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Demand forecasting and information platform in tourism

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Abstract: Information asymmetry and the bullwhip effect have been serious problems in the tourism supply chain. Based on platform theory, this paper established a mathematical model to explore the inner mechanism of a platform’s influence on stakeholders’ ability to forecast demand in tourism. Results showed that the variance of stakeholders’ demand predictions with a platform was smaller than the variance without a platform, which meant that a platform would improve predictions of demand for stakeholders. The higher information-processing ability of the platform also had other effects on demand forecasting. Research on the inner logic of the platform’s influence on stakeholders has important theoretical and realistic value. This area is worthy of further study.

Keywords: Tourism supply chain, Information platform, Demand forecasting ability, Information processing ability, Information acquiring ability

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1 Introduction

Demand is the driving mechanism behind businesses and supply chains [6]. Demand forecasting refers to make predictions about the future demand for products or services [8], including quantities, sums of money [9], quality and timing [1]. Demand forecasting aims to respond to uncertain factors in future business activities and decisions [10]. Demand forecasting is the premise of strategic planning, resource distribution and ordering decisions [11], so the accuracy of demand forecasting plays an essential role in improving business operation efficiency, customer satisfaction and market competitiveness [12]. Demand forecasting has been a hot topic in many industries, such as tourism [13–16], electric power [17], water [18, 19] and telecommunications [20]. Scholars have focused on exploring better forecasting models and methods compared to previous ones [15, 18]. In the tourism supply chain, which consists of tourists, travel agencies, tour operators and tourism suppliers [21], links between members are more dynamic and changeable [22] compared to manufacturing. Stakeholders in tourism, especially those in the upstream supply chain, suffer from the bullwhip effect [23] and asymmetric information [25] more seriously than do stakeholders in manufacturing supply chains. Demand uncertainty will usually be even worse for tourism stakeholders [26]. Besides this, with the development of technology and the growth of tourism, the number of tourism products and services has sharply increased, and competitiveness in tourism is more and more serious [2]. Time has gradually become a pivotal factor in market competition [3] and this has promoted the appearance of instant customerisation [1]. The quicker a supplier is able to respond to market changes, the more tourist share and return they will get. Simultaneously, social progress has brought benefits to individual tourists, and tourism is experiencing a transition from group to independent travel [27], especially for young people [28]. Young people are inclined to arrange flexible itineraries and try their best to experience something special [28]. Under these circumstances, the accuracy of demand prediction cannot be guaranteed and stakeholders’ order quantities tends to deviate from realistic tourists demand, which can lead to negative results, such as the waste of resources, blocked plans, diseconomy, financial crisis and reduced tourists satisfaction and loyalty. So, how to improve the forecasting ability of stakeholders in tourism supply chain should be a vital topic. Many scholars have investigated methods for improving stakeholders’ demand predictions. However, most research has only focused on information sharing, and has overlooked organizations’ information-processing ability. H L Lee [24] believed that stakeholders in supply chains should share information fully. Akkermans [33] also maintained that information sharing would be an efficient way to improve the accuracy of demand prediction. Byrne and Heavey [34] mentioned that stakeholders should concen-

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tate demand information they acquired in order to better facilitate demand forecasting. There is no doubt that information sharing will lead to benefits by improving demand prediction. But information sharing is just one aspect of this complex problem. Information-processing ability is another vital factor. Lots of research has proved that platforms are an effective and efficient method to concentrate, transmit and share information [24, 29, 31]. Also, use of platforms has been a hot topic in recent years, forming an intersection center of technology systems with indirect network effects [29]; platforms also promote stakeholder interactions and transactions by attracting and benefiting both sides of the transaction [31]. In addition, platforms are a structure, which possess information-acquiring and information-processing abilities and could make full use of organization ability [32]. Gawer is a master in this field, and she thought that platforms would evolve out of individual enterprises and gradually extend to supply chain and then to platform system [31]. Platforms can connect almost all stakeholders in the tourism supply chain, such as suppliers, communities, operators, agencies, governments, scientific institutions and even tourists, which will facilitate stakeholders’ information acquisition and contribute to the participation of customers [31]. In summary, platforms bring a new idea for us to solve the bullwhip effect in supply chain. Platforms can not only increase the information-acquiring ability of stakeholders, but also improve the supply chain’s information-processing ability. In this paper, we will take tourism as an example and try to establish a mathematic model to explore the relationship between an information platform and stakeholders’ forecasting of demand.

2 Demand forecasting in different situations

This paper takes a tourism supply chain consisting of tourists, travel agencies (a), operators (o), suppliers (s) and communities (c) as an example. In the traditional pattern, tourism agencies make their order planning according to the existing market demand and their predictions for the near future. These plans are communicated to tourism operators, which will make their own predictions of numbers of orders, and pass these orders on to to tourism suppliers according to retailers’ orders. Similarly, communities and residents supply tourism-relate resources, such as labor, vegetables and rooms, for suppliers based on orders and forecast demand. With the improvement of living standards in our society, demand for tourist services and products become more varied and individualized. In an unstable market, all stakeholders are often faced with a high degree of uncertainty. According to our analysis above, a platform is an effective way to implant flexibility and response to uncertainty. In this paper, the Lead Time, which means the period from the time of signing an order to the time of actual delivery, is divided into a great number of discrete periods. In this way, all members in the tourism supply chain can constantly and flexibly adjust their predictions of market demand according to the information they get, thereby reducing distortion in results. Thus dynamic demand management can be achieved. To set up the mathematical model, we make the following hypotheses.

1. We suppose that \( Q_t \) is the real demand in the tourism market and forms a normal distribution with an average of \( \mu \), and a standard deviation of \( \sigma \), while \( Y_t^m \) is the projected demand of the stakeholders in the market and \( \xi_t^m \) is the forecast error, then we can get the equation as follow.

\[
Q_t = Y_t^m + \xi_t^m
\]  

(1)

2. We suppose that the projected demand by the subjects in the market is comprised of two parts: the current and exact demand in the form of orders \((d_{t-L})\) from the supply chain plus the predicted and adjusted demand \((D_t^m)\) in the Lead Time based on a number of factors. From this \(d_{t-L}\) forms a normal distribution with an average of \(\mu_d\), and a standard deviation of \(\sigma_d\).

\[
Y_t^m = d_t + D_t^m
\]  

(2)

3. In the Lead Time (L), stakeholders constantly adjust their predictions of market demand according to the information they get. Since L is divided into a great number of independent discrete periods, the adjustment can be expressed as a data series. \(D_{t-L,i}^m\) forms a normal distribution with an average of \(\mu_{D_i}\), and a standard deviation of \(\frac{1}{\sqrt{L}} \times \sigma_i\). We define \(\frac{1}{\sqrt{L}} \times \sigma_i\) as the forecast accuracy and \(\lambda^m\) as the ability to make predictions.

\[
D_t^m = \sum_{i=0}^{L} D_{t-L,i}^m
\]  

(3)

Based on the above formulas, we can deduce an expression for \(\varepsilon_t^m\).

\[
\varepsilon_t^m = Q_t - Y_t^m = Q_t - d_{t-L} - \sum_{i=0}^{L} D_{t-L,i}^m
\]  

(4)
We define $\sigma^m_t$ as the standard deviation of $\xi^m_t$. And we know that $Q_t$, $d_{t-L}$ and $D^m_t$ are independent from each other. So we can get the following equation:

$$\left( \delta^m_t \right)^2 = \delta^2 + \delta^2_d + \left( \frac{1}{L^m} \right)^2 \sum_{i=0}^{L^m} \sigma^2_i$$  \hspace{1cm} (5)

4. We suppose that the prediction ability of each stakeholder is the combined result of their information-acquiring ability ($Q^m_t$) and their information-processing ability ($\lambda^m_t$). These two abilities have a positive influence on members’ forecasting ability ($\lambda^m_t$). So we can get an expression of prediction ability:

$$\lambda^m_t = \alpha^m \times Q^m_t$$  \hspace{1cm} (6)

For stakeholders such as agencies, operators, suppliers and communities, there are three situations they will face. We try to compare the results in these three situations.

1. Before the information platform is introduced, information in the tourism supply chain is scattered, and stakeholders adjust their predictions according to information they get by means of the traditional paths, for example, the downstream members of supply chain. Then based on statements mentioned above, the variance of stakeholders’ prediction errors can be expressed as follows:

$$\begin{align*}
\left( \delta^a_{t,b} \right)^2 &= \delta^2 + \delta^2_d + \left( \frac{1}{L^a} \right)^2 \times \sum_{i=0}^{L^a} \delta^2_i \\
\left( \delta^b_{t,b} \right)^2 &= \delta^2 + \delta^2_d + \left( \frac{1}{L^b} \right)^2 \times \sum_{i=0}^{L^b} \delta^2_i \\
\left( \delta^c_{t,b} \right)^2 &= \delta^2 + \delta^2_d + \left( \frac{1}{L^c} \right)^2 \times \sum_{i=0}^{L^c} \delta^2_i \\
\left( \delta^T_{t,b} \right)^2 &= \delta^2 + \delta^2_d + \left( \frac{1}{L^T} \right)^2 \times \sum_{i=0}^{L^T} \delta^2_i
\end{align*}$$  \hspace{1cm} (7)

In the formula (7), $\sigma^m_t$ is the standard deviation of members’ prediction errors in time $t$, when they make their own predictions without the help of an information platform. $\lambda^m$ refers to each member’s ability to make predictions.

2. After the information platform is introduced, stakeholders gain information by means of both the traditional paths and the information platform. They adjust their predictions accordingly. Under this circumstance, the variance of stakeholders’ prediction errors can be expressed as follows:

$$\begin{align*}
\left( \delta^a_{t,a} \right)^2 &= \delta^2 + \delta^2_d + \left( \frac{1}{L^a} \right)^2 \times \sum_{i=0}^{L^a} \delta^2_i \\
\left( \delta^b_{t,a} \right)^2 &= \delta^2 + \delta^2_d + \left( \frac{1}{L^b} \right)^2 \times \sum_{i=0}^{L^b} \delta^2_i \\
\left( \delta^c_{t,a} \right)^2 &= \delta^2 + \delta^2_d + \left( \frac{1}{L^c} \right)^2 \times \sum_{i=0}^{L^c} \delta^2_i \\
\left( \delta^T_{t,a} \right)^2 &= \delta^2 + \delta^2_d + \left( \frac{1}{L^T} \right)^2 \times \sum_{i=0}^{L^T} \delta^2_i
\end{align*}$$  \hspace{1cm} (8)

3. When the information platform is introduced, tourism demand information flows to the platform. The platform then makes predictions, taking advantage of its human capital and technology advantages. Stakeholders can compare their original predictions with the predictions of the platform to make more reliable new estimates. The variance of the platform’ prediction errors can be expressed as follows:

$$\left( \delta^p_{t} \right)^2 = \delta^2 + \delta^2_d + \left( \frac{1}{L^p} \right)^2 \times \sum_{i=0}^{L^p} \delta^2_i$$  \hspace{1cm} (9)

In the equation, $\sigma^p_t$ is the standard deviation of the platform prediction error. $\lambda^p$ refers to the platform’s ability to make predictions. Comparing these three situations, we can easily find that each situation’s prediction ability will determine the best demand forecast result. According to formula (5), we should analyze the information quantities and information-processing abilities of each stakeholder in these situations. To simplify the operation, we take community as an example. The community’s ability to make predictions in these three different situations can then be shown as follows:

$$\begin{align*}
\lambda^m_b &= \alpha^c \times Q^m_{I,b} \\
\lambda^m_a &= \alpha^c \times Q^m_{I,a} \\
\lambda^p &= \alpha^p \times Q^p_{I}
\end{align*}$$  \hspace{1cm} (10)

We use $X$ to represent the information sets the community gets without an information platform, and $Y$ to indicate the information sets the community gets when a platform is used. So $Q^m_{I,b}$ is the information quantity $X$ contains, and $Q^p_{I}$ is the information quantity $Y$ contains. Then we derive the following expression:

$$X \cup Y = X + Y - X \cap Y$$  \hspace{1cm} (11)

We suppose that $Q^c_{I,a}$ is the information quantity $\{XY\}$ contains. So it is easy to deduce that $Q^m_{I,a} Q^c_{I,b}$ and $Q^c_{I,a} Q^p_{I}$. Besides this, in the traditional information path, there are many information nodes and information transitions. The platform has a direct link with all stakeholders. So compared to the platform, the traditional means of information sharing will result in greater information losses. We can then deduce that $Q^c_{I,a} Q^c_{I,b}$. The relationship of $Q^c_{I,a}$, $Q^c_{I,b}$ and $Q^p_{I}$ can be shown as follows:

$$Q^c_{I,a} \geq Q^c_{I,b} \geq Q^p_{I}$$  \hspace{1cm} (12)

Information processing ability is related to the knowledge systems and technology systems used by stakeholders, and consists of the management ability of information...
resources, informatization-competence of business process, and the organization cultural and management ability. Information processing ability can be expressed as follows:

\[ a = w_1 l_1 + w_2 l_2 + w_3 l_3 + \cdots = \sum_{k=1}^{n} w_k l_k \] (13)

In this equation, \( I_k \) is the specific information-processing ability, and \( w_k \) is the weight of each aspect. Generally, the information platform, compared to the community without a platform, has many advantages, such as professional talents, technologies, capital, software and hardware systems. So it is easy to deduce that \( a^p \) is bigger than \( a^c \). But we must note that this cannot be suitable for all stakeholders, because some tour operators own strong financial, material and human resources. So in this paper, we will analyze these two situations.

1. \( a^p > a^c \)

Based on the above analysis, we can get the relationships between \( (\lambda^c_{k}, \lambda^c_{b}, \lambda^c_{p}) \) and \( \lambda_p \), shown as follows:

\[
\begin{align*}
\lambda^c_{k} & \geq \lambda^c_{b}, \lambda^c_{p} > \lambda^c_{b} \\
\lambda^c_{b} & \geq \lambda_p, \text{ if } \frac{Q^c_{k}}{Q^c_{b}} \geq \left( \frac{a^c}{a^c} \right) \\
\lambda^c_{p} & \geq \lambda^c_{b}, \text{ if } \frac{Q^c_{p}}{Q^c_{b}} \leq \left( \frac{a^p}{a^c} \right)
\end{align*}
\] (14)

Then,

\[
\begin{align*}
(\sigma^c_{k,a})^2 & \leq (\sigma^c_{b,a})^2, (\sigma^c_{p})^2 \leq (\sigma^c_{b,a})^2 \\
(\sigma^c_{b,a})^2 & \leq (\sigma^c_{p})^2, \text{ if } \left( \frac{Q^c_{k}}{Q^c_{b}} \right) \geq \left( \frac{a^c}{a^c} \right) \\
(\sigma^c_{p})^2 & \leq (\sigma^c_{b,a})^2, \text{ if } \left( \frac{Q^c_{p}}{Q^c_{b}} \right) \leq \left( \frac{a^p}{a^c} \right)
\end{align*}
\] (15)

In summary, when the platform’s information-processing ability is stronger than the community’s ability without the platform, the community’s variance of prediction error will be smaller than the variance without a platform. The platform’s variance will also be smaller than the variance without a platform. Besides this, the platform’s variance would be bigger or smaller than the community’s variance with a platform, which is related to the relationship between the value of \( (\frac{Q^c_{p}}{Q^c_{b}}) \) and the value of \( \frac{a^p}{a^c} \).

2. \( a^p < a^c \) Based on the above analysis, we can get the relationship of \( (\lambda^c_{k}, \lambda^c_{b}, \lambda^c_{p}) \) and \( \lambda_p \), shown as follows:

\[
\begin{align*}
\lambda^c_{k} & \geq \lambda^c_{b}, \lambda^c_{p} < \lambda^c_{b} \\
\lambda^c_{b} & \leq \lambda_p, \text{ if } \frac{Q^c_{k}}{Q^c_{b}} \geq \left( \frac{a^c}{a^c} \right) \\
\lambda^c_{p} & \leq \lambda^c_{b}, \text{ if } \frac{Q^c_{p}}{Q^c_{b}} \leq \left( \frac{a^p}{a^c} \right)
\end{align*}
\] (16)

Then,

\[
\begin{align*}
(\sigma^c_{k,a})^2 & \leq (\sigma^c_{b,a})^2, (\sigma^c_{p})^2 \geq (\sigma^c_{b,a})^2 \\
(\sigma^c_{b,a})^2 & \geq (\sigma^c_{p})^2, \text{ if } \left( \frac{Q^c_{k}}{Q^c_{b}} \right) \geq \left( \frac{a^c}{a^c} \right) \\
(\sigma^c_{p})^2 & \geq (\sigma^c_{b,a})^2, \text{ if } \left( \frac{Q^c_{p}}{Q^c_{b}} \right) \leq \left( \frac{a^p}{a^c} \right)
\end{align*}
\] (17)

In brief, when the information-processing ability of platform is smaller than the community’s own ability, the community’s variance of prediction error with a platform will be smaller than the variance without a platform, and the variance of the platform itself. In addition, the variance of the platform would be bigger or smaller than that for the community without a platform, which is related to the relationship between the value of \( (\frac{Q^c_{p}}{Q^c_{b}}) \) and the value of \( \frac{a^p}{a^c} \).

3. \( a^p = a^c \) In this situation, we can deduce the relationships between \( \lambda^c_{k}, \lambda^c_{b} \) and \( \lambda_p \) according to formula (12), shown as follows.

\[ \lambda^c_{k} \geq \lambda^c_{b} \geq \lambda^c_{p} \] (18)

Then,

\[ (\sigma^c_{k,a})^2 \leq (\sigma^c_{p})^2 \leq (\sigma^c_{b,a})^2 \] (19)

All in all, when platform’s information-processing ability is equal to the community’s ability, the community’s forecasting ability with a platform will be bigger than the ability of the platform alone or the community’s ability without a platform. The variance of prediction error with a platform will then be smaller than the platform’s own variance, which will itself be smaller than that for a community without a platform.

## 3 Conclusions

Demand prediction plays an essential role in the decision making of stakeholders in a tourism supply chain. This paper compares stakeholders’ demand forecasting in three different situations: stakeholders without a platform, stakeholders with a platform and forecasting by the platform itself. Results show that the variance of stakeholders’ prediction error with a platform will be smaller than the variance without a platform in all three situations. The implantation of a platform therefore improves stakeholders’ forecasting ability. According to our study, if we want to make full use of the functions of an information platform, its information-processing ability must
be strong enough, which means that the structure of the platform should be well designed to increase the management ability of information resources, use advanced information technology, and the system should be used to improve the informatization-competence of business processes. Additionally more professionals should be employed to establish a positive and efficient organization cultural. Most scholars focus on the structural design of information platforms and their functions for information sharing. There is currently little research about the inner mechanisms of platforms’ influence on stakeholders’ demand predictions. This paper selected the tourism industry and its stakeholders as the research objectives and established a mathematic model to analyze the inner logic. We took not only information-acquiring ability, but also information-processing ability, into the consideration of forecasting ability, which is more comprehensively and realistic. However, there are some drawbacks in this paper. For example, we have not yet made a case analysis, which will be done in a future study. Research on the inner mechanism of a platform’s influence on stakeholders in a tourism supply chain has important theoretical and realistic value. This is an area worthy of further study.

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