Economic Modelling 40 (2014) 76–80

Contents lists available at ScienceDirect

Economic Modelling

journal homepage: www.elsevier.com/locate/ecmod

Application of artificial neural networks in tendency forecasting of economic growth

Lihua Feng *, Jianzhen Zhang

Department of Geography, Zhejiang Normal University, Jinhua 321004, China

ARTICLE INFO

Article history:
Accepted 17 March 2014
Available online xxxx

Keywords:
Artificial neural networks
Mapping
Tertiary industry proportion
Economic growth
Forecasting

ABSTRACT

Economic growth results from the synthesis influence of various known or unknown and certain or uncertain factors. Mapping of the stimuli effects and the input and output estimates of artificial neural networks (ANN) are obtained via combinations of nonlinear functions. This approach offers the advantages of self-learning, self-organization, self-adaptation, and fault tolerance, as well as the potential for use in forecasting applications of economic growth. Furthermore, the ANN technology allows the use of multiple variables in both the input and output layers. This capability is very important for economic growth calculations because economic development is often a function of many influential variables. Herein, a forecasting system of economic growth with related application has been proposed, based on ANN. The results show that the Zhejiang proportions of tertiary industry in China for 1995, 1996, and 1997 were 32.305%, 32.174%, and 32.114%, respectively, and the comparative errors e_{ann} were 0.64%, −0.08%, and −0.27%, respectively, indicating that the forecast result of ANN was better than that of the GM(1.1) model. This method offered better performance and efficiency.

1. Introduction

Situated on China's eastern coast, Zhejiang has one of the strongest economies in China. In 2012, the gross domestic product (GDP) of Zhejiang reached US$548.2 billion. Based on the annual average resident population of 54.7 million, the GDP per capita is approximately US$10,022. Zhejiang's GDP per capita was US$1000 in 1996, and it took 47 years to reach this level from 1949 when the PRC was founded. It only took 16 years for Zhejiang to increase its GDP per capita from US $1000 US$10,000, whereas it took about 38 years (between 1973 and 2011) to increase the worldwide GDP per capita from US$1000 to US $10,000. Singapore and South Korea took 18 years to achieve this. According to the World Bank's 2000 classification criteria, in 2012 Zhejiang met the criteria of a high-income region. Even if the most recent 2010 classification criteria are used, Zhejiang would still be classified as a middle- to high-income region and it approaches the high-income threshold. If calculated on the basis of purchasing power parity, Zhejiang's GDP per capita reached US$10,000 in 2006. UBS released a survey of national revenue per capita based on purchasing power parity comparing various provinces as of March 2006 and the results indicate that Zhejiang's GNI per capita was US$12,355, indicating that Zhejiang is the richest province in China (Wang and Feng, 2013).

Since 1978, Zhejiang has boldly explored new development approaches, made innovations to further implement the country's reform and opening-up policy, and created a new development style. As a result, Zhejiang has distinctive advantages with unique features (i.e., main determinants). These advantages include the following:

(1) A well-established private sector: by the end of 2011, there were 720,000 private enterprises and 2.3 million private business owners in Zhejiang (accounting for 40% of China's total number of 9.24 million private business owners). According to the 2011 edition of China's Top 500 Private Enterprises released by the All-China Federation of Industry and Commerce, 144 of these companies are from Zhejiang, which is the highest number of all the provinces and regions. The private sector has developed a trend of industrialization, growth in scale, and capital socialization.
(2) A well-developed market economy: by the end of 2011, there were 4212 merchant trading markets in Zhejiang, representing a total transaction value of US$238 billion per year. Zhejiang has held a leading place for 21 consecutive years. In particular, the Yiwu Commodities Market exports products to 215 countries and regions. The UN Refugee Agency, China's Ministry of Foreign Affairs, and other organizations have established procurement information centers in Yiwu. Import offices have been set up by 55 countries and regions in the Yiwu Commodities Market. A business model of buying and selling global commodities has formed.
(3) A well-developed massive economy: Zhejiang has developed its economy according to local conditions. As a result, many counties, townships, and villages have formed their own business models. According to a 2009 survey, there are 312 industrial

* Corresponding author. Tel.: +86 579 82281008.
E-mail address: fenglh@zjnu.cn (L. Feng).

http://dx.doi.org/10.1016/j.econmod.2014.03.024
0264-9993/

clusters with annual output exceeding US$160 million in Zhejiang. In addition, Zhejiang has 13 national economic and technical development zones, thereby ranking in second place among all the provinces in China. There are 72 development zones and parks with an annual output exceeding US$1.6 billion.

(4) Well-developed county economies: Zhejiang's strong economy is built on its counties' economies. In 2010, Zhejiang's county-level administrative regions (59 counties and cities, excluding districts under cities) contributed a GDP of US$232 billion, accounting for 52.4% of the total GDP of the province. Twelve counties or cities have a GDP exceeding US$6.5 billion. According to analysis from the Zhongjun County Economy Institute, 25 of the 59 counties in Zhejiang are listed among China's top 100 counties.

(5) A highly foreign-oriented sector: by the end of 2011, Zhejiang had 49,408 companies that are directly owned by foreign companies. Among Fortune 500 companies, 143 have invested in 415 foreign-invested companies in Zhejiang. Currently, investors from Zhejiang have invested in 138 countries and regions abroad. Among all provinces and regions, Zhejiang holds first place in terms of the number of companies engaging in overseas investment, the number of overseas operations, and the number and scale of overseas mergers and acquisitions (Guo, 2012).

From this it can be seen why Zhejiang has been experiencing fast economic growth since 1978. However, the future development of Zhejiang's economy is an issue of concern. The principles and methods found in artificial neural networks (ANN) will be used to forecast the growth rate of Zhejiang's economy.

2. Literature review

Many scholars have been investigating Zhejiang's fast economic growth. Wang (2006) explored the development of the private economy and how it integrates different industries with specific markets by analyzing the leading private sector in Zhejiang. He also examined the trends of industrial clusters and the formation of the agglomerative economy and their effects on private economy development. Xiang (2006) described the regional distribution and development trends for the migration of merchants to Zhejiang and concluded that the key to attracting those merchants to promote the development of Zhejiang was to create an excellent and efficient soft environment. Wang et al. (2009) explored the innovative reforms adopted by Zhejiang through land development rights (LDR) transfer within a locality and LDR trading across localities and argued that the Zhejiang model of LDR transferring and trading has significant implications. Xu (2012) believed that Zhejiang's fast economic growth was the result of its advantageous coastal position, business-oriented local culture, and the huge drive stimulated by policy change. Wang and Feng (2013) classified the economic development stages of Zhejiang and pointed out the problems caused by huge development differences between regions, concluding that the urbanization process is not intensive enough.

Economic growth forecasting has long been a subject of extensive research. In the calculation of economic growth, it is common to set up mathematical models or draw related graphs based on existing data. Hence, it involves issues of pattern recognition (Acharya and Bhat, 2003). However, there is no satisfactory mathematical model, $y = f(x)$, that would fix the elements of economic growth (Anwar and Cooray, 2012; Mukhopadhyay, 2003).

Since the newly developed technology of ANN has advantages in terms of self-learning, self-organizing, and self-adapting, there are many successful applications of it in pattern recognition (Emiroglu et al., 2011; Loukachine and Loeb, 2003). For example, In terms of flooding, Campolo et al. (1999) developed a neural network model to analyze and forecast the behavior of the Tagliamento River in Italy during heavy rain periods. Oh et al. (2006) established sub-DFCIs (daily financial condition indicators) for various daily financial variables using an ANN and used the DFCI for the Korean financial market as an empirical case study. Garcia (2007) exploited some aspects of functional approximation techniques in parameter estimation procedures applied to fault detection and isolation tasks using backpropagation neural networks as functional approximation devices. Hardalaç and Güler (2008) examined static and 50 Hz electric field effects on tissues and found that the predictive accuracy of the hybrid genetic algorithm and neural network approach was on average 99.25–99.99%. Tiwari and Chatterjee (2010) quantified the parametric uncertainty involved in flood forecasting using ANN models. Hourly water level forecasting models were developed and uncertainty assessment was carried out for hourly water level forecasting. So far, there has been no report forecasting and analyzing Zhejiang's economic growth rate using ANN.

3. Methodology

An ANN is a complex network that consists of many simple neural cells (Lippmann, 1987). It is roughly modeled on the human brain. It has a parallel distribution information processing device and can approximate the mapping between input and output by compositions of nonlinear functions (Srivaree-ratana and Konak, 2002). ANN does not require any design of mathematical models. It can learn solely based on experience; process various fuzzy, nonlinear, noisy data through neuron simulation, memory, and association; and process calculation analysis using the method of self-adapting pattern recognition (Brion and Lingireddy, 2003).

ANN algorithms include Hebbian, Delta, Kohonen, and BP. The BP algorithm (Error Back Propagation) was presented in 1985 by Rumelhart and his PDP team. It realized Minsky's thoughts on multilayer neural networks. A typical multilayer-feed-forward neural network consists of a number of neurons that are connected together, usually arranged in layers. Its first layer is the input layer and its final layer is the output layer. All other layers are hidden and contain the neurons that do the real work. Its topological structure is shown in Fig. 1.

A neural network that uses the error backpropagation algorithm is said to be a BP network, with a learning process that consists of a feed-forward and feed-backward. Each sample signal in the feed-forward process has the sigmoid function $f(x) = 1/(1 + e^{-x})$ applied to it before it is passed to the next layer. The situation of neurons on each layer can only affect the situation of neurons on the next layer. If the output layer does not produce the desired value then the errors will be fed back from the outputs to the inputs through the network

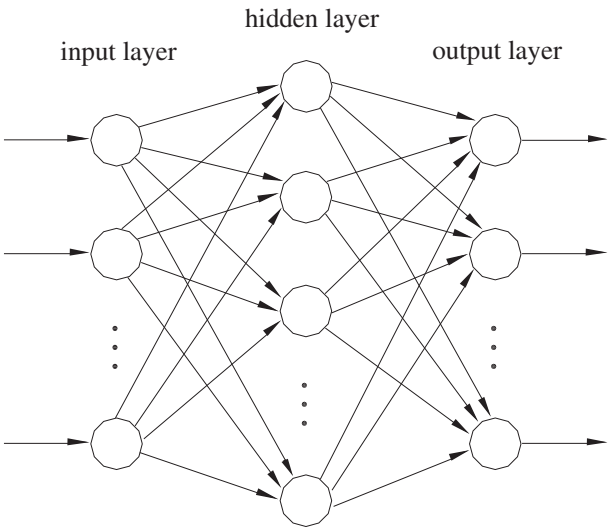

Fig. 1. Schematic diagram of topological structure of ANN.