customer location to the nearest location of a store or object.

GIS and Data Warehouses

Data warehousing is the process of integrating internal, external data, and their processing. This allows the data to be easily accessible to decision makers. Data processing may include storage of aggregated data (e.g. placement of sales by product and by month or by region and by month) in addition to the raw data. The data can also be stored in a format that is easily understood by the expected consumer.

GIS has three roles in DW: storage of data, performing the analysis, supporting the decision-making. When spatial data are stored in the data warehouse, tools such as Oracle Spatial can be used for extraction, analysis, and presentation of data from large data warehouses. An important transformation that is often performed on data with spatial component is geocoding of street addresses. Activities for transaction processing of the company data (adding customer, sales data, etc.) usually do not require spatial models and do not perform geocoding. In this case, marketing analysis can use these values. For this reason there are many products designed to perform geocoding "wholesale" as part of the transformation between operational systems and data warehouses. GIS are particularly suitable for geocoding when both types of data have spatial component.

Location Intelligence/Location Analytics

The solution for the integration of Business Intelligence (BI) and GIS is called Location Analytics or Location Intelligence. Location Analytics reinforces the business systems of the organization giving new geographic perspective on data and allows spatial analysis. Location Analytics seamlessly integrates maps into the BI system using technology that is inherent in the core business system. This is one of the fundamental principles of Location Analytics—ability of GIS to be a natural part of business systems of the organization.

Location Analytics decisions allow communication between table and spatial data:

- cartography and visualization;
- spatial analytics—gives possibility to analyze the business information spatially via map. When the analyzer chooses spatial information on the map, the appropriate information is displayed automatically with tables, diagrams, and graphics;
- geocoding via creating geographical coordinates of addresses or postal codes;
- forecasting the future trends to estimate the consequences of the concurrency;
- enriching the data meanning that the analyzers can add key demographic information as business information.

Location Analytics solutions allow communication between table and spatial data. They deliver bigger context for investigation of business information, figure out models and trends, and help to enlarge the business:

- usage of economical, demographics, geographical, and other data, are connected with the location. So location analytics helps to find out models, risks and possibilities which is hard to analyze using an ordinary spread sheet;
- location analytics leaves many advantages to the financial, insurance, and communication operations, which transforms in higher revenues and lower costs and enhances effectiveness for every organization.

Over 80% of all data held by organizations around the world contain the component location. Location Analytics has many similarities with the concept of customer intelligence, which became known in the 90s. It is based on software for customer relationships management (CRM). The basic idea behind customer intelligence and software CRM is that if a company knows more about demographics, preferences and buying habits of clients, they can prepare marketing offers for customers in a way that will increase the tendency of customers to buy and improve customer's quality of life (Esri, 2012).

Location intelligence provides many advantages for the financial, insurance, and communication operations that are translated into higher revenues, reduced costs, and improved efficiency for any organization.

In almost every industry, managers, executives, and employees are increasingly using digital maps with enterprise applications such as business intelligence (BI) and CRM. The world now understands the power of digital map, which is largely due to the mass spread of web mapping and mass ownership of smartphones and tablets mapped applications.

TechTarget (2012) and Esri (2012) conducted a survey and found that managers and leaders typically used mapped data for a number of reasons, including asset management, business intelligence (BI), customer relationships management systems (CRM), enterprise resource planning systems (ERP), estate planning, risk management, and supply chain management systems (SCM).

Location Analytics solutions are used in following branches (Esri, 2012):

- insurance industry—for analyzing the Total Insured Value (TIV) by regions and insurance policies;
- financial industry—for analyzing key finance indicators like total sum of deposits, the savings of the households, households automobile loans, and ready money;
- communal services—for review and analysis of key measures like electricity blackouts, the connected expenses with it, and anomalies by the delivery;
- transportation sector—for review and analysis of the routs based on real time schedules, for analysis of the average revenue of a given location, percentage of delayed deliveries, and flights;

- retail—for analysis of the income in territory and profitableness by region and location;
- public sector—for review and analyses of the deliveries and prices of the services depending of the service zone, as for analysis of projects in the public sector;
- education.

Information System for Analysis and Visualization of Marketing, Statistical, and Macroeconomic Data

An information system which stores, maintains, visualizes, and analyzes statistics, macroeconomic, and marketing data is developed to combine the statistical analysis and GIS. The system uses and processes the following data:

- Demographic data;
- Business data and data on business demography;
- Data on consumption;
- Data from marketing researches;
- Data on quality of life;
- Specialized data.

Data loading process includes:

- Processes of extracting, transforming, and loading (ETL) data from the source systems (local excel files) into the data warehouse that happen periodically or monthly. Data loading process occurs in two stages during the process of filling the data warehouse: (1) During an initial load when the DW is first created; (2) During subsequent updates (normally performed on a periodic basis) to keep the DW current and/or to expand it. Data loading can be presented as a process, consisting of five steps: mapping and metadata management, capture/extract, scrub/cleanse, transform, load and index;
- In the database of the information, system was created separate into logical schema, which stores and maintains introduced digital information for the territorial map of the country displayed by statistical regions, districts, and municipalities;
- data for all tables and charts is described in the repository database. It stores descriptive information about each table (dimensional or fact table), which is designed to store data.

System program modules are:

- Module GIS—Instruments for navigation on the country map, component for searching, component for information from the country map objects;
- Module data warehouse—Creating and support of the data warehouse;
- Module data loading—ETL process;
- Module data exporting;
- Module for administration—System administration, statistics of use, resources, and data base administration;
- Module for analysis, reports, and graphics.

The software of the information system for storage, visualization, and analysis of data is written mainly in the programming language Python (version 2.7.3). It is used database management system PostgreSQL 9.1.14. The software system is located on a server managed by the operating system Linux-3.8.0-29-generic.

System advantages are following:

- Improving access to statistical and macroeconomic data;
- Improving the quality of marketing services;
- Reducing time and cost to implement statistical analysis;
- Improving coordination in the implementation of marketing researches;
- Ensuring transparency in the implementation of statistical surveys;
- Improving the search, visualization and execution of data analysis and forecasting.

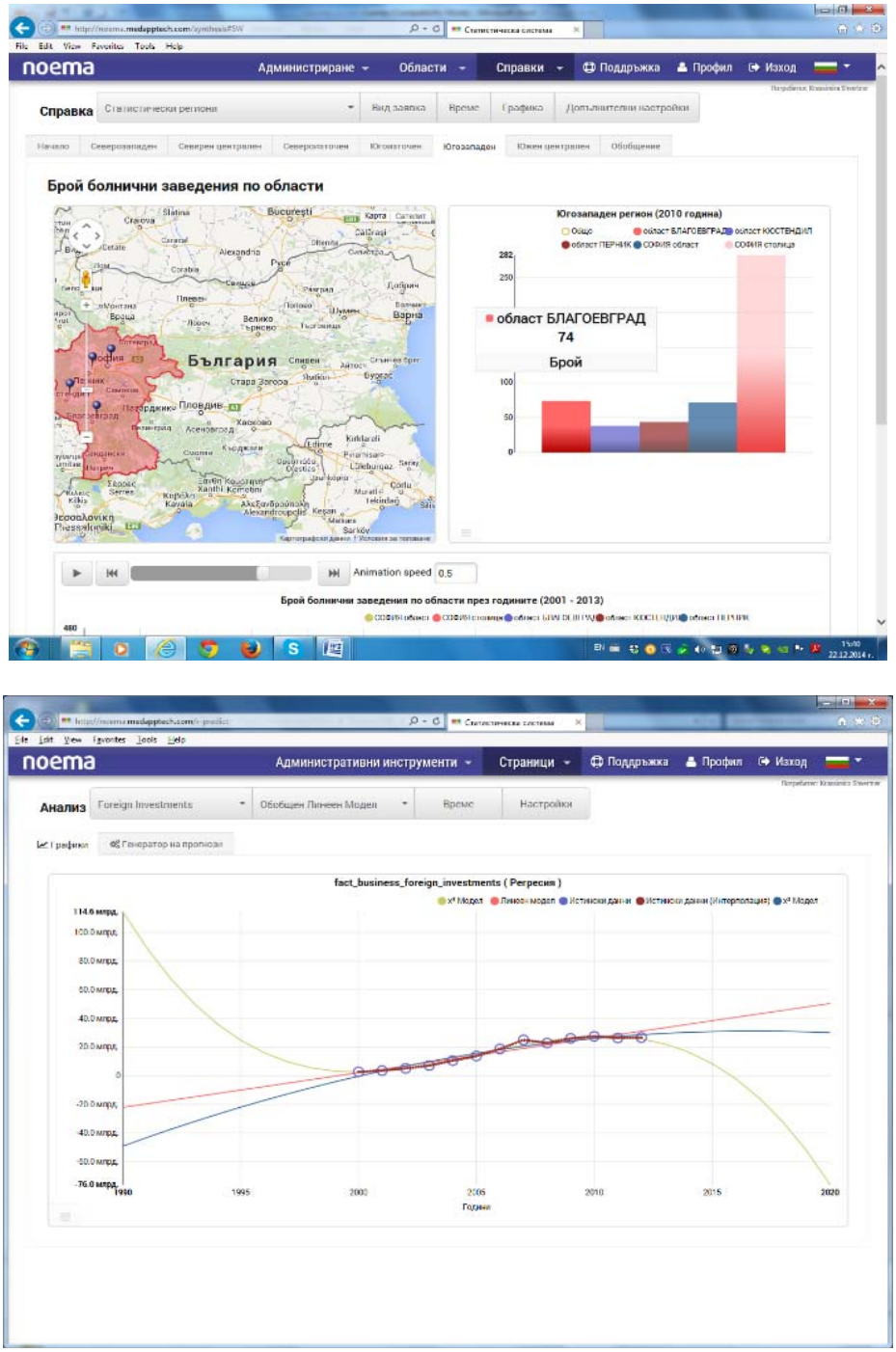

Figure 1. System screenshots.

Conclusion

GIS ensures visualization and analysis of data with spatial element. It is possible to add components for prognosis and forecasting. GIS gives many possibilities for geospatial statistical analysis and ensures models and algorithms which give the possibility to make predictive analytics based on geographical principles.

GIS enhances the data processing and adds new possibilities to speed up the data processing.

The new Hardware and Software environment need new specific knowledge and training efforts.

It would be interesting, however, in addition to visualization and data analysis with spatial element to add forecasting and prediction. GIS provides many opportunities for spatial statistical analysis and certainly there are models and algorithms that allow the execution of predictive analytics based on geographical principle.

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