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The use of e-commerce and the COVID-19 outbreak: A panel data analysis in Japan

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ABSTRACT

This study analyzes the changes in Japanese consumers' psychological intentions toward the use of e-commerce and the corresponding reasons before and after the COVID-19 outbreak using panel data. Several insights emerge on changes in consumers' fundamental behaviors. First, the share of e-commerce use differs across the types of goods. Grocery goods showed a significant increase immediately after the COVID-19 outbreak. In contrast, machinery/PC applications and book/DVD/software showed only a slight increase immediately after the outbreak. However, only a slight decrease was observed during the third survey. Overall, consumers recognized the importance of e-commerce immediately after the pandemic, with no subsequent significant decline. Second, there may be a positive relationship between the time spent at home and the importance of e-commerce One reason is that an increase in stay-at-home duration decreases the opportunity to shop at retail stores. Consequently, trips to stores decreased during the initial spread of COVID-19. The modes of transportation for shopping and in the living area (infection status) were not significant factors of e-commerce usage. Finally, if consumers recognize its usefulness, they continued to consider e-commerce as important. However, their attitudes toward e-commerce improved after the COVID-19 outbreak because they wanted to avoid infection risks and follow social distancing and safety protocols.

1. Introduction

In Japan, COVID-19 began to spread in January 2020. As shown in Fig. 1, the first infection case was identified on January 16, 2020. As of July 2021, Japan had experienced rapid outbreaks four times (April–May 2020, July–August 2020, November 2020–February 2021, and April–June 2021). In the first event, a maximum of 720 cases per day were identified throughout Japan, and the first state of emergency (SOE) was declared from April 7, 2020, until May 25, 2020. During this declaration, teleworking, online classes, and refraining from out-of-home trips, among others, were strongly requested by the government without any corresponding legal challenges, which was different from most foreign countries. For example, there was a decrease in approximately 85% of people near Tokyo station in April–May 2020, measured annually (Agoop Corp, 2021), while the volume of parcel deliveries increased by 11.6% annually in the fiscal year 2020 (MLIT, 2021). The second and third outbreaks were more serious, with a maximum of 1605 and 7882 cases per day, respectively. During these periods, the number of people near Tokyo station decreased by approximately 50%, and 40%, respectively (Agoop Corp, 2021).

The COVID-19 outbreak also caused major changes in the values and lifestyles of people, such as a decrease in outdoor trips. A significant drop in activity levels in Tokyo, especially for leisure activities and eating out, was observed (Parady et al., 2020). Regarding consumers' shopping behavior in Japan, many consumers utilized e-commerce instead of physical stores. In June 2020, e-commerce usage in the country increased by 10.8% (JADMA, 2020), while retail sales decreased by 13.4% annually (MEXT, 2020b). Suppose e-commerce becomes the "new-normal" shopping mode, the number of physical retail stores will eventually decrease. Additionally, the penetration ratio of teleworking has drastically increased than before COVID-19: 67.3% of Japan-based companies enforced teleworking in June 2020 when the first SOE was declared (MHLW, 2020). During that time, most universities in Japan were closed to students, who were then forced to take online classes from home. These students are one of the main contributors to e-commerce (METI, 2020a). Suppose telework and online classes continue in

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the post-corona era, trips to physical retail stores will further decrease. The continuous use of e-commerce triggered by the COVID-19 outbreak would significantly affect future transport and logistics planning. The shift from physical stores to e-commerce will decrease shopping trips. In contrast, logistics-related trips such as deliveries would significantly increase, requiring changes in logistics policies such as warehouses and logistics center planning, and truck driver shortage issues, among others. Thus, it is necessary to understand the attitude toward e-commerce, which significantly affects transport and logistics-related trips. Nevertheless, such change in shopping behavior, including choosing between e-commerce and retail stores, would differ in terms of geographical characteristics such as city size, population density, and consumer attributes such as age and income. The continuation of e-commerce usage in the post-corona era could change urban planning, including transportation planning. According to the Nationwide Person Trip Survey of Japan in 2015, shopping-related trips account for approximately 15% of the total number of trips. Thus, a shift in shopping behavior towards e-commerce would be a significant factor influencing transport policies. The intentions toward the use of e-commerce differ among individuals and change over time. The COVID-19 pandemic has changed people's lifestyles (e.g., stay-at-home duration and shopping behavior) and psychological state (e.g., intention towards the use of e-commerce) immediately after the pandemic. Some lifestyle and psychological states may not revert to their pre-pandemic state. Thus, it is important to understand the reasons for using e-commerce by individuals, grouped by chronological changes in the intention to use e-commerce in multiple periods.

Several studies regarding e-commerce, shopping behavior, and COVID-19 have focused on the experiences of several countries. During the pandemic in the United States, a 65% growth in online grocery shopping along with a significant increase in teleworking was observed (Shamshiripour et al., 2020). Consumers were less willing to shop at physical grocery stores in situations where COVID-19 was spreading (Grashuis et al., 2020). In Italy, people who had access to online food channels shifted from shopping at supermarkets to shopping online for food. Thus, people's frequency of trips to physical stores significantly dropped (Alaimo et al., 2020). In Istanbul, online shopping significantly increased after the virus outbreak, especially among female users (Shakibaei et al., 2021). Eger et al. (2021) found that fear of infection was the main reason for starting e-commerce in the Czech Republic. In China, the COVID-19 outbreak increased the possibility of consumers purchasing food online, especially young people (Gao et al., 2020).

The pandemic has affected consumers and retailers worldwide (Feng and Fay, 2020). For example, Beck and Hensher (2020) observed that online grocery shopping increased because of the COVID-19 outbreak in Australia. However, older households were less likely to use it. Fresh food e-commerce channels are more likely to be associated with panic stockpile behaviors because of the higher likelihood of supply shortages than offline channels in some cases in China (Hao et al., 2020). Bhatti et al. (2020) stated that e-commerce had become a substitute for retail stores. Hashem (2020) found that COVID-19 positively influenced customer behavior, along with its adopted variables (such as frequency, necessity, payment method, price, and availability of product/service) by increasing the tendency of e-shopping. Laato et al. (2020) identified unusual purchasing behavior during the early stages of the COVID-19 pandemic, implying that consumer behavior changed before and after the pandemic. Akhtar et al. (2020) identified a significant relationship between COVID-19 restrictions and consumers' psychological reactions toward offline shopping freedom restoration. Friesen (2020) discussed safety issues at grocery stores, as grocery shopping remains a necessity during this pandemic. Meanwhile, several studies discussed COVID-19's impact on the supply side of logistics. Loske (2020) examined COVID-19's impact on German food retail logistics and found that transport volume did not depend on the pandemic but individual preferences. Grida et al. (2020) showed that the impact of COVID-19 prevention policies on the supply chain could be accurately evaluated. Tran (2021) extended research on the perceived effectiveness of e-commerce platforms during the COVID-19 pandemic.

However, based on our literature survey and using panel data collected in multiple periods after the COVID-19 outbreak in Japan, no study has traced the chronological changes in the psychological intention to select e-commerce or retail stores. Furthermore, no study has identified the differences between consumer groups, such as the increase or decrease in the intention to use e-commerce. This study aims to reveal the chronological changes in the psychological intentions of consumers' behavior to use e-commerce before and after COVID-19 and the corresponding reasons for lifestyle changes, such as the expansion of telework that has extended the stay-at-home duration. As the psychological state of consumers is constantly changing due to the pandemic situation and new knowledge regarding the COVID-19, we collected panel data of Japanese consumers to trace psychological changes towards e-commerce over three periods: before the COVID-19 pandemic, during the first spread of the COVID-19 (May 2020), and during the second spread of the COVID-19 (September 2020). Notably, in the second period, the

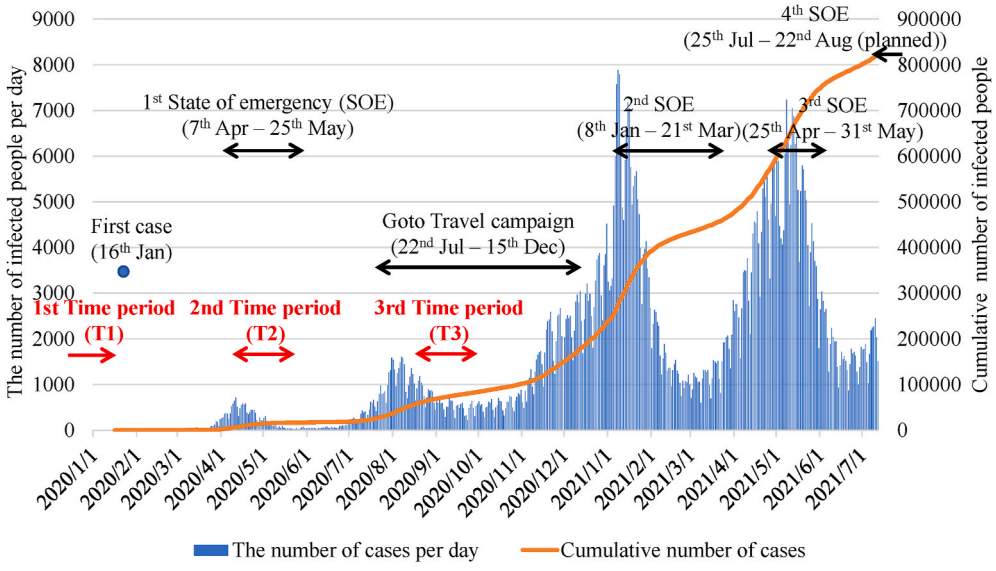

Fig. 1. Survey period, number of cases, and main events in Japan (as of July 13, 2021).
(Source: NHK, 2021)

SOE was declared in Japan. The collected panel data were analyzed using descriptive statistics and hypothesis tests.

The remainder of this paper proceeds as follows. In Section 2, we present an overview of the questionnaire as a panel survey and describe the demographic characteristics of the samples. In Section 3, we use a descriptive analysis of the panel data to examine consumers' fundamental attitudes and behaviors toward e-commerce and chronological and geographical changes in their lifestyles. In Section 4, psychological and chronological changes toward e-commerce are further analyzed using statistical tests. In particular, the recognition of the importance of e-commerce was traced. Finally, in Section 5, we present the conclusions of this study and discuss directions for further research.

2. Questionnaire survey

A questionnaire survey was conducted to collect data on the chronological changes in e-commerce usage in Japan. Note that this study addresses only business-to-consumer (B to C) online shopping. Consumer-to-consumer (C to C) online shopping, including online flea markets and food delivery services, were excluded. Consumers' attitudes in Japan likely changed due to the COVID-19 outbreak as people were requested to stay at home for non-essential reasons, and telework was encouraged by the government without any legal enforcement, unlike many other countries. As shown in Fig. 1, we collected panel data in three periods: before the COVID-19 outbreak (T1), during the first spread of COVID-19 (May 2020; T2), and during the second spread of COVID-19 (September 2020; T3).

In the questionnaire, we asked respondents to describe their psychological and behavioral states over the three periods. For T1, before COVID-19 (i.e., before January 15, 2020), respondents were requested to describe their attitudes by recalling their behavior and psychological states compared to their states at T2 and T3. By comparing multiple periods for each question, respondents could recall their behavior and psychological states precisely and easily. During the second period, the first SOE was declared in seven seriously infected prefectures (i.e., Tokyo, Kanagawa, Saitama, Chiba, Osaka, Hyogo, and Fukuoka) on April 7, 2020. Several restrictions were implemented: stay-at-home requests for non-essential reasons, school closure, and restrictions on visiting places with large crowds, which were likely to reduce stepping out of their homes. During this period, the telework implementation rate increased from 20.2% in July 2019 to 31.5% in May 2020 (JPC, 2020). Online classes were implemented in Japanese universities; 91% of national universities conducted only online classes, and 9% offered a combination of online and face-to-face classes (MEXT, 2020b). No university had a face-to-face class in May 2020. In Tokyo, restaurants providing alcohol were requested to close by 8 p.m., and the national government compensated some part of their sales. During this period, the passenger traffic near the Tokyo station decreased by approximately 85% (Agoop Corp, 2021), while the number of parcel deliveries increased by 12.4% annually in April–May 2020 in Japan (MLIT, 2021). The target prefectures of the SOE were expanded nationwide on April 16, 2020. On May 25, 2020, the first emergency restrictions were lifted nationwide.

The third period was in September 2020, after the relaxation of movement restrictions between the prefectures on June 19, 2020. In this period, people near Tokyo station decreased by approximately 45% annually (Agoop Corp, 2021). Furthermore, the telework implementation rate dropped to 18.9% (JPC, 2020). Online-only classes were gradually changed to the combined use of online and face-to-face classes. In the second semester (i.e., from September 2020 to March 2021), 96.5% of national universities adopted the combination of online and face-to-face classes (MEXT, 2020b). During this period, the 'GoTo Travel' campaign was first promoted by the Japanese government. This campaign offered 35% discounts and coupons worth 15% of the total travel expenses spent within Japan. This campaign was suspended on December 15, 2020, due to the third outbreak of COVID-19 towards the end of 2020. Another campaign, the 'GoTo Eat' campaign, was started on October 1, 2020, to encourage people to dine out by offering discounts (or savings) up to 25% of total costs. This campaign was also suspended in prefectures with serious infection situations.

An overview of the questionnaire survey is presented in Table 1, and all the questions are presented in the Appendix. The questionnaire survey was conducted with monitors registered at a survey company on November 4 and 5, 2020. Respondents were evenly stratified based on age (i.e., 20s and less, 30s, 40s, 50s, and more than 60s) as possibly influential attributes for shopping behavior. The sample included students as they are also e-commerce users. Questions on the actual shopping behavior (e.g., frequency of e-commerce and retail stores usage, among others), respondents' lifestyle (e.g., stay at home duration), and geographical situations (e.g., distance to the most frequently used retail store) were asked. Psychological and chronological changes in the importance of e-commerce were evaluated using a five-point Likert scale for each period. Finally, the samples were collected from 2680 monitors, and all the data were found to be valid.

Table 2 shows demographic characteristics, such as age, gender, occupation, income, and living area. The sample size of each age group was equally stratified so that age bias was eliminated and differences between generations were identified. In general, we postulate that younger generations use e-commerce more. Regarding gender, although we did not control the sample size according to this attribute, males and females were almost evenly distributed. The most common occupation was worker at 66% of the sample, including company employees and public servants. The income distribution almost matches Japan's population; the average income of Japan was 4.4 million JPY in 2018 (NTA, 2019). The distribution across living areas was almost identical to the actual population share of each living area.

3. Descriptive analysis

Descriptive analysis was conducted to understand chronological changes in fundamental aspects such as consumer behavior and psychological intention toward e-commerce and real stores and the corresponding effects due to the COVID-19 outbreak.

3.1. Stay-at-home duration

The Japanese government requested stay-at-home and promotion of telework due to the spread of COVID-19. This request became particularly stronger during the SOE, even though there was no legal penalty for going out. A longer stay-at-home duration meant more opportunities to use e-commerce (i.e., less opportunity to visit retail stores). Fig. 2 shows the stay-at-home duration per week for each period. Note that the respondents provided these data by recalling a normal week in each period. The frequency of categories of stay-at-home duration between

Table 1
Overview of the questionnaire survey.

Items	Contents
Survey period	November 4 and 5, 2020
Target respondents	- 2680 monitors of the survey company - Equal sample number across age groups (20s or less, 30s, 40s, 50s, and more than 60) groups
Method	- Distributed to 2680 monitors on the survey company's website - Answered on the website
Main survey contents	- Frequency of shopping at real retail stores and e-commerce - Lifestyle before and after (with) COVID-19 (e.g., stay-at-home duration, frequency of shopping trips, etc.) - Psychological changes towards the use of e-commerce - These questions were asked for three periods (before COVID-19, immediate after COVID-19 (May), and after COVID-19 (September))
Valid answers	2680 samples (100%)

Table 2
Demographic characteristics of the collected sample.

Item	Category	Sample size	Share
Age	15–29	536	20.0%
	30–39	536	20.0%
	40–49	536	20.0%
	50–59	536	20.0%
	>60	536	20.0%
Gender	Male	1243	46.4%
	Female	1437	53.6%
Occupation	Worker	1776	66.3%
	Homemaker	418	15.6%
	Student	135	5.0%
	Others	351	13.1%
Income 10,000 JPY (1 USD = 109 JPY)	<200	192	7.2%
	200–400	495	18.5%
	400–600	539	20.1%
	600–800	351	13.1%
	800–1000	202	7.5%
	>1000	217	8.1%
	No answer	684	25.5%
Living area	Hokkaido	135	5.0%
	Tohoku (e.g., Sendai, etc.)	149	5.6%
	Kanto (e.g., Tokyo, Yokohama, etc.)	1027	38.3%
	Chubu (e.g., Nagoya, etc.)	490	18.3%
	Kinki (e.g., Osaka, Kobe, etc.)	452	16.9%
	Chugoku (e.g., Hiroshima, etc.)	145	5.4%
	Shikoku (e.g., Matsuyama, etc.)	53	2.0%
	Kyushu (e.g., Fukuoka, etc.)	229	8.5%

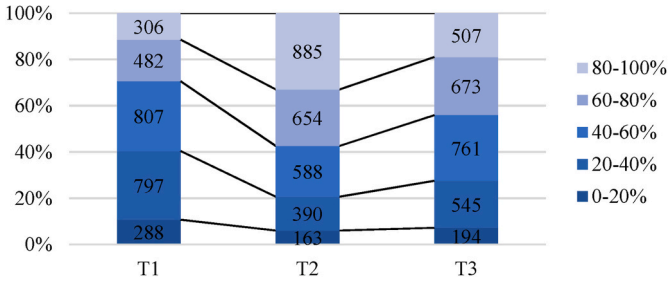

Fig. 2. Share of the stay-at-home duration in a week for each period.

periods was tested using the goodness-of-fit test. All combinations of periods, including the combination of T1 and T3, had differences in terms of frequency of categories at the 1% significance level. For T1 to T2, the frequency of longer duration at home (i.e., 80%–100% and 60–80%) increased from 788 to 1539, while shorter frequencies (i.e., 20%–40% and 0–20%) decreased from 1085 to 553. For T2 to T3, the frequency of longer duration (i.e., 80%–100%) decreased from 885 to 507, while shorter frequencies (i.e., 40%–60%, 20%–40%, and 0–20%) decreased from 553 to 739. These changes are expected because the first SOE had already been lifted, and requests for refraining from moving between the prefectures were relaxed during T3. However, from T1 to T3, the frequency of longer stay-at-home duration (i.e., 80%–100% and 60%–80%) increased from 788 to 1180, while shorter durations (i.e., 20%–40% and 0–20%) decreased from 1085 to 739. This means that respondents' lifestyle, refraining from going out, did not revert to pre-COVID-19 levels. Table 3 shows the results of the tests of independence and residual analysis, across occupations, for the stay-at-home duration in a week. First, tests of independence were conducted to observe significant differences in shares between the groups. Subsequently, a residual analysis was performed to identify significant differences in the categories of each group. The results show that the share of "80–100%" and "60–80%" were significantly high for housewife/husband in all periods, while those for worker were low in all periods. This result implies that housewife/husband might have more opportunities to use e-commerce than working people did.

The change rate[1] of the average value of stay-at-home duration for each prefecture between each period was computed to observe changes in the stay-at-home duration across prefectures and periods (shown in Fig. 3). The red-hatched prefectures exhibited increases in the stay-at-home duration, while the blue-hatched prefectures exhibited decreases. From Fig. 3, comparing the changes between T1 and T2, the before and immediately after the COVID-19 outbreak, it is evident that the increasing rates of stay-at-home duration are particularly high in populated areas such as Tokyo, Kanagawa (Yokohama), Osaka, and Fukuoka, the initial target prefectures of the first SOE, and their surrounding prefectures. However, some other areas, such as Yamagata and Fukui, also showed increasing rates. Subsequently, in the transition from T2 to T3, the rates decreased, particularly in populated areas such as Tokyo and Osaka and their surrounding prefectures.

A cross-tabulation for the stay-at-home duration was conducted based on city size and periods, and tests of independence were conducted to verify the observation statistically (see Table 4). The classification of city size is as follows: (i) large cities: 20 cities designated by a government ordinance and 23 wards of Tokyo; (ii) medium cities: cities with a population of 150,000 or more, excluding large cities; (iii) small cities A: a city with a population of 50,000 or more, but less than 150,000; and (iv) small cities B: cities and towns with a population less than 50,000. Note that a city with a population greater than 500,000 is also designated by the government ordinance and the order of the Cabinet of Japan. A significant increase (decrease) in the ratio of time spent at home from T1 to T2 (from T2 to T3) was observed in large cities. Thus, more drastic changes in time spent at home are observed in populated areas, while comparatively less populated areas exhibited stable changes. Finally, comparing T1 and T3, Tokyo and its surrounding prefectures and Yamagata exhibited the highest increase in stay-at-home duration. This may be because the Tokyo area was the most infected, and the first SOE was in effect much longer here than in other areas. However, the increase in infections Yamagata prefecture is difficult to interpret because the infection case load was 43rd out of all 47 prefectures. One possible reason may be the small sample size of the Yamagata prefecture (n = 16). Future studies could collect larger samples for better insight.

3.2. Shopping behavior

Fig. 4 shows the share of the frequency of going out for shopping in each period. Note that shopping here defines visiting any type of physical retail store, including supermarkets and convenience stores. The goodness-of-fit tests for the frequency of each shopping category between periods showed significant differences between all combinations of periods at the 1% significance level. From T1 to T2, the number of respondents for more than two visits (i.e., the sum of "more than four times a week" and "twice a week") for retail stores declined from 1666 to 1316. Among people who reduced their shopping frequency in T2 and increased it in T3 (n = 504), 62.8% also increased their stay-at-home duration in T2 and decreased it in T3. Thus, shopping frequency at retail stores is likely to be negatively correlated to the stay-at-home duration. Among people who increased their shopping frequency in T3, the share of bicycle usage was significantly higher (p = 0.012), while

[1] Since we collect the data as class intervals (e.g., 0–20%, 20–40%), class value of the category is used to obtain average duration of activities at each period. Next, the change rate between each period is calculated; for example, the change rate from T1 to T2 is calculated as (T2/T1)-1.

Table 3
Results of tests of independence and residual analysis for the stay-at-home duration in a week for different occupations.

Time period	Category	Occupation				
		Worker	Housewife/husband	Student	Other	Total
T1	80–100%	99 (5.6%)***	95 (22.7%)***	7 (5.2%)**	105 (29.9%)***	306 (11.4%)
	60–80%	216 (12.2%)***	147 (35.2%)***	19 (14.1%)	100 (28.5%)***	482 (18.0%)
	40–60%	562 (31.6%)**	121 (28.9%)	45 (33.3%)	79 (22.5%)***	807 (30.1%)
	20–40%	649 (36.5%)***	48 (11.5%)***	52 (38.5%)**	48 (13.7%)***	797 (29.7%)
	0–20%	250 (14.1%)***	7 (1.7%)***	12 (8.9%)	19 (5.4%)***	288 (10.7%)
	Total	1431	235	20	994	2680
	Test of independence: p = 6.90e-102+++					
T2	80–100%	398 (22.4%)***	243 (58.1%)***	73 (54.1%)***	171 (48.7%)***	885 (33.0%)
	60–80%	404 (22.7%)***	115 (27.5%)	40 (29.6%)	95 (27.1%)	654 (24.4%)
	40–60%	494 (27.8%)***	37 (8.9%)***	15 (11.1%)***	42 (12.0%)***	588 (21.9%)
	20–40%	350 (19.7%)***	13 (3.1%)***	3 (2.2%)***	24 (6.8%)***	390 (14.6%)
	0–20%	130 (7.3%)***	10 (2.4%)***	4 (3.0%)	19 (5.4%)	163 (6.1%)
	Total	1431	235	20	994	2680
	Test of independence: p = 6.87e-76+++					
T3	80–100%	196 (11.0%)***	153 (36.6%)***	17 (12.6%)*	141 (40.2%)***	507 (18.9%)
	60–80%	365 (20.6%)***	153 (36.6%)***	52 (38.5%)***	103 (29.3%)**	673 (25.1%)
	40–60%	576 (32.4%)***	84 (20.1%)***	39 (28.9%)	62 (17.7%)***	761 (28.4%)
	20–40%	480 (27%)***	16 (3.8%)***	23 (17%)	26 (7.4%)***	545 (20.3%)
	0–20%	159 (9.0%)***	12 (2.9%)***	4 (3.0%)**	19 (5.4%)	194 (7.2%)
	Total	1431	235	20	994	2680
	Test of independence: p = 8.69e-88+++					

+++1%, ++5%, and +10% significance level for tests of independence.
***1%, **5%, and *10% significance level for residual analysis.

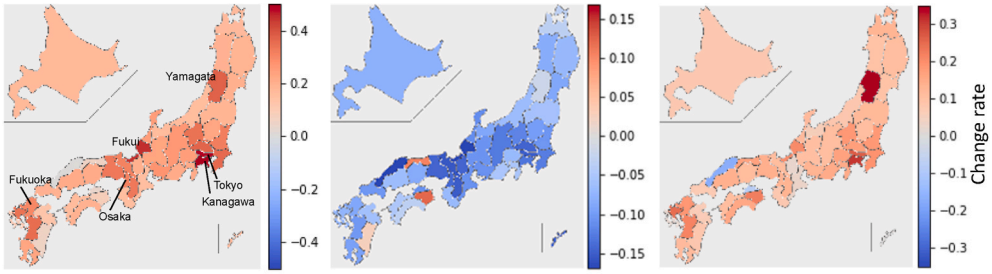

Fig. 3. Geographical and chronological change in the stay-at-home duration for each prefecture.

automobile usage was significantly lower (p = 0.033) than the other groups. This implies that shopping at retail stores might have relatively reverted to its pre-COVD-19 state in the proximity of the respondents' homes. This is because bicycles were used for relatively short trips instead of automobiles.

The average percentage of shopping frequency per week for each prefecture was calculated to observe inter-prefectural differences between the changes in stay-at-home duration.[2] Fig. 5 shows the geographical and chronological change rates for each prefecture between each period. Unlike Fig. 3 (change in the stay-at-home duration), Fig. 5 shows that change rates in populated areas such as Tokyo, Kanagawa, Osaka, and Fukuoka were not particularly different from those in other prefectures. Table 5 shows the results of the tests of independence for the frequency of change rates of each category between city sizes and at each time transition. No significant differences in shopping frequency between city sizes were observed at the 5% significance level. However, some variability in change rates for individual prefectures among each city size was observed. For example, in Shikoku Island, connected to the Japanese mainland (Honshu) by bridges, three prefectures exhibited increased shopping frequency from T1 to T3. This trend is different from that of the other regions. This may be because the number of infection cases was very small on Shikoku Island. As of January 30, 2021, the cumulative number of infection cases on Shikoku Island was 2,856, or 0.74% of the nationwide case count (i.e., 38.7 thousand cases).

Fig. 6 shows the usage of e-commerce and retail stores for each good. Apart from the chronological change in consumer behavior, the share of e-commerce use differs across the types of goods in T1. A high share of e-commerce usage (sum of 'only EC' and 'EC is higher') is observed for book/DVD/software and machinery/PC applications at 27.5% and 20.9%, respectively, compared to other goods. In contrast, the share of e-commerce usage for grocery goods and beverages or alcohols accounted for only 3.8% and 6.6%, respectively.

The trend of chronological changes in the usage rate of e-commerce and retail stores is similar among the goods. The use of e-commerce increases approximately twice from T1 to T2, except for book/DVD/software and machinery/PC applications. These shares subsequently showed a slight decrease from T2 to T3 (see Fig. 7). Thus, machinery/PC applications have a relatively high possibility of continued e-commerce usage as the main shopping mode in the post-COVID-19 era. For example, grocery goods achieved an increase of 1.62-times compared to

[2] Each category is replaced specific number of times per week; such as more than four times a week: 4 (times/week), twice a week: 2 (times/week), once per a week: 1 (times/week), once per a month: 0.25 (times/week). It might be controversial to convert more than 4 times/week as 4 times/week. However, we consider this conversion acceptable only to observe overall trends of change rates of shopping frequency.

Table 4
Change rate of the stay-at-home duration in a week between periods for each city size.

Time period	Category	City size				
		Large	Medium	Small-A	Small-B	Total
T1→T2	Increase	527 (53.4%) ***	361 (43.0%) *	227 (38.4%) ***	102 (38.6%) **	1217 (45.4%)
	Same	425 (43.1%) ***	436 (52.0%)	333 (56.3%) ***	145 (54.9%) *	1339 (50.0%)
	Decrease	34 (3.4%)*	42 (5.0%)	31 (5.2%)	17 (6.4%)	124 (4.6%)
	Total	986	839	591	264	2680
	Test of independence: p = 3.26e-08+++					
T2→T3	Increase	46 (4.7%)	42 (5.0%)	33 (5.6%)	15 (5.7%)	136 (5.1%)
	Same	599 (60.8%) ***	568 (67.7%)	399 (67.5%)	193 (73.1%) ***	1759 (65.6%)
	Decrease	341 (34.6%) ***	229 (27.3%)	159 (26.9%)	56 (21.2%) ***	785 (29.3%)
	Total	986	839	591	264	2680
	Test of independence: p = 3.24e-04+++					
T1→T3	Increase	338 (34.3%) ***	263 (31.3%)	148 (25%) ***	74 (28.0%)	823 (30.7%)
	Same	593 (60.1%) **	521 (62.1%)	397 (67.2%) **	178 (67.4%)	1689 (63.0%)
	Decrease	55 (5.6%)	55 (6.6%)	46 (7.8%)*	12 (4.5%)	168 (6.3%)
	Total	986	839	591	264	2680
	Test of independence: p = 3.97e-03+++					

+++1%, ++5%, and +10% significance level for tests of independence.
***1%, **5%, and *10% significance level for residual analysis.

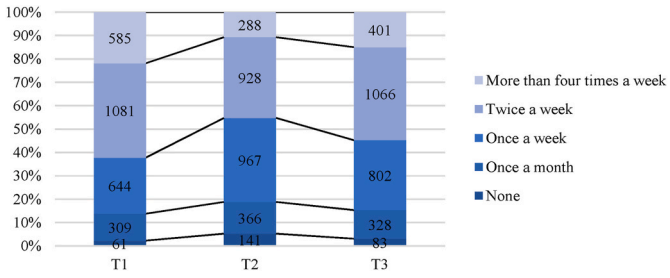

Fig. 4. Share of the frequency of going out for shopping at each period.

pre-COVID-19. In contrast, machinery/PC applications and book/DVD/software only increased by approximately 35% from T1 to T2. For grocery goods, the absolute original share of e-commerce usage at T1 is smaller (higher) than other goods (machinery/PC applicants and Book/DVD/Software). This is unexpected because grocery goods are sensitive goods as they are consumed directly into the consumer's body.

4. Chronological change in psychological attitudes towards e-commerce

Regarding the psychological attitudes toward the use of e-commerce, the share of respondents recognizing the importance of e-commerce increased after the COVID-19 outbreak (see Fig. 8). A goodness-of-fit test on the frequency of respondents between periods showed significant differences between T1 and T2 ($p = 0.00$) and T1 and T3 ($p = 0.00$) at a 1% significance level, while there was no significant difference between T2 and T3 ($p = 0.81$). Specifically, from T1 to T2, the frequency of negative answers (i.e., strongly disagree and disagree) increased from 535 to 416, while positive answers (i.e., strongly agree and agree) increased from 1451 to 1666, implying that the importance of e-commerce possibly increased from T1 to T2; however, it did not decline T2 to T3. This implies that consumers continued using e-commerce after COVID-19 as the respondents continued to recognize the importance of e-commerce at T3. To observe detailed changes in individual psychological attitudes, we traced individuals over the three periods and identified the characteristics of each group.

4.1. Tracing individuals at periods 1-2

The sample was divided into four groups to reveal the characteristics of the respondents and their reasons to consider e-commerce as important (see Table 6). We focused on the chronological changes in consumers' attitudes toward the importance of e-commerce. This is because we consider recognizing its importance as a significant indication for the continued use of e-commerce post-COVID-19, increasing the demand for freight transport. Group 1 recognized the importance of e-commerce before and after the COVID-19 outbreak. This group accounted for 56.6% of the participants. In Group 2, psychological intention toward e-commerce became positive after the COVID-19 outbreak, although they did not recognize the importance of e-commerce or were neutral at T1. In Group 3, which was relatively small, the importance of e-commerce became negative. Group 4 exhibited negative attitudes toward e-commerce from the start, and their attitudes did not change over time between periods T1 and T2.

The differences between the groups were tested using the tests of independence and residual analysis (see Table 6), based on personal attributes (i.e., age, gender, and occupation), living environment (i.e., population density, and modes of transportation), the severity of infection status, stay-at-home duration, and travel time to retail stores; Table 7 presents the results. The severity of infection status was classified based on the declaration of the SOE in Japan. Regarding personal attributes, significant differences at the 1% significance level were observed between the groups for all three personal attributes. In Group 1, there were significantly more workers in their 30s and 40s than in the

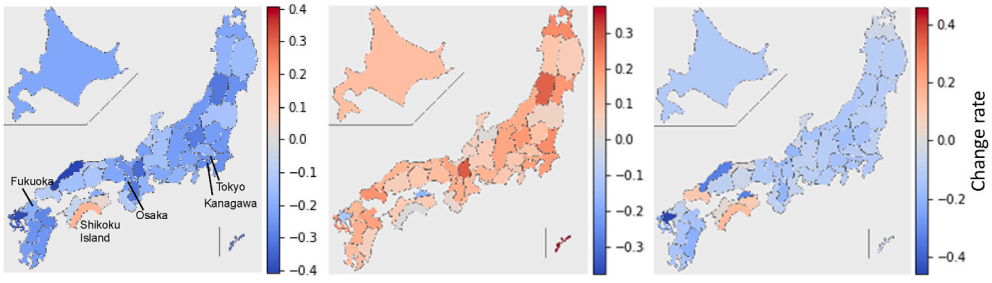

Fig. 5. Geographical and chronological change in frequency of going out for shopping for each prefecture.

Table 5
Change rate of the frequency of going out for shopping in a week between periods for each city size.

	Category	Large	Medium	Small-A	Small-B	Total
T1→T2	Increase	49 (5.0%)	45 (5.4%)	25 (4.2%)	9 (3.4%)	128 (4.8%)
	Same	587 (59.5%)	501 (59.7%)	370 (62.6%)	176 (66.7%)	1634 (61.0%)
	Decrease	350 (35.5%)	293 (34.9%)	196 (33.2%)	79 (29.9%)	918 (34.3%)
	Total	986	839	591	264	2680
		Test of independence: p = 0.37				
T2→T3	Increase	228 (23.1%)+	174 (20.7%)	120 (20.3%)	50 (18.9%)+	572 (21.3%)
	Same	723 (73.3%)	621 (74%)	449 (76%)	210 (79.5%)+	2003 (74.7%)
	Decrease	35 (3.5%)	44 (5.2%)	22 (3.7%)	4 (1.5%)	105 (3.9%)
	Total	1431	235	20	994	2680
	Test of independence: p = 0.063*					
T1→T3	Increase	65 (6.6%)	56 (6.7%)	33 (5.6%)	16 (6.1%)	170 (6.3%)
	Same	716 (72.6%)	592 (70.6%)	434 (73.4%)	200 (75.8%)	1942 (72.5%)
	Decrease	205 (20.8%)	191 (22.8%)	124 (21%)	48 (18.2%)	568 (21.2%)
	Total	1431	235	20	994	2680
	Test of independence: p = 0.69					

+++1%, ++5%, and +10% significance level for tests of independence.
***1%, **5%, and *10% significance level for residual analysis.

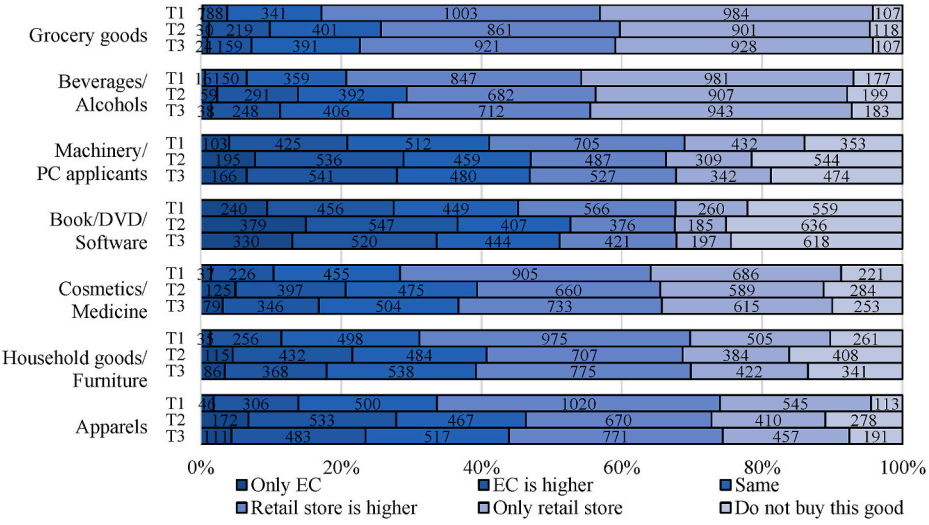

Fig. 6. Share of the use of EC and retail stores by each good.

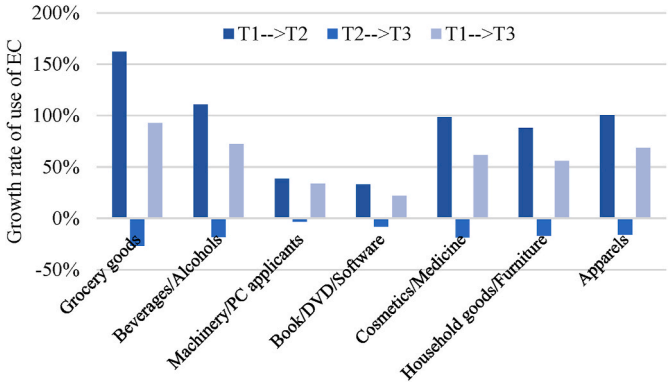

Fig. 7. Change in share of e-commerce use compared to retail stores for each good between periods.

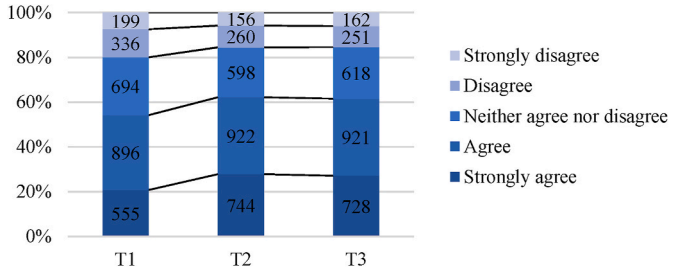

Fig. 8. Responses for the question on whether e-commerce is essential for life.

entire sample. Furthermore, people in this group had a higher income (i.e., more than 8 million JPY). Group 2 had a significantly higher proportion of individuals aged less than or equal to 20 (34.5%). Furthermore, Group 2 had a significantly higher proportion of females (66.4%) than the entire sample. These results indicate that younger females positively changed their minds toward e-commerce after the pandemic outbreak. In Group 2, the stay-at-home duration was significantly longer (71.5%) than in the other groups at the 1% significance level. Moreover, the share of stay-at-home duration in Group 4 was significantly smaller than in the other groups (see Table 7). Therefore, there may be a positive relationship between the stay-at-home duration and the importance of e-commerce. Lastly, Group 4 had a higher share of males and older people, different from Group 2.

In Japan, the first SOE was declared in April 2020 and lifted in May 2020 at slightly different times for each prefecture. In the seven most

Table 6
Psychological change towards the importance of EC between periods 1 and 2.

		Time period 2				
		Strongly agree	Agree	Neither	Disagree	Strongly disagree
Time period 1	Strongly agree	Group 1 540	11	Group 3 3	1	0
	Agree	(n=1,431) 160	720	(n=20) 13	3	0
	Neither	Group 2 19	126	Group 4 532	16	1
	Disagree	(n=236) 19	51	(n=842) 45	218	3
	Strongly disagree	6	15	5	22	0

populated and infected regions of Tokyo, Kanagawa, Chiba, Saitama, Osaka, Kyoto, and Hyogo, the SOE was declared earlier due to the higher number of infections. We expected greater importance of e-commerce in these prefectures as e-commerce usage can reduce infection risk. However, no significant difference between these seven prefectures and other prefectures was observed among Groups 1 and 4. Additionally, we found no significant differences across areas among a group with people who exhibited at least a one stage improvement to "strongly agree" or "agree" (n = 396) and a group for the remainder exhibiting a constant perception (n = 2010) from T1 to T2. We postulated that a highly dense city with high infection risk would be of greater importance to e-commerce. However, a test of independence revealed no significant differences in population density among groups 1 to 4. The population density was also tested across areas between a group with people who exhibited at least a one-stage improvement to "strongly agree" or "agree" (n = 396) and a group for the remainder exhibiting a constant perception (n = 2010) from T1 to T2. However, no significant differences were observed between groups. Overall, these results show that perceptions of the importance of e-commerce are not dependent on regional characteristics, such as population density and infection situation. However, differences in stay-at-home duration between city sizes are observed (see Table 4).

Intuitions suggest that the importance of e-commerce should increase in more infected areas. Significant differences in the importance of e-commerce based on population density were expected. This indicates that awareness of the pandemic crisis was higher in the local areas of Japan. However, as Fig. 3 shows, some exceptional regions, such as Shikoku Island, witnessed fewer spikes in infections. There were no significant differences between the groups in terms of the mode of transportation for shopping. Group 1 was closer to retail stores, while Group 4 was farther. While these distances were significantly different, we could not identify a significant relationship between modes of transportation and changes in attitudes regarding the importance of e-commerce.

The share of positive answers for the usefulness or reasons for using e-commerce for Groups 1 to 4 for periods T1 and T2 are shown in Fig. 9. In these questions, respondents indicated their opinion towards each question on a five-point Likert scale: "strongly agree," "agree," "neutral," "disagree," and "strongly disagree." We interpreted "strongly agree" and "agree" as positive answers. The questions were divided into two parts: the reasons for the usefulness of e-commerce itself and those on COVID-19. Note that questions related to COVID-19 were not asked in T1, as COVID-19 had not yet spread. Two important insights emerge from Fig. 9. First, a higher positive answer rate for each question in T1 was observed, in order, from Groups 1, 3, 2, and 4. Nevertheless, the positive answer rate for Group 2 overtakes Group 3 in T2. This is expected because the order of magnitude of the importance of e-commerce in Group 2 is higher than that of Group 3 at T2. Furthermore, reasons related to COVID-19 were observed more frequently in Group 2 than in Group 1. This implies that the recognition of the usefulness of e-commerce in Group 2 is due to COVID-19 related reasons. Particularly, e-commerce was used because consumers were willing to follow the government's stay-at-home request and decreased the frequency of going out. Second, a rapid increase in all reasons related to the usefulness of e-commerce itself was observed for Group 2. These increases (i.e., 17.3 points increase on average) are overwhelmingly higher than those for other groups. This suggests that Group 2 recognized the usefulness of e-commerce. Therefore, it is expected that they will continue to use e-commerce even in the post-COVID era.

4.2. *Tracing individuals at periods 1-2-3*

To reveal the characteristics and potential reasons for continued intention to use e-commerce, Group 2 was further divided into two groups, Groups 2-1 and 2-2 (see Table 8). Group 2-1 represents people who show an improved intention to use e-commerce from T2 to T3 and T1 to T2. In this group, the psychological intention to use e-commerce increased, or they continued to consider e-commerce as important for their life. Approximately 80% of Group 2 continued to recognize the importance of e-commerce from T2 to T3. In contrast, Group 2-2 represents people whose psychological intention to use e-commerce has returned to negative or neutral in T3. However, this group only accounted for approximately 20% of Group 2, significantly smaller than Group 2-1. Therefore, most people who increasingly recognized the importance of e-commerce from T1 to T2 continued to consider it in T2 to T3. For the other groups, most of the samples did not change their attitudes from T2 to T3. For example, the sample size for Group 1-1 was overwhelmingly larger than that for Group 1–2. This means that Group 1 continuously considered e-commerce as important for their life, although slight psychological changes (e.g., "Agree" to "Strongly agree") are observed after several months had passed (T3). Similarly, Groups 3-2 and 4-2 have most respondents from Groups 3 and 4, respectively. This implies that Groups 3 and 4 still consider e-commerce unimportant, although the sample size for Group 3 is small. For Groups 3 and 4-1, it was difficult to interpret their psychological changes. Furthermore, the sample sizes were small. They may have changed their minds due to changes in their lifestyles, and perhaps not due to COVID-19. In our survey, we could not incorporate lifestyle changes, possibly affecting the intention to use e-commerce. This could be a future research area.

The share of positive answers for usefulness or reasons to use e-commerce in Groups 2-1 and 2-2 for both T2 and T3 are shown in Fig. 10. First, overall, a higher share of the recognition of the usefulness of e-commerce itself was observed for Group 2-1 in all questions for all periods. Additionally, the share of positive answers of Group 2-1, regarding the usefulness of e-commerce, declined by 2.1 points on average from T2 to T3, while that of Group 2-2 by −9.4 points on average. The difference-in-difference between the two groups for the usefulness of e-commerce itself is 7.3 points. This indicates that positive attitudes toward e-commerce remained more in Group 2-1 from T2 to T3. Particularly, a +0.1 points increase in positive feelings for the usefulness of e-commerce itself was observed for Group 2-1, while Group 2-2 exhibited reduced positive attitudes by −6.4 points. This result implies

Table 7
Results of test of independence and residual analysis for each group (Period 1 to 2).

Item	Category	Group 1	Group 2	Group 3	Group 4	Total
Age	<20s	272 (19.0%)	81 (34.5%)***	5 (25.0%)	178 (17.9%)**	536 (20.0%)
	30s	314 (21.9%)***	49 (20.9%)	6 (30.0%)	167 (16.8%)***	536 (20.0%)
	40s	304 (21.2%)*	39 (16.6%)	4 (20.0%)	189 (19.0%)	536 (20.0%)
	50s	292 (20.4%)	33 (14.0%)**	4 (20.0%)	207 (20.8%)	536 (20.0%)
	60s<	249 (17.4%)***	33 (14.0%)**	1 (5.0%)*	253 (25.5%)***	536 (20.0%)
	Total	1431	235	20	994	2680
		Test of independence: p = 2.93e-10+++				
Gender	Male	653 (45.6%)	79 (33.6%)***	9 (45.0%)	502 (50.5%)***	1243 (46.4%)
	Female	778 (54.4%)	156 (66.4%)***	11 (55.0%)	492 (49.5%)***	1437 (53.6%)
	Total	1431	235	20	994	2680
	Test of independence: p = 5.07e-05+++					
Occupation	Workers	989 (69.1%)***	139 (59.1%)**	11 (55.0%)	637 (64.1%)*	1776 (66.3%)
	Housewife/husband	211 (14.7%)	50 (21.3%)**	5 (25.0%)	152 (15.3%)	418 (15.6%)
	Student	59 (4.1%)**	27 (11.5%)***	1 (5.0%)	48 (4.8%)	135 (5.0%)
	Other	172 (12.0%)*	19 (8.1%)**	3 (15.0%)	157 (15.8%)***	351 (13.1%)
	Total	1431	235	20	994	2680
	Test of independence: p = 1.09e-06+++					
Income 10,000 JPY	<200	101 (7.1%)	13 (5.5%)	1 (5.0%)	77 (7.7%)	192 (7.2%)
	200–400	247 (17.3%)*	36 (15.3%)	6 (30.0%)	206 (20.7%)**	495 (18.5%)
	400–600	279 (19.5%)	50 (21.3%)	4 (20.0%)	206 (20.7%)	539 (20.1%)
	600–800	201 (14%)	31 (13.2%)	1 (5.0%)	118 (11.9%)	351 (13.1%)
	800–1000	122 (8.5%)**	21 (8.9%)	2 (10.0%)	57 (5.7%)***	202 (7.5%)
	>1000	137 (9.6%)***	15 (6.4%)	1 (5.0%)	64 (6.4%)*	217 (8.1%)
	Other	344 (24%)*	69 (29.4%)	5 (25.0%)	266 (26.8%)	684 (25.5%)
	Total	1431	235	20	994	2680
	Test of independence: p = 3.53e-02++					
Population density	<7000	447 (31.2%)	85 (36.2%)	6 (30.0%)	321 (32.3%)	859 (32.1%)
	1500–7000	403 (28.2%)	55 (23.4%)	6 (30.0%)	283 (28.5%)	747 (27.9%)
	>1500	581 (40.6%)	95 (40.4%)	8 (40.0%)	390 (39.2%)	1074 (40.1%)
	Total	1431	235	20	994	2680
	Test of independence: p = 0.86					
Transport mode to retail stores	Walk	342 (24.1%)	57 (24.6%)	3 (15.0%)	230 (23.9%)	632 (24.1%)
	Bicycle	256 (18.1%)	52 (22.4%)	6 (30.0%)	163 (16.9%)	477(18.1%)
	Auto	779 (54.9%)	115 (49.6%)	10 (50.0%)	544 (56.5%)	1448 (55.0%)
	Bus	8 (0.6%)	4 (1.7%)	1 (5.0%)	6 (0.6%)	19 (0.7%)
	Train	21 (1.5%)	2 (0.9%)	0 (0%)	12 (1.2%)	35 (1.3%)
	Other	12 (0.8%)	2 (0.9%)	0 (0%)	7 (0.7%)	21 (0.8%)
	Total	1418	232	20	962	2632
	Test of independence: p = 0.30					
The state of emergency	7 areas	697 (48.7%)	102 (43.4%)	10 (50.0%)	468 (47.1%)	1277 (47.6%)
	Other areas	734 (51.3%)	133 (56.6%)	10 (50.0%)	526 (52.9%)	1403 (52.4%)
	Total	1431	235	20	994	2680
	Test of independence: p = 0.47					
Time duration at home	Increase	671 (47.0%)	168 (71.5%)***	9 (45.0%)	370 (45.0%)***	1219 (46.9%)
	Same	700 (48.9%)	55 (23.4%)***	6 (30.0%)*	577 (30.0%)***	1337 (48.9%)
	Decrease	60 (4.1%)	12 (5.1%)	5 (25.0%)***	47 (25.0%)	123 (4.2%)
	Total	1431	235	20	994	2680
	Test of independence: p = 4.28e-23+++					
Time from house to retail store	<10 min	642 (45.3%)**	98 (42.2%)	5 (25.0%)*	397 (41.3%)*	1142 (43.4%)
	10–30 min	701 (49.4%)	119 (51.3%)	10 (50.0%)	490 (50.9%)	1320 (50.2%)
	30-60 min	74 (5.2%)	14 (6.0%)	5 (25.0%)***	60 (6.2%)	153 (5.8%)
	60–120 min	1 (0.1%)***	1 (0.4%)	0 (0%)	12 (1.2%)***	14 (0.5%)
	<120 min	0 (0%)*	0 (0%)	0 (0%)	3 (0.3%)**	3 (0.1%)
	Total	1431	235	20	994	2680
	Test of independence: p = 1.40e-04+++					

+++1%, ++5%, and +10% significance level for tests of independence.
***1%, **5%, and *10% significance level for residual analysis.

that people who recognize the usefulness of e-commerce will continue to use it in the new normal era as usefulness is a time-independent attribute.

Second, a higher share of positive answers for reasons related to COVID-19 was observed for Group 2-2 than Group 2-1. This suggests that Group 2-2 showed increased importance of e-commerce from T1 to T2 to cope with the COVID-19 outbreak. Subsequently, these shares rapidly decreased for Group 2-2 (i.e., −13.5 points on average from T2 to T3), while Group 2-1's shares decreased by only −5.0 points on average. These results imply that people, such as those in Group 2-2, are less likely to continue to use e-commerce post-COVID-19 because they started using it to cope with COVID-19 related risks and requests.

5. Conclusion

In this study, we explored the changes in the psychological intentions of consumer behavior toward e-commerce usage in Japan, which significantly affects future transport and logistics-related policies. Additionally, the corresponding reasons before and after the COVID-19 outbreak were analyzed. Panel data were collected for three periods

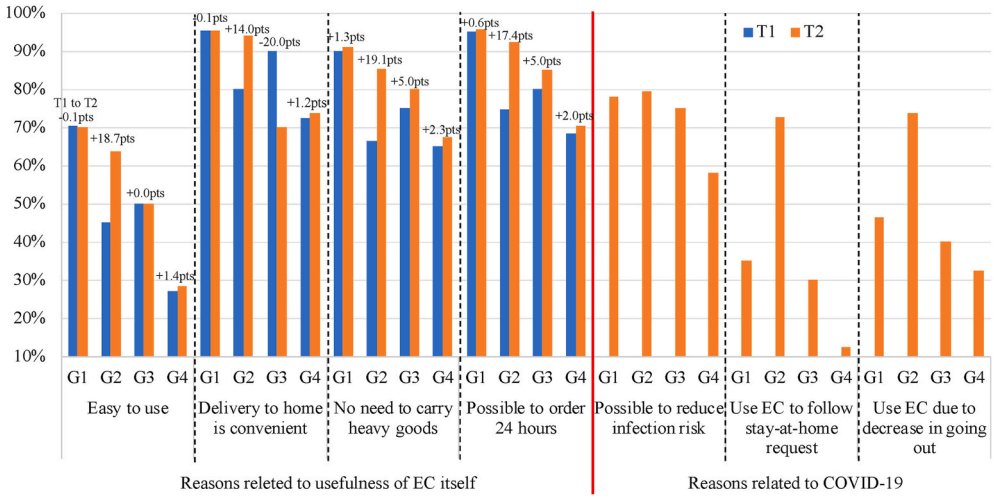

Fig. 9. Share of positive responses for usefulness or reasons to use e-commerce in each group for T1 and T2.

Table 8
Psychological change of Group 2 towards the importance of EC at T2 and T3.

		Time period 3				
Group at T1 to T2	Time period 2	Strongly agree	Agree	Neither	Disagree	Strongly disagree
Group 1	Strongly agree	Group 1-1 647	50	Group 1-2 3	0	0
	Agree	(n=1,415) 35	683	(n=16) 11	2	0
Group 2	Strongly agree	Group 2-1 27	14	Group 2-2 1	2	0
	Agree	(n=188) 17	130	(n=47) 38	5	1
Group 3	Neither	Group 3-1 0	6	Group 3-2 10	0	0
	Disagree	(n=6) 0	0	(n=14) 3	1	0
	Strongly disagree	0	0	0	0	0
Group 4	Neither	Group 4-1 1	33	Group 4-2 530	18	0
	Disagree	(n=40) 1	5	(n=954) 20	219	11
	Strongly disagree	0	0	2	4	150

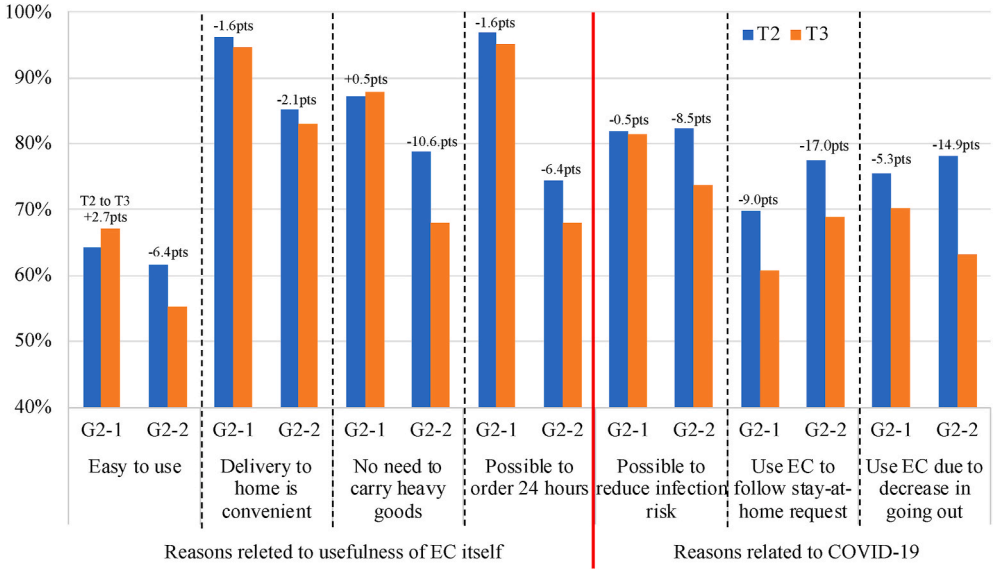

Fig. 10. Share of positive answers for usefulness or reasons to use e-commerce in Groups 2-1 and 2-2 for both T2 and T3.

from e-commerce users registered with a Japanese web survey company. Through descriptive analysis and statistical tests, we obtained several insights into the use of e-commerce, especially those applicable after the pandemic, and fundamental changes in consumer behaviors and lifestyles. The initial set of insights relate to several fundamental overall effects due to COVID-19. First, immediately after the COVID-19 outbreak, stay-at-home duration increased, while the frequency of going out for shopping decreased. Then, the stay-at-home duration decreased, while the frequency of going out for shopping increased. However, these did not reach the pre-pandemic level. Stay-at-home duration differed with city size; more populated areas had a higher stay-at-home duration than less populated areas. Second, e-commerce usage differed across different types of goods. Grocery goods experienced a significant increase compared to those before COVID-19. However, the total share of e-commerce usage for goods was still smaller than that of other goods. Meanwhile, machinery/PC applications and book/DVD/software showed only a slight increase in usage; however, only a slight decrease was observed in the third period. This implies that these goods have a relatively high probability of being purchased through e-commerce in the post-pandemic era.

Using statistical analysis on panel data of consumers, we explored shopping behaviors, intentions to use e-commerce, and the corresponding reasons. First, as an overall trend, consumers recognized the importance of e-commerce immediately after the pandemic outbreak. Furthermore, this recognition did not subsequently significantly decline. Second, consumers who changed their attitudes toward e-commerce stayed significantly longer at home than those in other groups did. This implies a positive correlation between stay-at-home duration and the necessity of e-commerce. Additionally, younger females were more likely to use e-commerce. However, modes of transportation for shopping and living areas (infection status) did not significantly affect the intention of e-commerce usage. Third, consumers mostly and consistently considered it as important. People who recognized e-commerce's usefulness were likely to continue using it. In contrast, people who gave decreasing importance to e-commerce used it to reduce their infection risk rather than its benefits. Thus, these individuals were less likely to continue using e-commerce post the pandemic.

The results obtained show that if the frequency of going out decreases in the future due to the normalization of teleworking and online classes, the importance of proximity between office or school and commercial facilities may decrease. This implication applies to Japan as a whole because regional characteristics, such as population density, city size, and mode of transport used for shopping, were seemingly irrelevant to consumer shopping behavior. Notably, consumers may not purchase some items, such as grocery goods, via e-commerce. Additionally, many respondents used e-commerce as they recognized its importance, convenience, and usefulness. Therefore, even if teleworking and online classes do not become the norm after COVID-19, e-commerce usage is expected to continue to grow in the future. Therefore, future urban planners should consider the need for changes in the location of commercial facilities. Accordingly, logistics networks should also change; particularly, more enlarged warehouses are needed because e-commerce demand is likely to increase after COVID-19.

Another important future research topic is the continuous collection of panel data. This is because several situations, such as infections, vaccine development, and social restrictions, change over time. For example, due to the third and fourth outbreaks in Japan, fourth SOEs have been declared as of July 2021. However, people went out more than the first SOE (Agoop Corp, 2021), despite a higher number of infected cases than the first SOE and the Japanese government's request to stay at home. As we identify the relationship between the frequency of going out and the use of e-commerce, data for this second SOE and in the future should be collected.

We also reveal psychological changes in the intention to use e-commerce. However, it is important to identify the mechanism of consumer perception changes when using e-commerce. Finally, the important factors that affect consumers' behavior and intentions toward e-commerce can be identified via statistical modeling methods, such as structural equation modeling.

Acknowledgment

This work was supported by the School of Engineering of The University of Tokyo.

Appendix. Contents of the questionnaire (excluding personal attributes)

Section 1 Shopping behaviors

No	Question	Time period	Answer format
1	How often do you do online shopping?	T3	More than two times per a week Once per 1–2 week Once per a month Once per 3 months Never
2	Which websites do you use for online shopping?	T3	Amazon, Rakuten, Yahoo, Bic camera, Others
3	How often do you go shopping at physical retail stores (including supermarkets and convenience stores)?	T1, T2, T3	More than four times per a week Twice a week Once per a week Once per a month None
4	How often do you eat out in a week?	T1, T2, T3	More than 11 per a week 8–10 times per a week 3–7 times per a week 1,2 times per a week None
5	How much percentage of time do you spend at home in a week on average?	T1, T2, T3	80–100% 60–80% 40–60% 20–40% 0–20%
6	What is the main transport mode for your general shopping?	T3	Walk, Bicycle, Auto, Bus, Train, Others
7	How long does it take from your house to retail stores in general?	T3	Less than 10 min , 10–30 min, 30–60 min ,

(continued on next page)

(*continued*)

Section 1 Shopping behaviors			
No	Question	Time period	Answer format
			60–120 min , More than 120 min
Section 2: Use of e-commerce and type of goods			
No	Question	Time period	Answer format
8	Which shopping means do you use, e-commerce or retail stores to buy grocery goods?	T1, T2, T3	EC only EC > On-site Same On-site > EC On-site only Did not buy this commodity
9	Which shopping means do you use, e-commerce or retail stores to buy beverages/Alcohols?	T1, T2, T3	Same as above
10	Which shopping means do you use, e-commerce or retail stores to buy machinery/PC applicants?	T1, T2, T3	Same as above
11	Which shopping means do you use, e-commerce or retail stores to buy book/DVD/Software?	T1, T2, T3	Same as above
12	Which shopping means do you use, e-commerce or retail stores to buy Cosmetics/Medicine?	T1, T2, T3	Same as above
13	Which shopping means do you use, e-commerce or retail stores to buy Household goods/Furniture?	T1, T2, T3	Same as above
14	Which shopping means do you use, e-commerce or retail stores to buy Apparels?	T1, T2, T3	Same as above
Section 3: Perceptions towards e-commerce			
No	Question	Time period	Answer format
15	Online shopping is easy to use.	T1, T2, T3	Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree
16	Online shopping is a necessity for me.	T1, T2, T3	Same as above
17	If online shopping is available, I would like to use it.	T1, T2, T3	Same as above
18	Online shopping increases the efficiency of my life.	T1, T2, T3	Same as above
19	Online shopping is convenient because goods are delivered to my house.	T1, T2, T3	Same as above
20	Online shopping makes it easy to buy heavy items that are difficult to carry.	T1, T2, T3	Same as above
21	Online shopping is cheaper than retail stores.	T1, T2, T3	Same as above
22	Online shopping has a better line-up of products than retail stores do.	T1, T2, T3	Same as above
23	Online shopping is faster to get products than retail stores.	T1, T2, T3	Same as above
24	The advantage of online shopping is point service.	T1, T2, T3	Same as above
25	Online shopping is convenient because it is possible to order 24 h.	T1, T2, T3	Same as above
26	Online shopping is fun.	T1, T2, T3	Same as above
27	Online shopping is for young people.	T1, T2, T3	Same as above
28	My parents and family use online shopping; thus, I use it.	T1, T2, T3	Same as above
29	My friends use online shopping; thus, I use it.	T1, T2, T3	Same as above
30	I am concerned that personal information is leaked or misused on e-commerce shopping.	T1, T2, T3	Same as above
31	Feel fear of being scammed on e-commerce shopping.	T1, T2, T3	Same as above
32	The use of e-commerce can decrease the risk of infection.	T2, T3	Same as above
33	I use e-commerce to follow the stay-at-home request.	T2, T3	Same as above
34	The use of e-commerce was recommended by TV and newspapers to prevent infections.	T2, T3	Same as above
35	Opportunities to go out have decreased than before COVID-19.	T2, T3	Same as above
36	Opportunities to go shopping have decreased than before COVID-19.	T2, T3	Same as above
37	Re-delivery had decreased than before COVID-19.	T2, T3	Same as above

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