Tourism Economics, 2008, 14 (3), 445–468

Developing a Web-based tourism demand forecasting system

HAIYAN SONG, STEPHEN F. WITT AND XINYAN ZHANG

School of Hotel and Tourism Management, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong. E-mail: hmsong@polyu.edu.hk.

Tourism demand is the foundation on which all tourism-related business decisions ultimately rest and so accurate forecasts of tourism demand are crucial for tourism industry practitioners. From the functional point of view, a tourism demand forecasting system (TDFS) is a forecasting support system capable of providing quantitative tourism demand forecasts and allowing users to make their own 'what-if' scenario forecasts. From the technical point of view, a TDFS is an information system consisting of a set of computer-based modules or components that support tourism demand forecasting and scenario analysis. This paper establishes a widely accessible Web-based TDFS which not only takes advantage of advanced econometric tourism demand forecasting techniques but also incorporates the real-time judgemental contribution of experts in the field. Furthermore, scenario forecasts are permitted within the system. Built on Web-based technology, the system provides advanced information sharing and communication and brings considerable convenience to various stakeholders engaged in tourism demand forecasting at different locations. In attempting to generate more accurate tourism demand forecasts, the system is designed to incorporate a two-stage forecasting methodology, which integrates judgemental adjustments with statistically based forecasts. The software architecture, detailed components and development environment of the Web-based TDFS are described in detail. A three-tiered client–server architecture is employed, which offers great flexibility, reusability and reliability. The prototype system has been developed and screen shots of interaction with the system are presented using Hong Kong tourism as an example.

Keywords: tourism demand forecasts; econometric models; forecasting systems; judgemental forecasts; Web/Internet; Hong Kong

Accurate forecasts of tourism demand are crucial for practitioners in the tourism industry (see Song and Witt, 2006). Over the past few decades, numerous researchers have been involved in the area of tourism demand forecasting and a wide variety of techniques have been developed. Most articles focus on quantitative modelling techniques, especially econometric and time-series methods

The authors would like to thank the Hong Kong Polytechnic University for financial support (Grant No 1-BB08).

(for detailed reviews of the tourism demand forecasting literature see Witt and Witt, 1995; Li *et al*, 2005). Many advanced quantitative tourism demand forecasting models have therefore been developed in the academic literature, but practitioners usually have little interest in scholarly journals and so either are not familiar with modern forecasting methods, or do not have the time to be involved in the design and development of advanced models to generate more accurate forecasts. For practitioners, one way of achieving more accurate forecasts is through a specialized forecasting system. The development of such systems is expensive and they often suffer from the limitations of individual knowledge, absence of expert opinion, etc. A new kind of forecasting system which is generally accessible and which can facilitate the transfer of information and knowledge from experts in tourism forecasting to practitioners in the tourism industry is highly desirable.

Statistical methods tend to produce acceptable forecasts on the basis of adequate data. However, special events or conditions in origins or destinations which are not incorporated in statistically based models may inevitably render such forecasts of tourism demand inappropriate. Experts' opinion adjustments to statistically based forecasts on the basis of specialized knowledge can result in improved accuracy. Many published studies also suggest that a combination of quantitative and qualitative techniques is often the best approach in forecasting future events (Archer, 1980; Edgell *et al*, 1980; Armstrong and Collopy, 1998; Goodwin, 2005; Fildes *et al*, 2006). Thus, a tourism demand forecasting system (TDFS) which captures both statistical factors and judgemental factors is highly desirable.

The current study aims to establish a Web-based TDFS, which not only integrates the advantages of modern forecasting methods and the scenario analysis, but also allows for a prompt judgemental contribution from a wide range of experts. At the functional level, a TDFS is a forecasting support system that is capable of providing quantitative tourism demand forecasts and allowing users to perform scenario analyses or make their own 'what-if' forecasts. Scenario analysis is an important and systematic method of studying the future, which incorporates uncertainty by including alternative future values for the influencing factors. At the technical level, a TDFS can be defined as an information system consisting of a set of computer-based modules or components that support tourism demand forecasting and scenario analysis. A Web-based TDFS, specifically, is a computerized information system that delivers tourism demand forecasts and provides decision support to policymakers and business strategists via a Web browser. Such a system facilitates information sharing and communication, and brings considerable convenience to various users engaged in tourism demand forecasting at different locations. The Web has become a ubiquitous and cost-effective communication medium for gathering and sharing information. Over the past decade, Web-based technology has evolved very rapidly. There are many Web-based applications developed for various design and decision making problems, such as mechanical design and manufacturing (Huang and Mak, 1999; Huang *et al*, 2001), collaborative research and development (Huang *et al*, 2003; Xu and Liu, 2003), hydrological forecasting (Dawson *et al*, 2007; Li *et al*, 2006) and product price forecasting (Zhang *et al*, 2005). However, there is almost no research on Web-based TDFSs. The exception is a study by Patelis *et al* (2005), who proposed a TDFS within an e-government environment where government information was published via the Internet (see the section on forecasting systems). The Web-based environment is starting to emerge as an important development and delivery platform for TDFSs.

The unique contributions of this study are: it provides a widely accessible Web-based TDFS; the statistical forecasts are based on modern econometrics; the TDFS incorporates rapid judgemental adjustments to the statistically based forecasts; and users can carry out scenario analyses.

The rest of this paper is organized as follows. The next section gives an overview of the Web-based TDFS as applied to the specific example of Hong Kong tourism. Then, the related literature on tourism demand forecasting, forecasting systems and Web-based forecasting services are reviewed. This is followed by a description of the two-stage forecasting methodology employed by the Web-based TDFS. Specifically, statistical forecasts produced at the initial quantitative forecasting stage are adjusted judgementally by experts at the second stage. The system architecture, along with specifics about its six main components, is then presented, followed by an illustration of the implementation and use of the system by including detailed screen shots of interaction with the Web-based TDFS. The paper concludes by identifying possible future directions for research.

Web-based TDFS

Background: Hong Kong tourism

Tourism is the second largest foreign currency earner of the Hong Kong economy. The income generated from inbound tourism contributed 8% to the Hong Kong gross domestic product (GDP) in 2006, representing a growth of 11% over 2005. International tourist arrivals in 2006 reached 25 million, an increase of 8% compared with 2005. Although the tourism industry has played an ever-increasing role in the generation of wealth and employment in Hong Kong, it also faces the critical problem of creating and maintaining a sustainable competitive advantage in an environment of increased globalization and economic integration in Asia. In particular, Hong Kong will have to compete for international tourists with such destinations as Singapore, Taiwan and Thailand. In order to respond effectively to this challenge, policymakers and businesses need all the support they can get to be aware of the comparative position of the industry in the region in their policy formulation and decision making. A tourism demand forecasting system (TDFS) can provide this much needed support.

Overview

The basic aim of this TDFS is to provide forecasts based on economic theory that postulates the relationship between the demand for Hong Kong tourism and its influencing factors. The specific forecasting outputs of the system include quarterly forecasts of:

- tourist arrivals by source markets up to 10 years ahead
- tourist expenditures by source markets up to 10 years ahead
- demand for hotel rooms by source markets and by room types up to 5 years ahead
- tourist expenditure on accommodation, retail products, restaurant meals and transportation by source markets up to 5 years ahead
- Hong Kong outbound tourism flows to key destinations up to 5 years ahead

Several national/regional tourism organizations and international organizations (World Tourism Organization, World Travel and Tourism Council and Pacific Asia Travel Association) have developed their own tourism forecasting systems which provide useful information for policymakers at various levels. For example, in Scotland, VisitScotland designs and uses a complex scenario planning process as a framing device for the possible future of the regional tourism industry. The process is constructed based on a scenario-planning group, environmental scanning (a qualitative process for capturing future events) and the MOFFAT model, which integrates structural time-series forecasting with quantifiable forecasts from a computable general equilibrium model (Yeoman and McMahon-Beattie, 2005). Other countries, such as New Zealand (Ministry of Tourism) and Australia (Tourism Forecasting Council), generate tourism forecasts through a process which involves combining quantitative forecasts and judgemental adjustment. Specifically, the New Zealand tourism forecasts are generated by modifying the initial quantitative forecasts through judgemental adjustment during a Delphi meeting (Ministry of Tourism, New Zealand, 2006). In the case of Australia, the Tourism Forecasting Council produces tourism forecasts which are obtained by initially generating econometric forecasts which are then examined, and may be further adjusted, by a technical committee (Organization for Economic Co-operation and Development, 2003).

The forecasts given by these systems normally can be accessed by users via the Internet through various downloadable reports or Web pages with forecasting results, although the systems themselves are inaccessible to users outside the forecasting team and therefore cannot be used interactively by practitioners. The Web-based TDFS proposed in this paper is, by contrast, widely accessible and interactive (rather than just informational) and permits subscribers to carry out scenario analyses.

The TDFS proposed in this paper will provide a useful source of information for the following stakeholders:

- Government offices responsible for tourism policymaking and implementation.
- Business executives in the travel, hotel, catering, retail and other tourism-related sectors.
- Planning and marketing agencies/departments of various tourism sectors.
- Consultancy firms focusing on tourism.
- Education and research establishments focusing on tourism.

Figure 1 illustrates the conceptual architecture of the Web-based TDFS at a high level. Its engine resides in a Web server and it is capable of using data (local and remote) and statistical forecasting models, facilitating judgemental

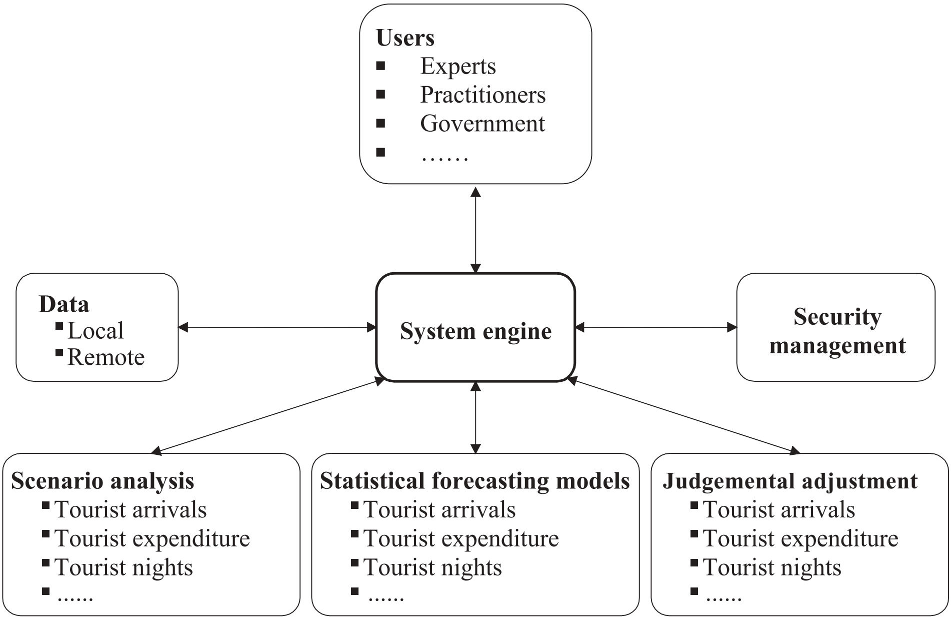

Figure 1. Conceptual architecture for the Web-based TDFS.

adjustments to the statistical forecasts and enabling scenario analyses which provide sensitivity studies on the parameters for a variety of scenarios. These scenarios are plausible predictions that are produced by integrating the statistical forecasting models and different user requests. User requests are initiated from within a Web browser and are responded to by the system. Users with different permissions under different service levels are identified and managed by the security management module (Figure 1).

The TDFS is implemented as a Web-based, distributed computing system as opposed to a stand-alone one for the following reasons:

- Ease of use – users are familiar with Web browsers so it is very easy to feel comfortable with the application user interfaces. In addition, the Web-based system is platform independent and provides easy access from anywhere.
- Easy to update – the Web-based system is easily upgradeable with no costs or burden to the clients. Normally, the forecasting models are continuously updated as new data and models become available.
- Cheap solution – the Web-based system is a cheaper solution than buying expensive forecasting packages and it does not require special and expensive software or hardware. The user can stop using the application at any time, so he or she is not trapped in the investment.
- Improved collaboration among stakeholders – all stakeholders are able to use open standard Web browsers to access this system, regardless of where they are and when they start, and are allowed to interact with each other through the system. Hence, the sharing of information among stakeholders could be improved. Also, the Web-based system is capable of providing significant convenience to multiple experts, allowing them to make real-time

judgemental adjustments to the statistical forecasts at different locations. Therefore, the transfer of knowledge from experts to tourism practitioners is likely to be enhanced.

Literature review

Tourism demand forecasting

Tourism demand is usually measured in terms of the number of tourist visits from a source market to a destination market; or in terms of expenditures by tourists from a source market in a destination market; or in terms of nights spent by tourists from a source market in a destination market (Witt and Witt, 1992, 1995; Song and Witt, 2000). Tourism demand forecasts traditionally are generated by either quantitative or qualitative approaches, but the majority of studies use econometric and/or time-series modelling techniques (see reviews by Witt and Witt, 1995; Li *et al*, 2005). Time-series methods use past patterns in data to extrapolate future values and, whilst time-series approaches are useful tools for tourism demand forecasting, a major limitation of these methods is that they cannot be used for policy evaluation purposes. By contrast, econometric models, which estimate the quantitative relationship between tourism demand and its determinants, can be used for policy evaluation. The large body of literature that has been published on tourism demand forecasting using modern econometric techniques is reviewed by Li *et al* (2005).

Forecasting systems

A forecasting system (FS) is an example of a decision support system (DSS) because a detailed forecast is an essential input to planning or decision-making processes. Armstrong (2001) gave a formal definition of a forecasting support system as 'a set of procedures (typically computer based) that supports forecasting'. He pointed out that such a system might also enable the analyst to incorporate judgement and monitor forecast accuracy.

Advanced forecasting systems can be grouped into two large categories according to their features: general forecasting systems and specific forecasting systems. General forecasting systems focus on general market research and are often partially automated due to the large number of time series involved. For example, having recognized the potential benefits of the integration of statistical forecasting systems with knowledge-based techniques, Mentzas *et al* (1995) described an intelligent forecasting information system (IFIS) in which, besides the traditional components of a DSS (that is, database, model base and dialogue management systems), the system contains four constituents that try to model the required expertise: a process expert, a learning expert, a data expert and a model expert. In another study, Cortez *et al* (1996) developed an intelligent time-series forecasting system by integrating artificial neural networks and genetic algorithms. Similarly, Yuan *et al* (2000) set up an intelligent forecasting support system based on radial basis neural networks and applied the system to the material department of a hotel. Nikolopoulos and Assimakopoulos (2003) designed and implemented a Theta intelligent forecasting information system (TIFIS), which adopted an object-oriented approach to produce forecasts and exploited the forecasting engine of the Theta model integrated with automated rule-based adjustments and judgemental adjustments. The TIFIS was designed primarily for business forecasting and especially for sales, inventory, demographics and financial time series. More recently, after presenting a survey on the available bibliography and applications of forecasting systems within an e-government framework, Nikolopoulos *et al* (2004) proposed the basic architectural elements of a forecasting system for e-government. The proposed architecture consisted of two interfaces, five components (e-government forecasting process, security, forecasting, data management and judgemental and political intervention), a database management system, a knowledge management system and databases.

From the above literature, it can be seen that the basic forecasting algorithm embedded within a general forecasting system is either an artificial intelligence technique or an integration of a statistical forecasting system with knowledge-based techniques. Although such systems should be very useful, it is difficult to develop a really general one as different forecasting problems normally have different characteristics. Hence, it is not surprising that the research on general forecasting systems is limited. In contrast, the literature on specific forecasting systems, which concentrates on the solutions to specific forecasting problems, is extensive. Many of these systems have been developed for electric load forecasting (Kim *et al*, 1995; Khotanzad *et al*, 1997; Vermaak and Botha, 1998; Charytoniuk and Chen, 2000; Vilcahuamán *et al*, 2004). The rest are mainly for weather forecasting (Nelson and Winter, 1964; Kallos *et al*, 1997; Stern, 2002), stock price forecasting (Baba and Kozaki, 1992; Hiemstra, 1994), sales forecasting (Kuo, 2001; Thomassey and Fiordaliso, 2006) and flood forecasting (Kouwen, 2000; Li *et al*, 2006). Research on tourism demand forecasting systems (TDFSs), however, is rare. Petropoulos *et al* (2003) established a DSS for tourism demand forecasting; namely, a statistical and forecasting tourism information system (SFTIS). The SFTIS was designed on the basis of a proposed two-step econometric approach by splitting inbound tourism demand for a destination into the outbound tourism flow from a source market and the market share of the source market for the particular destination. A stepwise forward-with-a-backward-look regression algorithm was then used to decide the best subset of explanatory variables for each of the dependent variables. Judgemental techniques were not included in the system.

Web-based forecasting services

Web technology has evolved very rapidly over the last decade and increasingly has been used to support various activities. In the field of forecasting, traditional ways of forecasting through stand-alone forecasting software have started to move towards Web-based applications (Nikolopoulos *et al*, 2003, 2006; Tavanidou *et al*, 2003). In an extensive survey, Nikolopoulos *et al* (2003) provided a simplified general framework for establishing forecasting Web services and defined five categories of Web-based forecasting services:

(1) Online forecasting services in which the user has the ability to upload his or her data, perform forecasting and see the forecasts online.
(2) Forecasting software packages with web-enabled modules.

(3) Offline forecasting services in which the user has the ability to upload his or her data and then the forecasting process takes place offline.
(4) Sites that provide forecasting using specific data where the user cannot upload his or her data but can make forecasts using the existing data.
(5) Sites that provide forecasts using specific data where the user can register and buy from the company specific forecasts according to his or her needs.

Nikolopoulos *et al* (2003) found that there was very little research in the field of Web-based forecasting and there were not many forecasting services on the Internet. They also pointed out that Web-based forecasting was still in the early stages of implementation and was not receiving adequate attention. Tavanidou *et al* (2003) have developed an e-forecasting application over the Internet, namely eTIFIS. This eTIFIS is a Web-based version of the TIFIS discussed in the section on forecasting systems.

While the eTIFIS aims to provide a general Web-based forecasting service, a few studies on specific Web-based forecasting services have also been published over the past few years. Delen *et al* (2007) developed a Web-based DSS, namely a movie forecast guru (MFG), to help Hollywood managers make better decisions about important movie characteristics, which are used to build different types of prediction models (including neural networks, decision trees, ordinal logistic regression and discriminant analysis) to classify a movie. Zhang *et al* (2005) established an aquatic products price forecasting support system (APPFSS). This system takes advantage of Web-based technology, a knowledge base and time-series techniques to produce real-time estimations of future market conditions. Li *et al* (2006) have set up a Web-based flood forecasting system (WFFS) which includes five main modules: real-time rainfall data conversion, model-driven hydrologic forecasting, model calibration, precipitation forecasting and flood analysis. They state that the WFFS is helpful for users engaged in flood forecasting and control and allows the real-time contribution of a wide range of experts at other spatial locations in times of emergency. Dawson *et al* (2007) have constructed an open access website that can be used by hydrologists and other scientists to evaluate time-series models. This site provides a uniform set of quantitative tests that will ensure transparency and consistency between hydrological models.

There is virtually no research on Web-based tourism demand forecasting systems. The exception is a study by Patelis *et al* (2005), which extends and modifies the stand-alone statistical and forecasting tourism information system (SFTIS) proposed by Petropoulos *et al* (2003) (see the section on forecasting systems). Patelis *et al* (2005) proposed a possible architecture for integrating the SFTIS within an e-government system, named eSFTIS, so that tourism forecasting would be one component of a government website. The eSFTIS is supposed to serve end users such as hoteliers, tour operators, scientists, engineers, researchers and academics via e-government services, which are citizen focused and accessible via various modes, including the Internet. The key modules of the system are the Statistical Manager, which is responsible for the statistical analysis of the historical data, and the Forecasting Manager, which is responsible for the generation of forecasts. In this study, the authors also discuss in detail the practical benefits of the eSFTIS for both public and private tourism sectors, although the system itself has yet to be developed.

Forecasting methodology

In this study, the tourism demand forecasts are produced in two stages. In the first stage, econometric methods are applied to historical data to produce statistical forecasts, these forecasts then become the initial input into the second stage, in which a panel of experts is encouraged to adjust the statistical forecasts according to their intuition, experience and practical knowledge. Details of this two-stage forecasting method are now presented. The problem, the data set and the variables used to develop the forecasting model are specified; then, the econometric forecasting model employed in the first statistical forecasting stage is presented and, finally, the Delphi method used for the second judgemental adjustment stage is described.

Problem description and data set

Standard economic theory suggests that the most important factors that influence the demand for tourism are the own price of the tourism product, the prices of substitute tourism products (Martin and Witt, 1988), potential tourists' incomes, tourism marketing expenditure for the destination in the origin country/region (Witt and Martin, 1987), travel costs from origin country/region to the destination and one-off socio-economic events. For a general discussion, see Witt and Witt (1992) and Song and Witt (2000). The tourism forecasting model may be written as:

$$Q_i = f(P_i, P_{is}, X_i, M_i, C_i, dummies, \varepsilon_i) \ , \quad (1)$$

where Q_i is the quantity of the tourism product demanded in Hong Kong by tourists from country/region i; P_i is the cost of living for tourists in Hong Kong relative to the cost of living in the origin country i; P_{is} is the cost of living for tourists from origin country i in substitute destinations relative to the cost of living in Hong Kong; X_i is the level of income in origin country/region i; M_i is tourism marketing expenditure for Hong Kong in origin country i; C_i is the average travel cost from country i to Hong Kong; *dummies* are one-off socio-economic events, such as the SARS epidemic and the handover of Hong Kong from the UK to China; and ε_i is the disturbance term that captures all the other factors which may influence the quantity of the tourism product demanded in Hong Kong by tourists from origin country/region i.

Equation (1) is a theoretical model of tourism demand which is simply a statement that indicates that there is a relationship between the variables under consideration. However, in practice, it is necessary to specify the mathematical form of the tourism demand function. In this study, the tourism demand model is specified as a log–log demand function, in common with most previous tourism demand models (Li *et al*, 2005).

Tourism demand is measured by the number of tourist arrivals (or tourist expenditure) from a particular origin country/region in Hong Kong. The data are quarterly, covering the period Quarter 1 1985 – Quarter 4 2006, and were supplied by the Hong Kong Tourism Board (HKTB). The cost of living for tourists in Hong Kong relative to the origin country/region is measured by the consumer price index (CPI) in Hong Kong divided by the CPI in the origin country and adjusted by the appropriate exchange rates. The CPIs and exchange rates are collected from the International Monetary Fund's Statistical Database. Martin and Witt (1987) provided the justification for the use of this variable to represent tourists' cost of living in the destination country and numerous researchers have since used it in their empirical studies of tourism demand (Witt and Witt, 1992; Song and Witt, 2000, 2003; Song *et al*., 2000, 2003a,b; Kulendran and Witt, 2001). The substitute price for all origin countries/regions is measured by the CPI in substitute countries/regions adjusted by the appropriate exchange rates relative to the Hong Kong exchange rate adjusted CPI. The income level in the origin country/region is measured by the GDP indices in the origin country/region in real terms. The GDPs for all origin countries/regions except Taiwan are obtained from the International Monetary Fund (IMF). The data for Taiwan are obtained from Taiwan's official statistics. The research team is still seeking to obtain data on tourism marketing expenditure and travel costs from various sources.

The statistical forecasting model

Since the economic factors with respect to inbound tourism demand to Hong Kong are country specific, it is necessary to construct and estimate demand models for each of the major tourism origin countries/regions. According to the statistics published by the Hong Kong Tourism Board (HKTB), the following were the top tourism generating countries/regions for Hong Kong in 2006: China (53.8%), Taiwan (8.6%), Japan (5.2%), the USA (4.6%), Korea (2.9%), Singapore (2.3%), Macau (2.3%), Australia (2.2%), the UK (2.1%) and the Phillipines (1.8%). Tourist arrivals from these ten countries/regions accounted for 85.8% of the total tourist arrivals in Hong Kong.

In this study, the vector autoregressive (VAR) model is used to forecast the demand for Hong Kong tourism by tourists from the above ten major origin countries/regions. In the VAR model, all the variables, apart from the deterministic variables such as trend, intercept and dummy variables, are modelled purely as dynamic processes; that is, the VAR model treats all variables as endogenous. Furthermore, the VAR technique has been closely associated with some of the recent developments in multivariate cointegration analysis, such as the Johansen (1988) cointegration method. The VAR approach is selected for the following reasons:

- It has been shown in empirical studies that the VAR model can generate relatively accurate medium- and long-term forecasts of tourism demand (Witt *et al*, 2003, 2004).
- The VAR model does not require the generation of forecasts for the explanatory variables in order to obtain forecasts of the dependent variable.

In the VAR model, the current values of the variables are regressed against lagged values of all the variables in the system. If we use the following vector to represent the variable set in the system: $Y_t = (Q_{it}, P_{it}, P_{ist}, X_{it}, M_{it}, C_{it}, dummies, \varepsilon_t)$, then a general VAR($p$), where p is the lag length of the VAR, can be written as:

$$Y_t = \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \ldots + \Pi_p Y_{t-p} + U_t; \quad U_t \sim IID(0,\Sigma) \quad (2)$$

The above equation is known as Sims' general (unrestricted) VAR model (Sims, 1980). U_t is a vector of regression errors that are assumed to be contemporaneously correlated but not autocorrelated.

If a VAR model has m equations, there will be $m + pm^2$ coefficients that need to be estimated (including the constant term in each equation). This suggests that an unrestricted VAR model is likely to be overparameterized. A practical problem with estimating a VAR(p) model is that it is desirable to include as much information as possible for the purposes of forecasting and policy analysis, but degrees of freedom quickly run out as more variables are introduced. Therefore, the process of lag length selection is very important for the specification of a VAR model. If the lag length p is too small, the model cannot represent correctly the data generating process (DGP); if, on the other hand, p is too large, lack of degrees of freedom can be a problem and OLS estimation is unreliable. We use the likelihood ratio (LR) statistic, the Aikake information criterion (AIC) and the Schwarz Bayesian criterion (SBC) (Song and Witt, 2000: pp 93–94) to determine the lag length of the VAR model and, in most cases, four lags are included in the forecasting models.

The VAR model is used to produce the forecasts of the demand for Hong Kong tourism measured either by tourist arrivals or tourist expenditure. Forecasts can also be produced for disaggregated markets, such as the demand for hotel rooms, culture and heritage provision, programmes/events and Disneyland, when appropriate input variables are used in the model estimation.

Judgemental adjustment

The second stage of the forecasting process consists of a Delphi-type revision through a panel of tourism experts. The primary advantage of Delphi is that it is a technique that allows contributions from a group of experts who may be geographically dispersed. Most importantly, Delphi is more accurate than statistical groups and traditional interacting meetings (Rowe and Wright, 1999).

There are several important features of Delphi: (a) responses are anonymous; (b) the respondents are experts in the subject area; (c) there is more than one round – that is, the experts are asked for their opinions on each question more than once; and (d) controlled feedback is provided – that is, respondents are told about the group's responses in the preceding round (Armstrong, 1985).

Martino (1983) claimed that the selection of experts was the most important decision when using Delphi. The size of the Delphi panels reported in past studies ranged from tens to hundreds (Kaynak *et al*, 1994). Delbecq *et al* (1975) contended that 10–15 respondents sufficed where the panel comprised a homogeneous group. Yong *et al* (1989) asserted that a minimum of 15–20 participants was necessary. More recently, after a scrutiny of relevant research literature, Rowe and Wright (1999) stated that there was no consistent relationship between panel size and effectiveness of the method. Related literature also does not provide any consensus on the knowledge or expertise required for one to be included as a panel member. Another main feature of the Delphi technique is iteration. Rowe and Wright (1999) found that in the published studies on the Delphi technique, the number of rounds was variable, but seldom went beyond one or two iterations. In another survey of related literature, Armstrong (1985) concluded that additional rounds yielded only small gains in accuracy.

In this study, Delphi experts are selected from three different stakeholder sectors of expertise – academics, practitioners and the public sector. Finally, a group of 12 persons was chosen in which five were from the first sector, four from the second sector and three from the third sector. The Delphi survey is initiated by the administrator once every quarter and there are two rounds per Delphi survey. The workflow in each round follows:

Step 1 – the system presents statistical forecasts produced by the quantitative models and (if it is not the first round) the results and group's responses of the preceding round;

Step 2 – panel members are encouraged to give (a) their own estimates of the future values of tourism demand and (b) reasons for their answers;

Step 3 – responses are submitted independently through Web pages;

Step 4 – at the end of each round, the administrator develops adjusted forecasts, usually the statistical average (median) of the changes suggested by the panel members. The corresponding reasons are also summarized anonymously by the administrator for the next round.

System design

This section provides details about the software design of the Web-based TDFS. The system architecture is presented first and then main components of the system are described (Figure 2).

Software architecture for the Web-based TDFS is presented in Figure 2. As is the case for many Web applications, the Web-based TDFS follows the Microsoft Windows distributed Internet applications (DNA) multi-tiered architecture. The client tier contains system clients such as general/subscribing users, experts in tourism forecasting, the system administrator, etc. They can simultaneously access the Web-based system independently through local computers running open-standard Web browsers such as Internet Explorer. The clients and their machines are not actually a part of the Web-based system initially. They become a part of the system only when they visit the Web server and interact with the system directly for data inputting, forecasting, analysing, decision making, etc.

The application tier is the centre of the system. It provides the procedures used by the clients and controls the information communication between various tiers. Specifically, it contains a collection of software procedures written in ASP and hosted on a Microsoft IIS (Internet Information Server) Web server. Procedures residing in the application tier constitute six main components: security management, user interfaces, registration and billing, forecasting using models, judgemental adjustment and scenario analysis.

In the data tier, the data source (database) provides the data for the system.

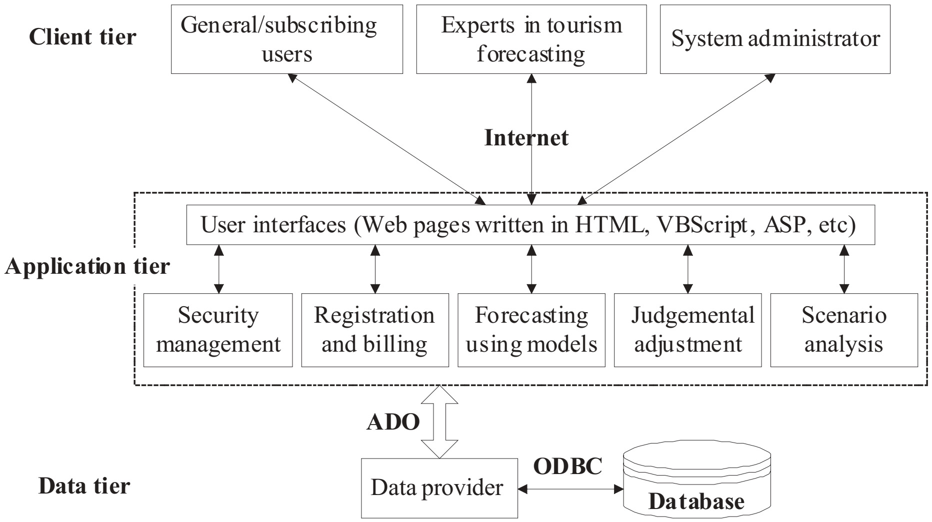

Figure 2. System architecture.

It is a remote computer running the relational database management system (RDBMS) such as Access, SQL server, Oracle, etc. The data provider is also a remote computer acting as the information broker between the data source and the application client, which retrieves data from the database by open database connectivity (ODBC) and transfers data to clients by ActiveX Data Objectives (ADO).

In the following, the six main components included in the application tier are described in detail.

Security management – user control

This component is responsible for authentication and permission regarding the level of service for the users, the entrance of a user to the system and the customization of the application environment. It supports the following basic types of users: administrator, general/subscribing users and experts.

- *Administrator* – the administrator can register a new user and maintain the user details. He or she can also set the specific permission of a user and alter their details. Another responsibility is the administration of the Delphi process during the judgemental adjustment stage.
- *General/subscribing user* – a general user who does not subscribe to the system can only view the annual statistical forecasts of tourist arrivals, while a subscribing user can access all the quarterly statistical and judgemental forecasts and perform scenario forecasting. Subscribing users can also take advantage of all the other services provided by the system (for example, a discussion forum).
- *Expert* – in addition to all the permissions possessed by a subscribing user, an expert can also review statistical forecasts through judgemental adjustment.

User interfaces

User interfaces of the system are provided in the application tier in the format of Web pages. They are responsible for the interaction between the system and its users, especially acting on the users' preferences and commands and controlling the input/output data and the form of display. In this component, OWCs (Office Web Components) are used to display data graphically (the same as in MS Office).

Registration and billing

This is the application component where a new account is created and maintained. In the registration process, the user's details, the level of service and the service duration (3 weeks to 12 months) are entered. The billing process takes place offline but it will be updated to online paying by credit card in the next version of the system. The card validation will be done through the organizations that supply this service. After the registration and billing processes have been completed, the user is authenticated to use the service. The user's profile preferences are restored and can be updated by the user anytime he or she wishes.

Quantitative forecasting

This component presents statistical forecasts produced by the VAR models. It takes as input the selected origin countries/regions and the forecasting horizon and returns statistical forecasts on Hong Kong tourism demand in both tabular and graphical formats. The current forecasts are produced by the VAR technique only. Other modern forecasting methods, for example, autoregressive distributed lag model (ADLM), will be incorporated in the next version of the system. These models will be implemented as Web services, that is, middleware components which can be developed in any kind of programming language and can be accessed by any kind of software application located in near and remote locations.

Judgemental adjustment

This component is responsible for the procedure of judgemental adjustment of the statistical forecasts and the adjustment process can only be accessed by the Delphi panel and administrator. In each Delphi survey, the component provides panel members with the following alternative ways to make their own adjustment: (a) setting percentage changes for the point forecasts directly, ranging between +50% and –50%; or (b) changing the average growth rate of the tourism demand forecasts and then the point forecasts will be generated accordingly; or (c) changing the average growth rates of the forecasts for the determinant variables of tourism demand and then the point forecasts of tourism demand will be obtained accordingly. The component also provides a variety of information needed by panel members when carrying out judgemental adjustment, such as the statistical forecasts on the determinant variables of tourism demand, the previous trend of tourism demand, recent magazine publications related to Hong Kong tourism, etc.

After the Delphi survey is completed, the component will publish the final judgemental forecasts on Hong Kong tourism demand produced by the panel and the additional insights offered by the Delphi experts, which will be accessible to users.

Scenario analysis

This is one of the key components of the forecasting system. The component takes the statistical forecasts produced by the VAR models as baseline forecasts and these forecasts are used as benchmarks against which to portray other possible scenario forecasts. The component creates four possible scenarios (two optimistic scenarios and two pessimistic scenarios) for each determinant variable of tourism demand in the VAR models for each selected source market. It also allows users to input their own scenarios. After a specific scenario is entered, the component will return the scenario forecasting results together with the baseline statistical forecasts in both tabular and graphical formats. Although the current system does not allow for the 'best forecast scenarios', the system will be configured in the future to allow for such forecasts to be generated, as tourism decision makers are likely to be interested in this function. Additional details and screen shots of the system implementation are included in the following section.

Implementation

The prototype Web-based TDFS has been implemented on Windows XP Professional on the basis of the architecture described previously. The database in this version of the Web-based system is small enough to run under Microsoft Access. The system can be accessed through a Web browser. Once in the homepage (Figure 3), the user is presented with a site introduction and links to various areas, as described in Table 1. On account of space limitations, this section focuses on the *Tourism Forecasts* and *Scenario Analysis* of tourist arrivals. The *Tourism Forecasts* pages and process are discussed first.

The first step in obtaining the tourism forecasts (Figure 4) involves the user's selection of source markets and forecasting horizons for tourism demand forecasts. Once all the parameters are entered, and the 'view the forecasts' button is clicked, the system displays the corresponding forecasts. If the user is a general user who does not subscribe to the site, he or she can only access the annual forecasts of tourist arrivals in tabular format (Figure 5a); if the user has subscribed to the site and logged into the system, he or she can view the quarterly forecasts in both tabular and graphic formats (Figure 5b).

Next, let us consider the *Scenario Analysis* pages and process. The first page of the scenario analysis (Figure 6) consists of the user selection of a source market and the point of scenario forecasting (quarterly from Quarter 1 2008 to Quarter 4 2017). Suppose that the user selects Taiwan in the source market list and chooses Quarter 4 2010 as the forecasting point, as shown in Figure 6. After he or she clicks the 'start' button, the system responds (Figure 7) with the following information: (a) the baseline forecasts of tourist arrivals from Taiwan over the period from Quarter 1 2008 to Quarter 4 2010 in both tabular

Figure 3. Web-based TDFS home page.

and graphical formats; (b) the baseline average growth rates of the determinant variables of tourist arrivals over the same period; and (c) lists of suggested scenarios for each variable. The user can also specify scenarios by entering his or her scenario growth rates. After the user enters a specific scenario and clicks the 'submit scenario' button, the system returns the scenario forecasting results (Figure 8) in both tabular and graphical formats through a pop-up window.

Conclusion

A Web-based TDFS which takes full advantage of Web-based technologies and advanced tourism demand forecasting techniques is implemented as a new and innovative way to generate tourism demand forecasts. Like other Web-based systems, this system has four significant features – wide accessibility, flexibility, reusability and user friendliness. More specifically, policymakers and industry leaders can use inexpensive Web browsers to access the information regarding

Table 1. Contents of various links.

Link name	Description of the content
Links in the top navigator bar:	
Project Information	Detailed information about the project.
Research Team	A brief introduction to the project team members.
Research Outputs	Related books/monographs, journal articles and working papers produced by the team.
Contact Us	Contact information for the research team.
My Account	Allows subscribing users to login, logoff, or update their information
Links in the left-hand main menu:	
Forecasting Methods	A brief background on classical forecasting methods and description of the forecasting methods used in this system.
Tourism Forecasts	Statistical forecasts of Hong Kong tourism demand.
Scenario Analysis	Allows subscribing users to conduct scenario analysis on Hong Kong tourism demand forecasts.
Forecasting Adjustment	Judgemental forecasts of Hong Kong tourism demand.
Glossary	Defines keywords or phrases used in the site.
Discussion Forum	Allows subscribing users to raise questions related to tourism forecasting and to participate in a discussion on issues or questions of interest.
Site Map	Provides an overview that contains links to all key pages.
Suggestions and Comments	Allows users to give their suggestions and comments on the website.
Related Websites	Provides a list of links related to this research.
Subscribe to this Site	Starting with this link, users can subscribe to this site.

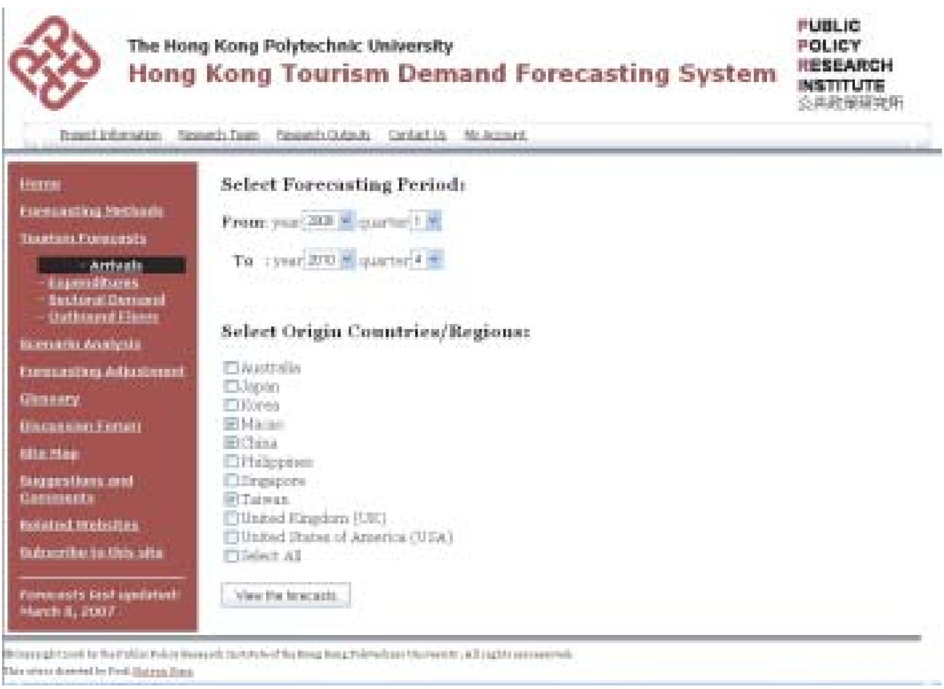

Figure 4. Tourism forecast (arrivals) parameter selection interface.

(a)

(b)

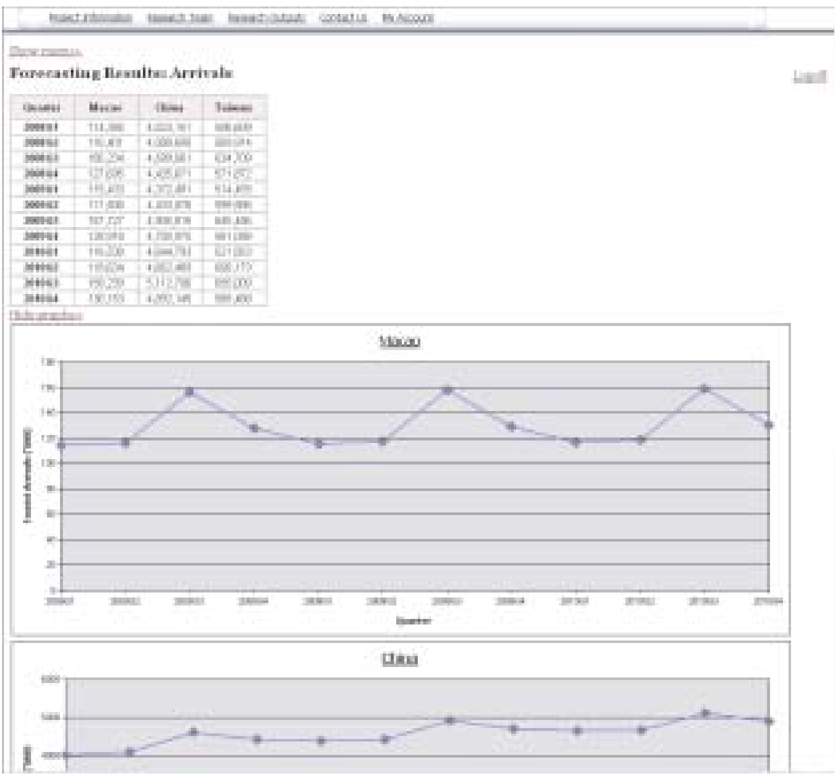

Figure 5. Tourism forecast (arrivals) results interfaces (a) before login and (b) after login.

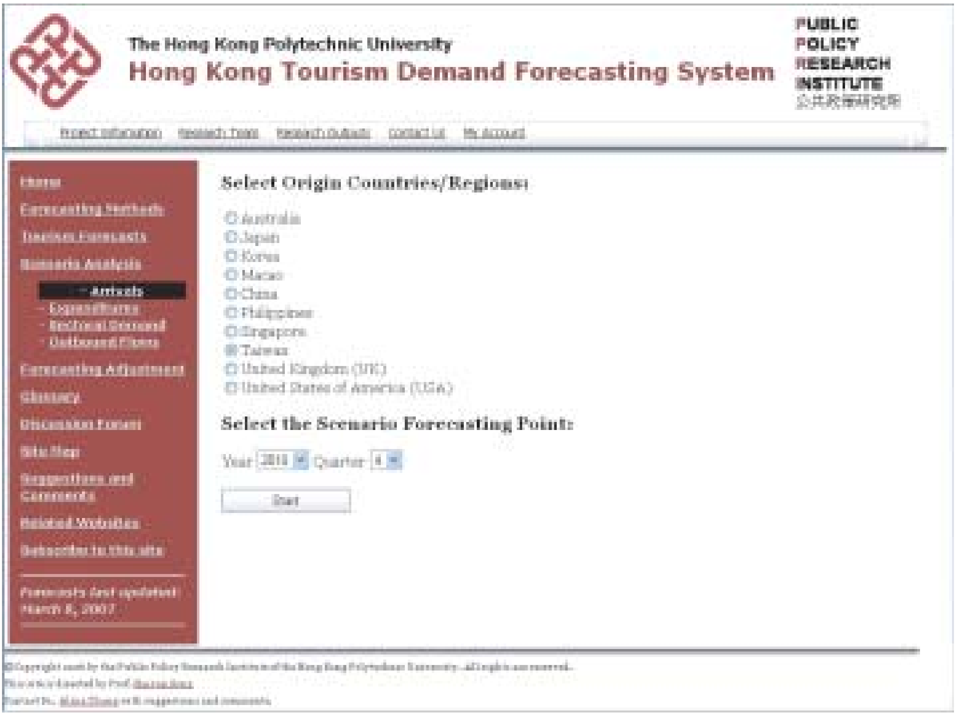

Figure 6. Scenario analysis (arrivals) parameter selection interface 1.

the future trend of tourism demand, regardless of where they are and when they start. The TDFS developed incorporates judgemental adjustments of statistical forecasts by tourism experts and so the transfer of knowledge from experts in tourism forecasting to tourism-related decision makers is improved considerably. Experts at various locations can visit the website and make real-time judgemental adjustments to the statistical forecasts of tourism demand through Web browsers. Together with the advanced statistical forecasting techniques, which can be integrated into the Web-based TDFS, forecast accuracy and reliability can be enhanced. Also, this system makes it easier for policymakers and industry leaders to perform 'what-if' scenario analyses on tourism demand forecasts by including alternative values for the determinant variables, which can be very useful for policy evaluation and decision making.

Although tourism has become an increasingly important sector in the Hong Kong economy, there has been only minimal effort to establish a reliable and effective forecasting system catering for the needs of both the public and private sectors in managing and planning tourism activities in Hong Kong. The Hong Kong economy tends to be over-responsive to market conditions and this response has been rather myopic and lacking long-term development considerations. As a result, the performance of the various sectors related to tourism is vulnerable to the cyclical influence of the economy and this often leads to undesirable social and economic consequences, such as prolonged unemployment and inability to attract foreign direct investment. Since tourism in Hong Kong is particularly sensitive to seasonality, external shocks such as

Figure 7. Scenario analysis (arrivals) parameter entry/selection interface 2.

SARS and economic conditions in tourism-generating countries/regions, a forecasting system that can be accessed by policymakers and business strategists is needed to minimize the negative impacts of these factors on the development of the tourism industry in Hong Kong. This study addresses this need by designing and developing a Web-based TDFS.

There are several possible directions for further enhancing the TDFS. The system can be modified to incorporate more forecasting methods through Web service technology. Forecasting results produced by these additional methods will provide more support for the tourism demand forecasts and the scenario analysis process. For instance, Delphi experts can get more information support from the forecasting results generated by other methods (such as ADLM) when doing judgemental adjustments. Once in use by the stakeholders, a survey can be conducted to get comments to help improve the Web-based TDFS to address the needs and wants of these users. Meanwhile, the forecasting results obtained over time can be stored and matched with the actual tourism demand data to check how good the forecasts are. Based on the results, the forecasting models may need to be modified. Finally, once it is up and running, the Web-based TDFS can be enhanced by establishing a knowledge base. The TDFS can store

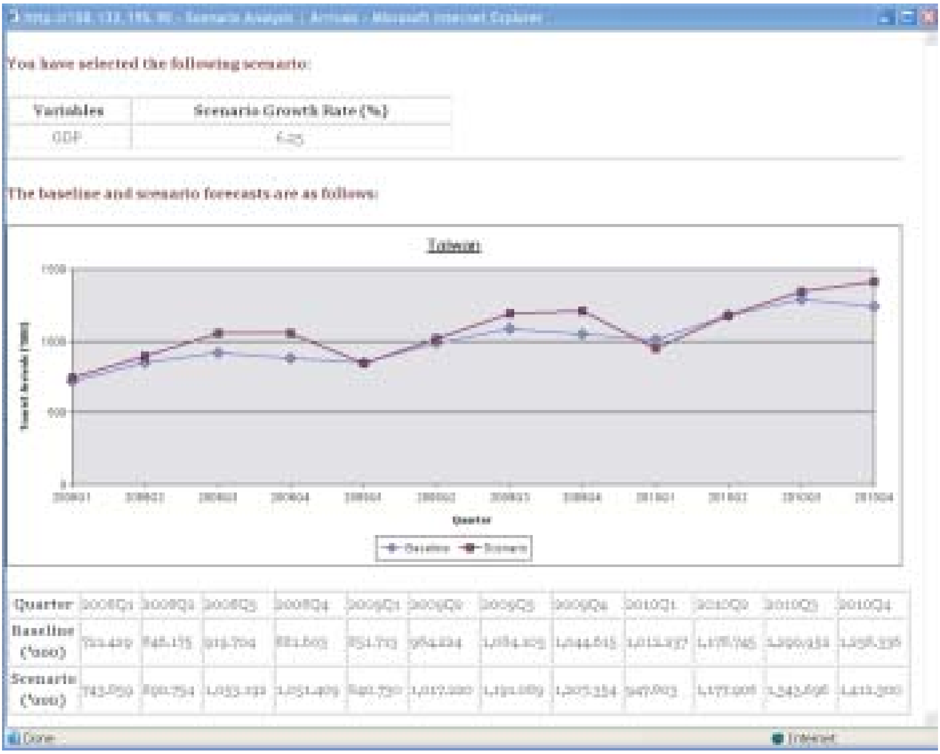

Figure 8. Scenario analysis (arrivals) results interface.

the information and knowledge that Delphi experts have accumulated from previous judgemental forecasting using the system. This knowledge base can serve as a forecasting support module or a system expert in the Web-based TDFS.

References

Archer, B.H. (1980), 'Forecasting demand: quantitative and intuitive techniques', *Tourism Management*, Vol 1, No 1, pp 5–12.

Armstrong, J.S. (1985), *Long-Range Forecasting*, second edition, John Wiley and Sons Ltd, New York.

Armstrong, J.S. (2001), *Principles of Forecasting: A Handbook for Researchers and Practitioners*, Kluwer Academic Publishers, Boston, MA.

Armstrong, J.S., and Collopy, F. (1998), 'Integration of statistical methods and judgment for time-series forecasting: principles from empirical research', in Wright, G., and Goodwin, P., eds, *Forecasting with Judgment*, John Wiley and Sons Ltd, New York, pp 269–293.

Baba, N., and Kozaki, M. (1992), 'An intelligent forecasting system of stock price using neural networks', Proceeding of the International Joint Conference on Neural Networks (IJCNN'92), 7–11 June 1992, Baltimore, MD.

Charytoniuk, W., and Chen, M.-S. (2000), 'Very short-term load forecasting using artificial neural networks', *IEEE Transactions on Power Systems*, Vol 15, No 1, pp 263–268.

Cortez, P., Machado, J., and Neves, J. (1996), 'An evolutionary artificial neural network time series forecasting system', Proceeding of the International Conference on Artificial Intelligence, Expert Systems and Neural Networks (IASTED'96), Honolulu, HI.

Dawson, C.W., Abrahart, R.J., and See, L.M. (2007), 'HydroTest: a Web-based toolbox of evaluation metrics for the standardised assessment of hydrological forecasts', *Environmental Modelling & Software*, Vol 22, No 7, pp 1034–1052.

Delbecq, A., Van de Ven, A., and Gustafson, D. (1975), *Group Guide to Nominal Group and Delphi Processes*, Scott, Foresman, Glenview, IL.

Delen, D., Sharda, R., and Kumar, P. (2007), 'Movie forecast guru: a Web-based DSS for Hollywood managers', *Decision Support Systems*, Vol 34, No 4, pp 1151–1170.

Edgell, D.L., Seely, R.L., and Iglarsh, H.J. (1980), 'Forecasts of international tourism to the USA', *International Journal of Tourism Management*, Vol 1, No 2, pp 109–113.

Fildes, R., Goodwin, P., and Lawrence, M. (2006), 'The design features of forecasting support systems and their effectiveness', *Decision Support Systems*, Vol 42, pp 351–361.

Goodwin, P. (2005), 'How to integrate management judgment with statistical forecasts', *Foresight: The International Journal of Applied Forecasting*, Vol 1, No 1, pp 8–11.

Hiemstra, Y. (1994), 'A stock market forecasting support system based on fuzzy logic', Proceedings of the 27th Annual Hawaii International Conference on System Sciences, 4–7 January 1994, Maui, HI.

Huang, G.Q., and Mak, K.L. (1999), 'Design for manufacture and assembly on the Internet', *Computers in Industry*, Vol 38, pp 17–30.

Huang, G.Q., Yee, W.Y., and Mak, K.L. (2001), 'Development of a Web-based system for engineering change management', *Robotics and Computer Integrated Manufacturing*, Vol 17, pp 255–267.

Huang, G.Q., Lee, S.W., and Mak, K.L. (2003), 'Collaborative product definition on the Internet: a case study', *Journal of Materials Processing Technology*, Vol 139, pp 51–57.

Johansen, S. (1988), 'A statistical analysis of cointegration vectors', *Journal of Economic Dynamics and Control*, Vol 12, pp 231–254.

Kallos, G., Kotroni, V., and Lagouvardos, K. (1997), 'The regional weather forecasting system SKIRON: an overview', Proceedings of the Symposium on Regional Weather Prediction on Parallel Computer Environments, University of Athens, pp 109–122.

Kaynak, E., and Macauley, J.A. (1984), 'The Delphi technique in the measurement of tourism market potential: the case of Nova Scotia', *Tourism Management*, Vol 5, No 2, pp 87–101.

Kaynak, E., Bloom, J., and Leibold, M. (1994), 'Using the Delphi technique to predict future tourism potential', *Marketing Intelligence & Planning*, Vol 12, No 7, pp 18–29.

Khotanzad, A., Afkhami-Rohani, R., Lu, T.-L., Abaye, A., Davis, M., and Maratukulam, D.J. (1997), 'ANNSTLF – a neural-network-based electric load forecasting system', *IEEE Transactions on Neural Networks*, Vol 8, No 4, pp 835–846.

Kim, K.-H., Park, J.-K., Hwang, K.-J., and Kim, S.-H. (1995), 'Implementation of hybrid short-term load forecasting system using artificial neural networks and fuzzy expert systems', *IEEE Transactions on Power Systems*, Vol 10, No 3, pp 1534–1539.

Kouwen, N. (2000), *WATFLOOD/SPL9: Hydrological Model & Flood Forecasting System*, University of Waterloo, Waterloo, available online from http://www.watflood.ca/.

Kulendran N., and Witt, S.F. (2001), 'Co-integration versus least squares regression', *Annals of Tourism Research*, Vol 28, pp 291–311.

Kuo, R.J. (2001), 'A sales forecasting system based on fuzzy neural network with initial weights generated by genetic algorithm', *European Journal of Operational Research*, Vol 129, pp 496–517.

Li, G., Song, H., and Witt, S.F. (2005), 'Recent developments in econometric modeling and forecasting', *Journal of Travel Research*, Vol 44, No 2, pp 82–99.

Li, X.-Y., Chau, K.W., Cheng, C.-T., and Li, Y.S. (2006), 'A Web-based flood forecasting system for Shuangpai region', *Advances in Engineering Software*, Vol 37, pp 146–158.

Martin, C.A., and Witt, S.F. (1987), 'Tourism demand forecasting models: choice of appropriate variable to represent tourists' cost of living', *Tourism Management*, Vol 8, No 3, pp 233–246.

Martin, C.A., and Witt, S.F. (1988), 'Substitute prices in models of tourism demand', *Annals of Tourism Research*, Vol 15, No 2, pp 255–268.

Martino, J. (1983), *Technological Forecasting for Decision Making*, second edition, Elsevier, New York.

Mentzas, J., Linardopoulos, I., and Assimakopoulos, V. (1995), 'An architecture for intelligent assistance in the forecasting process', Proceeding of the 28th Annual Hawaii International Conference on System Sciences (HICSS'95), 3–6 January 1995, Maui, HI, pp 167–176.

Ministry of Tourism, New Zealand (2006), *New Zealand Tourism Forecasts 2006–2012 Methodology Report*, Ministry of Tourism, Wellington.

Nelson, R.R., and Winter, S.G. Jr (1964), 'A case study in the economics of information and coordination: the weather forecasting system', *The Quarterly Journal of Economics*, Vol 78, No 2, pp 420–441.

Nikolopoulos, K., and Assimakopoulos, V. (2003), 'Theta intelligent forecasting information system', *Industrial Management and Data Systems*, Vol 103, No 8/9, pp 711–726.

Nikolopoulos, K., Metaxiotis, K., Assimakopoulos, V., and Tavanidou, E. (2003), 'A first approach to e-forecasting: a survey of forecasting web-services', *Information Management and Computer Security*, Vol 11, No 3, pp 146–152.

Nikolopoulos, K., Patrikakis, C.Z., and Lin, B.-S. (2004), 'Forecasting systems for e-government', *Electronic Government*, Vol 1, No 4, pp 374–383.

Nikolopoulos, K., Metaxiotis, K., and Assimakopoulos, V. (2006), 'E-forecasting: challenges and opportunities', *International Journal of Business Performance Management*, Vol 8, No 1, pp 93–106.

Organization for Economic Co-operation and Development (2003), *National Tourism Policy Review of Australia*, OECD, Paris.

Patelis, A., Petropoulos, C., Nikolopoulos, K., Lin, B., and Assimakopoulos, V. (2005), 'Tourism planning decision support within an e-government framework', *Electronic Government: An International Journal*, Vol 2, No 2, pp 134–143.

Petropoulos, C., Patelis, A., Metaxiotis, K., Nikolopoulos, K., and Assimakopoulos, V. (2003), 'SFTIS: a decision support system for tourism demand analysis and forecasting', *Journal of Computer Information Systems*, Vol 44, No 1, pp 21–32.

Rowe, G., and Wright, G. (1999), 'The Delphi technique as a forecasting tool: issues and analysis', *International Journal of Forecasting*, Vol 15, pp 353–375.

Sims, C. (1980), 'Macroeconomics and reality', *Econometrica*, Vol 48, pp 1–48.

Song, H., and Witt, S.F. (2000), *Tourism Demand Modelling and Forecasting: Modern Econometric Approaches*, Pergamon; Oxford.

Song, H., and Witt, S.F. (2003), 'Tourism forecasting: the general-to-specific approach', *Journal of Travel Research*, Vol 42, No 1, pp 65–74.

Song, H., and Witt, S.F. (2006), 'Forecasting international tourist flows to Macau', *Tourism Management*, Vol 27, No 2, pp 214–224.

Song, H., Romilly, P., and Liu, X. (2000), 'An empirical study of outbound tourism demand in the UK', *Applied Economics*, Vol 32, pp 611–624.

Song, H., Witt, S.F., and Jensen, T.C. (2003a), 'Tourism forecasting: accuracy of alternative econometric models', *International Journal of Forecasting*, Vol 19, No 1, pp 123–141.

Song, H., Wong, K.F., and Chon, K. (2003b), 'Modelling and forecasting the demand for Hong Kong tourism', *International Journal of Hospitality Management*, Vol 22, pp 435–451.

Stern, H. (2002), 'A knowledge-based system to generate Internet weather forecasts', Proceeding of the 18th Conference on Interactive Information and Processing Systems, Orlando, FL.

Tavanidou, E., Nikolopoulos, K., Metaxiotis, K., and Assimakopoulos, V. (2003), 'eTIFIS: an innovative e-forecasting web application', *Journal of Software Engineering and Knowledge Engineering*, Vol 13, No 2, pp 215–236.

Thomassey, S., and Fiordaliso, A. (2006), 'A hybrid sales forecasting system based on clustering and decision trees', *Decision Support Systems*, Vol 42, pp 408–421.

Vermaak, J., and Botha, E.C. (1998), 'Recurrent neural networks for short-term load forecasting', *IEEE Transactions on Power Systems*, Vol 13, No 1, pp 126–132.

Vilcahuamán, R., Meléndez, J., and de la Rosa, J.L. (2004), 'FUTURA: hybrid system for electric load forecasting by using case-based reasoning and expert system', in *Topics in Artificial Intelligence*, Series of Lecture Notes in Computer Science, Springer, Berlin.

Witt, S.F., and Martin, C.A. (1987), 'International tourism demand models – inclusion of marketing variables', *Tourism Management*, Vol 8, No 1, pp 33–40.

Witt, S.F., and Witt, C.A. (1992), *Modeling and Forecasting Demand in Tourism*, Academic Press, London.

Witt, S.F., and Witt, C.A. (1995), 'Forecasting tourism demand: a review of empirical research', *International Journal of Forecasting*, Vol 11, No 3, pp 447–475.

Witt, S.F., Song, H., and Louvieris, P. (2003), 'Statistical testing in forecasting model selection', *Journal of Travel Research*, Vol 42, No 2, pp 151–158.

Witt, S.F., Song, H., and Wanhill, S. (2004), 'Forecasting tourism-generated employment: the case of Denmark', *Tourism Economics*, Vol 10, No 2, pp 167–176.

Xu, X.W., and Liu, T. (2003), 'A Web-enabled PDM system in a collaborative design environment', *Robotics and Computer Integrated Manufacturing*, Vol 19, No 4, pp 315–328.

Yeoman, I., and McMahon-Beattie, U. (2005), 'Developing a scenario planning process using a blank piece of paper', *Tourism and Hospitality Research*, Vol 5, No 3, pp 273-285.

Yong, Y., Keng, K., and Leng, T.L. (1989), 'A Delphi forecast for the Singapore tourism industry: future scenario and marketing implications', *International Marketing Review*, Vol 6, No 3, pp 35–46.

Yuan, D., Yan, J., Xi, Q., and Zhang, H. (2000), 'A forecasting support system based on neural network', Proceedings of the 3rd World Congress on Intelligent Control and Automation, pp 1036–1039.

Zhang, X., Hu, T., Revel, B., and Fu, Z. (2005), 'A forecasting support system for aquatic products price in China', *Expert Systems with Applications*, Vol 28, pp 119–126.