How does purchasing intangible services online influence the travel to consume these services? A focus on a Chinese context

Abstract: A considerable number of empirical studies have explored the effects of information & communication technologies (ICT) on travel in recent years. In particular, the most attention has been paid to whether the use of ICT increases or decreases trip frequency (i.e., substitution or complementarity effects). However, the subject of whether or how travel distance and mode choice are altered by ICT (i.e., modification effects) has almost been ignored. Against this background, using data collected in Beijing, China, this paper aims to explore how purchasing intangible services (e.g., eating out at restaurants, hairdressing, and visits to zoos and movie theatres) online alters the distance and mode choice of the travel to consume these services. The results suggest that due to online purchases of intangible services, people tend to travel farther to consume these services. Consequently, 25.4% of online buyers change their travel mode choices from walking or cycling (i.e., nonmotorized modes) to public transit, private cars, or taxis (i.e., motorized modes). These findings confirm the existence of modification effects of ICT on travel. Additionally, a stepwise multinomial logistic regression model and a stepwise binomial logistic regression model are used to detect the factors influencing changes in travel distance and mode choices, respectively. The regression outcomes suggest that people who have lower living costs or feel more satisfied with online purchases are more likely to increase their travel distances and to change from nonmotorized modes to motorized modes.

Keywords: ICT; online purchases; intangible services; travel distance; travel mode choice; China

Highlights:

(1) The modification effect of ICT on travel is examined, focusing on purchases of intangible services online;

(2) Online purchases of intangible services increase travel distance;

(3) Online purchases of intangible services increase consumers' use of motorized travel modes.

1. Introduction

Information & communication technologies (ICT), which may profoundly affect travel, have important implications for urban transportation systems (Gössling 2018; Mokhtarian et al. 2006; Wang and Law 2007). In earlier conceptual research, four types of ICT impacts on travel were proposed (Mokhtarian 1990, 2002; Salomon 1985, 1986): (1) substitution – the use of ICT decreases the frequency of travel; (2) complementarity – the use of ICT increases the frequency of travel; (3) modification – the characteristics of travel, such as changes in destination (and its consequences for travel route and distance) and mode choice, are altered due to the use of ICT; and (4) neutrality – the effects of ICT on travel are negligible. To date, a considerable number of empirical studies have fully examined whether travel demand is replaced (i.e., substitution effect) or generated (i.e., complementarity effect) by the use of ICT (mostly focusing on e-shopping and teleworking) (e.g., e Silva and Melo 2018a,b; Shabanpour et al. 2018; Shi et al. 2019; Weltevreden and Rotem-Mindali 2009; Xi et al. 2020). However, these studies leave the modification effect underexamined.

Notably, a change in travel destination (i.e., a modification effect) due to the use of ICT could constitute either substitution or complementarity, depending on whether new travel is shorter or longer than previous travel (Mokhtarian 2002). More importantly, the travel mode could possibly be altered once the one-way distance (i.e., distances from origins to destinations) changes due to ICT since this one-way distance is strongly associated with travel mode choices (Ding et al. 2017). Therefore, an investigation into modification effects (especially on travel distance and mode choice) has valuable implications for urban transportation systems (e.g., congestion levels).

Clark and Unwin (1981) noted that travel for some purposes, such as participating in recreational activities and consuming intangible services (e.g., hairdressing), cannot be replaced by online activities. However, the unavoidable travel may be modifiable because of the use of ICT. As a frequent ICT-based activity, searching and paying for intangible services via the internet (i.e., online purchases of intangible services) may alter one-way distances and travel mode choices to consume these services. When purchasing these services online, people can extend their search spaces to become aware of service information that they were unaware of before. Consequently, they may travel longer distances and increase the use of motorized transportation modes.

In recent years, China has become the largest e-retailing market in the world (McKinsey Company 2016). It is reported that e-retail sales in China were ¥ 4.7 trillion (≈US$ 0.70 trillion, and ≈EUR 0.62 trillion) in 2016, approximately 80% more than in the United States (IResearch 2017b). Chinese consumers very frequently purchase intangible services online. For instance, online sales of intangible services in China were up 56.8% in 2016 (compared to sales in 2015) to ¥ 612.4 billion (≈US $ 91.3 billion, and ≈EUR 80.9 billion) (IResearch 2017a). In this context, using data drawn from structured interviews (714 valid records) conducted in 2015 in Beijing, China, this study aims to answer the following questions: 1) Do online purchases of intangible services increase or decrease the one-way distances of the travel to consume these services, and if so, what are the determinants of the changes in travel distances? 2) Correspondingly, is travel mode choice altered by online purchases of these services, and if so, what are the determinants of the changes in travel mode choice? The remainder of this paper is organized as follows. A literature review is offered in the next section. Section 3 presents the methodology. Section 4 contains the results, followed by a conclusion and discussion in the final section.

2. Literature review

2.1 Effects of ICT on travel

With respect to the topic of how ICT affects travel, four effects – substitution, complementarity, neutrality, and modification – have been theoretically proposed in earlier work (Mokhtarian 1990, 2002; Salomon 1985, 1986). In the past two decades, continuously increasing empirical attention has been paid to the topic.

Mainly focusing on online shopping and teleworking, previous empirical studies have frequently confirmed the existence of substitution and complementarity effects. For instance, some studies show that online shopping leads to a reduction in shopping travel frequency (Shi et al. 2019; Weltevreden 2007; Xi et al. 2020) and in the distances traveled for shopping during a given period (Weltevreden and Rotem-Mindali 2009). Similarly, some researchers found that teleworking via the internet likely results in a decrease in total (commuting) travel distances or durations during a given period (Melo and e Silva 2017; Shabanpour et al. 2018). These findings support the substitution effect. In contrast, other research supports the complementarity effect because it finds that frequent e-shoppers shop at physical stores more frequently (Ding and Lu 2017; Zhen et al. 2016), and teleworkers make more frequent trips for other purposes (Budnitz et al. 2020) and travel longer total distances during a given period (e Silva and Melo 2018a,b; Melo and e Silva 2017). In addition to online shopping and teleworking, Wang and Law (2007) found that the general use of ICT increases the durations of outdoor recreational activities and travel. Notably, these studies on e-shopping often do not confirm an increase or reduction in overall travel due to online shopping (i.e., a net complementarity or substitution effect). Moreover, some research reveals that the use of ICT (e.g., making online purchases) has a negligible effect on travel frequency, confirming the neutrality effect (Calderwood and Freathy 2014; Sim and Koi 2002).

Compared to the complementarity and substitution effects, far less attention has been paid to the modification effect of ICT on travel. Several conceptual studies propose that ICT may potentially alter travel characteristics, such as route, mode choice, and timing (Mokhtarian 1990, 2002; Pawlak et al. 2015; Salomon 1985, 1986). Changes in travel destination (and its consequences for travel distance) and mode choice are particularly relevant for transportation systems. However, quite limited empirical research has investigated this topic. One of the exceptions is the work by Farag et al. (2006, 2007), suggesting that online shopping has a modification effect on shopping travel. They revealed that the frequency of e-shopping has a negative effect on the duration of visiting physical stores (excluding the time of the shopping trip). However, it remains unknown whether the transportation system benefits or suffers from modification effects because the authors did not find changes in the duration of the shopping trip caused by e-shopping. More importantly, the effects of ICT on travel mode choice have been mostly ignored in existing empirical studies.

The present study focuses on online purchases of intangible services and their modification effects on the travel to consume these services. First of all, online purchases of intangible services need to be clearly defined. It is widely accepted that e-shopping refers to the use of the internet to acquire product information or purchase products (Mokhtarian 2004). In addition, online products are regularly categorized into two groups. The first group is tangible goods or physical goods, such as books, clothing, and groceries (Francis and White 2004; Keisidou et al. 2011). The second group is intangible services, including dining-out services, travel services, and ticket services (Francis and White 2004; Keisidou et al. 2011; Rushton and Carson 1989). Rigorously speaking, buying intangible services is not included in regular shopping activities. Therefore, the object of the present study – the internet-based purchases of intangible services – is named online purchases of intangible services.

A plausible assumption on the modification effects of purchasing intangible services online can be proposed. In general, intangible services are sold in a different way than tangible goods online. Information about local intangible services is normally published on e-retail websites (e.g., Meituan.com and Nuomi.com in China and Tripadvisor.com elsewhere). Consumers can search for information and pay for these services online. Afterward, they visit physical stores or places to consume the services because these services are usually non-transportable (Shi et al. 2020). In this case, e-buyers are less spatially constrained since they can acquire service information on more distant places online that conventional buyers are unaware of. Consequently, compared to conventional buyers, e-buyers are expected to make trips that are longer in distance (i.e., exhibit the modification effect) after browsing and paying for services online. More importantly, this might further lead to an increase in the use of motorized transportation modes.

2.2 Factors influencing travel distance and mode choice

The modification effects of ICT on travel distance and mode choice might be affected by a wide range of factors. Therefore, it is worthwhile to identify these factors. However, we are unaware of any previous empirical study on this issue. A number of previous studies have analyzed the factors affecting travel distance and mode choice independent of ICT usage. Notably, the present study specifically concentrates on the one-way distance and mode choice of the travel to consume intangible services, which can broadly be categorized as nonwork travel. Therefore, we will primarily review previous studies on determinants of one-way distance and mode choice of nonwork travel.

Sociodemographic characteristics are most frequently considered to be explanatory factors of one-way distance and mode choice of nonwork travel. For example, previous studies reveal that men and those with higher incomes tend to use private cars and travel longer distances per trip (Chen 2017; Cheng et al., 2019b; Ding et al. 2017; Hu et al. 2018; Yang et al. 2013), partly because they like driving and can afford a car. In contrast, those who are better educated are likely to make shorter-distance trips than those with lower education (Chen 2017), though they prefer to use private cars (Yang et al. 2013). This may be attributable to the higher perceived value of travel time for them (Chen 2017).

Spatial attributes are regularly treated as explanatory factors for travel distance and mode choice as well. In general, compared to people living in highly urbanized areas, those living in weakly urbanized areas tend to travel by cars and make long-distance trips for nonwork activities (e.g., shopping and leisure activities) (Cheng et al., 2019a; De Vos and Witlox 2016; Jiao et al. 2016; Scheiner and Holz-Rau 2013). This is mostly the consequence of lower accessibility to opportunities in weakly urbanized areas (Scheiner and Holz-Rau 2013), an idea supported by existing research. For instance, Ding et al. (2017) found that people with lower accessibility to the nearest bus stop are inclined to travel farther and use private cars. Similarly, Jiao et al. (2011) indicated that people who live far from grocery stores tend to drive a car to stores.

According to the abovementioned studies, we can reasonably assume that sociodemographics and spatial attributes may relate to the changes in travel distances and mode choices caused by online purchases of intangible services. In addition to the two categories of factors that are regularly considered, some factors in relation to internet use may influence changes in travel behavior due to online purchases as well. First, a history of internet use and attitudes toward online purchases can influence the frequency of online searching for products/services (Farag et al. 2007) and thus possibly relate to the one-way distances and mode choices of the travel to consume services purchased online. Second, in principle, the frequency of online purchases of intangible services may influence changes in travel distances and mode choices resulting from purchasing online. For instance, people with frequent online purchases of intangible services must travel frequently to consume them. To reduce the total distances traveled for these services, they may tend to travel shorter distances per trip and thus alter their travel mode choices.

Given the existing knowledge gaps in relation to modification effects and their determinants, this study aims to achieve the following two objectives. First, using empirical evidence from China, we aim to verify whether purchasing intangible services online increases the one-way distance of the travel to consume these services and, more importantly, whether the use of motorized modes is facilitated due to online purchases. Second, according to previous empirical studies, it can be assumed that factors such as sociodemographic characteristics, spatial attributes, internet experience, online purchase frequency and attitudes may influence travel behavior. In this study, regarding these factors as explanatory factors, we aim to detect which factors influence changes in travel distance and mode choice due to online purchases (see Fig 1).

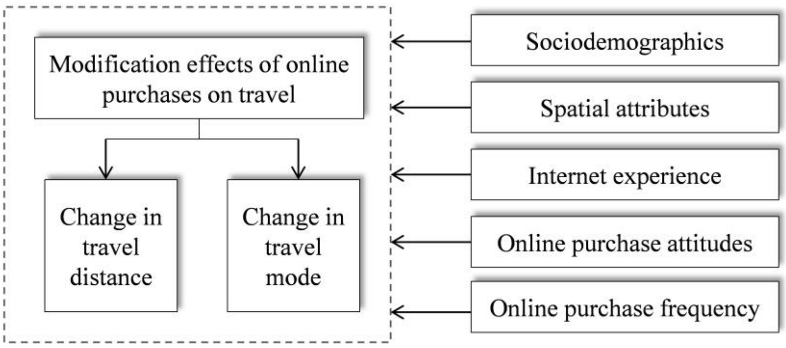


Fig 1 Research framework

3. Methodology

3.1 Data collection

In this study, the data are drawn from structured interviews performed in Beijing, China, by the Urban and Regional Planning (URP) research group of Lanzhou University. Before conducting these interviews, the URP research group selected sample units using a cluster sampling approach in the following four steps (Daniel 2012). First, the target population was defined. In theory, people who have at any point made a purchase online should be defined as the target population in studies on e-shopping's effects on shopping travel (Rotem-Mindali and Weltevreden 2013; Shi et al. 2019; Sim and Koi 2002; Weltevreden and Rietbergen 2007). Since the focus of this study is online purchases of intangible services, the target population in this study is defined as anyone who has ever made a purchase online for intangible services. Second, given budgetary constraints, the desired sample size was finally determined to be 600-1000 so that the data can be collected with sufficient confidence. Third, the sample area was chosen as the built-up area within the fifth ring road of Beijing, where most residents live.

Fourth, the sample units were determined. Ideally, residential neighborhoods would be selected as sample units to recruit participants. Researchers from the URP research group first attempted to conduct the survey in residential neighborhoods. However, they did not succeed because most residential neighborhoods are tightly blocked to protect the privacy of the residents in Beijing. This situation is not unusual in China's large cities and has been reported in some Chinese studies (e.g., Sun et al., 2017). According to the Chinese study by Sun et al. (2017) and based on the principle of the cluster sampling approach (Daniel 2012; Shi et al. 2019), another alternative is to perform a survey in public spaces such as shopping centers, parks, and squares when it is impossible to recruit participants in residential neighborhoods. As public spaces, shopping centers are the destinations of most trips to consume intangible services purchased online since intangible services are densely concentrated there. Hence, shopping centers are desirable alternatives for conducting interviews. Moreover, it is essential to ensure that participants are from each part of the city since spatial attributes might affect online purchasing behavior. Therefore, city-level shopping centers serving residents across the whole city should be randomly geographically chosen as potential sample units in this survey. In the end, seven city-level shopping centers were selected: Guomao Shopping Center, Xin'ao Shopping Center, Xidan Shopping Center, Wangfujing Shopping Center, Zhuozhan Shopping Center, Xinzhongguan Shopping Center, and Kaide-Mall Shopping Center in Wangjing (Fig 2). As a result, however, e-buyers for intangible services who do not frequently go to these city-level shopping centers might be underrepresented.

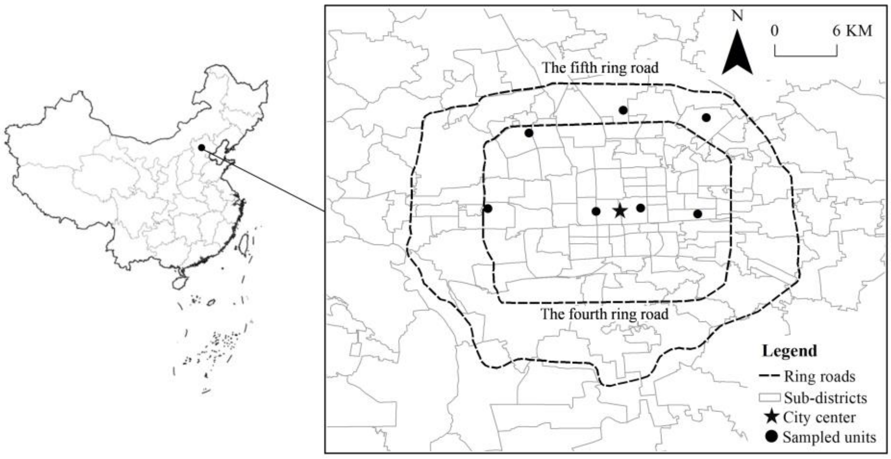


Fig 2 Spatial distribution of sampled units

After determining the sample units, researchers from the URP research group conducted face-to-face structured interviews using paper-based questionnaires in October and November 2015. To ensure the quality of the data, all interviewers had been trained before the interviews started. In the end, using the convenience sampling method (Etikan et al. 2016), approximately 2300 residents were approached, of which 800 participated in this survey. Consequently, the response rate was approximately 35%. After the removal of questionnaires missing key information, 714 valid records were obtained. The basic characteristics of valid participants are shown in Table 1.

Table 1 Basic characteristics of valid respondents

Characteristics	Definitions	Percentage
Gender	Male	39.1%
	Female	60.9%
Age (Years)	20 or less (Value=1)	10.5%
	21-25 (Value=2)	41.0%
	26-30 (Value=3)	28.4%
	more than 30 (Value=4)	20.0%
Education	High school or less (Value=1)	7.3%
	Colleges and technical school (Value=2)	17.6%
	Undergraduate school (Value=3)	52.8%
	Graduate school or more (Value=4)	22.3%
Income (¥/month)	2000 or less (Value=1)	19.0%
	2001-6000 (Value=2)	32.6%
	6001-10000 (Value=3)	29.6%
	More than 10000 (Value=4)	18.8%
Cost of living (¥/month)	1000 or less (Value=1)	8.7%
	1001-3000 (Value=2)	45.0%
	3001-5000 (Value=3)	27.5%
	More than 5000 (Value=4)	18.9%
Years of using the internet on PCs	5 or less (Value=1)	10.1%
	6-9 (Value=2)	36.4%
	More than 9 (Value=3)	53.5%
Departure location	Urban area	52.4%
	Suburban area	25.9%
	Exurban area	21.7%

According to the report by the China Electronic Commerce Research Center (2016), 47.4% of e-shoppers in 2016 in China were men, and 48.8% were more than 26 years old. Of the 714 valid participants, 39.1% were men, and 48.4% were 26 years old or older. Participants in this study could be considered representative with respect to broad age classifications, while a possible selection bias in terms of gender is observed. This may be due to the following reasons. (1) As stated before, e-buyers are defined in this study as those who have ever purchased intangible services online. In contrast, the China Electronic Commerce Research Center (2016) defines e-shoppers as those who have ever made a purchase online (including both tangible goods and intangible services). (2) China has a vast territory with considerable regional differentiation in the socioeconomic attributes of residents. Therefore, it seems reasonable that the sociodemographic characteristics of e-purchases in Beijing are somewhat different from those across the whole country. It should be noted that we are not aware of any other reports concerning e-shoppers in Beijing or e-buyers for intangible services in China in 2015. Hence, it is impossible to compare the attributes of the respondents with a more accurate report on the e-purchasing population of China or Beijing. (3) In this survey, shopping centers were chosen as the sample units. Compared to men, women visit shopping centers more frequently in China (e.g., Feng et al. 2015). As a result, the valid respondents might overrepresent women to a certain degree. Beyond age and gender, they are of unknown representativeness regarding other attributes.

3.2 Method of analysis

3.2.1 Measurement of changes in travel distance and mode choice

Four categories of intangible services that are most frequently purchased online in China were selected for this study. The first category refers to daily life services, including hairdressing visits and photography services. The second category is dining-out services, which refers to going out to eat food at restaurants, snack and dessert stores, etc. The third category is leisure services, including visits to movie theatres, (karaoke) bars, and fitness services. The last category refers to local tourism, such as visits to zoos, theme parks, museums, and resorts.

In China, most online buyers tend to combine both online and conventional purchases for intangible services. For example, sometimes an online buyer browses and orders food online before going to a restaurant to consume it (i.e., uses the online channel). At times, however, he/she also directly goes to the restaurant without searching and ordering online beforehand (i.e., uses the conventional channel). In this context, only the respondents who used both channels were asked two questions: In the recent past, 1) how far away was your most visited place for consuming intangible services when adopting the online channel? 2) How far away was your most visited place for consuming intangible services when adopting the conventional channel? Thus, the self-reported travel distance was obtained in this survey. Noting the differences among these types of intangible services, the respondents were asked to provide information about the travel distance for the four categories of intangible services separately. Not every respondent purchased all four types of services using both online and conventional channels. Participants who purchased at least one type of these services using both channels were included as valid respondents.

By comparing travel distance for the online channel and the conventional channel reported by each respondent, we can determine whether he/she increased or decreased his/her travel distance due to online purchases of intangible services. For example, if a respondent indicated a longer distance for the online channel than for the conventional channel, it suggests that his/her travel distance was increased by online purchases. In contrast, if a respondent reported a shorter distance for the online channel than for the conventional channel, it can be assumed that his/her travel distance decreased due to online purchases. Additionally, if a respondent indicated that his/her travel distance for the online channel was not significantly different from that for the conventional channel, we consider online purchases to have had a negligible effect on travel distance.

It may be argued that it was not easy for participants to accurately recall the distances of their typical trips, resulting in a possible recall bias. Nevertheless, the quality of the data in this study is credible for two reasons. First, respondents were asked to provide the most visited location for intangible services beforehand. It then became easier for them to estimate the travel distance. This is the value of face-to-face interviews. Second, the focus of this study is not to accurately estimate the distance traveled by online buyers. We aim to focus on whether travel distance increases due to online purchases and, more importantly, whether a greater use of motorized travel modes results from an increase in travel distance. A number of previous studies have suggested that the self-reported distance of a single trip is strongly associated with travel mode choice (e.g., Mehdizadeh et al. 2017; Piatkowski and Marshall 2015). Nelson et al. (2008) even postulated that, compared to the actual distance, the self-reported distance might be more related to travel mode choice. Hence, it could be assumed that using the self-reported distance was suitable in this study.

Following the method frequently used in previous studies (e.g., Barata et al. 2011; Duarte et al. 2016; Heinen et al. 2011; Motoaki and Daziano 2015), two questions were set in the questionnaire for travel mode choice: In the recent past, 1) which transport mode did you use the most to travel to consume an intangible service ordered online? 2) Which transport mode did you use the most to travel to consume an intangible service without an online order? Three answers to the two questions were set as options: private car or taxi, public transit (e.g., bus, metro), and walking or cycling. Thus, we were able to determine changes in travel mode choice due to online purchases. One should note that the questions concerning mode choices were not asked separately for the four categories of intangible services.

3.2.2 Measurement of explanatory factors

As shown in Fig 1, the explanatory factors can be grouped into five categories. The first category includes sociodemographic characteristics, which consist of gender, age, income, education, and cost of living. Age, education, income, and cost of living are measured by ordinal scales. The values assigned to them are shown in Table 1.

The second category refers to spatial attributes. In previous studies, most scholars have used residential location to reflect spatial attributes (e.g., De Vos and Witlox 2016; Jiao et al. 2016). Notably, using residential location as a spatial attribute might have shortcomings. For instance, it is normally expected that compared to people living in urban areas, those living in suburban areas have lower accessibility to activity places (e.g., stores) and thus usually travel longer distances per trip. However, there may be a trip chain. For example, a person living in a suburban area and working in an urban area is more likely to visit activity places on the way home from the workplace because of the workplace’s higher accessibility to these places. In this circumstance, this person is expected to travel a shorter distance even though he/she lives in a suburban area. Therefore, one-way distance is influenced not only by residential location but also mainly by departure location (which might differ from residential location). In this study, we therefore use the location where respondents mostly depart for trips to consume intangible services as a spatial attribute. Considering that the degree of urbanization continuously decreases from the city center to the city fringes in Beijing, urban areas, suburban areas, and exurban areas are bounded by the fourth and fifth ring roads, respectively, in a number of empirical studies (e.g., Mao et al. 2016; Li et al. 2019; Lin et al. 2018; Wang et al. 2015; Zhao and Li 2017; Zhao and Zhang 2018). Following these previous studies, we define the areas within the fourth ring road as urban areas, the areas between the fourth ring road and the fifth ring road as suburban areas, and the areas outside the fifth ring road as exurban areas (Fig 2). Thus, of 714 valid records in the study, 52.4%, 25.9%, and 21.7% mostly depart for trips from urban areas, suburban areas, and exurban areas, respectively (see Table 1).

The third explanatory category is internet experience, which is reflected by the number of years using the internet on PCs (the assigned values are shown in Table 1). The fourth category refers to online purchasing behavior. The respondents were asked to provide information on the average frequency of online purchases of four types of intangible services separately. Online purchasing frequency for daily life services and local tour services was measured in a regular year and that for dining-out services and leisure services was measured in a regular month. Considering that the measurement scales differ according to the type of services, the frequency values were normalized using the technique of min-max normalization. We further summed the normalized frequency values for the four types of intangible services, representing the level of total online purchase frequency. In this study, the normalized frequency values were used to reflect respondents' online purchasing behavior.

The final category is attitudes toward purchasing intangible services online. Respondents were asked to respond to 18 statements using a 5-point scale ranging from strongly disagree to strongly agree. Performing factor analysis (principal axis factoring, Promax rotation) obtained five factors (mainly based on eigenvalue>1.0) explaining 52.6% of the total variance: ease of travel, satisfaction, following trends, convenience, and price consciousness (see Table 2). In this paper, the scores of these five factors are used to capture respondents' attitudes toward online purchases.

Table 2 Pattern matrix from factor analysis on attitudes toward online purchases (n=713)

Factors	Statements	Loadings
Ease of travel	Online purchase is a strategy to save travel time	0.92
	Online purchase is a strategy to reduce travel distance	0.86
	The places publishing service information online are highly accessible	0.69
	I can find the sites of places providing services and plan the travel route online	0.42
Satisfaction	I usually purchase online again after first buying online	0.78
	Compared to conventional purchase, I am more satisfied with online purchase	0.68
	I am pleased to recommend online purchase to my friends and relatives	0.66
	I usually feel satisfied with online purchase	0.56
Following trends	Online purchase is a popular lifestyle choice	0.95
	Online purchase is a process that seeks novelty	0.78
	I purchase online because people around me do it (Herd behavior)	0.46
Convenience	It is convenient to select services online	0.86
	I can find a large variety of services online	0.67
	I can find high-quality services online	0.44
	I enjoy the freedom of the online purchase environment	0.43
	It is convenient to pay for services online	0.38

Price-consciousness	I enjoy the discounts by purchasing online	0.93
	The price of online services is lower	0.83

The "loading" reflects the relative importance of each statement in the factors.

3.2.3 Modeling approach

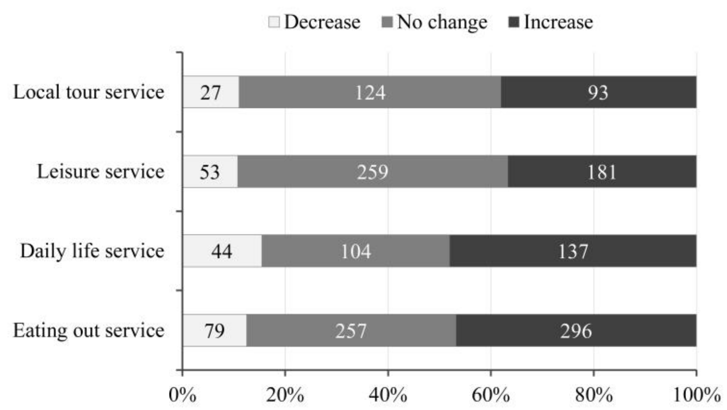
Using logistic regression models, we aimed to identify the determinants of changes in travel distance and mode choice due to online purchases. In these models, changes in travel distance or mode choice were employed as the dependent variable, and the five categories of explanatory factors were used as independent variables. Regarding changes in travel distance, respondents who indicated purchasing more than one type of intangible service online were included in the model more than once. In other words, one case represents the online purchase of one type of service. In this study, there were 714 respondents and 1653 observations for changes in travel distance. The service types were controlled for in the regression model concerning changes in travel distance.

4. Results

4.1 Do online purchases increase travel distance?

4.1.1 Changes in travel distance

In this section, we explore how online purchases of intangible services affect the one-way distance of the travel to consume these services. As shown in Fig 3, a considerable number of respondents reported increasing their travel distances. In particular, for daily life services and dining-out services, more than 40% of respondents indicated an increase in travel distances. However, just knowing that more e-buyers choose to increase than decrease their travel distances due to online purchases does not convey the full picture. It remains unknown whether the distances increased by online purchases are larger than the distances decreased by online purchases. Accordingly, the outcomes of the Wilcoxon signed-rank test[1] in Table 3 confirm that on average, the self-reported travel distance for the online channel is significantly longer than for the conventional channel ($p<0.01$). It suggests that, as expected, online purchases likely stimulate online buyers to travel longer distances.



[1] Given that the distances are not normally distributed, the Wilcoxon signed-rank test, which is a nonparametric method, was adopted in this study.

Fig 3 Number of respondents who decreased, increased or did not change their travel distance

Table 3 Comparison of travel distance for purchases made through conventional and online channels

Type of services	Type of purchases	Travel distance (km)		
		Mean	S.D.	Wilcoxon signed-rank test
Eating out service (N=632)	Conventional channel	3.34	3.63	Z=-10.44
	Online channel	4.70	4.18	Sig.=0.00
Daily life service (N=285)	Conventional channel	3.69	3.85	Z=-6.74
	Online channel	5.13	4.50	Sig.=0.00
Leisure service (N=493)	Conventional channel	4.19	3.83	Z=-7.84
	Online channel	5.26	4.37	Sig.=0.00
Local tour service (N=244)	Conventional channel	10.02	10.70	Z=-5.60
	Online channel	12.46	11.49	Sig.=0.00

4.1.2 Factors influencing changes in travel distance

After respondents were categorized into three groups to indicate increasing, decreasing, or unchanged travel distances, a multinomial logistic regression model was developed to detect the factors influencing changes in travel distance (Table 4). To improve the efficiency of the estimators, the backward stepwise regression method was used to exclude the far less relevant explanatory variables. Insignificant variables with $p>0.20$ were removed from the model because an excessively stringent threshold value (e.g., $p>0.05$) might result in a loss of important correlates (Hosmer Jr et al. 2013). Meanwhile, the Hausman test suggests that the assumption of the independence of irrelevant alternatives was not violated by the pruned model. Additionally, cluster-robust standard errors were estimated since some respondents were included more than once.

Afterward, the prediction accuracy of the regression estimation was calculated to assess its validity. It is traditionally predicted that a choice-maker chooses the alternative with the highest predicted probability. The prediction accuracy is computed according to the comparison between the predicted outcomes and the actual observations. However, the method receives many critiques (e.g., Train 2009; Young and Blainey 2018). In general, researchers perform a regression estimation using partial information. Thus, they can only estimate the probability that a choice-maker chooses each of the alternatives, respectively (Train 2009). In this case, the traditional method is crudely used for prediction without any consideration of other alternatives with relatively low predicted probabilities. To overcome the limitations of the traditional measure, a better approach is introduced (McFadden 2001). The prediction accuracy for an alternative is computed as the average of the predicted probabilities for that alternative across respondents who actually chose the alternative. Similarly, by combining all alternatives, the prediction accuracy in total can be calculated. Using the latter approach, the present study computed prediction accuracy (Table 5). The prediction accuracies for the three categories (decrease, no change, and increase) are 14.77%, 47.48%, and 45.68%, respectively, resulting in a total level of 42.69%. The prediction accuracies for “no change” and “increase” are nearly acceptable, while that for “decrease” is quite low. It should be noted that prediction accuracies using the latter approach are often lower but more appropriate than those using the traditional approach (Kim and Mokhtarian 2018).

As a whole, sociodemographic characteristics, internet experience, and attitudes toward online purchases were found to be significantly associated with changes in travel distance ($p<0.10$). As suggested in Table 4, people who are better educated tended to increase their travel distances due to online purchases. People with lower living costs were inclined to increase their travel distances. It could be assumed that people with lower living costs care more about the price of services. Thus, they may travel a longer distance so that they can consume the services at a lower price. Additionally, people with fewer years of experience using the internet were more likely to change (either increase or decrease) their travel distances. They may have been more curious about online purchase activity than people who have used the internet for multiple years. Thus, they might have more actively searched online for stores/places situated within easy access or distantly situated to break their dependence on regularly visited stores/places. Regarding attitudes toward online purchases, people who paid more attention to the ease of travel were less likely to increase their travel distances and more likely to decrease their travel distances. This is in line with our expectations. People who felt satisfied with online purchases were more likely to change (either increase or decrease) their travel distances, which could be similarly attributed to their greater engagement in online searching. Furthermore, respondents who considered online purchases convenient were less likely to decrease their travel distances. We did not find that online purchase frequency and spatial attributes had associations with changes in travel distance at a significance level of $p<0.10$.

Table 4 Stepwise multinomial logistic regression model concerning changes in travel distance (no change=ref.)

Independent variables	Decrease			Increase		
	B	Robust S.E.	Sig.	B	Robust S.E.	Sig.
Education	0.00	0.14	0.988	0.25	0.09	0.007
Cost of living	0.10	0.13	0.460	-0.21	0.09	0.020
Years of using the internet on PCs	-0.50	0.18	0.006	-0.33	0.12	0.007
Attitudes toward purchasing online						
Ease of travel	0.32	0.12	0.007	-0.31	0.09	0.001
Satisfaction	0.27	0.14	0.049	0.17	0.10	0.093
Convenience	-0.27	0.14	0.052	0.03	0.10	0.779
Types of services (daily life service=ref.)						
Local tour service	-0.66	0.26	0.012	-0.63	0.17	0.000
Leisure service	-0.77	0.21	0.000	-0.71	0.14	0.000
Eating out service	-0.35	0.21	0.093	-0.19	0.13	0.163
Constant	0.04	0.53	0.938	0.94	0.38	0.013
Log pseudolikelihood at zero	-1816.0					
Log pseudolikelihood at constants only	-1620.3					
Log pseudolikelihood at convergence	-1552.9					
McFadden's R^2 at constants only	0.00					
McFadden's R^2 at convergence	0.04					
Number of observations	1653					

Table 5 Prediction accuracy of the stepwise multinomial logistic regression model

Categories	Prediction accuracy (%)
Decrease	14.77
No change	47.48
Increase	45.68
Total	42.69

4.2 Do online purchases change the travel mode choice?

4.2.1 Changes in travel mode choice

In this section, we aim to investigate the effect of purchasing intangible services online on travel mode choice. The matrix of changes in mode choice is presented in Table 6. The results suggest that a considerable share of respondents (36.3%) indicated changing their travel mode choices due to online purchases. In particular, more than a quarter of respondents indicated changing their travel mode choices from walking or cycling to using a private car, a taxi, or public transit (i.e., changing from nonmotorized modes to motorized modes). Among the 714 valid respondents, 45 (6.3%) reported changing their travel mode choice from walking or cycling to using a private car or a taxi, and 136 (19.0%) indicated changing to using public transit. Additionally, the Chi-squared test indicates that the probability that respondents used motorized modes for trips with online orders and for trips without online orders is significantly different (χ^2=86.2, $p<0.01$).

Table 6 Changes in travel mode choice

		Online channel			
		Car/taxi	Public transit	Walking/cycling	Total
Conventional channel	Car/taxi	114	27	13	154
	Public transit	19	279	19	317
	Walking/cycling	45	136	62	243
	Total	178	442	94	714

As assumed before, trips to consume intangible services are normally unavoidable, even when purchasing online (Clark and Unwin 1981). More importantly, additional trips might be further generated by online purchases in some situations. In general, consumers can acquire massive information on goods/services online (Cao et al. 2012; Shi et al. 2019). Moreover, online goods/services usually have better prices compared to goods/services in stores (e.g., larger discounts) (Rotem-Mindali and Weltevreden, 2013). These circumstances may lead to additional online purchases and consequently more trips to consume services. To verify this expectation, following the measurement method of previous studies (e.g., Shi et al. 2019; Weltevreden 2007; Xi et al. 2020), the self-reported changes in the frequency of the travel to consume intangible services due to online purchases were obtained in the survey. The results show that of 714 valid respondents, 52.8% indicated an increase in trip frequency because of online purchases, while only 6.9% reported a decrease in frequency. Additionally, as shown in Table 7, respondents quite frequently purchased intangible services online, and trips with online orders accounted for a considerable share (45.6% to 60.6%) of their total trips to consume intangible services. These results suggest that the use of motorized modes for consuming intangible services could be considerably stimulated by purchasing online.

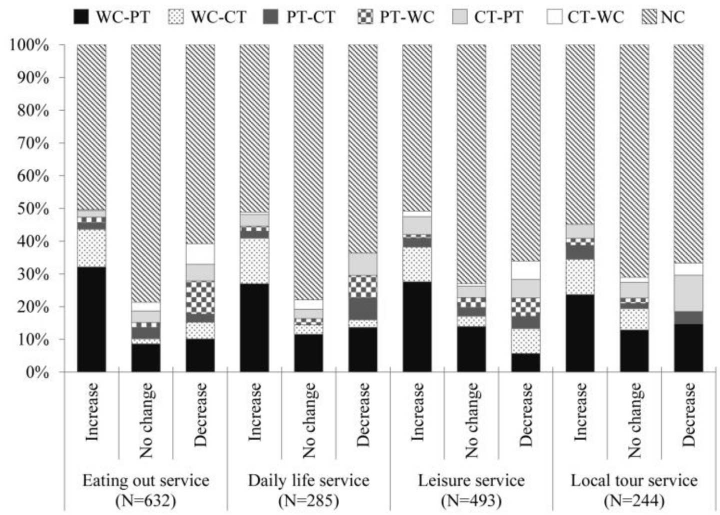
Table 7 The frequency of trips with online orders and their shares in total trip frequency

Type of services	Type of purchases	Trip frequency		Share of trips with online orders (%)	
		Mean	S.D.	Mean	S.D.
Eating out service (N=654)	Conventional channel	9.51 [a]	11.87 [a]	45.6	20.0
	Online channel	6.13 [a]	5.61 [a]		
Daily life service (N=295)	Conventional channel	16.03 [b]	25.00 [b]	46.4	19.2
	Online channel	11.47 [b]	13.58 [b]		
Leisure service (N=598)	Conventional channel	3.31 [a]	4.27 [a]	60.6	22.4
	Online channel	3.61 [a]	3.45 [a]		
Local tour service (N=271)	Conventional channel	8.86 [b]	15.59 [b]	53.5	21.0
	Online channel	8.62 [b]	12.84 [b]		

a - monthly frequency, b - yearly frequency;

Total trip frequency - the sum of the frequency of trips with online orders and without online orders.

By and large, changes in travel mode choice could be attributed to changes in travel distance according to Fig 4. In particular, respondents who indicated increasing travel distances were more likely to change their travel mode choices from walking/cycling to public transit and car/taxi. Not surprisingly, people who reported not changing their travel distances were inclined to keep their travel mode choices constant. Additionally, those indicting a decrease in travel distances tended to change their travel mode choices from public transit or car/taxi to walking/cycling.



"WC-PT" change from walking/cycling to public transit; "WC-CT" change from walking/cycling to car/taxi; "PT-CT" change from public transit to car/taxi; "PT-WC" change from public transit to walking/cycling; "CT-PT" change from car/taxi to public transit; "CT-WC" change from car/taxi to walking/cycling; "NC" no change.

Fig 4 Changes in travel mode choice by changes in travel distance

4.2.2 Factors influencing changes in travel mode choice

Considering that more than one-quarter of respondents changed from nonmotorized travel modes to motorized modes due to online purchases of intangible services, we aimed to identify the determinants of that change using a binomial logistic regression model. Following Hosmer Jr et al. (2013), the backward stepwise regression method was used to exclude independent variables that were quite insignificantly associated with the dependent variables ($p>0.20$). The outcomes are reported in Table 8. Similarly, the prediction accuracy was computed and reported in Table 9. The prediction accuracy in total reaches a reasonable level (63.44%), suggesting that, despite a relatively low pseudo R^2, the goodness-of-fit is acceptable or nearly acceptable.

The outcomes suggest that people who had lower living costs, cared less about the ease of travel, or were more satisfied with online purchases were more likely to change from nonmotorized modes to motorized modes (at a significance level of $p<0.10$). This finding is consistent with our expectations since these respondents were (more or less) likely to increase their travel distances. Additionally, gender and spatial attributes were significantly associated with the change from nonmotorized modes to motorized modes. Men were more likely to change from nonmotorized modes to motorized modes, which could be partly attributed to their higher probability of using a car in China (Yang et al. 2013). Compared to people mostly departing from weakly urbanized areas (i.e., exurban areas), those mostly departing from strongly urbanized areas (i.e., urban and suburban areas) were more likely to change from nonmotorized modes to motorized modes, probably because of their higher accessibility to public transit.

Table 8 Stepwise binomial logistic regression model concerning change in travel mode choice

Independent variables	From nonmotorized modes to motorized modes (Yes=1, No=0)		
	B	S.E.	Sig.
Gender (Female=ref.)	0.42	0.18	0.019
Cost of living	-0.26	0.10	0.010
Departure location (Exurban area=ref.)			
Urban area	0.31	0.24	0.196
Suburban area	0.56	0.26	0.032
Online purchase frequency	0.38	0.24	0.119
Attitudes toward purchasing online			
Ease of travel	-0.17	0.10	0.085
Satisfaction	0.20	0.11	0.064
Constant	-1.07	0.34	0.002
Log likelihood at zero	-494.2		
Log likelihood at constant only	-404.2		
Log likelihood at convergence	-392.1		
McFadden's R^2 at constant only	0.00		
McFadden's R^2 at convergence	0.03		
Number of observations	713		

Table 9 Prediction accuracy of the stepwise binomial logistic regression model

Categories	Prediction accuracy (%)
From nonmotorized modes to motorized modes (Yes)	27.88
From nonmotorized modes to motorized modes (No)	75.51
Total	63.44

5. Conclusion and discussion

With the widespread use of ICT in recent years, numerous researchers have demonstrated the effects of ICT on travel. Although it has been conceptually proposed that ICT have modification effects on travel distance and mode choice, very limited empirical evidence has been presented to support this idea. Therefore, using data drawn from a questionnaire survey in Beijing, China, this study aimed to explore the modification effects of purchasing intangible services online on travel. The results suggest that the distance of a single trip likely increases due to online purchases. Consequently, 36.3% of online purchasers indicate changes in their travel mode choices, with changes from nonmotorized modes to motorized modes being the most common (25.4%). Furthermore, using logistic regression models, the determinants of changes in travel distance and mode choice were identified. The outcomes suggest that sociodemographic characteristics, spatial attributes, internet experience, and attitudes toward online purchases are significantly associated with changes in travel distance and the change from nonmotorized modes to motorized modes.

Our findings have two important implications. On the one hand, this study fills research gaps from previous studies. First, we extend the knowledge of the modification effects of ICT on travel using empirical evidence from China. Our results suggest that online buyers of intangible services tend to increase the distance of trips to consume services and thus have a greater probability of using motorized travel modes. Second, we also detect the factors affecting changes in travel distance and mode choice. These findings add new knowledge to the body of existing literature.

On the other hand, policy makers and urban planners consequently need to cope with the new challenge brought about by purchases of intangible services online. Online purchases of intangible services seem to result in a greater use of motorized travel modes for the consumption of these services, which might be a challenge for the transportation system and might increase transport

CO_2 emissions. Nevertheless, since both the frequency of trips and the distance of a single trip increase due to online purchases of intangible services, online buyers may reduce their time budget for trips for other purposes. As a result, the use of motorized modes for other purposes might be correspondingly reduced. Therefore, the net effect of online purchases of intangible services on the use of motorized modes needs to be considered when policy is made. Additionally, online buyers particularly change travel mode choices from walking or cycling to public transit. The demand for public transit might therefore be stimulated to a certain extent.

Although new insights have been gathered regarding the understanding of the travel effects of ICT, a few limitations exist in this study. First, a possible selection bias resulting from recruiting participants at shopping centers might limit the generalizability of the findings. In particular, the modification effects of purchasing intangible services online on travel might be slightly overestimated because less-mobile online buyers may be underrepresented in this study. In future research, the issue of selection bias needs to be addressed. Second, only the self-reported travel distance was used to measure changes in travel distance due to online purchases, which limits our empirical analyses in two aspects. On the one hand, we cannot analyze the factors influencing the exact extent to which the one-way travel distance increased or decreased due to online purchases because the self-reported distance cannot accurately represent the actual distance. On the other hand, the exact total amount of the increase in travel distances due to online purchases cannot be estimated in this study. In the future, by using the actual travel distance and taking trip frequency into account, researchers can address these two issues. Third, with respect to regression models, two improvements can be made in future research. On the one hand, due to relatively limited observations, changes in mode choice are crudely classified into binary variables to be used as dependent variables in the regression model. More observations are needed to derive more varied dependent variables for modeling in future studies. On the other hand, the low values of the pseudo R^2 suggest that a considerable share of the variance in the change in travel distance and mode choice is not explained by our regression models. The outcomes of the regression models may change if additional relevant variables are included. This could be regarded as an issue to be addressed in future research.

Authors’ contribution

K. Shi: Identification of research gaps, conceptualization, literature search and review, analysis, and manuscript writing; L. Cheng, J. De Vos, and W. Cao: Conceptualization, analysis and manuscript editing; Y. Yang: Identification of research gaps and manuscript editing; F. Witlox: Manuscript editing and final approval of the paper.

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Disclosure statement

The authors note that there is no conflict of interest regarding this manuscript, and the submission of this manuscript is approved by all authors.

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