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AgriRiskIDSS: Development of an intelligent decision support system for price risk management of agricultural product supply chain

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Abstract

New and increasing competitive pressures derived from opening market, consumer growing behavior and global trade patterns have a strong exposure that the agricultural products sector faces many types of uncertainty and price volatility. Consequently, the risk associated with price uncertainties has been wreaked havoc on the financial performance of the agricultural products stakeholders. An intelligent decision support system for price risk management across agricultural products supply chain (AgriRiskIDSS) is developed as decision aids tools to help the stakeholders manage price risk. The intelligent technologies, i.e. vertical search engine and intelligent information processing technologies are adopted as the key development methods in order to resolve the internal problems relevant to data update and predication algorithm during the system development. This paper firstly analyzes the decision problems and user needs based on survey, then describes the system architecture and development, especially application of the intelligent technologies. At last some discussion and conclusions are given based on the experience of the system development and promotion.

Key words: China, IDSS (intelligent decision support system), price risk management, vertical search engine, intelligent information process.

Introduction

New competitive pressures, which are derived from opening market, consumer growing behavior in product variety, freshness, convenience, and year-round availability stimulated by rising incomes and global trade patterns after China entered the WTO with new traffic rules and quality safety traceability requirement [1-4], have a strong exposure that the agricultural industry faces many types of uncertainty and price risk, which is likely to increase in the future, especially agricultural producers would be expected to be particularly vulnerable to the price risk given that they operate at a small, specialized scale. It is different with other developed countries. These have contributed to agricultural stakeholders seek efficiency gains through managing price risk and strengthen their competitive positions and steady their income instead of react to market changes.

Yet such volatility can arise from any of several sources, so identification of effective intervention strategies depends fundamentally on locating the source(s) of variability in agricultural prices. Although there is plenty of tools of price risk management, and this anticipated price volatility emphasizes the necessity for managing price risk [5], agricultural stakeholders cannot mitigate price risk because they lack the knowledge of risk management in China. So it is evident to provide help or tools for agricultural stakeholders on agricultural price risk management.

AgriRiskIDSS, a web-based intelligent decision support system for price risk management across agricultural supply chain, aims at identifying and test the feasibility of the use of various price risk management tools in China. This paper describes the experience for AgriRiskIDSS.

The System Design and Development

Taking into account cost-benefit ratio, it is obvious that development of the system is not absolutely following the entire process of risk management. AgriRiskIDSS has tailored the requirement and only considers the risk evaluation, early warning, risk management and e-learning. Fig. 1 illustrates the architecture. In more detail each of the subsystems is described below.

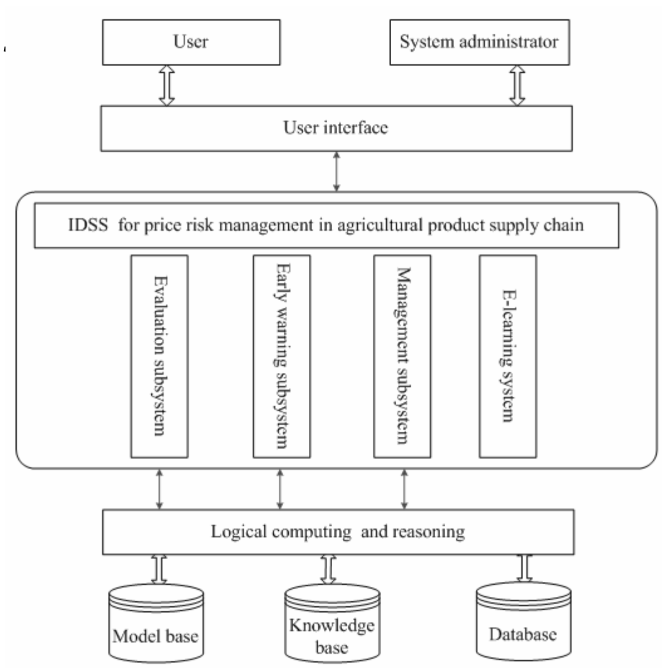

Figure 1. The architecture of the AgriRiskIDSS.

evaluation subsystem is responsible for assessing the level of price risk. It consists of the following modules.

1) Data collection module. The data collection module is responsible for gathering data from a multitude of stakeholders and preparing the data sets for the evaluation module. There are three methods of collecting the data: input the data manually; transfer from other resource in a common EXCEL format; automatically collect from settled relevant website via vertical search engine. The searched website can be changed manually.

The evaluation subsystem has a data input sub-module, which enables experienced or less experienced users mount the coverage onto the system. All the data are stored in database.

2) Risk evaluation module. The module is the key component of the evaluation subsystem and it is responsible for carrying on qualitative analysis to the risk in order to find out the influence factor and quantify the price risk [2].

- The method of coefficient of variation is adopted as the external price risk evaluation of supply chain, due that it is a simple and effective method to evaluate the volatility of price given that it only needs to calculate the mean and standard deviation of time series of prices of vegetable.
- The decomposition model is adopted to identify which of the factors is a more important source to cause the price risk across the vegetable supply chain, due that it can be easier to estimate the probable degree of a variety of price risk factors. Based on the model, price risk is attributable to volatile inter-market margins, intraday variation, intra-week (day of week) variation, or terminal market price variability [6].

***The early warning subsystem**:* The early warning subsystem is responsible for monitoring the level of macro and micro price and issuing a warning signal. It consists of the following modules.

1) Data forecasting module. The module runs prediction model to provide a quick estimation to agricultural products market or related factors. A kind of intelligent information process method is adopted to improve the forecast precision.

2) Early warning module. This module is responsible for integrating information and operational experience with the results coming form previous subsystem to evaluate the degrees of market risk and identify the potential increasing trends in their probability and provide an early warning. Each individual indicator is examined to determine whether it has crossed its threshold value, that has historically been associated with heightened probability acquired by expert experience at user need analysis process. When an observed outcome of an individual leading indicator crosses its threshold value, it is considered as issuing a warning signal.

The risk management subsystem: The risk management subsystem is responsible for comparing different strategies and providing the management decision based on consequences from the early warning sub-system to hedge, stabilize earnings or reduce risk.

The e-learning subsystem: A miniaturized e-learning subsystem was also constructed to help users, who have a little prior knowledge or understanding of the techniques, learn and manage price risk. The e-learning subsystem consists of introduction of the process of risk management, description of tools of price risk management and some technical aspects. The e-learning subsystem also provides multiple channels for learner to communicate with each other and/or the teacher.

Knowledge-based system in AgriRiskIDSS: Intelligent decision support systems (IDSSs) are interactive computer-based systems that use data, expert knowledge and models to support decision makers in organizations to solve semi-structured problems by incorporating artificial intelligence techniques [7]. Also, the knowledge and knowledge-based systems are a key component in AgriRiskIDSS.

Knowledge-based module in e-learning subsystem: This module is responsible for proving the basic knowledge for the learner including type of knowledge (question, problem, pure data, solution, and reference), field of information (e.g. demand, supply, etc.), source of knowledge, date of storage, expiration date, link for reference and status of knowledge (active, inactive, pending, complete, incomplete, growing). There is also inference engine that tells the user or programmer how to use knowledge.

Knowledge base is composed of a private base and a public base. The private base is the own base of models, which can be used only by those models with which they are affiliated. They can store the knowledge perceived by models responding to the external environment and judging the next action or problem.

Knowledge-based module in early-warning subsystem: This module is responsible for integrating information and operational experience experts accumulated from previous management experiences with the results coming from previous subsystem to evaluate the degrees of market risk and issue a warning signal. Each individual indicator is examined to determine whether it has crossed its threshold value that has historically been associated with heightened probability acquired by expert experience at user need analyze process. When an observed outcome of an individual leading indicator crosses its threshold value, it is considered as issuing a warning signal.

The following are examples of rules reflecting the part of the knowledge base:

If IR <14 then the information/institutional risk is safety (0).
If IR >14 and IR < 24 then the information/institutional risk is at a low level (1);
If IR > 24 and IR < 34 then the information/institutional risk is at a middle level (2);
If IR > 34 and IR < 44 then the information/institutional risk is at a high level (3);
If IR > 44 then the information/institutional risk is high (4).

The system development: The structure of AgriRiskIDSS adopted B/S (Browser/Server), which is able to better apply information system to network production. The solution, ASP.NET + ADO.NET + MS SQL Server 2003 + IIS 6.0 + COM, is adopted to develop this system. Among the development plan:

- ASP.NET is serving as the main develop language to bridge user interface and web server and database server.
- MS SQL Server 2003, a relational database management system and data storage development tool, is serving as the back-end of the workstation to facilitate data storage and retrieval and as a means to preserve analysis methodologies and knowledge.

- IIS 6.0 is serving as a web server to provide information service.
- Microsoft COM (Component Object Model) technology enables software components to communicate. COM is used to create reusable software components, link components together to build applications, and take advantage of Windows services.
- ADO.NET (Activex Data Object) is adopted to access the database.

Application of the Intelligent Technologies in AgriRiskIDSS

During the AgriRiskIDSS development process, two key internal problems have arisen.

- One is data collection and update. There is a wealth of data about agricultural products supply chain produced by municipal, county, province, state agencies, academies, universities and markets. Unfortunately the data are scattered among a multitude of producers with dissimilar formats, resolutions. So it is a key factor for decision support system development how to retrieve the data from multiple resources and provide the latest data. Vertical search engine is adopted as the resolution.
- Another is the precision of prediction model given that prediction function is basic to provide further early warning and risk management strategies. The intelligent information process is adopted as the proposal algorithm.

Also this section focuses on the above technologies application in AgriRiskIDSS.

Vertical search engine application: Compared with traditional web search engines, vertical search engines also mean domain-specific search engines built to facilitate more efficient search in various domains with domain knowledge can provide more precise results and more customizable functions. So it is adopted for automatic collection of the agricultural products price data in AgriRiskIDSS integrated classification knowledge. There are two main problems in developing vertical search engines:

- The synonymous and ambiguous problems of the key words. There are some keywords that can be used in different domains and have different meaning or the same meaning has different keywords in the same domain. So extra knowledge is required to disambiguate the query when the vertical search engines begin to search and retrieve the information across the website.
- Web pages classification. After the spider has retrieved the webpage from the special, how to classify requiring supervised automatic categorization of text documents into specific and predefined topic areas, i.e. divide large volumes of data into several discrete classes, which are a priori determined on the basis of a training dataset and a user-provided taxonomy [8]. In order to reduce the dimensionality of the web page classifier and thus the number of training examples needed, feature-based approach is proposed, instead of representing each document as a bag of words. Then each of webpage is represented by a limited number of features. The characteristics of web structure also can be incorporated into these features.

Taking into account neural networks one can learn nonlinear mappings from a set of training patterns and present various properties, such as massively parallel architecture, noise tolerance, self-organization and generalization [9] and ontology can capture domain knowledge in a generic way and provide a commonly agreed upon understanding of a domain [10], a framework is proposed to integrate both of their values adopted in vertical search engine module of AgriRiskIDSS.

There are also four kinds of artificial neural networks which are often used for competitive learningof feature vector extraction: SOFM (Self-Organizing Feature Map), LVQ (Learning Vector Quantization), CPN (Counter-Propagation Network) and ART (Adaptive Resonance Theory). Comparing with other networks, LVQ network has better classification precision with lower computation complexity [11]. Fig. 2 illustrates the proposed integrated framework, which consists of the following stages. The first stage is collecting and pre-processing agricultural products web pages in Chinese. The second stage is inputting the result of the pre-processing to LVQ network as train sets. The similarity between input web pages and output classes is calculated by the cosine of their feature vector. This means that each web page should be represented by its feature vector.

A hybrid predication method in AgriRiskIDSS: Previous literatures show that chaos prediction method can produce better results than other prediction approaches based on time series because it utilizes all reconstructed phase space information (local fractional dimension) and determines the longest delay time by the self-relation coefficient model. For price fluctuation it is easier to predict the trend if the phase space information can be analyzed and extracted. The wavelet transformation or wavelet analysis is probably the most recent solution for using a full-scale modulated window that solves the signal-cutting problem. The window is shifted along the signal and for every position the spectrum is calculated. Then this process is repeated many times with a slightly shorter (or longer) window for every new cycle. In the end the result will be a collection of time-frequency representations of the signal, all with different resolutions. So firstly the wavelet analysis is adopted to extract the local fractional dimension of price fluctuation.

After wavelet analysis, the original signal of agricultural products price is decomposed in different independently time-frequency channels, where energy can form a vector. Then, neural network is used to analyse the non-linear relationship between local fractional dimension (wavelet analysis coefficient) and price future data. There are two methods to couple wavelet analysis and neural network:

- Time as benchmark. Wavelet analysis coefficients of different scales with the same time as input character vectors of neural network to predict future data.
- Scale as benchmark. Wavelet analysis coefficients of different times with the same scale as input character vectors of neural network to predict future data.

AgriRiskIDSS integrates above two methods. Among neural network applications, BP neural network Back-propagation neural network is adopted as the basic structure because it is one kind of the most common and mature model and implements any continuous function.

During design of a neural network, the key problem is how to design and confirm its structure. Generally the structure is confirmed in advance or by means of increase/decrease by degrees. The method of increase by degrees begins firstly from a simple network structure, and then makes the structure more complex until the structure meets the problem requirement. The method of decrease by degrees is reverse one, which starts with a complex network, and makes the structure simpler until the best

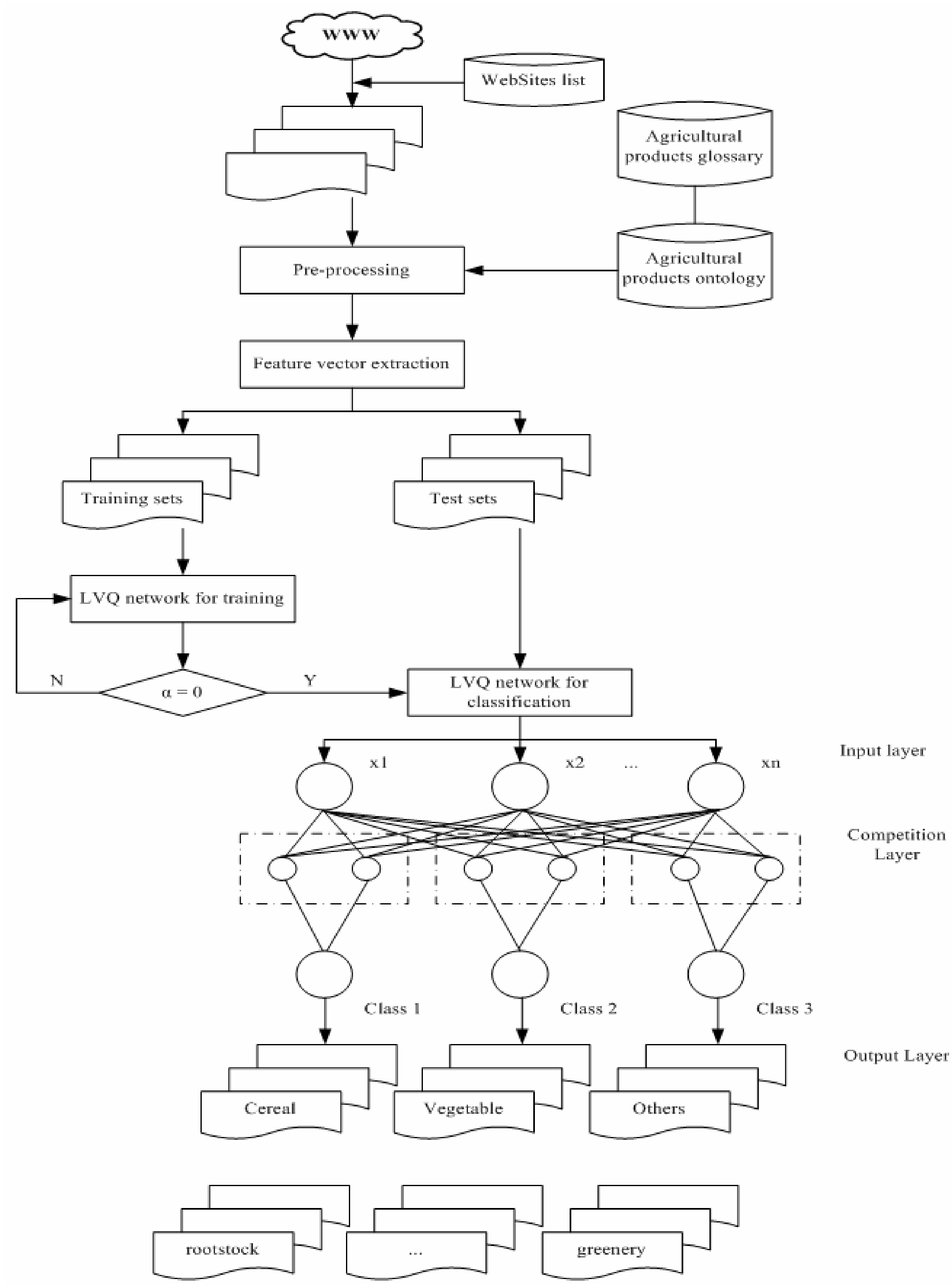

Figure 2. The integrated framework in vertical search engine.

structure is achieved. For both methods it is difficult to achieve the best structure within limited time.Genetic algorithm is introduced taking into account that it has advantage to search the best wavelet analysis coefficients and parameters of neural network.

Based on the above analysis, Fig. 3 shows the whole architectural framework of predication method integrated wavelet analysis, neural network with genetic algorithm (GA).

Discussion and Conclusions

This paper reports a research attempt in developing an intelligent decision support system for price risk management across agricultural products supply chain. The system is able to evaluate price risk and detect the most severe risk source in the agricultural products market. The system is also offering the most effective price risk management method to the user by union of risk evaluation and risk management.

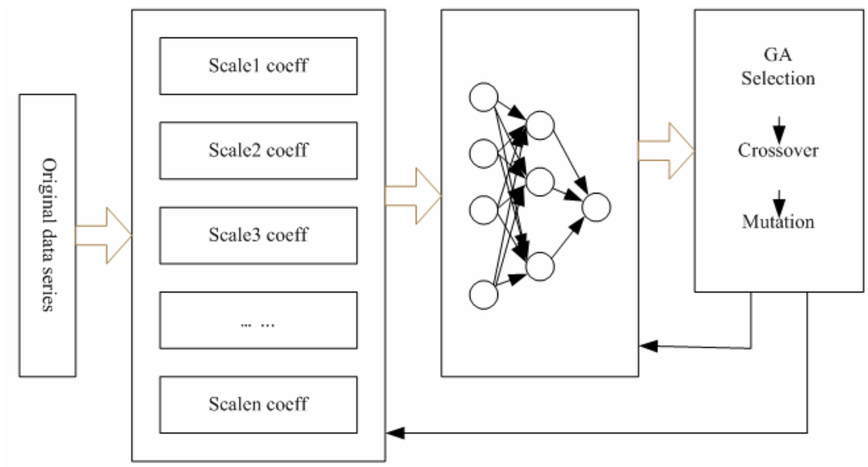

Figure 3. The structure of the whole framework.

• AgriRiskIDSS is an open distributed web-based platform. The user can gain access to the system through any commonly used commercial browser such as Internet Explorer, Netscape, etc. and not install other software in every computer and requires low skill and training. It also can be easy to use as a stand-alone system. The interface of AgriRiskIDSS is friendlier and the function is more abundant due to the use of various computer techniques, such as HTML, etc.
• Database, the decision model, intelligent technologies, knowledge base from experiment can be successfully integrated into the system. The integration enhances the system performance. Especially the intelligent technologies, like vertical search engine, Wavelet analysis and generic algorithm have integrated successfully into AgriRiskIDSS to improve the system data collection resource and predication precision.
• This application of e-learning subsystem provides a quality and intuitive understanding with user guidance and assistance for the process and tools of the price risk management. It is useful to promote the awareness of risk management of the stakeholder and related knowledge.

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