



ARTICLE



<https://doi.org/10.1057/s41599-023-02582-1>

OPEN

Evaluating information asymmetry effects on hotel pricing: a comparative analysis before and during the COVID-19 pandemic in the Taiwan's market

Meng-Ying Wang^{1✉} & Li-Chen Chou^{2✉}

The outbreak of the COVID-19 pandemic has imposed substantial impacts on the global hotel industry. This study employed a two-tier stochastic frontier model to investigate the dynamics of transaction information distribution within the tourist hotel lodging prices in Taiwan from July 2019 to November 2020. The primary objective was to analyze the disparities in price information between consumers and hoteliers before and after the outbreak of COVID-19. Empirical findings reveal a notable reduction in the divergence of lodging price information between consumers and hoteliers post the COVID-19 outbreak, particularly in metropolitan areas. The shift in consumer group structures within hotel operations induced by the pandemic has, in turn, exerted an influence on the pricing strategies adopted by hoteliers. The empirical results underscore that the outbreak of COVID-19 has contributed to a more transparent and comprehensive market price information environment, consequently diminishing the asymmetry in information between hoteliers and consumers.

¹School of Economics, Zhejiang Gongshang University, Hangzhou 310018, China. ²School of Economics, Shantou University, Shantou 515063, China.
✉email: 22010020006@pop.zjgsu.edu.cn; lczhou@stu.edu.cn

Introduction

One of the main differences between pricing strategies in traditional offline and online retail channels is the implementation of price discrimination (Brynjolfsson and Smith 2000). As one of the mainstream strategies of marketing administration, price discrimination provides different prices for different consumer groups with specific attributes, characteristics or price information (Narasimhan 1984; Barron et al. 2004; Syverson 2007), and leading to price dispersion. The emergence of countless online channels in a number of service industries has proven the success of price discrimination strategy, such as cruise lines (Petrick 2005 years; Langenfeld and Li 2008), airlines (Giaume and Guillou 2004; Brunger 2010), and hotels (Law et al. 2007; Pan 2007). The price discrimination strategy of a company has a direct influence on its competitiveness in the market, thereby affecting sales, revenue, and market share (Kimes and Wirtz 2003). The characteristics of the hotel industry, such as non-storability, inelastic supply, and quasi-fixed investment, make managers use price discrimination to maximize profits in deal with multiple online and traditional offline markets (Shriver and Bollinger 2022), which results in price dispersions within and across distribution channels (Kim et al. 2014). In reality, the setting of hotel lodging price reflects the degree of competition in the market; if different transaction prices occur in the consumption behavior of the same type of guest room, it shows that buyers and sellers have asymmetry in the perception of commodity information. In other words, when market information is insufficient, room providers or hoteliers may offer unfair prices due to market information barriers; consumers may also spend higher expenditures on housing services due to insufficient information, and both supply and demand face information tax due to information asymmetry (Osborne 1990).

Since the outbreak in late 2019, COVID-19 has become a global pandemic and caused a qualitative change in society and the economy (Avdiu and Nayyar 2020; Wiersinga et al. 2020, Aigbedo 2021). In order to slow down the spread of inflection, many countries have made wearing masks mandatory and keep the social distance for their citizens not only in the closed public spaces but also in the open areas (Tobol et al. 2020). In addition, countries also require foreign travelers to undergo isolation inspections when entering the country. However, while preventing the spread of COVID-19, the government is also facing how to carry out economic activities to maintain social operations. While preventing the pandemic from abroad and the spread of the domestic epidemic, the government is not as strict on the migration of domestic residents as the entry of foreign travelers. COVID-19 has suppressed the economic activities of various countries, causing most countries in the world to face an economic recession. As a labor-intensive service industry, traditional tourism provides a large number of jobs and creates a lot of wealth for local people and the country. With the COVID-19 epidemic, tourism has been hit hard and the economy and employment have suffered huge losses. According to UNWTO (2022), a billion fewer international tourists, a loss of \$1.3 trillion in total revenue from international tourism exports, and between 100 million and 120 million direct tourism jobs are at risk.

The primary objective of this article is to employ the two-tier stochastic frontier model (SFA2tier) to examine the distribution of transaction information in the lodging prices of tourist hotels in Taiwan. Additionally, we aim to analyze the disparities in price information between consumers and hotel operators before and after the outbreak of COVID-19. We selected Taiwan as our research focus due to its prompt and strict measures taken in response to the emergence of COVID-19 cases in Wuhan, China in January 2020. Taiwan implemented immediate border closures and imposed rigorous isolation and medical checks for incoming

individuals. This stringent entry screening effectively prevented the entry of COVID-19 cases, and any confirmed cases in the country received proper care and treatment. Consequently, Taiwan did not undergo the urban closures or migration restrictions witnessed in European and American countries throughout 2020. The domestic tourism industry is still operating normally. As of the end of January 2021, the cumulative number of confirmed COVID-19 cases across Taiwan has reached only 907 cases.¹ After the epidemic gradually becomes serious after March 2021, and before strict control is implemented in May, Taiwan is suitable to be a research object and analyze the impact of the COVID-19 pandemic under the normal operation of the tourism industry during the period 2019–2020.

In the digital era, buying and selling in tourism are easily accomplished in a completely electronic environment. The application of digital technology makes it easier to verify the identity of transacting parties and gain knowledge of reputations. They make it easier to communicate and accomplish the retracting of exchanges (Colin et al. 2015). Because of the low costs of switching a supplier over the Internet, the bargaining power of consumers will strengthen (Hojeghan and Esfangareh 2011). For suppliers, online reputation and dynamic price management are what they need to pay attention to in the era of the digital economy (Rodríguez-Díaz et al. 2018). Under the COVID-19 epidemic, digitalization has had a positive impact on tourism. The digitalization of tourism products can make tourists more memorable and lay a foundation for the recovery of tourism after the normalization of the epidemic recovery and relaxation of regulations (Gordon et al. 2021). The pandemic has also created a digital demand for tourism. For instance, the hotels develop unique digital solutions that address the safety concerns of hotel guests. With the use of innovative technologies, guests can achieve “untact” check-in and check-out process, touch-less unlocking of the door, in-room voice controls, and ensure no-touch for a light switch or TV remote (Awan et al. 2021). However, according to the Tourism 2025-Taiwan Sustainable Tourism Development Plan of the Executive Yuan of the Taiwan government, the digitalization of the tourism industry in Taiwan is still in the stage of fragmentation. At present, Taiwan is still facing problems with the lack of supporting measures in the service systems around some tourist bases; the existing tourist information system is not friendly and needs to be improved in internationalization, etc.² Therefore, the government hopes that by improving the integrated application of Information and Communication Technology (ICT) during 2021–2025, Taiwan will transform from a traditional tourism industry to a digital integration type.

The utilization of the two-tier stochastic frontier model has garnered growing attention in recent research endeavors (Parmeter 2018). It can be employed to analysis the incomplete information existing on various domains, such as the effects of financing constraints on estate transactions (Pu et al. 2022), the impacts of environmental regulation on energy efficiency (Song and Han 2022), the bargaining and its effect of match uncertainty on labor market (Kumbhakar and Parmeter 2009), Job satisfaction (Poggi 2010), tourist shopping (Zhang et al. 2018), and timber bidding (Feron and Tsionas 2012). The advantages of the two-tier stochastic frontier model lie not only in its capacity to dissect opposing facets but also in its ability to capture the individual heterogeneity intrinsic to both sides. In the context of this study, we leverage these methodological advantages to disentangle the changes in information asymmetry's impact on lodging prices before and during the epidemic.

To our knowledge, scholars have paid limited attention to the shifts in information asymmetry amid the impact of the

pandemic, resulting in a dearth of quantitative assessments in this regard. To address this gap, we initiated our exploration from the vantage point of the hotel market in Taiwan, aiming to scrutinize the changes in information asymmetry within hotel transactions both before and during the COVID-19 pandemic and examine the impact of changes in information asymmetry on hotel prices, along with delving into the underlying reasons for this shift.

This article's potential contributions are multifaceted. Firstly, it employs microscopic data to empirically gauge the degree of information asymmetry in the formation of hotel transaction prices in Taiwan. Secondly, the article introduces the bilateral stochastic frontier analysis method, offering a fresh approach for quantitatively estimating information challenges among market participants. This research concept promises to usher in a new perspective for subsequent studies. Furthermore, through a comparative analysis of changes in bargaining power and residual distribution pre and post-epidemic, we aim to more authentically portray the epidemic's impact on Taiwan's tourism economy. Finally, for an economy whose tourism industry is in the stage of digital transformation, analyzing the changes of Taiwan's accommodation industry before and after the epidemic and giving reasonable adjustment measures have certain reference significance for the development of other regions that rely on tourism to support the economy.

The remaining sections of this paper are organized as follows. Section 2 provides a comprehensive review of the relevant literature. Section 3 outlines the research methodology. Section 4 primarily focuses on empirical data presentation and offers an analysis of the empirical results. The concluding section summarizes the key findings.

Literature review

Economic modeling of hotel pricing. Over the last two decades, tourism has been rapidly growing and become an important economic sector in the world and become the fourth largest export industry (Balli et al. 2015; Tugcu 2014). Service and quality of tourist attractions are significant factors affecting the willingness of the visitors' payment (Schwartz and Lin 2006; Kuminoff et al. 2010; Steckenreuter and Wolf 2013). Service and price provided by the hotel is an important part of it (Kandampully 2000). Hotel pricing is also vital because it plays a dominant role in determining hotel revenue (Blengini and Heo 2020) and is an important determinant of overall guest satisfaction (Mattila and O'Neill 2003). Previous researchers have put forward their own views on hotel pricing. Some studies do their research on the basis of hedonism pricing (Rosen 1974; Wang et al. 2019; Castro et al. 2016; Chen and Rothschild 2010; Conroy et al. 2020; Arora and Mathur 2020) which presumes a linear relationship between room rates and the various attributes of the hotel service product (Chen and Rothschild 2010; Rosen 1974). Arora and Mathur (2020) have demonstrated that there is a positive correlation between rental premiums and star ratings in emerging markets, and this relationship is particularly stable in developed markets. Based on a database of 9992 cases, Soler et al. (2019) constructed a hedonic pricing model and found that the category and reputation of a hotel are critical factors affecting customers' greater propensity to pay.

Some scholars try to find out hotel reasonable pricing through revenue management pricing (RMP) (Schwartz and Lin 2006; Schwartz et al. 2012; Vives et al. 2019; Méatchi and Camus 2020; Lee et al. 2021), which pay attention to optimizing the balance of reactions from consumers with a fixed supply. For instance, based on RMP, fairness and transparency possess strong positive individual and interaction effects on decreasing the unfairness and enhancing the willingness of customers to pay (WTP)

(Méatchi and Camus 2020). Similarity, based on non-pricing tools which is one of the key operational strategies, respondents reflect it was fairer to post a higher room rate on the hotel website than no room availability of the hotel (Lee et al. 2020). There are also some scholars based on the game theory to study hotel pricing (Ling et al. 2014; Guo, Ling et al. 2016; Mousavi et al. 2021). By building a Stackelberg model of government as the leader and hotels as the follower, Mousavi et al. (2021) propose that adopting appropriate interference by the government will have a positive effect on hotel pricing, can promote the use of renewable resources in hotel managers, and lower potential damage to the environment. Guo et al. (2016) apply the Stackelberg game of backward induction to find the optimal pricing strategy between the hotel and online travel agencies.

In addition, to study hotel pricing from different angles, tourism seasonality, location, length of stay (LOS), market share, and ranking stars are very much related to hotel room prices and have been discussed in the relevant literature. Obviously, tourism seasonality and location bring a significant effect on hotel rates and have been verified by many studies (Schwartz et al. 2012; Wang et al. 2019; Raya 2011). For example, Wang et al. (2019) found that compared with the off-season, hotel prices increase by 23.1% in the peak season and by 159.9% during the Chinese New Year in Sanya in Hainan province. Raya (2011) found that changes in location, hotel category, and market share on the Catalan coast can have the largest marginal effect on hotel prices. Conroy et al. (2020) also find out the evidence of the effect of location on hotel prices that in Las Vegas, compared to the hotels beyond 2.25 miles, a center-of-strip premium of 70.23% for hotels located within 0.72 miles, 36.98% for the next 0.75 miles and 18.89% for the next 0.75 miles. Some studies have expanded the scope of the attributes that will have an impact on hotel rates. Riasi et al. (2017) firstly show that on average, the prices of the hotel charge higher per night when guests stay longer and suggest that hotel revenue managers devise pricing strategies to cope with the customers' misinformed expectations of getting lower prices for longer LOS. Star rating is also the attribute that has great impacts on room rates (Castro et al. 2016), guests tend to overestimate room rates in three- and four-star hotels and underestimate price in five-star hotels (Razavi and Israeli 2019).

Information asymmetry in the hotel pricing market. In contrast to the above literature, some studies focus on hoteliers' bargaining and consumers' bargaining in hospitality industry (Nicolau and Sellers 2010; Kim et al. 2014; Zhang et al. 2018; Kim et al. 2020; Ying et al. 2021). Most tourists use bargaining to seek potential value for money (Kozak 2016). As one of the features of market behavior, asymmetric information can distort expected prices. Services are more susceptible to asymmetric information than products. Within services, the asymmetric information phenomenon in the tourism industry is extremely serious (Nicolau and Sellers 2010). Zhang et al. (2018) found that tourists exhibit stronger bargaining power than sellers during the shopping process based on the data of Nanjing, China. When booking hotels, asymmetric information will stimulate price dispersion, which will lead to a decrease in hotel performance (Kim et al. 2014), travelers tend to choose a hotel option with wide price dominance dispersion, (Kim et al. 2020). Customers are skeptical of the hospitality industry that lacks transparency in health and safety information (Ying et al. 2021).

In the electronic era, the information asymmetry of hotel pricing has also emerged new factors. Sanchez-Lozano et al. (2021) found that star rating plays an important role in the hotel pricing. Consumer reviews and reply rate generate positive effects in affecting future bookings, credit information strengthens the

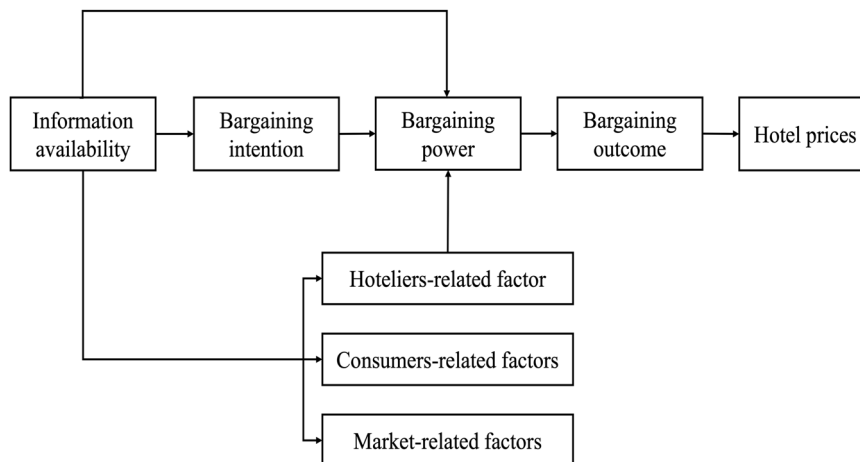


Fig. 1 Conceptual framework depicting bargaining dynamics in the hotel pricing market. This conceptual framework diagram systematically delineates the bargaining process inherent in the hotel pricing market.

effects of reply rate (Luo et al. 2021). Nicolau and Sellers (2010) found quality certification can be a useful tool for reducing information asymmetry. Manes and Tchetchik (2018) found that electronic word-of-mouth plays a greater role in reducing uncertainty when the degree of information asymmetry is large.

Conceptual framework of bargaining behavior in hotel pricing market. Asymmetry information can distort expect prices when booking a room (Sánchez-Pérez et al. 2019). Based on previous research, this paper develops a conceptual framework for describing bargaining behavior in the hotel pricing market (see Fig. 1). The conceptual framework contributes to understand bargaining behavior and pricing strategies in hotel pricing.

Before having bargaining intention, the consumers try their best to obtain information and decides to bargain. Once this begins, bargaining power plays an important role. Since hotels and customers have different bargaining power, they will use as much information as possible until the deal is made or cancelled (Perry 1986). Bargaining power determines the bargaining outcome. In our research, the factors affecting bargaining power are divided into three categories: hoteliers-related factors, consumers-related factors, and market-related factors.

Within the category of hoteliers-related factors include the price, attitude, service quality, location, eWOM, online comments, rankings and other characteristics of hotels (Cantallops and Salvi 2014; Manes and Tchetchik 2018; Sánchez-Pérez et al. 2019; Razavi and Israeli 2019; Wang et al. 2019; Hu and Yang 2020; Sanchez-Lozano et al. 2021). For instance, Price dispersion measures are negatively correlated with the average hotel price (Eden 2018), the hotel managers should provide customers with the full information on how the operate of price change, which will improve fairness perceptions and satisfaction among consumers (Choi and Mattila 2006; Cantallops and Salvi 2014).

In addition, the research of social media and online services has accumulated much evidence that online comments and rankings have had a dramatic impact on tourists and hoteliers' behavior (Cantallops and Salvi 2014). Online ratings have unbalanced effects on both location and time dimensions in hotel pricing, the online user rating plays a more significant factor for mid and low-priced hotels via mitigating the negative seasonal effects (Wang et al. 2019). Also, building an array of advanced machine learning regression models, Razavi and Israeli (2019) demonstrate that customer rating has more impact on hotel rates when the average rating was above 7.5 (out of 10), the adverse effects of price discounts are even more pronounced for hotels with lower online

ratings (rating ≤ 3) than those with higher ratings (Hu and Yang 2020). Besides, online reputation or more widespread as electronic word of mouth (eWOM) (Cantallops and Salvi 2014; Sánchez-Pérez et al. 2019) and review volume (Hu and Yang 2020) are positively related to the hotel rates, the effect of the online reputation is constant and contributes to hotel rates that are approximately 8% higher within the same star rating (Sánchez-Pérez et al. 2019).

Consumers-related factors in the second category include cultures, sociodemographic, personality traits and behavioral (Zhang et al. 2018). In terms of market-related factors, hotel concentration, market environment, market culture, search engines and government's policy are import factors (Choi and Mattila 2006; Zhang et al. 2018). For instance, Choi and Mattila (2006) demonstrate that the strategy that different type of information that vary by culture should be offered to the customers need to be taken, the U.S. customers should be provided full information about how variable-pricing practices operate, for Korean consumers, limited information is enough. Economides and Kontarlatou (2011) also find that prices are different among the search engines. In addition, consumers are more inclined to bargain when vacationing abroad than vacation home (Kozak 2016). If the government encourages exit or restricts entry, the bargaining process will be affected.

Methodology

Discussions on information asymmetry in economic analysis can generally be divided into applying game theory to construct theory or conducting empirical studies through econometric models. The application of empirical models can be derived from the commodity search theory. In the field of labor economics, it is assumed that workers are commodities in the market, and employers and employees strive for their own wages through their respective information masters (Mincer 1962, 1974; Zhao et al. 2019; Yang et al. 2019). However, although we can determine the influence of explanatory variables on salaries by using this empirical model, we cannot further analyze other issues that laborers face in the market such as the wage information that laborers face in the market (Shao et al. 2023). After Aigner et al. (1977) and Meeusen and van Den Broeck (1977) constructed the stochastic frontier model in the 1970s, Polachek and Yoon (1996) combined the Mincer equation with the econometric setting of the stochastic frontier model and provided the salary bargaining information obtained by laborers and employers in the market can be estimated by analyzing the variables of laborers' personal

characteristics. Kumbhakar and Parmeter (2009) revised the econometric model, and it became one of the most common empirical models applied to the industrial economy field.

The purpose of this study is to analyze the information regarding lodging prices during the year 2019–2020. Based on previous studies (Kumbhakar and Parmeter 2009; Pu et al. 2022), assumed there are many hotel guest room suppliers (hoteliers) and consumers in the market, both have the tendency to grasp market price information. Assumed the final price of the lodging price (P) set as follows:

$$P = \underline{P} + \eta(\bar{P} - \underline{P}) \tag{1}$$

Among them, \underline{P} is the lowest price that the suppliers can accept and \bar{P} is the highest price that can be paid by the consumer. η is an estimator of market information in the price determination process, ranging from 0 to 1. Hence, $\eta(\bar{P} - \underline{P})$ represents the surplus of profit earned by the hoteliers in the process of determining lodging prices.

To simultaneously show how much information that consumers and hoteliers hold in the lodging prices decision-making process, we expand the Eq. (1) into details. Firstly, given individual characteristics x , a fair lodging price³ can be written as $\mu(x) = E(\theta|x)$. θ is actual existence, and $\underline{P} \leq \mu(x) \leq \bar{P}$. Among which, $\bar{P} - \mu(x)$ denotes the consumer surplus in the transaction; $\mu(x) - \underline{P}$ denotes the hotel's surplus. Whether a higher surplus can be obtained depends on the bargaining power and information of buyers or sellers (Osborne, 1990). Hence, Eq. (1) can be showed as:

$$\begin{aligned} P &= \mu(x) + [\underline{P} - \mu(x)] + \eta[\bar{P} - \mu(x)] - \eta[\underline{P} - \mu(x)] \\ &= \mu(x) + \eta[\bar{P} - \mu(x)] - (1 - \eta)[\mu(x) - \underline{P}] \end{aligned} \tag{2}$$

It can be seen from Eq. (2) that the hoteliers can increase the deal price in the transaction via depriving parts of consumers' expected surplus, and the amount of the deprived surplus is $\eta[\bar{P} - \mu(x)]$. Also, the consumers can decrease the deal price of the hotel via depriving parts of suppliers' expected surplus, and the amount of the deprived surplus is $(1 - \eta)[\mu(x) - \underline{P}]$. The amount of information they have (η) and the total expected surpluses of the consumer decide the degree of deprivable surplus of hoteliers, denoted by $\bar{P} - \mu(x)$. In other words, the hoteliers can increase the deal price based on the information they have. Likewise, the information they have $(1 - \eta)$ and the hotelier's total expected surplus decide the degree of surplus available to consumers, represented by $\mu(x) - \underline{P}$. Consumers can use the information they have to lower deal price. Therefore, the two-tier stochastic frontier model for predicting the lodging price can be set as:

$$P_i = \mu(x) + \varepsilon_i, \varepsilon_i = w_i - u_i + v_i \tag{3}$$

Among which, $\mu(x) = x_i'\beta$, where β refers to the parameter vector to be estimated, and x_i presents the individual characteristics of the samples; $w_i = \eta_i[\bar{P}_i - \mu(x_i)] \geq 0$; $u_i = (1 - \eta_i)[\mu(x_i) - \underline{P}_i] \geq 0$;

v_i is a random error term in the general sense. w_i refers to the amount of surplus deprived by hoteliers with the information they possess and u_i is the amount of surplus that the consumers deprive through collecting effective information. Net surplus ($NS = \eta[\bar{P} - \mu(x)] - (1 - \eta)[\mu(x) - \underline{P}]$) can be used to reflect the overall impact of information asymmetry in the transaction process on lodging price. To simultaneously estimate the parameter β and the residual of deprivation by consumers and hoteliers using the information they possess, Maximum Likelihood Estimation (MLE) was used to estimate Eq. (3). Suppose w_i and u_i obey exponential distribution, $w_i \sim i.i.d.Exp(\sigma_w, \sigma_w^2)$, $u_i \sim i.i.d.Exp(\sigma_u, \sigma_u^2)$. v_i follows normal distribution, $v_i \sim i.i.d.N(0, \sigma_v^2)$. w_i , u_i and v_i are independent of each other. Therefore, the probability density

function for computing the compound error term can be expressed as:

$$\begin{aligned} f(\varepsilon_i) &= [\sigma_w + \sigma_u]^{-1} \left[\exp(a_i)\Phi(c_i) + \exp(b_i) \int_{-h}^{\infty} \phi(z)d(z) \right] \\ &= [\sigma_w + \sigma_u]^{-1} \left[\exp(a_i)\Phi(c_i) + \exp(b_i)\phi(h_i) \right] \end{aligned} \tag{4}$$

Where $\Phi(\cdot)$ and $\phi(\cdot)$ refers to the probability density function and cumulative distribution function of the standard normal distribution respectively. The settings of other parameters are as follows:

$$\begin{aligned} a_i &= \sigma_u^{-1} [\varepsilon_i + \sigma_v^2(2\sigma_u)^{-1}]; b_i = \sigma_w^{-1} (-\varepsilon_i + \sigma_v^2(2\sigma_w)^{-1}); \\ h_i &= \varepsilon_i\sigma_v^{-1} - \sigma_v\sigma_w^{-1}; c_i = -\varepsilon_i\sigma_v^{-1} - \sigma_v\sigma_u^{-1} \end{aligned}$$

For a sample including n observations, the log-likelihood function can be developed as follows:

$$\ln L(X; \theta) = -n \ln(\sigma_w + \sigma_u) + \sum_{i=1}^n \ln [e^{a_i}\Phi(c_i) + e^{b_i}\Phi(h_i)] \tag{5}$$

where $\theta = [\beta, \sigma_v, \sigma_w, \sigma_u]'$. Maximum likelihood estimates of all parameters can be obtained by seeking to maximize the log-likelihood function. The conditional distribution of u_i and w_i are $f(u_i|\varepsilon_i)$, $f(w_i|\varepsilon_i)$;

$$\begin{aligned} f(u_i|\varepsilon_i) &= \lambda \exp(-\lambda u_i)\Phi(u_i/\sigma_v + h_i)[\Phi(h_i) \\ &\quad + \exp(a_i - b_i)\Phi(c_i)]^{-1} \end{aligned} \tag{6a}$$

$$\begin{aligned} f(w_i|\varepsilon_i) &= \lambda \exp(-\lambda w_i)\Phi(w_i/\sigma_v + c_i) \exp(b_i - a_i)\{\Phi(h_i) \\ &\quad + \exp(a_i - b_i)\Phi(c_i)\}^{-1} \end{aligned} \tag{6b}$$

Where $\lambda = 1/\sigma_u + 1/\sigma_w$. According to the conditional distribution determined by Equation (6), the conditional expectations of u_i and w_i in the decision-making process of lodging price can be developed as:

$$\begin{aligned} E(u_i|\varepsilon_i) &= \lambda^{-1} + \exp(a_i - b_i)\sigma_v[\phi(-c_i) + c_i\Phi(c_i)] \\ &\quad [\Phi(h_i) + \exp(a_i - b_i)\Phi(c_i)]^{-1} \end{aligned} \tag{7a}$$

$$\begin{aligned} E(w_i|\varepsilon_i) &= \lambda^{-1} + \sigma_v[\phi(-h_i) + h_i\Phi(h_i)][(h_i) \\ &\quad + \exp(a_i - b_i)(c_i)]^{-1} \end{aligned} \tag{7b}$$

Additionally, the net surplus (NS) can be calculated as:

$$NS = E(1 - e^{-w_i}|\varepsilon_i) - E(1 - e^{-u_i}|\varepsilon_i) = E(e^{-u_i} - e^{-w_i}|\varepsilon_i) \tag{8}$$

As the parameter σ_u only appears in a_i and c_i , and σ_w only appears in b_i and h_i , they are both recognized. Hence, in subsequent model testing, there is no need to pre-assume the relative mastery advantages of hoteliers and consumers in having lodging price information. On the contrary, the mastery of market information depends entirely on the results of model estimation. This also demonstrates the fundamental advantage of the two-tier stochastic frontier model and is the reason why it is superior to traditional regression analysis.

Data and empirical results

The STATA 15 statistical software package and SFA2tier were used to analyze the data. The empirical data were sourced from the monthly government report on tourism statistics available in the Tourism Statistics Database of the Taiwan Bureau (<https://stat.taiwan.net.tw/>). The study focused on hotels from July 2019 to November 2020. After eliminating incomplete data within the specified sample period, we obtained a total of 2032 sample observations. Descriptive statistics are presented in Table 1. The

Table 1 Descriptive Statistics.

Variable	Definition	Mean	S.D.
Lodging price	Average lodging price of hotel rooms in the month. (Unit: N. T. Dollars)	3527.393	2520.046
Room	The number of hotel rooms in the month.	623.618	1899.596
Labor_M	The number of employees in the managerial department in the month.	34	36.830
Labor_R	The number of employees in the hotel room department in the month.	59	44.620
The average lodging price in each area. (Unit: N. T. Dollars)			
Area	Non-COVID-19	COVID-19	Growth Rate (%)
Taipei	3817.302	3288.197	-13.86
Taoyuan	2817.196	2797.962	-0.68
Taichung	2489.356	2336.587	-6.14
Tainan	3120.253	3127.372	0.23
Kaohsiung	2726.202	2518.597	-7.62
East	3202.932	3423.073	6.87
Scenic area	5685.973	5513.430	-3.03

Source: Tourism statistics monthly report in Taiwan.

Table 2 Estimation of bargaining power effects model.

OLS estimation			
log(Lodging price)	Coefficient	Std. Err	P-value
log(Room)	-0.029	0.050	0.568
log(Labor_M)	-0.500	0.085	0.000
log(Labor_R)	0.388	0.095	0.000
log(Room)xlog(Labor_M)	0.052	0.015	0.000
log(Room)xlog(Labor_R)	-0.062	0.018	0.000
log(Labor_M)xlog(Labor_R)	0.069	0.012	0.000
Constant	7.794	0.215	0.000
Sample	2032		
R-square	0.175		
Two-tier stochastic frontier estimation			
log(Room)	0.066**	0.032	0.037
log(Labor_M)	0.099	0.080	0.215
log(Labor_R)	-0.324***	0.077	0.000
log(Room)	-0.023**	0.011	0.032
xlog(Labor_M)			
log(Room)xlog(Labor_R)	0.015	0.011	0.165
log(Labor_M)	0.075	0.010	0.000
xlog(Labor_R)			
Constant	7.251***	0.183	0.000
σ_v	-1.612	0.104	0.000
σ_u	-1.773	0.104	0.000
σ_w	-0.837	0.037	0.000
Log likelihood	-1321.836		
Sample	2032		

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

average lodging prices in each area exhibit a declining trend, except for Tainan and the East region. Specifically, the data indicates a significant decrease in prices in Taipei, followed by Kaohsiung, while prices in Tainan and Taoyuan have remained relatively stable.

We apply the Translog function according to Christensen et al. (1973) and rewrite the Eq. (3):

$$P_i = \mu(x) + \varepsilon_i, \varepsilon_i = w_i - u_i + v_i; \mu(x) = \sum \beta_i \ln x_i + 0.5 \sum \sum \beta_{ij} \ln x_i \ln x_j \tag{9}$$

Where x is the variables log (Room), log (Labor_M) and log (Labor_R), which is estimated by MLE and analyzed according to the aforementioned Eqs. (4)–(8).

Drawing on the aforementioned mechanism for price formation in the hotel transaction market and the model assessing bargaining power under information asymmetry, this study

scrutinizes the effects of the information asymmetry degree between buyers and sellers on the pricing of hotel transactions. The estimation process employs both the OLS method and MLE method. The regression results, presented in Table 2, consistently indicate that variables such as the number of hotel rooms, the quantity of employees in the managerial department, and the hotel room department exhibit a significant negative impact on room prices. It is noteworthy that, in comparison to the OLS method, the application of the two-tier stochastic frontier method unveils nuanced dynamics captured with increased granularity and depth.

Table 3 presents the outcomes regarding the mastery of lodging price information by consumers and hoteliers, denoted as $\hat{E}(1 - e^{-u}|\varepsilon)$ and $\hat{E}(1 - e^{-w}|\varepsilon)$. These values represent the surplus attained by consumers and hoteliers as a percentage relative to the baseline prices. On average, the hotelier's surplus exceeds the baseline price by 30.31%, while consumers' surplus contributes to a 14.51% reduction in lodging prices. The discrepancy in price information mastery makes the actual lodging price 15.81% higher than the baseline price. In other words, due to the information asymmetry between consumers and hoteliers and the difference in price information mastery, consumers may need to pay 115.81 N.T. dollars for a room worth 100 N.T. dollars in a fair market.

Additionally, Table 3 indicates that hoteliers' surplus before the COVID-19 outbreak surpassed the total sample average and the post-epidemic period. This suggests a stronger price information advantage for hotels before the epidemic. Conversely, consumers' information advantage is more pronounced after the epidemic. In summary, consumers' ability to acquire surplus strengthened after the COVID-19 outbreak, while hoteliers' ability weakened.

To further examine the variations in information mastery before and after COVID-19, the last three columns of Table 3 display the surplus distribution for consumers and hoteliers. At the Q1 quantile, the net surplus is 0.59, indicating that the hotel room's lodging price closely aligns with the baseline in the total sample, signifying similar price information between hoteliers and consumers. At the Q2 and Q3 quantiles, the disparity in price information widens, reaching its maximum at the Q3 points.

We conducted an analysis of surplus frequencies acquired by both hoteliers and consumers. In Fig. 1, the horizontal axis represents the proficiency in price information, while the vertical axis indicates the sample proportion. A position further to the right on the horizontal axis signifies a stronger grasp of lodging price information. Figure 2 illustrates that the surplus acquired by hotels post-epidemic is more concentrated on the left half of the horizontal axis compared to the pre-epidemic period. Conversely,

Table 3 Surpluses that consumers and hoteliers get in the transaction process.

Category	Mean (%)	S.D. (%)	Q1(%)	Q2(%)	Q3(%)
Total sample					
Hoteliers $\hat{E}(1 - e^{-w} \epsilon)$	30.31	18.76	15.75	23.48	40.52
Consumer $\hat{E}(1 - e^{-u} \epsilon)$	14.51	6.31	10.92	11.94	15.15
Difference (Net Surplus)	15.81	22.64	0.59	11.54	29.60
Non-COVID-19					
Hoteliers $\hat{E}(1 - e^{-w} \epsilon)$	31.43	18.92	16.11	24.36	43.64
Consumers $\hat{E}(1 - e^{-u} \epsilon)$	13.90	4.94	10.90	11.80	14.84
Difference (Net Surplus)	17.52	22.07	1.27	12.56	32.75
COVID-19					
Hoteliers $\hat{E}(1 - e^{-w} \epsilon)$	29.69	18.64	15.40	22.84	38.95
Consumers $\hat{E}(1 - e^{-u} \epsilon)$	14.85	6.94	10.94	12.06	15.49
Difference (Net Surplus)	14.84	22.91	-0.08	10.78	28.01

Notes: Q1, Q2, and Q3 represent statistics at the 25%, 50%, and 75% quantiles.

the consumer surplus in the figure exhibits the opposite trend. The shift of consumer surplus to the right indicates an increase in consumers' information after the epidemic, leading to a corresponding increase in obtained surplus.

Table 4 presents a comparative analysis of regional disparities. The data indicates that, prior to the pandemic, hotels across various regions in Taiwan possessed higher price information compared to the post-pandemic period, with the exception of Taoyuan and the Scenic area. The divergence between hoteliers' and consumers' surplus witnessed a reduction following the COVID-19 outbreak, indicating a decline in price discrimination. Furthermore, when comparing urban areas to other regions, post-outbreak, the net surplus in urban areas diminished while it increased in other regions. Figure 3 encapsulates the shifts in net surplus in Taiwan's metropolitan areas from 2019 to 2020. The empirical findings suggest that the COVID-19 outbreak has contributed to aligning the distribution of lodging price information in metropolitan areas closer to a fair market.

Why the COVID-19 has improved the price discrimination phenomenon in Taiwan's metropolis, we think there are two possibilities. One is the structure of hotel consumer groups has changed. Before the epidemic, consumers in Taiwan's metropolitan area hotels included various consumer groups ranging from business activities, sightseeing and tourism, and overseas tourists. Intuitively, due to differences in language, currency prices, etc., we expect that overseas tourists possess less price information about hotels. Thus, hotels have the edge to implement price discrimination. After epidemic happen in 2020, except for certain incidents, the Taiwanese government has prohibited foreigners from entering the country or required inbound passengers to carry out isolate management for more than two weeks. This has virtually raised the travel cost for tourists, causing a drop in the number of overseas tourists. As shown in Fig. 4, after the outbreak, the proportion of accommodation for overseas tourists dropped significantly, and the structure of consumer groups has changed. The proportion of local tourists is gradually increasing among the hotel consumer groups in Taiwan's metropolitan areas. Compared with overseas tourists, residents have more information about hotel and possess stronger bargaining power. Hence, the space for price discrimination in hotels has shrunk after the epidemic.

Second, although the occurrence of COVID-19 in 2020 has not stopped Taiwan's local economic activities, Taiwan's society has maintained the same lifestyle before the epidemic for most of 2020. However, the outbreak of the epidemic may still affect the willingness of tourists to travel. The outbreak of COVID-19 decreases the number of tourists, caused the hoteliers to provide more price information and more promotion event to attach

tourists to deal with high hotel operating costs. The outbreak of the epidemic may prompt hoteliers to stimulate the production of the industry, and then promote more tourism projects. In addition, after the spread of COVID-19, the government's supervision and attention for epidemic prevention and control have caused hotel operators to provide more information and more transparency. These activities make market price information more transparent and complete, thereby reducing the difference in price control or discrimination between the supply and demand sides.

Conclusion

In this study, we construct a measurement model to quantify the degree of information asymmetry prevalent in the hotel transaction market. Utilizing micro-level data from the Taiwan Statistical Bureau, we apply the two-tier stochastic frontier method to scrutinize the distribution of transaction information in Taiwan's tourism hotel lodging prices, examining the disparities in price information between consumers and hoteliers both before and during the outbreak of COVID-19. The empirical findings reveal that: (1) Information factors held by transaction participants significantly influence the final lodging price, with hoteliers possessing more information and stronger bargaining power than consumers. The overall impact of information asymmetry factors on the final hotel lodging price is positive at 0.6954, indicating a tendency for hotel information factors to result in a higher price relative to the benchmark. (2) Analyzing unilateral effects in the entire sample, hoteliers increase hotel transaction prices by an average of 30.31%, leveraging their information, while consumers, with their information, raise prices by a similar magnitude. However, information mitigates hotel transaction prices by 14.51%. These opposing effects contribute to an overall increase of 15.81% in hotel transaction prices relative to the benchmark. Quantile analysis further shows that during the formation of hotel transaction prices, almost all consumers are compelled to accept prices exceeding the benchmark, with varying degrees of increase for heterogeneous consumers. (3) After the spread of COVID-19, the prices reached by hoteliers, based on their information advantage, are generally around 14.84% higher than the fair benchmark price. Compared to the price before the epidemic, approximately 17.52% higher than the fair benchmark, the information advantage possessed by hoteliers has declined. This suggests that during the outbreak, consumers have improved their grasp of lodging price information, weakening information asymmetry in hotel accommodation transactions in Taiwan. (4) Further analysis of the effect of consumer heterogeneity in regional factors on the final price reveals that almost all consumers face varying degrees of being forced to accept a hotel and

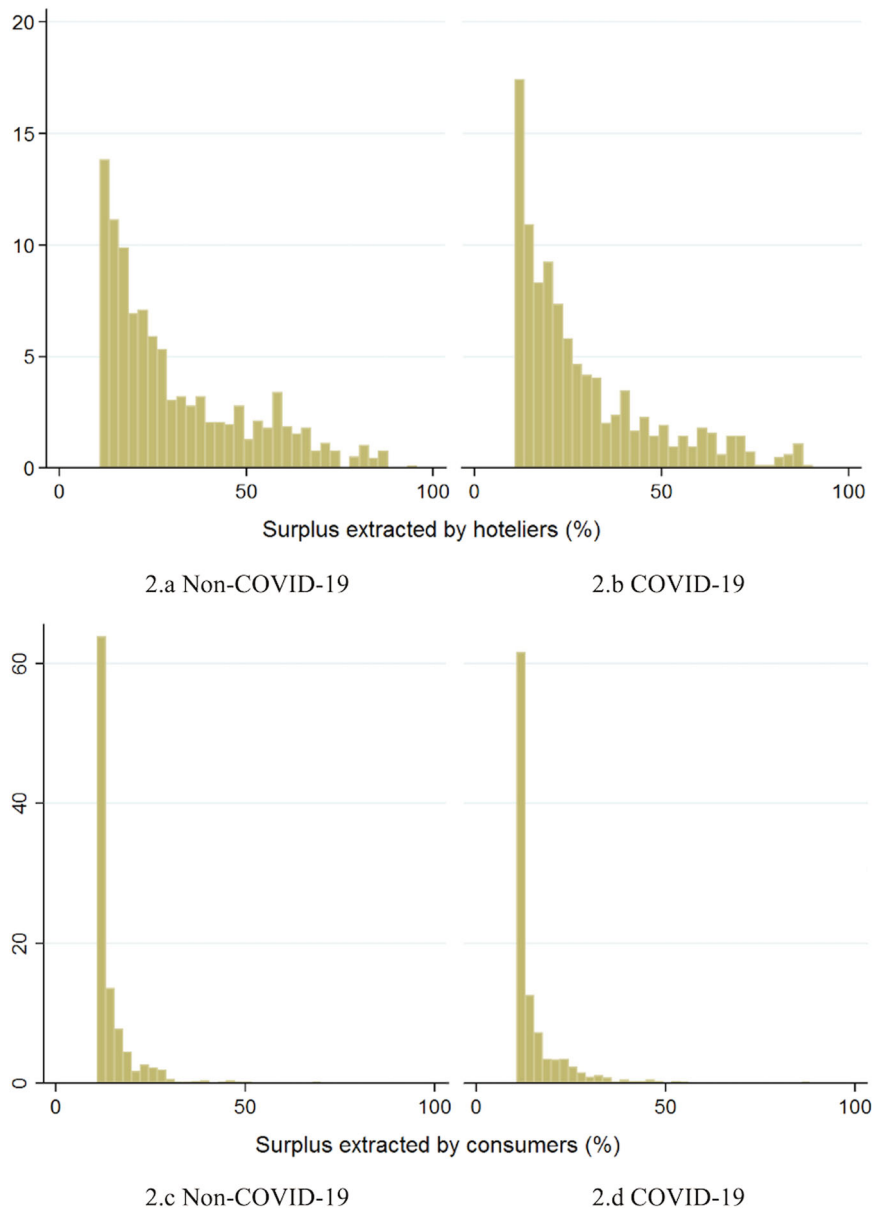


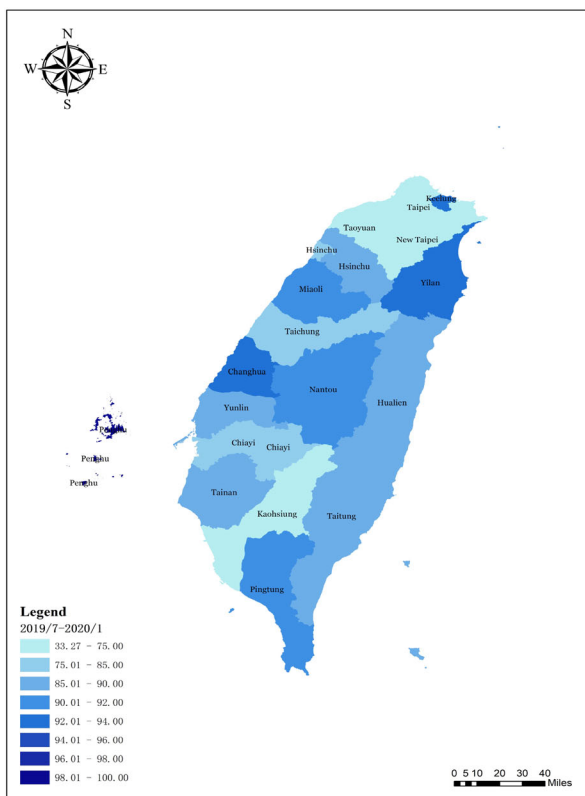
Fig. 2 Surplus extracted by hoteliers or consumers (%) before and after the COVID-19. **a** Surplus extracted by hoteliers before the epidemic. **b** Surplus extracted by hoteliers after the epidemic. **c** Surplus extracted by consumers before the epidemic. **d** Surplus extracted by consumers after the epidemic. The figure shows a post-epidemic concentration of hotel surplus on the left axis, contrasting the pre-epidemic period. Conversely, consumer surplus shifts right, indicating increased post-epidemic consumer information and corresponding surplus gain.

Table 4 The differences of surplus between regions before and after the epidemic.

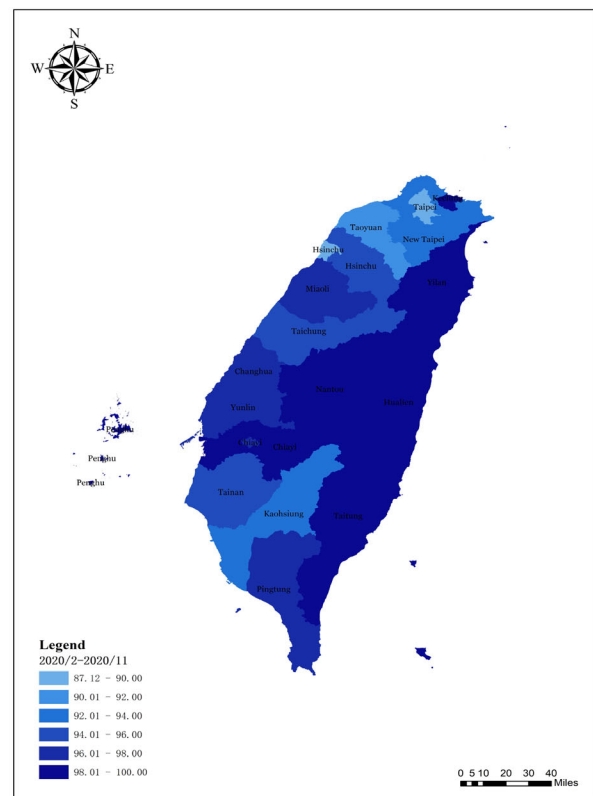
Period	Non-COVID-19			COVID-19		
	Hoteliers	Consumers	Difference	Hoteliers	Consumers	Difference
Taipei	30.80	14.12	16.68	27.03	16.94	10.09
Taoyuan	24.95	13.00	11.95	24.97	13.74	11.22
Taichung	19.19	14.92	4.27	18.58	15.41	3.16
Tainan	29.64	13.51	16.13	29.41	13.80	15.61
Kaohsiung	21.76	17.43	4.32	19.22	17.36	1.86
East	26.02	17.52	8.49	28.27	15.89	12.38
Scenic area	51.78	12.32	39.46	53.03	11.39	41.65



Fig. 3 Net surplus variation in Taiwan's metropolitan areas (2019-2020). This figure illustrates the changes in net surplus in Taiwan's metropolitan areas during the period of 2019-2020. It is evident that the net surplus in metropolitan areas of Taiwan was significantly higher in 2019 compared to 2020.



a Non-COVID-19



b COVID-19

Fig. 4 Proportion of domestic tourist accommodation in hotels in Taiwan's counties and cities from 2019 to 2020. **a** Proportion of domestic tourist accommodation in hotels in Taiwan's counties and cities in 2019 (pre-epidemic). **b** Proportion of domestic tourist accommodation in hotels in Taiwan's counties and cities in 2020 (post-epidemic). This figure shows a notable rise in the proportion of accommodation for local tourists post-outbreak, accompanied by a shift in the consumer group structure. Darker colors signify a higher percentage of local tourists.

housing price higher than the benchmark, allowing hoteliers to effectively implement discriminatory pricing strategies.

To summarize, information asymmetry in the Taiwan's hotel market leads to final transaction prices higher than the benchmark. The bargaining power of both parties is significantly different, with buyers at a disadvantage. The outbreak of COVID-19 may pilot an approach called true value information to disclose

transaction information in the hotel industry, guiding consumers to make rational and organized hotel choices. The study results provide practical insights for stakeholders in the tourism and hospitality market. It is suggested that hoteliers enhance transaction transparency to increase consumers surplus, subsequently improving hotel reputation and gaining a competitive advantage. As a market mechanism, hoteliers would wisely build a good

reputation by disclosing information to tourists, especially those with limited bargaining power, such as business travelers and unaccompanied tourists. Transparency can effectively reduce information asymmetry between tourist groups with different characteristics (including motivations).

Simultaneously, this study holds practical significance for market supervision of local tourism administrative units. At the destination level, for regions relying on tourism as a pillar industry, establishing a good reputation is crucial for long-term development (Chen et al. 2013). Therefore, local tourism management departments should strengthen market supervision mechanisms, actively guide hotel operators by providing quality products, enhancing transaction transparency, address barriers in the transaction chain, and encourage hotel transactions in an open and efficient environment. Secondly, government departments can establish appropriate reward and transaction subsidy mechanisms. Hoteliers who actively improve information transparency in transactions to help enhance the reputation and transaction enthusiasm of their location can be rewarded, such as tax incentives. Parties with weaker bargaining power in transactions can receive subsidies to promote fair benefits for both sides in the transaction. For example, tourists actively traveling to Taiwan can receive subsidies based on their consumption record. Thirdly, government departments can expand information dissemination and acquisition channels, providing consumers with real and effective transaction information through government disclosure to compensate for destination reputation losses due to information asymmetry. Finally, by estimating surpluses in different periods, local tourism departments can propose more specific strategies for the much-discussed issues such as zero-fare and group tours or the “lemon market” in the tourism industry (Chen et al. 2013).

While this study contributes to the development of the hotel industry in regions or countries with tourism as a pillar industry, several limitations offer potentially interesting avenues for further research. Since the two-tier frontier method is applied for data analysis, model estimation adopts maximum likelihood estimation method. However, issues such as initial value conditions and sample size may cause the model to fail to converge. In addition, the data may be difficult as panel data for analysis because of factors such as quasi-fixed inputs in the hotel operation or data aggregation in the tourist market. Therefore, it is hard to discuss fixed effects or random effects further. Future research maybe refers to Polachek and Yoon (1996), Lu et al. (2011), and use panel data for analysis to examine the mastery of intertemporal buyers and sellers on price information.

Data availability

The datasets generated and analysed during the current study are available from the corresponding author on reasonable request. These datasets were derived from the following public domain resources: <https://admin.taiwan.net.tw/BusinessInfo/Articles?a=118>; <https://stat.taiwan.net.tw/>.

Received: 23 August 2023; Accepted: 14 December 2023;

Published online: 08 January 2024

Notes

- 1 For the statistics of Taiwan’s COVID-19 confirmed cases, see <https://www.cdc.gov.tw/>.
- 2 See the Tourism 2025 - Taiwan Tourism Development Plan Towards 2025 (Years 110–114) available at <https://admin.taiwan.net.tw/zhengce/FilePage?a=210>.
- 3 The term “fair lodging price” denotes the hotel transaction price achievable by consumers and hoteliers under conditions of complete market information

transparency, ensuring the absence of information asymmetry. The terminology “fair price” has been widely utilized in cutting-edge literature (Lu et al. 2011; Yang et al. 2019; Pu et al. 2022; Shao et al. 2023). Sometimes, “fair price” is alternatively referred to as the “expected price” (Kumbhakar and Parmeter 2009; Zhang et al. 2018). The use of the term “fair” is grounded in the assumption of ideal market conditions characterized by perfect information symmetry, providing a benchmark for comparison in our model context.

References

- Aigbedo H (2021) Impact of COVID-19 on the hospitality industry: A supply chain resilience perspective. *Int J Hosp Manag* 98:103012. <https://doi.org/10.1016/j.ijhm.2021.103012>
- Aigner D, Lovell CK, Schmidt P (1977) Formulation and estimation of stochastic frontier production function models. *J Econometrics* 6(1):21–37. [https://doi.org/10.1016/0304-4076\(77\)90052-5](https://doi.org/10.1016/0304-4076(77)90052-5)
- Arora SD, Mathur S (2020) Hotel pricing at tourist destinations—A comparison across emerging and developed markets. *Tourism Manag Persp* 35:100724. <https://doi.org/10.1016/j.tmp.2020.100724>
- Avdiu B, Nayyar G (2020) When face-to-face interactions become an occupational hazard: jobs in the time of COVID-19. *Econ Lett* 197. <https://doi.org/10.1016/j.econlet.2020.109648>
- Awan MI, Shamim A, Ahn J (2021) Implementing ‘cleanliness is half of faith’ in redesigning tourists, experiences and salvaging the hotel industry in Malaysia during COVID-19 pandemic. *J Islamic Marketing* 12(3):543–557. <https://doi.org/10.1108/JIMA-08-2020-0229>
- Balli F, Curry J, Balli HO (2015) Inter-regional spillover effects in New Zealand international tourism demand. *Tourism Geogr* 17(2):262–278. <https://doi.org/10.1080/14616688.2014.1003394>
- Barron JM, Taylor BA, Umbeck JR (2004) Number of sellers, average prices, and price dispersion. *Int J Industrial Org* 22(8–9):1041–1066. <https://doi.org/10.1016/j.ijindorg.2004.05.001>
- Bhengini I, Heo CY (2020) How do hotels adapt their pricing strategies to macroeconomic factors? *Int J Hosp Manag* 88:102522. <https://doi.org/10.1016/j.ijhm.2020.102522>
- Brunger WG (2010) The impact of the Internet on airline fares: The ‘Internet Price Effect’. *J Revenue Pricing Manag* 9:66–93. <https://doi.org/10.1057/rpm.2009.35>
- Brynjolfsson E, Smith MD (2000) Frictionless commerce? A comparison of Internet and conventional retailers. *Manag Sci* 46(4):563–585. <https://doi.org/10.1287/mnsc.46.4.563.12061>
- Cantalalpo AS, Salvi F (2014) New consumer behavior: A review of research on eWOM and hotels. *Int J Hosp Manag* 36:41–51. <https://doi.org/10.1016/j.ijhm.2013.08.007>
- Castro C, Ferreira FA, Ferreira F (2016) Trends in hotel pricing: Identifying guest value hotel attributes using the cases of Lisbon and Porto. *Worldwide Hosp Tourism Themes* 8(6):691–698. <https://doi.org/10.1108/WHATT-09-2016-0047>
- Chen CF, Rothschild R (2010) An application of hedonic pricing analysis to the case of hotel rooms in Taipei. *Tourism Econ* 16(3):685–694. <https://doi.org/10.5367/000000010792278310>
- Chen Y, Mak B, Li Z (2013) Quality deterioration in package tours: The interplay of asymmetric information and reputation. *Tourism Manag* 38:43–54. <https://doi.org/10.1016/j.tourman.2013.02.010>
- Choi S, Mattila AS (2006) The role of disclosure in variable hotel pricing: A cross-cultural comparison of customers’ fairness perceptions. *Cornell Hotel Restaurant Admin Quart* 47(1):27–35. <https://doi.org/10.1177/0010880405281681>
- Christensen LR, Jorgenson DW, Lau LJ (1973) Transcendental logarithmic production frontiers. *Rev Econ Stat* 28–45. <https://www.jstor.org/stable/1927992>
- Colin N, Landier A, Mohnen P (2015) The Digital Economy. *Notes du conseil d’analyse économique* 26:1–12
- Conroy SJ, Toma N, Gibson GP (2020) The effect of the Las Vegas Strip on hotel prices: A hedonic approach. *Tourism Econ* 26(4):622–639. <https://doi.org/10.1177/1354816619858259>
- Economides AA, Kontaratos A (2011) Hotels Pricing at Travel Search Engines. *Int J Online Marketing* 1(4):64–74. <https://doi.org/10.4018/ijom.2011100105>
- Eden B (2018) Price dispersion and demand uncertainty: evidence from US scanner data. *Int Econ Rev* 59(3):1035–1075. <https://doi.org/10.1111/iere.12296>
- Feron A, Tsionas EG (2012) Measurement of excess bidding in auctions. *Econ Lett* 116(3):377–380
- Giaume S, Guillou S (2004) Price discrimination and concentration in European airline markets. *J Air Transport Manag* 10(5):305–310. <https://doi.org/10.1016/j.jairtraman.2004.04.002>
- Gordon R, Wadim S, Elena K (2021) Sustainable tourism in the digital age: Institutional and economic implications. *Terra Economicus* 19(4):141–159
- Guo X, Ling L, Gao Z (2016) Optimal pricing strategy for hotels when online travel agencies use customer cash backs: A game-theoretic approach. *J Revenue Pricing Manag* 15:66–77. <https://doi.org/10.1057/rpm.2015.44>

- Hojeghan SB, Esfangareh AN (2011) Digital economy and tourism impacts, influences and challenges. *Procedia-Soc Behav Sci* 19:308–316. <https://doi.org/10.1016/j.sbspro.2011.05.136>
- Hu XS, Yang Y (2020) Determinants of consumers' choices in hotel online searches: A comparison of consideration and booking stages. *Int J Hosp Manag* 86:102370. <https://doi.org/10.1016/j.ijhm.2019.102370>
- Kandampully J (2000) The impact of demand fluctuation on the quality of service: a tourism industry example. *Managing Service Quality: Int J* 10(1):10–19. <https://doi.org/10.1108/09604520010307012>
- Kim J, Franklin D, Phillips M, Hwang E (2020) Online travel agency price presentation: examining the influence of price dispersion on travelers' hotel preference. *J Travel Res* 59(4):704–721. <https://doi.org/10.1177/0047287519857159>
- Kim WG, Cho M, Kim D, Shin GC (2014) The effect of price dispersion on hotel performance. *Tourism Econ* 20(6):1159–1179. <https://doi.org/10.5367/te.2013.0343>
- Kimes SE, Wirtz J (2003) Has revenue management become acceptable? Findings from an international study on the perceived fairness of rate fences. *J Service Res* 6(2):125–135. <https://doi.org/10.1177/1094670503257038>
- Kozak M (2016) Bargaining behavior and the shopping experiences of British tourists on vacation. *J Travel Tourism Marketing* 33(3):313–325. <https://doi.org/10.1080/10548408.2015.1051199>
- Kumbhakar SC, Parmeter CF (2009) The effects of match uncertainty and bargaining on labor market outcomes: evidence from firm and worker specific estimates. *J Prod Anal* 31:1–14. <https://doi.org/10.1007/s11123-008-0117-3>
- Kuminoff NV, Zhang C, Rudi J (2010) Are travelers willing to pay a premium to stay at a "green" hotel? Evidence from an internal meta-analysis of hedonic price premia. *Agri Res Econ Rev* 39(3):468–484. <https://doi.org/10.1017/S1068280500007450>
- Langenfeld J, Li W (2008) Price discrimination and the cruise line industry: implications for market definition, competition, and consumer welfare. *Int J Econ Business* 15(1):1–25. <https://doi.org/10.1080/13571510701830440>
- Law R, Chan I, Goh C (2007) Where to find the lowest hotel room rates on the internet? The case of Hong Kong. *Int J Contemp Hosp Manag* 19(6):495–506. <https://doi.org/10.1108/09596110710775156>
- Lee M, Jeong M, Shea LJ (2021) Length of stay control: Is it a fair inventory management strategy in hotel market? *Tourism Econ* 27(2):307–327. <https://doi.org/10.1177/135481661990120>
- Ling L, Guo X, Yang C (2014) Opening the online marketplace: An examination of hotel pricing and travel agency on-line distribution of rooms. *Tourism Man* 45:234–243. <https://doi.org/10.1016/j.tourman.2014.05.003>
- Lu H, Lian Y, Lu S (2011) Measurement of the information asymmetric in medical service market of China. *Econ Res J* 4:94–106. https://kns.cnki.net/kcms2/article/abstract?v=vCcGnC-OR21mTuNkSBCJxhKBFHs8lBJ4vPSZX4F1Ngv_QCgRfT9u4Cct6TKevYSGB_W3aOwoxERs0OZnq3mWlXBxYwBp2nR9hCyVoAiK0K7U-1m0mFkYU-6ljjYnSY&uniplatform=NZKPT&language=CHS
- Luo P, Ma X, Zhang X, Liu J, He H (2021) How to make money with credit information? Information processing on online accommodation-sharing platforms. *Tourism Manag* 87:104384. <https://doi.org/10.1016/j.tourman.2021.104384>
- Manes E, Tchetchik A (2018) The effect of electronic word of mouth in reducing information asymmetry: An empirical investigation of online hotel booking. *J Business Res* 85:185–196. <https://doi.org/10.1016/j.jbusres.2017.12.019>
- Mattila AS, O'Neill JW (2003) Relationships between hotel room pricing, occupancy, and guest satisfaction: A longitudinal case of a midscale hotel in the United States. *J Hosp Tourism Res* 27(3):328–341. <https://doi.org/10.1177/1096348003252361>
- Méatchi S, Camus S (2020) Revenue management pricing in the hotel sector: Reducing perceived unfairness to encourage willingness to pay. *Recherche et Applications en Marketing* 35(3):102–123. <https://doi.org/10.1177/2051570720954760>
- Meeusen W, van Den Broeck J (1977) Efficiency estimation from Cobb-Douglas production functions with composed error. *Int Econ Rev* 435–444. <https://doi.org/10.2307/2525757>
- Mincer J (1962) On-the-job training: Costs, returns, and some implications. *J Political Econ* 70(5, Part 2):50–79. <https://doi.org/10.1086/258725>
- Mincer J (1974) *Schooling, Experience, and Earnings*. New York: earnings. Columbia University Press for National Bureau of Economic Research
- Mousavi ES, Hafezalkotob A, Makui A, Sayadi MK (2021) Hotel pricing decision in a competitive market under government intervention: A game theory approach. *Int J Manag Sci Eng Manag* 16(2):83–93. <https://doi.org/10.1080/17509653.2021.1873202>
- Narasimhan C (1984) A price discrimination theory of coupons. *Marketing Sci* 3(2):128–147. <https://doi.org/10.1287/mksc.3.2.128>
- Nicolau JL, Sellers R (2010) The quality of quality awards: diminishing information asymmetries in a hotel chain. *J Business Res* 63(8):832–839. <https://doi.org/10.1016/j.jbusres.2009.06.009>
- Osborne MJ (1990) *Bargaining and markets*. San Diego: Academic Press
- Parmeter CF (2018) Estimation of the two-tiered stochastic frontier model with the scaling property. *J Prod Anal* 49(1):37–47. <https://doi.org/10.1007/s11123-017-0520-8>
- Pan CM (2007) Market demand variations, room capacity, and optimal hotel room rates. *Int J Hosp Manag* 26(3):748–753. <https://doi.org/10.1016/j.ijhm.2006.04.004>
- Perry M (1986) An example of price formation in bilateral situations: A bargaining model with incomplete information. *Econometrica: J Econometric Soc* 313–321. <https://www.jstor.org/stable/1913153>
- Petrick JF (2005) Segmenting cruise passengers with price sensitivity. *Tourism Manag* 26(5):753–762. <https://doi.org/10.1016/j.tourman.2004.03.015>
- Poggi A (2010) Job satisfaction, working conditions and aspirations. *J Econ Psychol* 31(6):936–949. <https://doi.org/10.1016/j.joep.2010.08.003>
- Polachek SW, Yoon BJ (1996) Panel estimates of a two-tiered earnings frontier. *J Appl Economet* 11(2):169–178
- Pu G, Zhang Y, Chou LC (2022) Estimating financial information asymmetry in real estate transactions in China-an application of two-tier Frontier model. *Info Proc Manag* 59(2):102860. <https://doi.org/10.1016/j.ipm.2021.102860>
- Raya JM (2011) The effect of time on hotel pricing strategy. *Appl Econ Lett* 18(13):1201–1205. <https://doi.org/10.1080/13504851.2010.532091>
- Razavi R, Israeli AA (2019) Determinants of online hotel room prices: comparing supply-side and demand-side decisions. *Int J Contemp Hosp Manag* 31(5):2149–2168. <https://doi.org/10.1108/IJCHM-09-2018-0707>
- Riasi A, Schwartz Z, Liu X, Li S (2017) Revenue management and length-of-stay-based room pricing. *Cornell Hosp Quart* 58(4):393–399. <https://doi.org/10.1177/1938965517704372>
- Rodríguez-Díaz M, Rodríguez-Díaz R, Rodríguez-Voltes AC, Rodríguez-Voltes CI (2018) Analysing the relationship between price and online reputation by lodging category. *Sustainability* 10(12):4474. <https://doi.org/10.3390/su10124474>
- Rosen S (1974) Hedonic prices and implicit markets: product differentiation in pure competition. *J Political Econ* 82(1):34–55. <https://doi.org/10.1086/260169>
- Sanchez-Lozano G, Pereira LN, Chavez-Miranda E (2021) Big data hedonic pricing: Econometric insights into room rates' determinants by hotel category. *Tourism Manag* 85:104308. <https://doi.org/10.1016/j.tourman.2021.104308>
- Sánchez-Pérez M, Illescas-Manzano MD, Martínez-Puertas S (2019) Modeling hotel room pricing: A multi-country analysis. *Int J Hosp Manag* 79:89–99. <https://doi.org/10.1016/j.ijhm.2018.12.014>
- Schwartz Z, Lin LC (2006) The impact of fees on visitation of national parks. *Tourism Manag* 27(6):1386–1396. <https://doi.org/10.1016/j.tourman.2005.12.015>
- Schwartz Z, Stewart W, Backlund EA (2012) Visitation at capacity-constrained tourism destinations: Exploring revenue management at a national park. *Tourism Manag* 33(3):500–508. <https://doi.org/10.1016/j.tourman.2011.05.008>
- Shao WC, Zhang H, Chou LC, Ye XX (2023) Comparing athletes' mastery of salary information before and during the COVID-19 pandemic: Evidence from the national basketball association. *Econ Modell* 128:106517. <https://doi.org/10.1016/j.econmod.2023.106517>
- Shriver SK, Bollinger B (2022) Demand expansion and cannibalization effects from retail store entry: A structural analysis of multichannel demand. *Manag Sci* 68(12):8829–8856. <https://doi.org/10.1287/mnsc.2022.4308>
- Soler IP, Gemar G, Correia MB, Serra F (2019) Algarve hotel price determinants: A hedonic pricing model. *Tourism Manag* 70:311–321. <https://doi.org/10.1016/j.tourman.2018.08.028>
- Song W, Han X (2022) A bilateral decomposition analysis of the impacts of environmental regulation on energy efficiency in China from 2006 to 2018. *Energy Strat Rev* 43:100931. <https://doi.org/10.1016/j.esr.2022.100931>
- Steckenreuter A, Wolf ID (2013) How to use persuasive communication to encourage visitors to pay park user fees. *Tourism Manag* 37:58–70. <https://doi.org/10.1016/j.tourman.2013.01.010>
- Syverson C (2007) Prices, spatial competition and heterogeneous producers: an empirical test. *J Industr Econ* 55(2):197–222. <https://doi.org/10.1111/j.1467-6451.2007.00308.x>
- Tobol Y, Siniver E, Yaniv G (2020) Dishonesty and mandatory mask wearing in the COVID-19 pandemic. *Econ Lett* 197:109617. <https://doi.org/10.1016/j.econlet.2020.109617>
- Tugcu CT (2014) Tourism and economic growth nexus revisited: A panel causality analysis for the case of the Mediterranean Region. *Tourism Manag* 42:207–212. <https://doi.org/10.1016/j.tourman.2013.12.007>
- Vives A, Jacob M, Aguiló E (2019) Online hotel demand model and own-price elasticities: An empirical application in a mature resort destination. *Tourism Econ* 25(5):670–694. <https://doi.org/10.1177/1354816618800643>
- Wang X, Sun J, Wen H (2019) Tourism seasonality, online user rating and hotel price: A quantitative approach based on the hedonic price model. *Int J Hosp Manag* 79:140–147. <https://doi.org/10.1016/j.ijhm.2019.01.007>

- Wiersinga WJ, Rhodes A, Cheng AC, Peacock SJ, Prescott HC (2020) Pathophysiology, transmission, diagnosis, and treatment of coronavirus disease 2019 (COVID-19): a review. *Jama* 324(8):782–793. <https://doi.org/10.1001/jama.2020.12839>
- World Tourism Organization –UNWTO (2022) World Tourism Barometer. UNWTO, Madrid
- Yang PY, Chou LC, Wang ZA (2019) Estimation of the labor market information—an empirical study in Taiwan. *J Intelligent Fuzzy Sys* 37(3):3477–3487. <https://doi.org/10.3233/JIFS-179152>
- Ying T, Tan X, Wei W, Zheng Y, Ye S, Wu M (2021) I have to watch my back”: Exploring Chinese hotel guests’ generalized distrust and coping behavior. *Tourism Manag* 86:104355. <https://doi.org/10.1016/j.tourman.2021.104355>
- Zhang H, Zhang J, Yang Y, Zhou Q (2018) Bargaining power in tourist shopping. *J Travel Res* 57(7):947–961. <https://doi.org/10.1177/0047287517724917>
- Zhao XZ, Zhao YB, Chou LC, Hoinunnem Leivang B (2019) Changes in gender wage differentials in China: a regression and decomposition based on the data of CHIPS 1995–2013. *Econ Res-Ekonomska istraživanja* 32(1):3162–3182. <https://hrcak.srce.hr/229647>

Author contributions

M-YW: Conceptualization; methodology; formal analysis; resources; data curation; writing original draft. L-CC: Conceptualization; methodology; validation; reviewing and editing; supervision; project administration.

Competing interests

The authors declare no competing interests.

Ethical approval

Ethical approval was not required as the study did not involve human participants.

Informed consent

This article does not contain any studies with human participants performed by any of the authors.

Additional information

Correspondence and requests for materials should be addressed to Meng-Ying Wang or Li-Chen Chou.

Reprints and permission information is available at <http://www.nature.com/reprints>

Publisher’s note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit <http://creativecommons.org/licenses/by/4.0/>.

© The Author(s) 2024