Do e-shopping attitudes mediate the effect of the built environment on online shopping frequency of e-shoppers?

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Abstract: It is widely acknowledged that e-shopping has considerable effects on e-shoppers' travel behavior. Therefore, it is valuable to investigate how the built environment influences online shopping, which can help clarify whether land use policy is effective to manage online shopping and thus moderate travel demand. However, this issue has not been fully investigated in prior research. In particular, some existing studies fail to identify a significant link between the built environment and online shopping. One of the possible reasons is that the indirect effects of the built environment on e-shopping through e-shopping attitudes are rarely considered. Against this backdrop, considering the mediating role of e-shopping attitudes, this paper aims to explore the influence of the built environment on the frequency of e-shopping for clothes and shoes, food and drinks, cosmetics, and electronics. Data used in this study are acquired from 675 face-to-face interviews with online buyers in Chengdu, China, and the Structural Equation Modeling method is employed. The outcomes show that higher residential density has a positive impact on online shopping frequency. Higher accessibility to metro stations has an indirect and negative influence on e-shopping frequency through pro-e-shopping attitudes. In contrast, mediated by e-shopping attitudes, higher accessibility to bus stations has an indirect and positive impact on online shopping frequency. The mediating role of attitudes provides a possible explanation for the influences of transportation accessibility on e-shopping frequency. Land use policies seem influential in online shopping attitudes and frequency, and thus moderate e-shoppers' travel demand.

Keywords: online shopping, built environment, e-shopping attitudes, travel behavior, Chengdu (China)

Introduction

In recent years, online shopping has been widely adopted around the world. In 2018, the global e-retail sales were nearly US $ 3 trillion, accounting for 12.2% of the total retail sales (Lipsman, 2019). In particular, the widespread of the COVID-19 virus makes more and more people become e-shoppers and raises the dependence on e-shopping (De Vos, 2020; WTO, 2020). On 12~19 April 2020 (an early period of the COVID-19 pandemic all over the world), the number of online purchase orders increased by 142%, 129%, and 99% compared to the same period last year in Northern America, Europe, and the Asia Pacific region, respectively (Emarsys, 2020). Consequently, people may be more dependent on online purchasing even when the COVID-19 crisis disappears in the future (Rothengatter et al., 2021).

Given the rapid development of e-retailing, it is worthwhile to investigate how the built environment influences online shopping. Previous studies show that online shopping has considerable effects on in-store shopping. For example, some researchers found that e-shoppers tend to reduce visits to physical stores due to online shopping (e.g., Shi et al., 2019; Xi et al. 2020a; Weltevreden, 2007; Weltevreden & Rotem-Mindali, 2009). In such a situation, it can be assumed that e-shopping may be a valid solution to reduce transport demand, and lead to a decline in commercial land use in the long run (Zhang et al., 2016). In contrast, other scholars argue that online shopping can generate visits to physical stores (e.g., Cao et al., 2012; Farag et al., 2005, 2007; Etminani-Ghasrodashti & Hamidi, 2020; Zhen et al., 2016). In this circumstance, online buying may be adding pressure on transportation systems, and result in an expansion of land use for physical stores in the long run. Although it remains debatable whether the impacts of online shopping on in-store shopping are negative or positive, most researchers support that online shopping does have considerable implications for travel

63 demand and urban retail landscapes. In particular, these implications may be growing
64 because of the COVID-19 crisis. Against this backdrop, it is urgently important to study
65 the influence of the built environment on e-shopping. In doing so, it helps to clarify
66 whether land-use policies are effective to manage online purchase behavior, thus
67 moderating in-store visits to alleviate transportation problems (e.g., traffic congestion)
68 and optimize urban retail land use.

69 Moreover, it is important to understand the mechanism behind the impacts of the
70 built environment on e-shopping. In general, people with low accessibility to physical
71 stores or transit facilities face more difficulties in making in-store shopping trips. On the
72 contrary, they can easily access and buy a variety of products via the internet. By
73 purchasing online, they can avoid trips to physical stores. Therefore, they are expected
74 to have a more positive attitude toward e-shopping (i.e., pro-e-shopping attitude) (Perea
75 y Monsuwé et al., 2004; Wolfinbarger & Gilly, 2001). The theory of reasoned action
76 and its extension – known as the theory of planned theory – claim that certain behavior
77 is positively determined by a positive attitude toward the behavior (Ajzen, 1991;
78 Fishbein & Ajzen,1975). Researchers often use both theories to explain online shopping
79 behavior and postulate that a positive attitude toward online shopping tends to result in
80 frequent online purchases (e.g., Hansen et a., 2004; Islam & Daud, 2011; Yu & Wu,
81 2007). Therefore, online shopping attitudes may play a mediating role in the influence
82 of the built environment on e-shopping (Farag et al., 2005). Nevertheless, existing
83 studies rarely empirically examine the mediating role of e-shopping attitudes, leaving a
84 knowledge gap. In principle, a statistically significant association cannot robustly prove
85 a causal direction. A reasonable explanation (i.e., the mechanism) for the relationship
86 can improve the robustness of the causality (Singleton & Straits, 1999; Handy et al.,
87 2005). Revealing the mediating role of e-shopping attitudes in the effects of the built

environment on e-shopping can provide a possible explanation for the causal direction from the built environment to e-shopping.

China has experienced rapid growth in the e-retailing industry in the past several years. Since 2013, the size of online sales in China has overtaken that in the United States and become the largest one around the world. In 2016, the online retail transaction was 4.7 trillion Yuan[1] in China, while it was only 2.6 trillion Yuan in the United States (IResearch, 2017). A more recent report showed that a total of 782 million people were online buyers by the end of 2020 in China (CNNIC, 2021). The substantial use of online shopping in China suggests huge potential impacts on transportation systems and retail landscapes. In addition, China has also undergone unprecedentedly rapid urbanization in the past two decades. The share of urban residents in the total population rose from 36% in 2000 to 64% in 2020 (NBSC, 2021). Notably, China is the most populous country in the world. Rapid urbanization leads to many overpopulated cities. The population is even more than 10 million people in some cities such as Beijing, Shanghai, and Chengdu. Due to huge population, these cities are facing many intractable transportation problems (e.g., traffic congestion, fuel consumption, and air pollution) that need to be urgently resolved. Meanwhile, rapid urbanization also results in unreasonable land use in urban China (e.g., disorderly expansion of urban areas) (Liu et al., 2018; Yang et al., 2016). The land-use structure in urban areas needs to be further optimized. Exploring the influence of the built environment on online shopping can help provide a step in understanding how the transportation and land-use problems can be possibly addressed in the age of e-commerce in China.

[1] 1 Yuan was around 0.15 U.S. dollars or 0.14 EUR in 2016.

Against the above-mentioned background, this study aims to empirically investigate the impacts of the built environment on online purchase frequency and particularly examine the mediating effects of pro-e-shopping attitudes on the impacts. In doing so, we expect to fill the knowledge gap regarding whether/how the built environment influences e-shopping through e-shopping attitudes. Data used in the study are acquired from 675 face-to-face interviews with online shoppers in Chengdu (one of the megacities in China) in 2016. Structural Equation Modelling (SEM) is applied for the quantitative analysis. The rest of the study is structured as follows. Related work is briefly summarized in the next section, followed by the introduction to data sources and analysis methods. Then, the analysis results are presented. Lastly, this paper ends with a conclusions and discussion section.

Literature review

With the widespread use of e-commerce since the 2000s, it has become crucial to understand how online shopping impacts (shopping) travel behavior. Many researchers have explored this topic but failed to produce consistent results. For example, some studies show that online shopping is a substitute for in-store shopping, thus leading to a reduction in the frequency of shopping trips (i.e., substitution effect) (e.g., Shi et al., 2019; Xi et al. 2020a; Weltevreden, 2007; Weltevreden & Rotem-Mindali, 2009). On the contrary, other scholars argue that purchasing online is likely to increase shopping trips, because they reveal a positive association between online shopping frequency and in-store shopping frequency (i.e., complementary effect) (e.g., Cao et al., 2012; Farag et al., 2005, 2007; Etminani-Ghasrodashti & Hamidi, 2020; Zhen et al., 2016). Meanwhile, two pieces of work reveal a neutrality effect, meaning that online shopping has negligible impacts on shopping trip frequency (Calderwood & Freathy, 2014; Sim &

Koi, 2002). Moreover, a few studies indicate that consumers tend to change their travel distances, travel durations/in-store shopping durations, and mode choices due to online buying, suggesting a modification effect (Farag. et al., 2007; Shi et al., 2020a, 2020b). Despite inconsistent results, most scholars support the existence of online purchase impacts on travel demand, which suggests potentially considerable implications of e-shopping for urban transportation systems and commercial landscapes.

Given the implications of online purchases for urban systems, scholars start to investigate whether/how the built environment influences e-shopping. Anderson et al. (2003) first proposed two possible explanatory hypotheses – innovation diffusion hypothesis and efficiency hypothesis. The former states that people in highly urbanized areas may make more frequent online purchases because they are usually young, wealthy, well educated, and more receptive to new ways of shopping (i.e., e-shopping). In contrast, the latter assumes that residents in weakly urbanized areas may purchase online more frequently since they have lower accessibility to in-store shopping opportunities. Nonetheless, Anderson and colleagues did not empirically examine the two hypotheses.

Following the work by Anderson et al. (2003), other researchers conduct empirical studies to particularly investigate the role of in-store shopping accessibility, whereas resulting in conflicting findings. On the one hand, it is proven that lower accessibility to store shopping opportunities is positively associated with online shopping. For example, Ren and Kwan (2009) revealed that, in the Columbus Metropolitan Area of the United States, people with lower accessibility to in-store shopping have more tendency to purchase online. Additionally, Loo and Wang (2018) found that the lower accessibility to shopping centers is positively correlated with the duration of online shopping at home in Nanjing, China.

On the other hand, however, some studies indicate that accessibility to store purchase opportunities is not significantly correlated with online buying. For instance, Ding and Lu (2017) found an insignificant relationship between e-shoppers' online buying frequency and the density of in-store buying opportunities around their home locations in Beijing, China. Similarly, both studies by Lee et al. (2017) and Etminani-Ghasrodashti and Hamidi (2020) also suggested that online shopping frequency is not significantly associated with the accessibility to the nearest shopping center in Davis (US) and Shiraz (Iran), respectively. Cao et al. (2013) even indicated that higher accessibility to store buying opportunities is positively related to online buying frequency in Minnesota, the United States.

Additionally, the link between transportation accessibility and online purchases is frequently studied as well. Normally, higher transportation accessibility can indirectly represent higher shopping accessibility. Therefore, in principle, transportation accessibility and shopping accessibility have a consistent influence on online purchases. However, with respect to the role of transportation accessibility, mixed findings exist in previous studies as well. In Nanjing, China, Loo and Wang (2018) indicated that more time is spent shopping online for those who have lower metro accessibility (i.e., the shortest distance to the nearest metro station). In contrast, Lee et al. (2017) and Etminani-Ghasrodashti and Hamidi (2020) suggested an insignificant association between online shopping frequency and transportation accessibility (i.e., the shortest/self-reported distance to the nearest bus stop) in Davis (US) and Shiraz (Iran), respectively.

In addition to shopping accessibility and transportation accessibility, some researchers also consider other built environment elements such as residential density, population density, and employment density as the explanatory factors of online

shopping frequency (Etminani-Ghasrodashti & Hamidi 2020; Lee et al, 2017; Ren & Kwan, 2009). However, they mostly reveal insignificant links of these elements with e-shopping frequency (e.g., Etminani-Ghasrodashti & Hamidi 2020; Lee et al, 2017).

Moreover – as assumed in the section of Introduction – the built environment may influence consumers' attitudes toward online shopping. In particular, people in remote areas may perceive more value and have more liking for e-shopping because of limited in-store shopping opportunities (Perea y Monsuwé et al., 2004; Wolfinbarger & Gilly, 2001). Meanwhile, according to the theory of reasoned action and the theory of planned behavior, a positive attitude toward online shopping will promote the adoption of online shopping. Therefore, it can be reasonably assumed that the built environment can indirectly influence e-shopping behavior through e-shopping attitudes. However, very little scholarly attention has been paid to this assumption. To the best of our knowledge, Farag et al. (2005) are the only ones attempting to explore this topic in a Dutch context. They first proposed a conceptual path with pro-e-shopping attitudes as the mediating factor of the association between urban environment (suburban environment is defined as the reference category) and online shopping frequency. Using data collected from a shopping survey in the Netherlands and applying a path analysis, they revealed that pro-e-shopping attitudes have an insignificant mediating effect on the association between urban environment and e-shopping frequency. Except for the work by Farag et al. (2005), we do not find any other studies on the mediating effect of e-shopping attitudes.

Overall, there exist two research limitations/gaps in current studies. First, the issue of how the built environment impacts e-shopping has not been fully explored. Conflicting results are reported in previous studies. Cao (2009) supposed that the influence of the built environment on e-shopping may differ by types of products, and

researchers can hardly yield a consensus possibly because they focused on different types of consumer goods. In principle, the influence may particularly vary between experience goods and other types of goods. Experience goods refer to a category of goods having a nature that consumers cannot evaluate their quality until touching, testing, fitting, or smelling them (Rotem-Mindali & Weltevreden, 2013), such as clothes, shoes, electronics, and cosmetics. For experience goods, a hybrid shopping process possibly occurs (Zhai et al., 2017). For example, people may first visit physical stores to fit a coat or test a smartphone, and then purchase them online (i.e., showrooming behavior) (Rapp et al., 2015; Xi et al., 2020b). In this situation, higher accessibility to physical stores may have a positive effect on online purchases of experience goods. According to the efficiency hypothesis, however, higher proximity to physical stores may play a negative role in e-shopping for non-experience goods, such as packaged food.

Second, the issue of whether and how e-shopping attitudes mediate the influence of the built environment on online shopping has rarely been investigated. It should be noted that the link between the built environment and online shopping may be quite weak when built environment elements mainly indirectly impact e-shopping frequency through e-shopping attitudes. Therefore, one of the possible reasons why some previous studies (e.g., Etminani-Ghasrodashti & Hamidi 2020; Lee et al, 2017) fail to detect significant effects of the built environment on e-shopping is that they do not consider the mediating role of e-shopping attitudes. In principle, a study can considerably increase the probability of capturing the influence of the built environment on e-shopping when taking the mediating role of e-shopping attitudes into account.

In the present study, we aim to fill the above-mentioned two research gaps by distinguishing product types and considering the mediating role of the attitudes toward

online shopping. This study can contribute valuable insights to the knowledge of built environment influences on e-shopping.

Data sources and methods

Data sources

In this study, Chengdu – which is in the southwest of China – is chosen as the case city. As one of the megacities in China, Chengdu had a population of 20.9 million people in 2020, of which 79% were urban residents (CMDRC, 2021). According to WorldPop (2020), the population density was more than 5,000 persons/km^2 in most urban areas of Chengdu in 2016. In some areas, the density was even over 20,000 persons/km^2 (see Figure 1). The great population and overpopulated land use are leading to severe transportation problems. In 2017, for example, the level of traffic congestion of Chengdu ranked the 21st place among all cities of China (there are more than 650 cities in China). The average speed of vehicles was only 24.9 km/h during peak hours (Amap.com, 2018). Furthermore – in 2016 – the total retail sales of consumer goods reached 564.7 billion Yuan in Chengdu (CBS, 2017), and the number of internet users was more than 10 million (PGSP, 2017). This suggests a large potential for online purchases in Chengdu. According to the government of Chengdu, the total e-retail sales in Chengdu in 2016 were more than 171.9 billion Yuan (CMPG, 2017). This means that approximately 30% of consumer goods were bought via the internet. Therefore, it seems that online shopping has considerable impacts on transportation systems and the retail landscapes of Chengdu.

This study uses data from a face-to-face survey performed in Chengdu, China in 2016. In the survey, a two-stage sampling strategy was applied. In the first stage, sampled units (i.e., the sites where the survey was performed) were determined. In

general, residential neighbourhoods are considered as ideal sampled units. However, it is rather difficult to access residential zones in urban China because they are often gated to protect residents' privacy (particularly in megacities like Chengdu) (Sun et al., 2017). In order to approach residents with various attributes, we chose public spaces that all residents can access (e.g., parks, squares, and shopping centers) as potential sampled units. This is a commonly used solution in previous studies (e.g., Shi et al., 2020a, 2020b; Sun et al., 2017). A public space can be seen as a cluster where residents can be easily approached. Following a cluster sampling technique, we first defined that those who had ever purchased online before (i.e., online shoppers) were determined as the target population of the survey. Then, the desired sample size was determined to be around 600-1000 so that we can obtain ample respondents for quantitative analyses. The sampled areas were determined to be within the third ring road because most inhabitants lived there (see Figure 1). Finally, from all public spaces of Chengdu, 10 public spaces were randomly geographically selected as the final sampled units: Kaide Shopping Center, Chunxilu Shopping Center, Laifushi Shopping Center, Jinniu-Wanda Shopping Center, Tianfu Square, Hongpailou Shopping Center, Huanhuaxi Park, Dongjiaojiyi Music Park, Shahe Park, and Tazishan Park (see Figure 1).

Figure 1 around here

In the second stage, participants were recruited using the convenience sampling principle in the 10 sampled units. This means all people who were readily available in these selected spaces and had ever bought online were invited to participate in face-to-face interviews. All interviews were performed following a structured questionnaire which consisted of questions/statements for measuring respondents' sociodemographic characteristics, internet experiences, attitudes toward online shopping, spatial attributes, and online purchase behavior. This questionnaire was printed in a paper-based form to

record the answers of participants. In the end, a total of 1796 residents were invited, and 882 accepted the invitation and participated in the survey. In the present study, 675 interviews are eventually used, since 207 participants did not provide the information needed. Sociodemographic attributes of these valid records are shown in Table 1.

Table 1 around here

Online shopping frequency

In order to acquire e-shopping frequency, respondents were asked to answer the question in the survey: how often do you purchase online (times for a regular month)? Respondents answered this question with specific counts. As mentioned before, one of the aims of this study is to clarify whether the influence of the built environment on e-shopping frequency varies by product types. By asking the question in the survey, we obtained the frequencies of e-shopping for four types of goods: clothes and shoes, food and drinks, cosmetics, and electronics, respectively. These products are very commonly bought online in China. The monthly e-shopping frequencies are presented in Table 2. According to Rotem-Mindali and Weltevreden (2013), clothes and shoes, cosmetics, and electronics have more natures of experience products, while food and drinks can be roughly categorized as non-experience products.

Table 2 around here

E-shopping attitudes

One of the main goals of the present study is to explore the indirect influence of the built environment on online shopping frequency through online shopping attitudes. Therefore, we need to capture online shopping attitudes that are potentially influenced by the built environment. As assumed above, the built environment may in theory impact e-shopping attitudes regarding variousness of products, ease of travel, and

overall satisfaction. In analogy to previous studies (e.g., Farag et al., 2005, 2007; Hasan et al., 2010; Shi et al., 2020a), the following eight statements regarding these potential components of e-shopping attitudes were set in the questionnaire. Participants were asked to indicate to what extent they agree with them on a five-point scale from "strongly disagree" to "strongly agree".

- Shopping online is a strategy to reduce trips;
- Shopping online is a strategy to reduce shopping time;
- I can buy products online at any point of time (i.e., high time flexibility of e-shopping);
- I can access a wide variety of products online;
- I feel overall satisfied with online shopping;
- I feel more satisfied with online shopping than in-store shopping;
- I am very happy to recommend my relatives/friends to buy online;
- I usually purchase online again after buying online.

In order to reduce dimensions, the scores of these statements are summed into one variable (Cronbach's $\alpha = 0.79$). The sum is used to comprehensively reflect respondents' pro-e-shopping attitudes.

Built environment

In the present study, we will use the built environment of the departure location for shopping trips as the explanatory factor of e-shopping frequency. In previous studies, the built environment of e-shoppers' home location is usually derived to explain online shopping frequency (e.g., Ding & Lu, 2017; Ren & Kwan, 2009). This is because researchers mostly assume that people depart for shopping trips from home. The built

environment surrounding home locations is expected to influence shopping trips, thus potentially affecting online shopping. In reality, shopping trips, however, are often combined with trips for other purposes (e.g., commuting) (Hsiao, 2009). This means that online shopping may not necessarily be influenced by home locations but by other departure locations. In particular, home locations will rarely influence e-shopping behavior in the following two situations where shopping trips are linked with commutes. First, when a person lives in a suburban area but works in the city center, he/she may mostly depart for a shopping trip from the workplace after work. Consequently, the person may be less likely to adopt online shopping because it is easy for him/her to visit stores when departing from the workplace. Apparently – in such a situation – whether the person makes online purchases mainly depends on the accessibility to in-store shopping opportunities surrounding the workplace rather than the residential location. Second, when a person passes through and particularly makes a transfer in the city center on the way from work to home, he/she may tend to depart for a shopping trip from the transfer station. In this situation, the person has few difficulties making in-store purchases, even if he/she both lives and works far from the city center. Consequently, the person may have a low likelihood to purchase online. This means that online purchases may not be determined by work or home locations but by departure locations of shopping trips. In order to address this issue, Shi et al. (2019, 2020a, 2020b) recommended using the locations from which consumers primarily depart for shopping tips as the explanatory factor of online shopping. In the survey, following the recommended method, we captured the departure locations of respondents by asking them: Where do you primarily depart from for your shopping trips?

According to previous studies (e.g., Cao, 2013; Loo & Wang, 2018; Ren & Kwan, 2009), the number of physical stores and the number of bus and metro stations

around departure locations are employed to reflect shopping accessibility and transportation accessibility, respectively. In addition, residential density is also used in the study, because it may potentially influence online shopping. In China, the salary of postmen depends on how many parcels they deliver for consumers. In order to deliver parcels as many as possible, they usually have more willingness to serve consumers in areas with high residential density. Consequently, people living or working in areas with higher residential density can use deliver services more conveniently and efficiently. Meanwhile, they can frequently witness postmen delivering goods and e-shoppers collecting goods, possibly following the trend of online buying (i.e., herd behavior).

In the present study, physical stores, metro stations, bus stations, and residential places in the present study are indicated by the Points of Interest (POI) acquired from map.baidu.com[2] (one of the most-used e-maps in China) in 2017. Since we group products into four categories, data regarding physical stores for the four categories of products were collected, separately (see Table 3). Two points need to be clarified here. First, due to the lack of data availability, the POI only concerning clothing stores is acquired to indicate in-store shopping opportunities for clothes and shoes. Nonetheless, it may not be problematic for two reasons. First, shoes are often available at clothing stores. Second, in urban China, shoe stores are closely tied to clothing stores in geography. This means that shoe stores usually cluster in areas with a high density of clothing stores. Second, the POI regarding supermarkets is used to represent in-store shopping opportunities for food and drinks. In Chinese, the word “supermarket” mostly

[2] The POI data collected from e-maps are commonly used as the indicators of built environment elements in previous studies (e.g., Zhao and Li, 2019; Zhu et al., 2019).

refers to not only a real supermarket where a wide variety of products (including food and drinks) are available but also a convenience/grocery store.

These built environment elements are measured by the number of POI within a buffer distance of 800 m around departure locations, because the maximum travel distance by walking is 800 m for most residents in urban China (Pan et al., 2010). The detailed descriptions of these elements are shown in Table 3. By the way, the residential self-selection issue less likely exists in the present study, because the built environment is captured by departure locations instead of residential locations.

Table 3 around here

Control variables

In addition, two categories of control variables are considered in the modeling process. The first refers to sociodemographic characteristics, including respondents' gender, age, monthly income, and educational attainments. The second is internet experience which is indicated by the number of years using the internet on PCs. Gender is transformed into a dummy variable. Other factors are measured on ordinal scales. The assigned values are shown in Table 1.

Modeling approach

In order to effectively link the built environment and e-shopping frequency, and particularly examine the mediating role of pro-e-shopping attitudes, a Structural Equation Modeling (SEM) approach is applied. As shown in Figure 2, we expect that e-shopping frequency is influenced by pro-e-shopping attitudes. Both pro-e-shopping attitudes and e-shopping frequency could be affected by the built environment, sociodemographics, and internet experience. Meanwhile, internet experience is considered as an endogenous variable that is influenced by sociodemographics. Before

modeling, variance inflation factors (VIF) are calculated for all explanatory variables and control variables to diagnose the problem of multicollinearity. The results show that the maximum of VIF is 2.449 (i.e., lower than 5), suggesting that there is no severe multicollinearity between these variables.

Figure 2 around here

Results

Model fits and normality test

Using Amos 17.0, four initial SEMs are respectively established for four categories of products according to the conceptual framework in Figure 2. Given the sample size (N=675), the maximum likelihood method is used for estimations. In order to improve model fits, we remove all links that are not statistically significant (i.e., p>0.10) from models (e.g., De Vos et al., 2020; Ma & Cao, 2019). The goodness-of-fit of the four final models are shown in Table 4, which indicates that all fit indices fall in the range of reasonable values. This means that these final models fit data well.

Table 4 around here

In addition, the maximum likelihood method requires data to be multivariate normal. We tested the multivariate normality of these final models, and the results show that the critical ratios of models for clothes and shoes, food and drinks, cosmetics, and electronics were 4.54, 6.95, 7.05, and 0.61, respectively. The first three models violate the assumption of the multivariate normality, because their critical ratios are higher than 1.96. In order to handle this issue and assess the significance level, the bootstrapping method is used for estimations of all models (Ma & Cao, 2019). The sample size for bootstrapping is set to 1000, and the percentile method is used to assess the significance

level of direct, indirect, and total effects. The outcomes of final SEMs are displayed in Figure 3.

Figure 3 around here

Sociodemographics and internet experience

The outcomes suggest that sociodemographics are significantly correlated with e-shopping attitudes and frequency. Compared to men, women are more likely to buy clothes, shoes, and cosmetics online. In contrast, for electronics, men purchase online more frequently than women. This is largely consistent with the results of Zhen et al. (2016). This is partly because women usually tend to have higher shopping demands for clothes, shoes, and cosmetics, while men often have higher shopping demands for electronics. With respect to the frequency of e-shopping for food and drinks, there is no significant gender difference.

Age has significant correlations with internet experience, e-shopping attitudes, and e-shopping frequency. Older respondents have a longer history using the internet. In the present study, the respondents are relatively young (see Table 1) because only online shoppers are considered. Therefore, it is reasonable that – among these young respondents – the older they are, the more years they have used the internet. Younger e-shoppers tend to have a positive attitude toward e-shopping, which is in line with the findings of Farag et al. (2007). This may be because they usually show more interests in new products (e.g., e-shopping) (Farag et al., 2006). Meanwhile, older respondents are more likely to purchase clothes and shoes, cosmetics, and electronics via the internet. A possible explanation is that consumers have more shopping responsibilities for families and higher shopping demands for these products with increasing age (Shi et al., 2019).

Higher incomes are positively related to the number of years using the internet. This is an expected finding, because the wealthier people are, the earlier they can afford a PC and internet subscription. In addition, the results show that higher educational levels are positively associated with internet experience and the frequency of e-shopping for clothes and shoes, electronics, and cosmetics. This finding is also in line with the expectations and prior research (e.g., Farag et al., 2006, 2007; Zhen et al., 2018).

Besides, internet experience is positively related to e-shopping attitudes, which means that people having a longer history of using the internet are more likely to have a positive stance toward online purchases. This is a reasonable finding. People who have used the internet for multiple years usually find it easier to search and purchase products online, thus perceiving more convenience of e-shopping. Surprisingly but interestingly, internet is negatively correlated with the frequency of buying clothes and shoes, electronics, and cosmetics online. A possible reason is that people with a longer history of using the internet may have stronger risk consciousness regarding privacy, the quality of products, and payment security, which inhibits them from purchasing frequently online (Shi et al., 2019).

Built environment, e-shopping attitudes, and e-shopping frequency

The analyses show significant correlations between the built environment, e-shopping attitudes, and e-shopping frequency. As expected, a positive e-shopping attitude positively influences the frequency of e-shopping for clothes and shoes, cosmetics, and electronics. This means that people who have a positive attitude toward online shopping tend to purchase them online frequently, which is consistent with the theory of reasoned action and planned behavior.

For clothes and shoes, food and drinks, and cosmetics, a higher residential density has direct and positive effects on online purchase frequency. This may be because – as assumed before – activities regarding e-shopping (e.g., postmen delivering goods, e-shoppers collecting goods) can be more commonly seen in areas with high residential density. Thus, people may be more likely to adopt e-shopping due to herd behavior (i.e., following the trend). However, there is no significant evidence supporting the indirect influence of residential density on e-shopping frequency through e-shopping attitudes. This implies that such herd behavior is not necessarily motivated by a positive attitude toward online shopping.

In addition, higher accessibility to metro stations has direct and negative impacts on pro-e-shopping attitudes. Consequently, it has indirect and negative influence on the frequency of e-shopping for clothes and shoes, cosmetics, and electronics. This implies that people with limited access to metro services tend to have a positive attitude toward online buying and make online purchases more frequently. This finding is in line with previous studies (e.g., Loo & Wang, 2018) and supports the efficiency hypothesis raised by Anderson et al. (2003). The possible explanation is that those with low accessibility to metro services have more difficulties in making shopping trips. In this situation, they may have more liking for online shopping, because they can avoid making shopping trips to save travel time and costs by purchasing online.

Interestingly, the results show that higher accessibility to bus stations has positive effects on online shopping attitudes, thus indirectly and positively impacting online purchase frequency. This means that people with high access to bus services are more likely to have a positive stance toward online shopping, and therefore make frequent online purchases. This finding is counterintuitive and inconsistent with the role of metro services but seems reasonable in the context of Chengdu city. People with

sufficient provision of bus services may be more likely to make shopping trips by bus. Compared to rail-based metro services, road-based bus services usually have a lower level of time reliability (Li et al., 2017). Particularly, Chengdu almost experiences severe congestion every day and everywhere, which may make bus users often suffer from delayed bus services. In addition, due to a high population density, in-vehicle crowding is another problem for bus users in Chengdu. It is quite difficult for them to transport goods in a crowing and unsmooth bus movement. To sum up, consumers may hardly enjoy a bus trip for shopping in Chengdu. They may in turn perceive a high level of conveniences of online buying, thus having a positive e-shopping attitude and purchasing online frequently.

It should be noted that the total effects of accessibility to both metro and bus stations on shopping frequency are relatively weak because their direct effects are not statistically significant. Therefore – as we assumed above – this may be the reason why some studies fail to observe a significant influence of transportation accessibility on e-shopping when they do not consider the mediating role of e-shopping attitudes (e.g., Lee et al., 2017; Etminani-Ghasrodashti & Hamidi, 2020).

Different from transportation accessibility, shopping accessibility (i.e., the number of stores for each category of products) has insignificant direct or indirect effects on online purchase attitudes and frequency. In such a megacity of Chengdu, people may usually make long-distance shopping travel due to a large block size. Consequently, their shopping travel and online shopping behaviors may not mainly depend on shopping opportunities within an 800 m distance but more rely on the accessibility to public transit services.

Overall, the analysis results indicate that the (direct or indirect) effects of residential density and accessibility to public transit stations differ less by types of

products. There is only an exception that residential density has an insignificant influence on the frequency of e-shopping for electronics. A possible explanation is that people usually have a lower demand for electronics (compared to the other three types of products) (see Table 2). Herd behavior generated by a higher residential density can hardly promote their online purchase intentions for these products.

Conclusions and discussion

It is widely acknowledged that online shopping has considerable effects on people's in-store shopping visits and in the long run impacting urban retail landscapes. Studying the influences of built environment on e-shopping can clarify whether/how built environment interventions are useful to manage online shopping, thus moderating travel demand and optimizing urban commercial land use. Using data derived from 675 face-to-face interviews with online shoppers in Chengdu, China and applying a SEM, this paper investigated the effects of the built environment on frequencies of e-shopping for clothes and shoes, food and drinks, cosmetics, and electronics, respectively. The results show that a higher residential density has direct and positive influence on online shopping frequency. Meanwhile, lower accessibility to metro stations or higher accessibility to bus stations has indirect and positive impacts on e-shopping frequency through pro-e-shopping attitudes. The analyses also indicate that the impacts of built environment elements on e-shopping frequency differ less by types of products.

In the present study, we reinforced the causal relationship from the built environment to online buying frequency in two aspects. On the one hand, SEMs for four categories of products yield largely consistent outcomes regarding the effects of the built environment on online shopping frequency. This implies that these effects are highly robust across various types of products. On the other hand, we particularly

545 revealed the mediating role of e-shopping attitudes in the influence of transportation
546 accessibility on online shopping frequency. This provides a possible explanation for the
547 causal direction from the built environment to online shopping, which increases the
548 reliability of the causality.

549 Given the robust causal relationship from the built environment to online
550 shopping, it could be concluded that built environment interventions are valid to
551 manage online shopping frequency. Meanwhile, it is rather evident that online shopping
552 has considerable effects on in-store shopping trips (e.g., Cohen-Blankshtain & Rotem-
553 Mindali, 2016; Etminani-Ghasrodashti & Hamidi, 2020; Shi et al., 2019, 2020a; Xi et
554 al., 2020a, 2020b). Therefore, implementing land use policies to change online purchase
555 frequency becomes a possibility to indirectly moderate urban transportation problems
556 (e.g., congestion) and optimize urban commercial land use. The effectiveness of these
557 policies is expected to grow with the greater use of e-shopping due to the COVID-19
558 crisis. Notably, the development of specific policies depends on whether e-shopping
559 replaces or generates in-store shopping trips. However, as discussed before, this is still a
560 heated debate because there exist conflicting results regarding this issue in current
561 studies.

562 Finally, there is a need to point out a few limitations in the present study. First,
563 respondents in this study were mainly recruited in 10 public spaces of Chengdu, which
564 may lead to a sample selection bias. Second, in order to examine the mediating role of
565 the pro-e-shopping attitude, only e-shoppers are regarded as the target population. For
566 the general population, the influence of the built environment on online shopping
567 frequency might be different from the findings of the present study. Third, although the
568 mediating role of the pro-e-shopping attitude adds value to the interpretation of the
569 effect of the built environment on online shopping, the use of cross-sectional data may

generate uncertainty about the causality. The abovementioned limitations should be considered in future research because they may reduce the generalization of the conclusions of this study.

Disclosure statement

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760

761 Table 1. Basic characteristics of 675 participants

Variables	Description	Frequency	Percentage/%
Gender	Male (Value: 1)	345	51.1
	Female (Value: 0)	330	48.9
Age	20 or younger (Value: 1)	184	27.3
	21-25 (Value: 2)	206	30.5
	26-30 (Value: 3)	156	23.1
	Older than 30 (Value: 4)	129	19.1
Income	1000 or less (Value: 1)	203	30.1
	1001-4000 (Value: 2)	207	30.7
	4001-8000 (Value: 3)	202	29.9
	More than 8000 (Value: 4)	63	9.3
Education	High school or less (Value: 1)	143	21.2
	College/technical school (Value: 2)	119	17.6
	Undergraduate school (Value: 3)	350	51.9
	Graduate school or more (Value: 4)	63	9.3
Years of using the internet on PCs	5 or less (Value: 1)	108	16.0
	6-7 (Value: 2)	162	24.0
	8-9 (Value: 3)	133	19.7
	10-13 (Value: 4)	166	24.6
	More than 13 (Value: 5)	106	15.7
Total		675	100.0

762 Table 2. Monthly frequencies of e-shopping by categories of goods (N=675)

Categories	Mean	S.D.
Clothes & shoes	2.52	2.17
Food & drinks	2.83	3.28
Cosmetics	1.22	1.66
Electronics	0.92	1.31

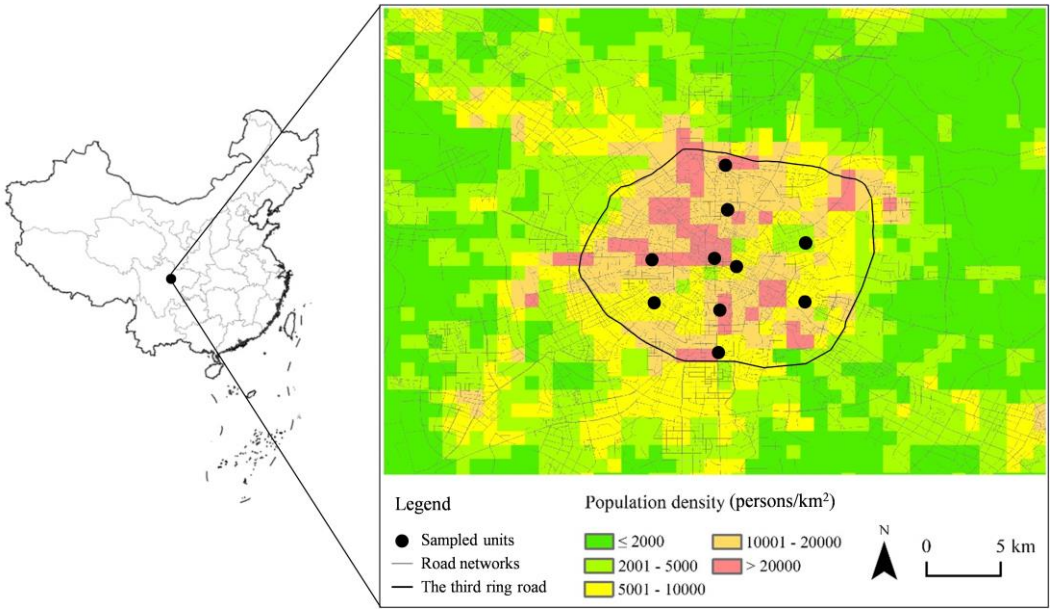
763

764 Table 3. Built environment elements (N=675)

Variables	Descriptions	Mean	S.D.
Accessibility to clothing stores	Number of POI of clothing stores within 800 m radius of departure locations	54.76	91.73
Accessibility to supermarkets	Number of POI of supermarkets within 800 m radius of departure locations	34.90	20.32
Accessibility to cosmetics stores	Number of POI of cosmetics stores within 800 m radius of departure locations	38.81	63.29
Accessibility to electronic stores	Number of POI of electronic stores within 800 m radius of departure locations	30.68	49.23
Accessibility to metro stations	Number of POI of metro stations within 800 m radius of departure locations	0.81	0.10
Accessibility to bus stations	Number of POI of bus stations within 800 m radius of departure locations	13.17	8.73
Residential density	Number of POI of residential places within 800 m radius of departure locations	41.50	30.33

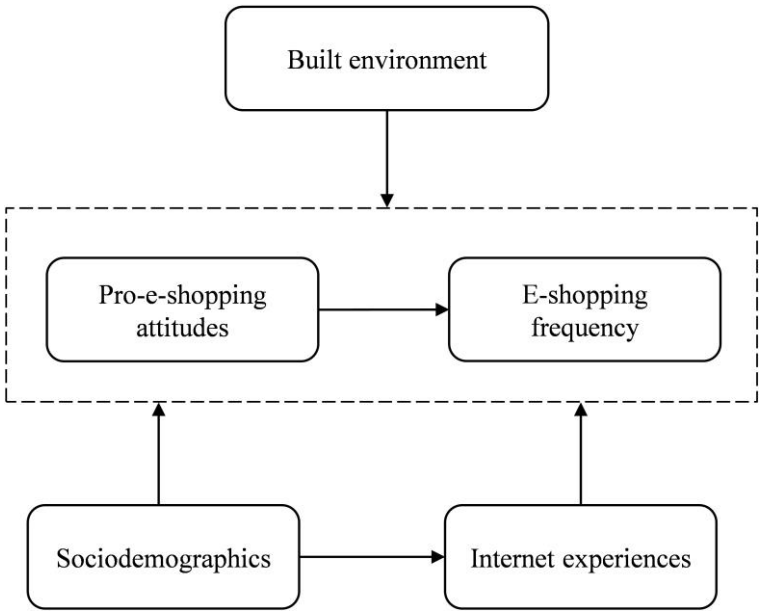
765 Table 4. Goodness-of-fit of four models

Fit indices	Reasonable values	Model for clothes & shoes	Model for food & drinks	Model for cosmetics	Model for electronics
χ^2/df	<2.000	1.122	1.226	1.124	1.107
RMSEA	<0.050	0.013	0.018	0.014	0.013
SRMR	<0.080	0.026	0.029	0.026	0.024
CFI	>0.950	0.997	0.995	0.997	0.998
GFI	>0.900	0.992	0.991	0.992	0.994
AGFI	>0.900	0.982	0.982	0.982	0.984



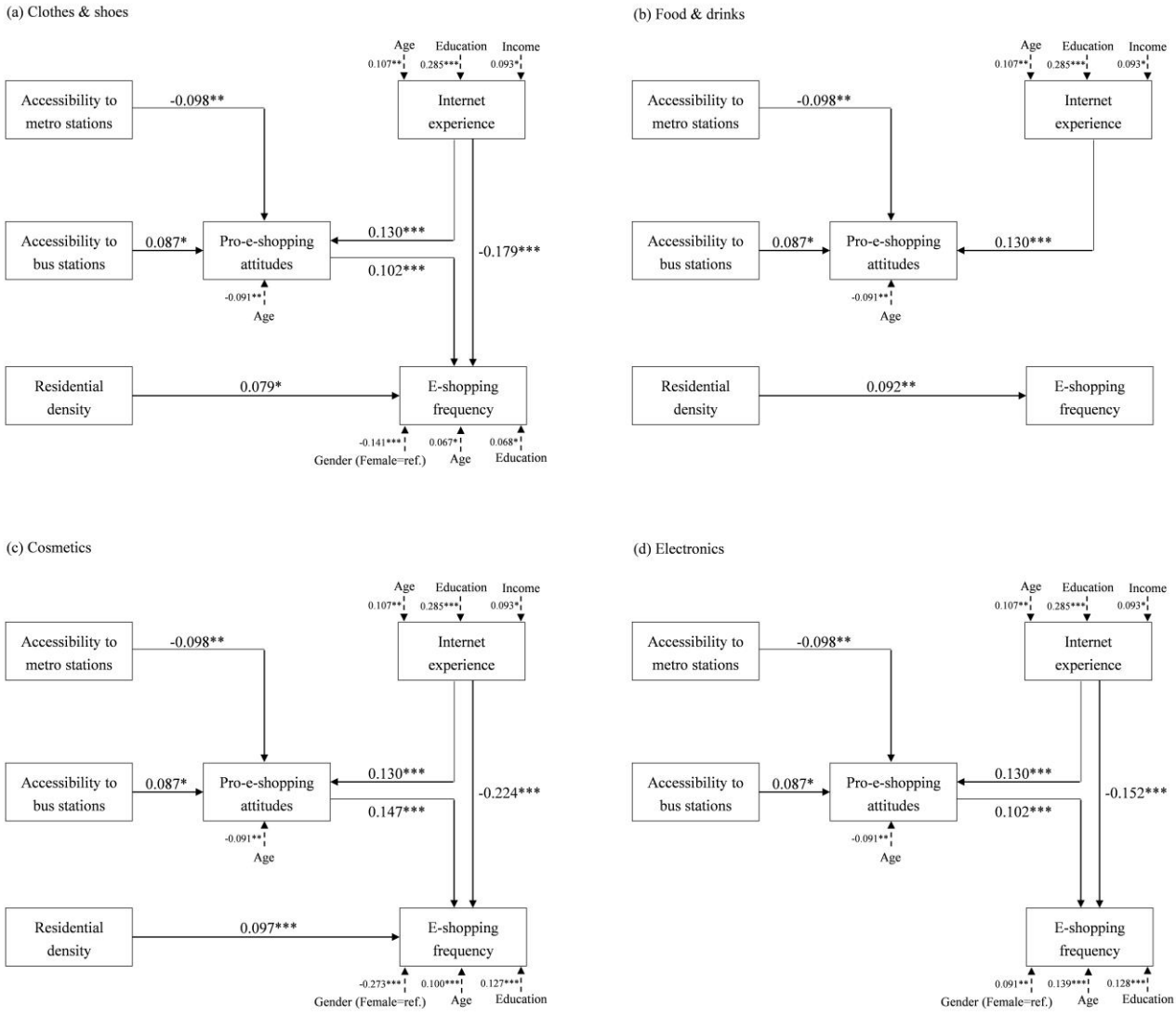
766

767 Figure 1. Locations of Chengdu and sampled sites



768

769 Figure 2. Conceptual framework



Note: "*" p<0.10; "**" p<0.05; "***" p<0.01.

Figure 3. SEM estimation results (standardized direct effects)