Web-Based Collective Intelligence Decision Support System for Future China's Economic Early Warning and Policy Making

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Abstract

The high complexity of economic system makes economic policy design an exceedingly difficult decision making problem. A web-based collective intelligence decision support system which integrates wisdom from a large number of domain experts from various economic sectors or research institutes is proposed for future China's macroeconomic adjustment. The system is basically composed of two sub-systems. The first one, a multidimensional economic monitoring and early warning framework based on economic cycle cube (EC cube), covers economic monitoring and early warning sub-systems for various economic sectors. It enables users to view economy from different levels and dimensions independently, as well as to explore how the economic activities diffuse and transmit among economic sectors. The second one, a collective intelligence consensus-building tool based on repeated open survey-response, provides an environment for users to discuss and draw the final conclusions about some key economic issues, such as economic policy making. The core characteristic of the system is to utilize the great power of collective intelligence. Domain experts are responsible for the construction and maintenance of single early warning sub-systems for their sectors. Their easy accessibilities to sector-related economic data and abundant background knowledge make this easy to complete and ensure the reliability of the monitoring results. In addition, they also join in the consensus-building process. The final suggestions for economy generated by collective intelligence of experts provide powerful support for economic policy making.

Keywords: economic cycle cube, collective intelligence, decision support, policy making, consensus-building

1 Introduction

The economic intervention aims at a variety of objectives, such as increasing economic growth, increasing employment and promoting equality. It is often adopted by governments as efficient efforts to address market failures. However, with the complexity of a social economic system, the economic policy design poses an exceedingly difficult decision making problem. It is hard to be solved efficiently by efforts of only a few experts and government officials. It is not unusual that many economic policies do not take expected effects, or even take reverse effects. Therefore, new tools should be introduced.

The early warning system based on leading indicator approach and signal approach [1; 2], having more than 500 practical applications all around the world, has been proved an efficient economic decision support tool. However, most of these systems only maintain indices for single aspect of economy and often insufficient if used for the national economy monitoring and early warning. The economic cycle research institute (ECRI) proposes to use an array of specified indices in the context of "economic cycle cube" (EC cube) covering various sectors and aspects of the economy. The successful implementation of such an EC cube for US by ECRI shows that it provides a coherent perspective to explore the economic dynamics and future trends. However, the implementation of EC cube for a large country like China requires not only timely update of many sector-related economic indicators, but also huge workload for building and reviewing monitoring models. Thus it is impossible to be maintained by a single institute.

However, the proposed collective intelligence decision support system (DSS) and a well designed mechanism, which aims at attracting a large number of experts from various economic sectors to participant in the system, make the EC cube for China feasible.

Besides the EC cube, a consensus-building and conflict clarification tool is also integrated in this system [3; 4]. With the help of a repeated response-survey process, it provides the experts an environment to discuss economic issues, helps discover key issues during discussion and clarifies the conflicts. The final conclusions for economy are important references for policy making.

Therefore the proposed platform mainly consists of two sub-systems. A multidimensional economic monitoring and early warning framework based on EC cube enables users to view economy from different levels and dimensions independently, as well as to explore how the economic activities diffuse and transmit among economic sectors. The other sub-system is a consensus-building and conflict clarification tool, aiming at encouraging users to give valuable advices for economic policies and reach agreements.

The core characteristic of the system is to utilize the great power of collective intelligence. Different from most of current economic monitoring systems, the number of participants in the system is enormous and the success of the system is seriously dependent on users' contributions. The foundation of the system is monitoring and early warning sub-system for single economic aspect, which is maintained by the experts. The final consensus for economic issues is generated by group opinions, an emerging collective intelligence rather than single user's suggestion.

In the following sections, we will first introduce the theoretical background in Section 2. Detailed decision support process and the system mechanism are given in Section 3. Section 4 describes the architecture and characteristics of the system. The conclusions are given in Section 5.

2 Theoretical Background

2.1 Economic Early Warning and Economic Cycle Cube

Since thorough understanding of current economic situation is prerequisite for efficient policy making, the monitoring function is provided in our system as foundations. For timely economic monitoring and short-term forecasting, economic early warning is the most usually used method. The history of early warning could be traced back to late 19th century and three methods are mainly used: leading indicator approach [1; 2], signal approach and business survey [5].

Leading indicator approach divides economic indicators into leading, coincident and lagging groups based on their relationships with monitoring targets, and then aggregates some indicators to corresponding indices. In practice, the coincident index is a good measure for current economic situations and the leading index can provide insight of the future trend.

The signal approach is based on the principle that several sensitive variables tend to exhibit unusual behavior in the periods proceeding an economic recession or crisis. Therefore, an economic variable which deviates from its normal ranges should be interpreted as a warning "signal" of a potential crisis. Signal approach monitors these sensitive variables. A signal index calculated as a composite of single indicator is treated as a measure for economic status.

Business survey collects the opinions about business situations from companies, consumers or researchers by questionnaires and then quantifies the qualitative information to forecast the possible future economic performance. It is often used as a complementary method to represent people's expectations and of great necessity in economic early warning since expectations can affect economic trends to some extent.

The early practices of early warning focused on single aspect in the economy, such as the economic growth, inflation or currency crisis. However, it is insufficient to capture the economy's high complexity. In order to accurately observe and forecast economic trends, the dynamic interrelationships and evolutions among different parts of the economy should be explored. ECRI proposed to combine all the single monitoring and early warning systems

into one coherent outlook and organize them as a cube according to the hierarchy of economy. One instance of EC cube is represented in fig. 1.

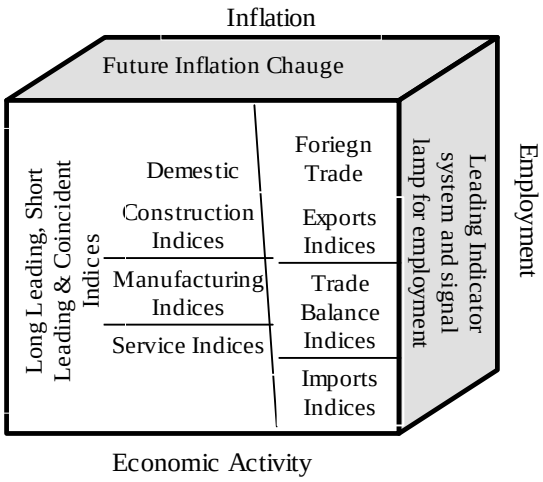

Figure 1. An Instance of EC cube implemented by ECRI.

The top level is the three aspects of economy: economic activity, inflation and employment. The economic activity can be divided into domestic and foreign trade. The domestic is sliced up both by sectors and by long and short leading indices. Each dimension can be rolled down to lower level. This cube is designed for single region. The cubes for different regions can be organized into a larger cube according to the relations of regions.

2.2 Web-based Consensus-building, and Conflict-clarification Tool

The web-based, consensus-building, and conflict-clarification tool is used to guide participants to discuss and make suggestions under some specific topic, and finally get the consensus. The core of the tool is online repeated survey. Through the surveys, the most important issues, how they are related, and how they reflect the inconsistencies among participants, are clearly explored. The tool clarifies potential conflicts between participants by identifying who is in conflict with whom as well as why they are in conflict. Finally, detailed documentation is provided.

The collective intelligence process would be summarized as follows (see fig. 2): 1) Participants individually review the available information in the form of an information repository, pick, rank and organize the issues relevant to the process, and add additional information to the storehouse for review by others if possible. 2) Participants express opinions through the online, open-response survey that allows freely typed input to questions and new issues to be described as well as to rank those opinions provided in the survey. 3) A survey analysis system synthesizes these survey responses, identifying areas of conflicts and consensus via graphics, mind maps [6], statistics and other relevant visualization instruments. 4) Results of the survey are posted in the system for feedback. Steps 2, 3, and 4 can be repeated as the participants react to areas of conflicts and agreements and individuals modify their positions. 5) Finally, new agreements are reached and the process is finally documented, which is easy as all steps are transparent with identifiable electronic traces.

Figure 2. The collective intelligence process summary [3].

The consensus-building tool is built on Internet/Intranet applications based on the range of usage. It consists of a knowledge base storing participant provided background information, a database storing response information, an open response survey unit, a survey analysis unit and visualization tools.

Successful applications of this collective intelligence method include: trends exploration within a scientific community [3], evaluations of governmental efficiency within the Navajo Nation [7], and the design of a Geographic Information System [8].

3 System Mechanism

Decision Support Process

The DSS can be roughly partitioned into two sub-systems: monitoring and early warning sub-system based on EC cube and business survey; policy design support sub-system based on consensus-building environment. The EC cube firstly provides an overall perspective for participants to understand China's economy as well as different sectors. Then, based on the monitoring results, the consensus building environment creates opportunities for participants to give their opinions on policy design and implementation. Suggestions either relevant to the overall economy or some specific sectors are welcome. The system administrators collect emerging issues and organize questionnaires. The participants, with some ideas about macroeconomic adjustment after reviewing relevant information, especially the results of the EC cube, join in the consensus-building process and finish the open-response survey. The system administrators finally report the suggestions and documented the building process.

Mechanism

The EC cube in this system provides an easy way to handle the economic status of different levels and dimensions, discover the disequilibrium in economy, understand the economic activities diffusion among sectors, and support further economic theoretical research. However, the workload for the construction and maintenance of a well-designed EC cube may be overwhelming and the data acquisition is a big problem, since so many economic sectors should be included in this cube. Therefore, the EC cube should be developed by domain experts from various economic sectors, rather than a single institute. The domain experts can access data of their sectors easily and are with abundant background knowledge. Thus it is much easier for them to construct and update the early warning sub-system for their sectors.

By including so many experts with different background in the system, the business survey can be implemented with low cost and receive quick responses.

Another advantage of involving domain experts as main users of the system is to inspire collective intelligence. The ultimate goal of this system is to support China's economic policy design and implementation. The EC cube supports decision making by providing a way to understand the developing economic status deeply. However, the collective intelligence generated in the domain experts' discussion is much valuable and direct. Therefore, the consensus-building and conflict-clarification tool is integrated in the system to guide experts to discuss and make policy suggestions.

A mechanism must be designed to attract domain experts to join in this collective intelligence system. In fact, these domain experts can get plenteous benefits from the system: the free use of advanced monitoring and early warning modeling tools, protection of private data and information, timely access to information of concrete economic situations (i.e. status of whole economy, upstream industries and downstream industries. These information is of great importance for the accurate forecasting of the future trends of any sector and even influences the strategy of sectors.), authority to publish their own judgments based on the monitoring and early warning results attained in this system (the publish is under subscription or for profit, based on the users themselves), deep discussion with other experts, and opportunities to present opinions to China's policy makers and make them to be adopt.

In details, the authority to deal with private data and monitoring models only belongs to its owners, for the data and models are valuable for users. The monitoring settings and private data can be stored on users' local machines for privacy or on the system server for share. Although common users are asked to store their monitoring results (in the form of composite and signal indices) in data warehouse for system administrators' further analysis, the system administrators do not have the authority to publish common users' monitoring results to public. Conversely, the user can publish its own results, through website or journals, for profit or under subscription. This makes users be willing to use this system and save their results in the system.

The transparence of the system ensures users submitting true results. In the EC cube, each sector's status is available to each user. Economics at higher levels and lower levels can

be validated correspondingly for each other. Therefore, improper information and data are easy to discover.

User Roles

According to the system mechanism, there are two categories of user roles in the system.

The users of the largest number are experts and researchers from various economic sectors and some research institutes. Their work is the foundation of the collective intelligence system. After the construction of leading indicator systems and signals for its responsible sectors, they must calculate the results each month and review settings at regular interval to ensure effectiveness. In addition, they could join in the business survey every month. Their judgments help adjust the evaluation about current and future economic trends. Finally, these users participate in the collective consensus-building and conflict clarifying process to give efficient suggestions for economic policy design.

The other kind of users is the system administrator. They work at a higher level than these common users mentioned above. They organize common users' monitoring results about independent sectors into data warehouse and analyze the constructed EC cube by OLAP tools. The analyses of business survey questionnaire and open survey-response are handled by system administrators too. In addition, they must manage the public database, knowledge base and model base. Finally, they summarize conclusions from EC cube, business survey and open survey into a comprehensive report and send it to policy makers for reference.

Researchers who are interested in this platform can apply to join in the system. They may bring some new ideas in and improve the quality of the survey. But the ability and authority of the user must be validated first.

4 System Architecture and Characteristics

In this section some of the fundamental issues with the platform as the architecture and characteristics are outlined.

4.1 System Architecture

From the perspective of software engineering, a good DSS should fulfill the requirements of flexibility, extensibility, modularization, intelligence, high efficiency, and user friendliness. Therefore, the system is based on Internet applications. Some techniques of web2.0 [9] and the traditional three-tier model [10] can be adopted for the development. The system is composed of bases including a model base, a knowledge base, a data base, and a data warehouse, as well as visualization tools, a survey system, user interfaces and online analysis processing (OLAP) tools (see fig.3).

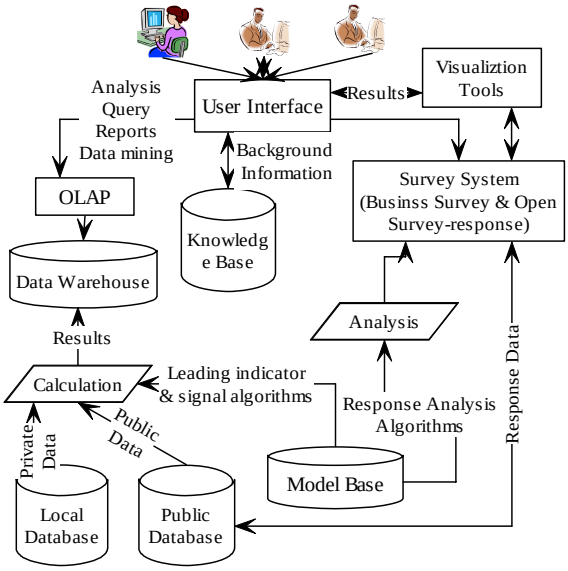

Figure 3. The system architecture.

Model base: Model base is defined as a collection of independent algorithms consisting of a set of methods or model objects. Economic early warning related models, data analysis models, statistics models, mind-maps algorithms [6] and some survey processing models are pre-stored in this repository. System administrators add and modify models through the interface provided by model base management system.

Data base: Users can store their private data in local data base or public data base located in the server depending on whether they are willing to share private data with others. Public data provided by system administrators and records of surveys are stored here for further analysis and documentation. Well-designed access control can protect users' privacy.

Data Warehouse：A data warehouse [11] is defined as a subject-oriented, integrated, time-variant, and nonvolatile collection of data

in support of management's decision-making process. It is responsible for storing and organizing each user's monitoring results, such as the leading, coincident, lagging indices for each month and signal values.

OLAP tools: The major task of the data warehouse is for OLAP. The OLAP tools are used to handle multidimensional data structures for the purpose of analysis and query. By operations such as drilling, rolling, slicing, dicing and pivoting, it helps discover the interrelationships between dimensions and levels.

Knowledge base: Knowledge base functions as an expert in this system. It consists of a library of background information, cases and users' experiences during usage. The quality of knowledge base determines supportive strength of the users.

Visualization Tool: Visualization is becoming a more and more important factor in today's DSS, because visualization can help discover implicit and useful knowledge from data sets. Since the OLAP tools can provide the visualization of data warehouse, this tool focuses on survey results visualization, representing results by graphical forms from different views.

Survey system: The functions of survey system include: organize, distribute questionnaires and analyze responses (The analysis models are stored in model base. But these models are called by the survey system for analysis). In details, the survey system contains business survey system and open survey-response system. The questions of business survey system, with the objective of making indices from the responses and be taken as a complementary method for economic status judgment and short-term forecasting, are multiple choices. However, the questions of open survey-response are of multiple formats, including simple yes/no, true/false, agree/ disagree dualities, freely-typed answers with restricted length, quantitative rankings or categories (degree of agreement/disagreement with the posed statement, percentages, etc.), and a free-response section of nearly unlimited length. Specific processing techniques such as natural language processing, text clustering are required for open questions analysis.

User interface：The user interface [12] is the aggregate of means by which people (the users) interact with the system. The design of a user interface affects the case of use when to provide input for the system and to interpret the output of the system, and how much effort it takes to learn how to use the system.

4.2 Characteristics

The system provides a more systematic, friendly, and consensus-building tool for collective decision support compared with the other existing economic policy making support systems. Its characteristics can be concluded as:

(1) Providing a unified platform for economic monitoring and early warning. The platform strongly pushes forward the monitoring and early warning work for regions and sectors without repeated developments of software and huge investments in hardware by providing free tools. And, it also provides opportunities for the interactions between domain professionals and economic policy makers.

(2) Making the EC cube feasible. The implementation of EC cube requires overwhelming workload and timely access to economic data. The involvement of researchers who are not only experts in some economic sectors but also able to access required statistical data solves this problem. .

(3) Providing comprehensive monitoring for economy. The platform is guided by the thinking of EC cube. It provides an easy way to handle the economic status in different levels and dimensions, as well as issuing alert immediately. Putting all sectors together helps discover the disequilibrium in economics, understand the economic activities transition during sectors, and support economic theory research by practices.

(4) Inspiring collective intelligence. A consensus-building and conflicts clarifying tool for large participants when facing complex issues is integrated in the platform. By organizing group perspectives and feeding this information back into the group, this method harnesses the collective intelligence of the participants by identifying the most important issues, showing how they are related, and showing their connections to the different subpopulations. The method facilitates consensus building in a large participant group by clarifying agreements and conflicts, and also easily documents collective decisions.

5 Conclusions

The monitoring and early warning system is successful for economic short-term forecasting in practice, and becoming a hot area in China these years. However, most of the existing systems are restricted to a single sector or region, which can not handle the complexity and dynamic relationships among economic systems. The proposed web-based collective intelligence DSS extends the monitoring and early warning from focusing a single sector to a multidimensional framework. An overall and hierarchy perspective for exploring the economic dynamics and future trends is provided. And a collective consensus-building tool based on repeated open survey-response is integrated in the system. Its mechanism encourages participants to express and discuss possible policy design and implementation. Since the system is proposed for future China's economic policy making support, it should be sponsored by some institution of government. And the final report generated from the system is sent directly to institution which is responsible for China's macroeconomic adjustment as reference.

The main contribution of the system is to utilize collective intelligence to support economic policy making. The cost of implementing and running such a system is low and the output is remarkable.

Moreover, some interesting issues may be addressed for such a system, for example how to prove the consensus-building process can generate the best solution. Some domain experts may make terms with each other in private and make their selfish suggestions be group consensus. Moreover, the expert's ability and authority is critical to this system. Therefore, further researches are needed. However, such a system is of great challenge for China's economic policy design, and can be developed for other potential usages.

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