PROTOTYPE FOR MACROECONOMIC DECISION SUPPORT SYSTEM WITH SPATIAL DATABASES SUPPORT

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Abstract
Network organized structures can be stored and subsequently represented using spatial databases. They are used in areas where the aspects connected to maps and photos are very important: weather, management of natural calamities (earthquakes, fires, cyclones, volcanoes, floods), transportation and macroeconomic fluctuations. Studying side by side several such networks may reveal new aspects that will support making Big Decisions. For such solutions, the latest computer technologies are required, such as storing and processing huge volumes of data, Cloud storing, retrieving data from multiple sources and even using alert messages from social networks. Also, spatial databases are optimized to store and allow optimal access to data regarding various spatial localized objects.
In this paper we propose a decision support system's prototype that uses macroeconomic indicators that are correlated with natural phenomena like cataclysm (flows, earthquakes, etc.) at regional level and using spatial representation. The data will be collected as social media from Google Trends with possible extension from social networks, forums, news, etc. We will show how Big Data leads to Big Decisions when processed in a decision support system.

Keywords
Spatial Databases, Big Data, Big Decisions, Decision Support System, Macroeconomic Policies

JEL Classification

M20, O30, E60

Introduction

The process of globalization, the intensification of connecting the international markets and business affairs has accelerated in the last two decades, as technological development facilitates the transportation, communication and international business.
The network approach is more oriented towards satisfying the flexibility and reactivity, adopting - mainly due to the new electronic communication and information transfer systems – more simple solutions to the problems generated by internal and external factors, influencing the dynamic of the environment and the companies. The company-network idea

came therefore as a response to the shortcomings of the existing structures in relation to the new demands of competition on a global scale.
When building macroeconomic policies a decision-maker should take into consideration as many factors as possible and gather as much available information in order to be proper informed. Just like the Butterfly Effect theory that states that a butterfly flapping its wings in the Amazon forests can generate a tornado on the other side of the world, we believe that an efficient decision can only be taken when Big Data is analysed and spatial databases support is offered.
Macroeconomic models are usually used to describe the robust dependencies between the main economic performance indicators and the decisional factors in order to predict the effects of changes in monetary, fiscal, or other macroeconomic policies. Based on macroeconomic models, "what if" scenarios can be built to enable the policy-makers to foresee the future economic trends and take prompt measures to ensure longer economic growth and quicker economic recovery.

Use of Big Data in decision making processes

The use of Big Data has increased considerably in the last few years and the new challenge becomes now on how to build efficient decision making processes based on Big Data. So far, it has been argued how Big Data Analytics can help the agriculture economy by enabling farmers to use various data sources (sensors, satellite images, historical use of fertilisers, etc.) to gain insights from the analyses to manage farms effectively.
But the implications of using Big Data upon Big Decisions are a lot more serious, since it can help modelling and forecasting long-term macroeconomic trends that are affected by business strategies and policy making.
For instance, Li, Shang and Wang (2014) proposed a mix frequency modelling approach to incorporate the recent high frequency part of social media data in traditional econometrics based macroeconomic forecasting with support of a multisource based macroeconomic forecast system. A mixed data sampling model was constructed and an empirical evaluation was presented to show how to incorporate Google search queries into Chinese CPI forecasting. The empirical results indicated a satisfactory improvement in forecasting performance. The multisource modelling and forecasting framework offers a practical and implementable solution for involving social media data sources into macroeconomic forecasting systems.
The Bank of Canada also uses non-official data to monitor the economy, by gathering perspectives on topics such as demand and capacity pressures, as well as views on future economic activity from quarterly consultations with businesses (Armah, 2013).
Big Data could also be used in studying labour market developments. For instance, Choi and Varian (2009) found that unemployment-related Internet searches can improve predictions of initial claims for unemployment benefits, while Askitas and Zimmermann (2009) and D'Amuri (2009) found that Internet searches can be relevant for predicting labour market conditions in Germany, Italy and Israel.
Moreover, McLaren and Shanbhogue (2011) examined the importance of online searches for predicting activity in the labour and housing markets in the United Kingdom. The authors specify two separate models in which either the growth in U.K. unemployment or growth in house prices is a function of previous growth rates. Their results indicate that the inclusion of Internet searches in these models improves the models' forecasting performance.
In another study, Wu and Brynjolfsson (2009) found that housing-related searches can improve on traditional models for predicting housing sales in the United States. Besides

that, Webb (2009) suggested that the high degree of correlation between the number of searches for “foreclosure” and the actual number of foreclosures can be the basis for an early-warning system to predict problems in the U.S. housing market.
Further on, we can state that a proper use of Big Data can help not only determine the vulnerability to several economic shocks, such as fuel price or inflation increase, but it could also provide valuable insights of the impact of an industry downturn on households or how the massive changes happening in the society, such as knowledge workers or telecommuting are going to affect the socio-economic climate.
Therefore, we draw on these arguments in order to assume that a decision support system that integrates high-performance tools and techniques for spatial databases support could facilitate a fast and effective analysis, better decision-making and more effective presentation and comprehension of results through faster use of Big Data analytics.

The technologies involved in a decision support system

Statistically the last decade was marked by an increase of worldwide frequency and intensity in manifestation of the natural disasters, one of the causes considered being the global heating, which generates a higher input of energy for all terrestrial processes. In general, natural phenomena (earthquakes, floods, storms, etc.) and the types of transport (rail, road, air, etc.), which are interdependent (for example, we can be interested in the railways affected by storms) can be modelled and optimized as network type structures.
In this context it is compulsory to identify new methods which should permit simultaneously:

- the improvement of prognosis regarding the place, moment and natural phenomena’s characteristics which can result in a disaster;
- scenarios regarding practical strategies for when the disaster comes;
- implementing strategies after a natural disaster to decrease the losses and faster recuperation;
- identifying the macroeconomic indicators that reflect the natural disaster in a region’s economy;
- spatially representing the regions naturally affected by catastrophic situations and by economic falls;
- making real time decision.

The use of GIS (Geographical Information System) in the study and natural disaster prevention is worldwide for more than 10 years. The unimpeachable advantages have imposed the use of those respective techniques in different domain, including the study of critical flood situations. GIS are geographical informatics systems having as foundation spatial databases.
The geographic information system is a system capable to store, manipulate, analyze and display geo-referenced data to a coordinate system (Brueckner and Tetiwat, 2008). The principles of a Web GIS application are described in research (Fu and Sun, 2010) and the spatial analysis is subject for the book (Rogerson and Fotheringham, 2007).
Currently, the most uses of spatial data involve maps and coordinates, but in the future, their applicability may include from precise 3D models to collecting and analyzing data generated by the sensors of the monitoring equipment of the network organized structures, integrating historical data for 3D spatial and object representations over time.
In a cloud solution using cloud storage can be a good idea. Cloud storage service is an emerging infrastructure that offers Platforms as a Service (PaaS) and there are many solutions available.

In research (Peng and Jiang, 2011) the authors propose a general architecture of a cloud storage service system called CS3 with a simple, flexible and modular architecture with a hierarchical design reflecting common resource environments found in many academic settings. The system allows users to access their own data using SOAP and REST interfaces, offers a Web interface for users.
GIS has to be the base for the decisional process because of the information it gives. The decisional model, along with Big Data, gives advantages and limitations that are described in research (Rosenzweig, 2014). The modern technology allows efficiently storing and querying the big data sets, and the emphasis is on using the whole data set and not just samples (Siddiqui and Gupta, 2014). More information about the Big Data current can be found in the articles (Shaw, 2014) and (Manyika, et al. 2011).

Prototype's architecture

The decision support system's (DSS) architecture includes the data sources, the database that stores data, the transformation of data by modelling, processing and analyzing it and the results.

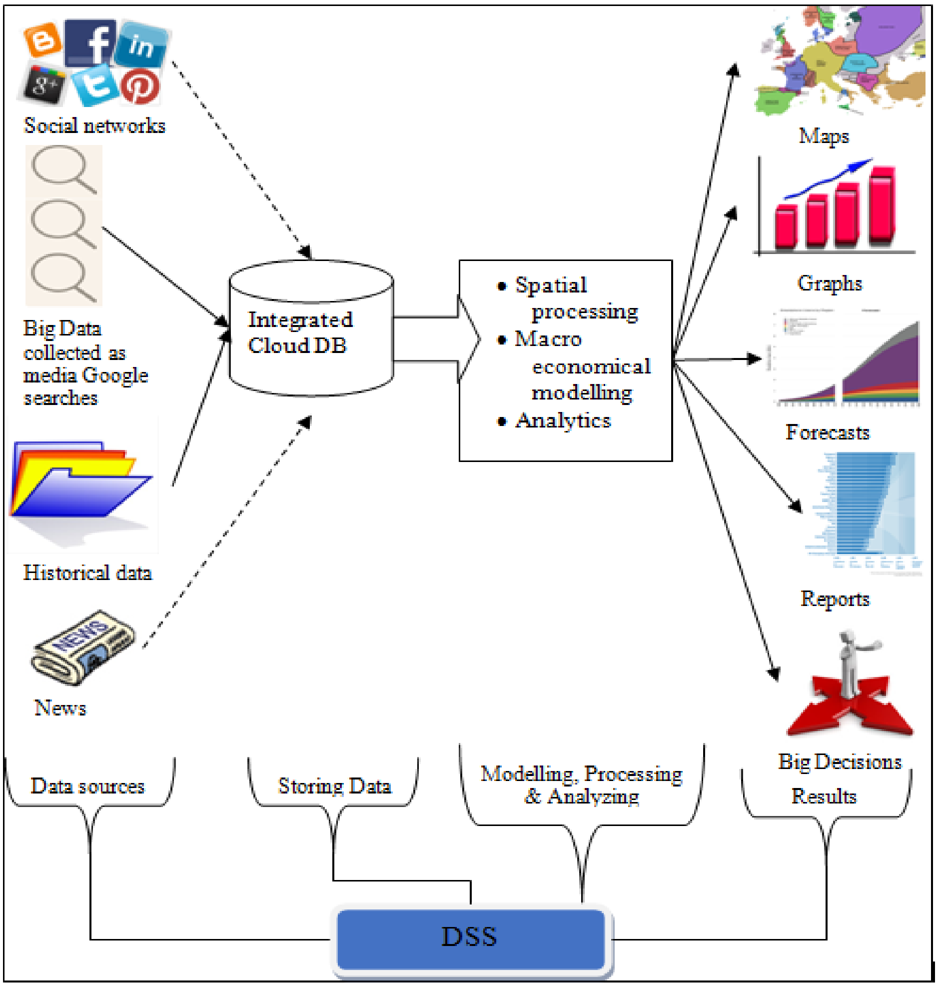

Fig. no. 1. System's architecture

The main data sources are big data collected as media Google searches and historical data for macroeconomic indicators and natural phenomena. Also, there could be two additional data sources: the social network data and data from news regarding the natural cataclysms.
DSS stores data in an integrated Cloud database (DB), which is continuously queried, processed and analyzed.
The results are obtained as maps, graphs, reports, Big Decisions, forecasts and combination of them.
The prototype's architecture is presented in (fig. nr. 1) and includes the four levels described above in which data is found as Big Data, stored data, processed data and information.

System's functionalities

The decision system requires research in many directions, following:
- Integrating existing data in a spatial database;
- Use of Big Data technologies to manage and integrate heterogeneous data sets, with spatial databases support;
- Development of an optimization model using specific algorithms, based on observations on natural phenomena;
- Implementing the developed model on network organizational structures;
- Macroeconomic approach for regional and territorial level data.

The main functions of the prototype will be accessible through a GIS that will be the main tool at decisional level and will include:

- Creating and maintaining the spatial database by using maps and location plans with different scales;
- Creating data collections containing functional elements from natural and transportation networks and also attributes of elements which are relevant to the situation. Multiple measurements will be used based on the *kriging* technique.
- Viewing information from the database (as maps, drawings, reports), the selected area being made graphically, alpha-numeric or through application;
- Making specific and optimal analyzes, using the position and the characteristics of elements;
- Using a macroeconomic model to determine regional impact of macroeconomic policies and to forecast economic performances.

The system will be a Cloud solution available through different platforms and developed using Oracle Suits.

Macroeconomic model

A highly performing spatial database support tool can give relevant insights of macroeconomic development at regional or even territorial level and could also facilitate the process of determining the impact of several macroeconomic policies (for active employment or regional development for example) upon the economic performances of one region. Moreover, an efficient macroeconomic decision support system based on spatial databases support can provide an excellent tool to timely and accurate forecasts of the main macroeconomic indicators. This can help the government control the gross domestic production, inflation levels, employment and unemployment rates and international payments balance, all of which are the concerns of the macroeconomic policy.
We draw on these arguments when building this decision support system that integrates macroeconomic data at regional and territorial level and allows spatial database support.

However, as a novelty in the field of developing macroeconomic policy for the case of Romania we propose a model that also incorporates high frequency social media information collected through Google search queries. Since big data for social media information can play a valuable role in developing macroeconomic policies, we decided to integrate in our econometric model the population interest upon several key indicators, such as: jobs, salary, unemployment, inflation and economic growth.

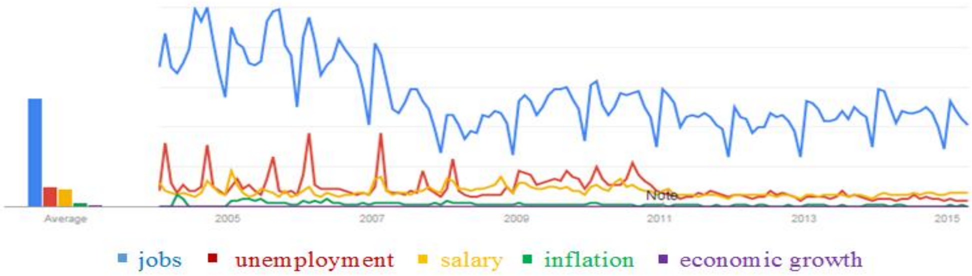

Fig. no. 2. Internet search for macroeconomic indicators in Romania
Source: Google Trends (www.google.com/trends)

The results are summarized in (fig. nr. 2) where we can see that the highest interest is dedicated to finding jobs and to a lower extend to the issues of unemployment and salaries, while the lowest interest is given to issues concerning inflation and economic growth.
Regarding the regional and territorial interest of the internet search upon these key indicators, as presented in (fig. nr. 3), we notice that in counties like Giurgiu, Ialomita, Iasi and Calarasi are registered the highest number of internet searches concerning jobs availability.
This kind of information can become extremely useful when building or improving an active labour market policy for reducing unemployment rates.

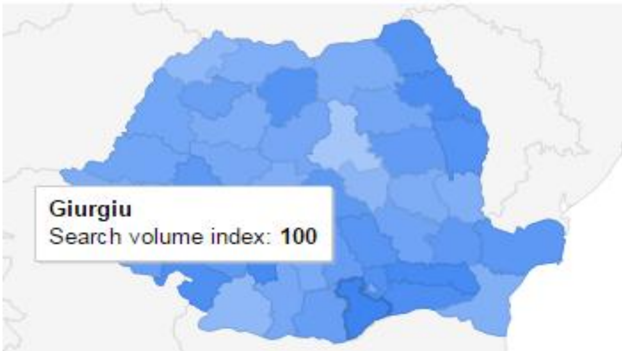

Fig. no. 3. Internet search results at regional and territorial level
Source: Google Trends (www.google.com/trends)

At regional or territorial level the short and long term evolution of macroeconomic indicators is generally modelled through a panel data model, which is by far the most common econometric approach. A typical panel data set has both a cross-sectional dimension (the *i* subscript*)* and a time series dimension – indicated by the *t* subscript and is described by the following equation:

$$Y_{it} = \alpha + \sum_{j=0}^{l} \beta_i X_{it-j} + \sum_{j=0}^{p} \varphi_i Social\_media_{it-j} + \varepsilon_{it}$$

where *l* and *p* are the lags of explanatory variables. β_i, φ_i are the parameters of variables, and ε_{it} are the error terms. As main dependent variables at regional level we can consider indicators such as GDP growth, employment rate and average gross earnings, while the explanatory variable list should also include high frequency social media information collected through Google searches.
In the extended version of this paper we will present in details the model that focuses on forecasting the employment rate in Romania based on regional and territorial macroeconomic data and also on high frequency social media information. Based on the econometric model incorporated in the decisional support system, a what-if scenario analysis will be conducted together with spatial databases support.

Conclusions

The prototype of the decision support system described in the paper has the main functionalities, the architecture, the technologies and the macro economical model that is to be used in order to reach Big Decisions, starting from Big Data. The system allows taking decisions of applying different macroeconomic policies for Romania's counties.
The extensions of the research will allow the implementation of the prototype, its testing and analyzing the results at regional level for Romania.
An econometric model will be implemented in the Decision Support System in a unique approach, as the general decisional variables are modelled through several explanatory variables and with the particularity of also incorporating the recent high frequency part of social media regarding macroeconomic indicators. Then a what-if scenario analysis will be conducted and the results will be represented in a GIS with spatial databases support.

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