Exploring the spatiotemporal impact of e-shopping usage within SuperApps on daily time use

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SHORT SUMMARY

This study investigates the spatiotemporal effects of e-shopping on daily time use, utilizing data collected among Indonesian Transport-SuperApp users as a case study in four Indonesian cities. Using data from a one-week time-use and app-use diaries and a Multiple Discrete-continuous model, the study examines variations across weekends and weekdays and between in-home and out-of-home activities. It explores how the timing of e-shopping (weekday/weekend) influences time use and employs simulations to evaluate the impact of e-shopping. Results confirm the rebound effects of e-shopping, with weekday usage substituting out-of-home maintenance tasks while boosting mandatory and leisure activities. Simulations indicate that increased usage leads to more substantial reductions in out-of-home maintenance activities in smaller cities. It also reshapes time allocation patterns, particularly in larger cities, which experience the most significant decreases in out-of-home activity durations. Overall, e-shopping contributes to a modest rise in total in-home activities, with leisure seeing the most notable growth.

Keywords: e-shopping, broader impact, time-use, mdcev

1. INTRODUCTION

Interest in examining the impacts of e-shopping has been growing across various fields, including economics, environmental studies, geography, and urban planning (Le et al., 2022). This surge in attention stems from the rapid expansion of e-shopping in recent decades, a trend projected to persist, and its transformative effects on land use patterns and transportation systems, particularly through its influence on logistics operations and passenger travel behaviour. Its influence on activity participation arises from the strategic advantages it provides to users. By removing the need for physical presence, e-shopping reduces the requirement for shopping-related travel, creating a substitution effect. At the same time, e-shopping platforms often enhance access to previously unavailable information, fostering new transactions and generating additional journeys that might not have occurred otherwise. Prior research has identified these substitution and generation

effects, shaped by socio-demographic profiles, the built environment, and psychological variables (Cao et al., 2010; Cao, 2009; Shi et al., 2019).

Another key strategic benefit of e-shopping is its ability to save time previously spent on travel for shopping. Additionally, it often offers a cost-effective alternative for acquiring goods/products. Since individuals typically structure their daily routines within a finite time budget (24 hours a day), these benefits carry broader implications. The time and cost savings gained through e-shopping can be redirected towards other activities, contributing to what is commonly referred to as the *rebound effects* of e-shopping. Despite this, many studies examining the impact of e-shopping have overlooked the readjustment of activities it prompts. The limited research exploring these rebound effects has identified e-shopping's role in increasing leisure or maintenance activities (Ding & Lu, 2017; Motte-Baumvol et al., 2023). However, these studies often focus solely on the types of activities (i.e., mandatory, leisure, and maintenance activities), neglecting the spatiotemporal dimensions involved. Firstly, it is logical that individuals allocate their time to various activities tied to spatial locations (i.e., in-home or out-of-home). Secondly, the flexible nature of shopping, which spans through a week (Sugie et al., 2003), contributes to temporal reorganisation across weekdays and weekends. In which patterns of time allocation are correlated between working days and non-working days (Yamamoto & Kitamura, 1999).

To contribute to this discussion, this study investigates the spatiotemporal effects of e-shopping on daily time use, placing particular emphasis on the activities of users within an Indonesian Transport-SuperApp (TSA). It draws on data from a one-week time-use and app-use diary collected in 2022. To explore the spatiotemporal impacts of e-shopping, the study employs a framework that differentiates between weekends and weekdays, as well as in-home and out-of-home activities, using the Multiple Discrete-Continuous (MDC) model. Furthermore, the analysis extends to examine the timing of e-shopping (weekend versus weekday) and includes simulations to evaluate its effects. Data is collected from four Indonesian cities with distinct population sizes, geographic scales, and economic profiles. Based on these residential locations, simulations are also conducted to assess the impact of e-shopping across diverse urban settings.

2. METHODOLOGY

One-week Time-use and App-use Diary

This study draws on data from a cross-dimensional survey conducted in 2022, focusing on smartphone users and their TSA usage behaviour, daily virtual and physical activities, and the influence of mobile app usage on their time-use patterns (Rizki et al., 2024). It utilised two self-reported questionnaires, one of which was a one-week time- and app-use diaries, while the other gathered information on respondents' sociodemographic characteristics, personality traits, TSA usage patterns, and perceptions of residential environments.

The survey was conducted in four Indonesian cities that represent varying populations and infrastructure: Jakarta, the megapolitan capital with over 10 million residents; Bandung, the capital of West Java Province with 2.5 million residents; Denpasar, Bali's tourism hub with 900,000 residents; and Cianjur, a smaller city with 160,000 people. Public transport systems in these cities range from Jakarta's extensive network, including rail and Bus Rapid Transit, to the more limited bus services in Bandung and Denpasar. Paratransit minibuses, known as *angkutan kota*, operate in all four cities. Indonesia's high rate of mobile phone usage has driven the rise of SuperApps such as Gojek and Grab, both launched in 2015. These apps now offer over 15 services each and have millions of active users (29 million and 21 million, respectively, as of 2020).

The one-week time-use and app-use diary was divided into two sections. The time-use diary recorded daily activities, including type, time, duration, and location, as well as travel details like time, mode, and cost. Activities were grouped into mandatory (e.g., work, personal care), maintenance (e.g., shopping, housekeeping), and leisure (e.g., entertainment, socialising). Respondents also classified activities as virtual (ICT-based) or physical, with travel time proportionally assigned to destination activities. The app-use diary tracked mobile app usage, detailing type, time, cost, location, and app name. Activities were similarly categorised into mandatory (e.g., online meetings), maintenance (e.g., e-shopping), and leisure (e.g., gaming). Based on the recorded data, this study summarises the frequency of TSA usage for e-shopping service. This study also collects information on respondents' socio-demographic characteristics, including age, education, gender, occupation, household income, and residential location.

Following a preliminary questionnaire survey in April 2022, the final survey ran from mid-May 2022 to mid-January 2023 using paper and online formats. Convenience sampling targeted individuals aged 18+ with app experience. Of 3,092 respondents approached, 1,193 respondents provided valid data. From this data set, this study only focuses on 661 TSA users who used e-shopping and 200 non-TSA users as a control group (N=861).

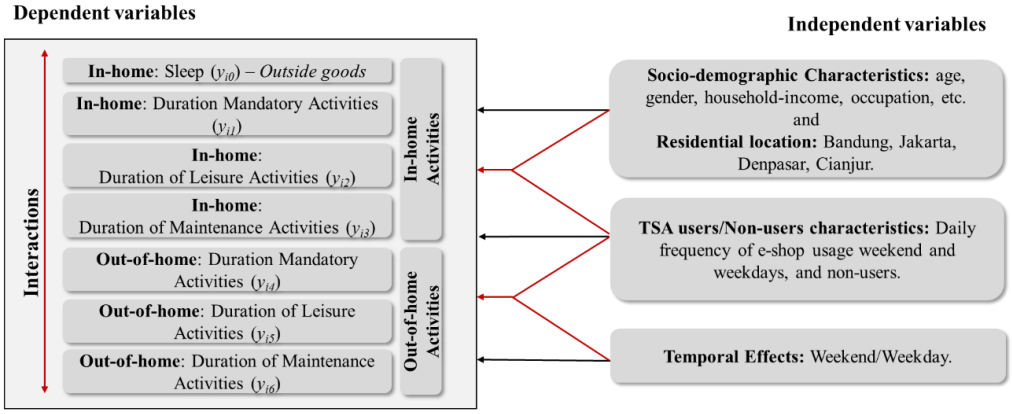

Figure 1: Modelling Framework

Multiple Discrete-Continuous Model

To analyse the impact of e-shopping on daily time use, this study employs the Multiple Discrete-Continuous Extreme Value (MDCEV) model (Bhat, 2008). The model assumes that individuals derive utility from allocating resources (time) across different activities (y), constrained by a total time budget (B) and subject to diminishing marginal returns (satiation effects/γ) for each activity-k. The time allocation is modelled as an interaction between activities and influenced by e-shopping usage and other independent variables. It uses the random utility maximisation process where it can be formulated as follows:

$$\underset{y_k \forall k}{\text{Max}} \sum_{k=1}^{K} \frac{\gamma_k}{\alpha_k} \psi_k \left(\left(\frac{y_k}{\gamma_k} + 1 \right)^{\alpha_k} - 1 \right), subject\ to \sum_{k=1}^{K} y_k = B, and\ \psi_k = \exp(V_k + \varepsilon_k) \quad (1)$$

Where K is the number of activities, y_k is the amount of time allocated for activity k, and B is the total time budget available a day (24 hours). Moreover ψ_k represents the baseline marginal utility consists of V_k as each alternative's baseline utility (i.e. its marginal utility at zero consumption) and ε_k is an independent and identically distributed random disturbance following a Gumbel.

V_k consist of independent variables *(β)* of socio-demographic characteristics, residential location, e-shopping usage, non-users, and temporal effects (e.g., weekdays or weekends). To delve deeper into the spatiotemporal impacts of e-shopping, the model allows interactions between e-shopping usage and both residential location and day type (weekday or weekend). Additionally, e-shopping usage segmented by weekday or weekend is included as an independent variable. The modelling framework is summarised in **Figure 1**. Model estimation using the Apollo package (Hess & Palma, 2019) in R programming, considering generic α_k, satiation parameters γ_k, alternative specific variables *β,* and assumed time duration for sleeping y_0 as outside good (base alternative).

3. RESULTS AND DISCUSSION

Respondents' Statistics

The respondents' statistics (N = 861) reveal that most participants were male (54%), employed (70%), and held undergraduate degrees (56%), with 41% from middle-income households (IDR3-8 million). The sample overrepresented individuals aged 20–34 and underrepresented those over 50 compared to the population demographics of the four cities, which were fairly distributed: Jakarta (31%), Bandung (27%), Denpasar (26%), and Cianjur (16%). E-shopping accounted for over 80% of shop and delivery TSA usage, with in-home usage averaging more than double that of out-of-home but remaining below one usage per day, indicating non-daily usage. In-home usage peaked on Wednesdays (0.50) and Thursdays (0.48), while out-of-home usage was highest on Tuesdays (0.20) and Mondays (0.19). On weekdays, both TSA users and non-users predominantly engaged in at-home mandatory activities, with out-of-home maintenance activities, such as shopping, taking the least time, likely deferred to weekends for larger purchases and leisure. Statistically significant differences in time allocation show that TSA users spent more time on in-home mandatory activities, whereas non-users dedicated more time to in-home maintenance and out-of-home mandatory and maintenance activities.

Impact of E-shopping on Daily Time Use Model

Table 1 presents the results of the MDCEV model analysing the impact of e-shopping on daily time use. Higher levels of mandatory out-of-home activities are associated with males and workers, whereas females and older users are linked to higher maintenance activities. In terms of urban areas, respondents from Cianjur tend to engage in fewer out-of-home activities, particularly mandatory and leisure activities. Conversely, respondents from Jakarta display higher levels of out-of-home mandatory activities, while those from Bandung show increased engagement in out-of-home leisure and maintenance activities. Regarding temporal effects, weekends are associated with shorter durations of mandatory activities and longer durations of out-of-home maintenance activities. E-shopping via TSA is linked to reduced out-of-home activities, whereas non-users are more likely to engage in out-of-home maintenance activities, suggesting a substitution effect. Weekday e-shopping usage appears to substitute for maintenance tasks while increasing out-of-home mandatory and leisure activities.

Interactions between e-shopping usage, residential location, and days (weekdays and weekends) significantly influence time allocation. In larger cities such as Bandung and Jakarta, higher weekday e-shopping usage is associated with increased out-of-home maintenance activities, indicating a generation effect. Interestingly, weekend e-shopping usage in Jakarta is linked to higher levels of out-of-home mandatory and leisure activities. These findings suggest the role of urban characteristics on the impact of e-shopping usage. Cross-day influences are also evident, supporting the

interplay between weekday and weekend time allocation (Yamamoto & Kitamura, 1999) where e-shopping usage triggers the time-use reallocation across days. Greater weekday e-shopping usage tends to reduce out-of-home maintenance activities on weekends, while higher weekend usage is associated with reduced out-of-home maintenance activities on weekdays.

Table 1: Impact of E-shopping on Daily Time-Use Model

Variables	In-home		
	Mandatory	**Leisure**	**Maintenance**
Base constant *(α)*	-22.615 **		
Alternative specific variables *(β)*			
Constant	1.583 **	0.416 **	-0.873 **
Socio-demography			
Male (ref.: female)	0.141 **	0.094 **	-0.678 **
Age (ref.: > 50 years old)			
< 20 years old [D]			-0.927 **
20 - 34 years old [D]		-0.275 **	-0.279 **
35 - 49 years old [D]		-0.237 **	
Occupation (ref.: non-workers)			
Workers [D]		-0.238 **	-0.415 **
Students [D]			
Household income (ref.: low income)			
Mid income [D]			
High income [D]			0.199 **
Residential location (ref.: Cianjur)			
Jakarta [D]		0.274 **	-0.329 **
Bandung [D]		0.508 **	-0.699 **
Denpasar [D]	-0.214 *	0.436 **	0.243 **
Temporal effects			
Weekend (ref.: weekday)	-0.055 **	0.075 *	
E-shopping usage			
Average daily e-shopping usage	-0.068 *		
Average weekday e-shopping usage			
Average weekend e-shopping usage			
Non-users		-0.197 **	
Interactions of e-shopping usage			
Average daily e-shopping usage x Jakarta			
Average daily e-shopping usage x Bandung	-0.115 **	-0.15 **	
Average daily e-shopping usage x Denpasar			
Average weekday e-shopping usage x weekend	-0.019 **	-0.058 **	
Average weekend e-shopping usage x weekday			
Average weekday e-shopping usage x Jakarta			
Average weekend e-shopping usage x Jakarta	0.118 *		
Average weekday e-shopping usage x Bandung			
Average weekend e-shopping usage x Bandung	0.116 *		
Average weekday e-shopping usage x Denpasar	-0.282 **	-0.198 **	
Average weekend e-shopping usage x Denpasar	0.299 *		
Satiation *(γ)*	0.059 **	0.337 **	0.898 **

Variables	Out-of-home		
	Mandatory	**Leisure**	**Maintenance**
Alternative specific variables *(β)*			
Constant	-3.687 **	-3.575 **	-3.255 **
Socio-demography			
Male (ref.: female)		0.233 **	-0.271 **
Age (ref.: > 50 years old)			
< 20 years old [D]	0.716 **	0.588 **	
20 - 34 years old [D]	0.457 **		
35 - 49 years old [D]	0.431 **		
Occupation (ref.: non-workers)			
Workers [D]	1.19 **	0.583 **	
Students [D]			
Household income (ref.: High income)			
Mid income [D]	0.279 **	0.274 **	
High income [D]	0.273 **	0.23 **	
Residential location (ref.: Cianjur)			
Jakarta [D]	0.335 **	0.772 **	
Bandung [D]	0.333 **	0.84 **	0.644 **
Denpasar [D]	0.308 **	0.666 **	0.314 *
Temporal effect			
Weekend	-0.484 **		0.129 *
E-shopping usage			
Average daily e-shopping usage	-0.225 **		-0.221 *
Average weekday e-shopping usage	0.099 **	0.081 **	-0.123 **
Average weekend e-shopping usage		-0.239 **	
Non-users	0.172 **	0.257 **	0.314 **
Interactions of e-shopping usage			
Average daily e-shopping usage x Jakarta			
Average daily e-shopping usage x Bandung		-0.229 *	
Average daily e-shopping usage x Denpasar			
Average weekday e-shopping usage x weekend			-0.081 **
Average weekend e-shopping usage x weekday		0.121 **	-0.137 **
Average weekday e-shopping usage x Jakarta	-0.16 **	-0.163 **	0.242 **
Average weekend e-shopping usage x Jakarta	0.233 **	0.301 **	
Average weekday e-shopping usage x Bandung	-0.161 **	-0.141 **	0.219 **
Average weekend e-shopping usage x Bandung			
Average weekday e-shopping usage x Denpasar	-0.126 *		
Average weekend e-shopping usage x Denpasar			
Satiation *(γ)*	3.403 **	1.042 **	0.566 **
LL Start; LL Final; AIC; BIC	-92063; -70564; 141434; 142460		

[D]: dummy variables; ** sig at 5%; * sig at 10%.

Table 2: Impact of Weekday and Weekend E-Shopping Simulations*

Changes	Variables	In-home			Out-of-home			Total IH	Total OH
		Mandatory	Leisure	Maintenance	Mandatory	Leisure	Maintenance		
Changing of E-shopping Usage Based on Weekend and Weekdays									
+10%WD	Weekday	-0.39%	+0.30%	+0.05%	-0.13%	-0.59%	+2.00%	+0.03%	-0.10%
+20%WD		-1.24%	+0.95%	+0.13%	-0.38%	-1.81%	+6.94%	+0.06%	-0.22%
+10%WK		-2.18%	+2.23%	-0.05%	-1.04%	-3.60%	+17.53%	+0.10%	-0.36%
+20%WK		-0.79%	+2.65%	-0.48%	-1.91%	-3.08%	+16.68%	+0.23%	-0.86%
+10%WD	Weekend	-0.45%	-0.53%	+0.36%	+0.11%	+0.37%	+0.31%	-0.05%	+0.22%
+20%WD		-1.43%	-1.69%	+1.12%	+0.41%	+1.24%	+1.16%	-0.16%	+0.76%
+10%WK		-2.69%	-3.22%	+2.05%	+1.02%	+2.14%	+3.99%	-0.36%	+1.69%
+20%WK		-1.62%	-2.09%	+1.34%	+0.84%	+0.44%	+5.89%	-0.26%	+1.21%
Changing of E-shopping Usage Based on City									
+10%WD	Jakarta	-0.30%	+0.53%	+0.44%	-1.41%	-1.67%	+4.54%	+0.30%	-1.14%
+20%WD		-1.00%	+1.66%	+1.36%	-4.46%	-5.25%	+15.54%	+0.93%	-3.53%
+10%WK		-1.69%	+3.92%	+1.98%	-9.30%	-10.36%	+39.83%	+1.77%	-6.75%
+20%WK		-0.24%	+4.62%	+0.15%	-8.24%	-8.18%	+41.01%	+1.41%	-5.36%
+10%WD	Bandung	-0.44%	+0.64%	-0.06%	-1.69%	-1.40%	+3.81%	+0.12%	-0.73%
+20%WD		-1.45%	+2.00%	-0.26%	-5.27%	-4.36%	+12.96%	+0.34%	-2.08%
+10%WK		-2.17%	+4.84%	-1.45%	-12.44%	-9.91%	+31.89%	+0.75%	-4.59%
+20%WK		+0.50%	+6.00%	-2.96%	-14.97%	-11.29%	+30.74%	+1.07%	-6.53%
+10%WD	Denpasar	-1.80%	-1.32%	+0.96%	+0.58%	+0.54%	+0.56%	-0.13%	+0.57%
+20%WD		-5.52%	-4.14%	+3.01%	+1.76%	+1.65%	+1.74%	-0.39%	+1.72%
+10%WK		-9.61%	-8.38%	+6.18%	+1.93%	+2.82%	+2.48%	-0.51%	+2.24%
+20%WK		-5.35%	-7.14%	+5.46%	+-1.63%	+1.70%	-0.02%	+0.11%	-0.49%
+10%WD	Cianjur	-0.36%	-0.52%	-0.41%	+2.30%	+2.17%	-3.01%	-0.39%	+1.97%
+20%WD		-1.18%	-1.69%	-1.36%	+7.55%	+7.14%	-9.07%	-1.28%	+6.51%
+10%WK		-2.52%	-3.68%	-3.01%	+16.50%	+15.14%	-17.76%	-2.80%	+14.25%
+20%WK		-1.89%	-3.27%	-2.51%	+14.06%	+11.84%	-16.17%	-2.33%	+11.86%

*Compared to baseline; WD: average weekday e-shopping change; WK average weekend e-shopping change; IH: In-home; OH: Out-of-home

Furthermore, to analyse the impact of e-shopping on daily durations of activities, simulations were conducted based on changes in e-shopping usage (considering when they performed it, weekday/WD and weekend/WK), with the results outlined in **Table 2**. The impact of increased e-shopping usage is found to differ across weekend and weekdays. While weekday out-of-home activities see a modest decline, weekends experience a compensatory increase in certain categories, suggesting that the flexibility of e-shopping usage might influence urban mobility trends. The increase in out-of-home maintenance activities is most prominent during weekends (0.2to1.7%), whereas in-home leisure activities rise modestly on weekdays (0.3to2.7%), reflecting the growing integration of digital consumption to maximise daily routines. On the other hand, out-of-home leisure activities (0.4to0.21%) increase during weekend due to more frequent e-shopping usage. Strategically, these shifts highlight a reorganisation of activity patterns, with e-shopping adoption driving a notable redistribution of maintenance and leisure activities.

Regionally, larger cities with well-established urban infrastructure and a high reliance on digital solutions (Jakarta and Bandung), demonstrate the greatest reductions in out-of-home activities (-0.7to-6.7%), showcasing higher e-shopping adoption rates and urban reliance on digital solutions. Conversely, smaller urban centres like Cianjur show higher substitution effects on in-store shopping durations (-3to-17.8%). The increase in out-of-home maintenance activities is most prominent in Jakarta, where a 20% increase in weekday e-shopping usage results in an increase of 15.5% durations, suggesting the generation effects are higher in bigger cities. Notably, as residents in mid-sized cities with moderate urban development increasingly adopt e-shopping, its impact on driving in-store shopping activities diminishes, indicating that over time, e-shopping may gradually replace traditional in-store shopping behaviours.

CONCLUSIONS

The analysis offers contributions by investigating the rebound effects of e-shopping on time use, integrating spatial (in-home and out-of-home activities) and temporal (weekend and weekday) dimensions, and examining the timing of e-shopping usage. Specifically, it highlights the transformative impact of e-shopping on daily time allocation and activity patterns, driven by urban characteristics, demographic factors, and temporal dynamics. E-shopping adoption reveals a substitution effect, reducing out-of-home maintenance activities while increasing in-home activities, particularly on weekdays. Bigger urban areas such as Jakarta and Bandung demonstrate pronounced shifts, with e-shopping reducing out-of-home engagements and integrating digital consumption into daily routines. This analysis underscores the dual role of e-shopping in fostering home-centric behaviours on weekdays and potentially triggering increased out-of-home activities on weekends, offering a nuanced understanding of its spatial and temporal impacts on time use.

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