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Investigation of online grocery shopping and delivery preference before, during, and after COVID-19

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A R T I C L E   I N F O

Keywords:
- COVID-19
- Grocery shopping (GS) preferences
- Online grocery shopping (OGS)
- Physical grocery shopping (PGS)
- Binary logit model

A B S T R A C T

This study investigates how the COVID-19 reshapes grocery shopping (GS) modes, physical grocery shopping (PGS) and online grocery shopping (OGS), by conducting an online survey that includes questions associated with social-economic characteristics, GS choices and reasons before, during, and in the short- and the long-term after COVID-19, as well as the adoption attitudes toward automated delivery services. A series of binary logit models are built to analyze what factors affect the OGS with the influence of COVID-19. The results show a significant shift from PGS to OGS due to the pandemic, which is also extended beyond COVID-19. People who are female, have more available vehicles, higher income, and health constraints, or worry the virus show more tendency to choose OGS as the primary mode during COVID-19, and stay with OGS after COVID-19. In addition, the elderly and those who frequently shop in person and by car before the pandemic and regard the OGS as either a primary or a supplementary mode are more likely to experience OGS after COVID-19.

Introduction

With the outbreak of COVID-19 pandemic, many states announced the stay-at-home order to limit the spread of the virus. The pandemic and the frequent quarantines have significantly influenced individuals’ normal lives, among which the grocery shopping (GS) and delivery preference has been one of the most affected ones. During the pandemic, many grocery stores have built their own online shopping platforms to increase their sales while slowing down the spread of COVID-19. In this case, people who usually shop in physical grocery stores (PGS) are able to buy products online, referred to as online grocery shopping (OGS). The Food Industry Association (2020) conducted an online survey from March 21 to 26, and found that about 77% of participants chose to shop groceries online, which is more than twice the percent of monthly online shoppers from the U.S. Grocery Shoppers Trends research one year ago. Among the studied participants, 17% were new to OGS, and 4% had the experience before and returned to the service for the first time during the pandemic. COVID-19 has made the OGS service a more popular and viable option, and this popularity has led to significant changes to freight and supply chain management (Perboli and Rosano, 2019), travel patterns (Calderwood and Freathy, 2014; Suel and Polak, 2018), environment (Cherrett et al., 2017; Dost and Maier, 2018), in-store shopping (Farag et al., 2007; Lee et al., 2017), and land use planning (Pettersson et al., 2018).

According to the Pew Research Center (Smith and Anderson, 2016), roughly four out of five Americans have at least one experience of purchasing items online, while the occupation is just 22% by a survey in June 2000. Online shopping is taking an increasing share of the total store sales, rising from 7.4% in 2015 to 11.9% in 2018 (eMarketer, n.d.). OGS was first introduced in the United States in the late 1980s (Belsie, 1998; Kurnia, 2003), and started to develop in the late 1990s (Saunders, 2018). However, unlike other online shopping activities (e.g., purchasing books or household items online), OGS developed slowly and was often stymied at that time.

In recent years, a variety of OGS services has emerged. The widely used services include: (1) pick-up service in which consumers order online and pick up in a store or warehouse, (2) home delivery by professional couriers arranged by a store (e.g., Amazon Fresh/Whole Foods home delivery), (3) home delivery by non-professional couriers (crowdshipping). Especially for the third service, some stores partner with third-party delivery platforms to reduce costs of picking, packing, and delivering. The largest start-up is Instacart created in 2012, which had partnered with over 15,000 grocery stores by the end of 2018 (Lien, 2017). Since then, a number of similar startups, such as Deliv, DoorDash,
The 2015 Nielsen Global E-commerce and New Retail Report surveyed more than 30,000 consumers in 60 countries in 2014, and revealed that 25% of the respondents used OGS with home delivery, 12% used OGS with pick-up service in the supermarket, and 12% and 10% used OGS with pick-up service in a drive-through and the curbside, respectively. More than half of the respondents indicated that they were willing to use OGS in the future (Nielsen, 2015). Along with the increasing popularity of OGS, the percentage of the grocery stores offering OGS home delivery or pick-up service in the United States also increased from 30% in 2017 to over 52% in 2019 (Conway, 2020). However, OGS sales of food, beer, and wine in the US currently represent only 0.35% of the total food and beverage purchases (United States Census Bureau, 2018).

Although there is a wide body of literature on grocery shopping preference, the occurrence of the COVID-19 pandemic has altered the speed of OGS development and shoppers’ behavior. Therefore, the objectives of this study are to compare GS preference before, during, and after COVID-19, and investigate the influencing factors. The findings of this research will inform policymakers and urban planners of necessary actions to accommodate/regulate increasing home delivery services particularly post COVID-19.

Literature review

OGS has received considerable attention from researchers, policymakers, and urban planners all over the world, especially in Europe. Numerous studies analyzed the socio-demographic profile to find the factors influencing people to choose the OGS service (Morganosky and Cude, 2000; Raijas, 2002; Clark and Wright, 2007; Hui and Wan, 2009; Ramachandran et al., 2011). Hui and Wan (2009) extended the Technology Acceptance Model to find that young people in Singapore (between 21 and 40 years) who are highly educated and have a high level of income are likely to use OGS. White (1997) and Anckar et al. (2002) reported that some seniors and disabled individuals also shop online for groceries. Some studies demonstrated that the consumers’ motivations are also important in adopting OGS services, in particular, the convenience and time saving advantages of OGS services (Janda and Fair, 2004; Picot-Coupey et al., 2009; Sinha et al., 2015). Although similar questions have been investigated in various studies, the findings can be different. For example, some studies found a significant relationship between gender and the adoption of OGS (Arce-Urriza and Cebollada, 2010; Naseri and Elliott, 2011), whereas others found no relationship between them (Hui and Wan, 2009). Arce-Urriza and Cebollada (2010) found that male shoppers are more likely to use online grocery shopping than female shoppers, while Naseri and Elliott (2011) found the exact opposite. This suggests that the findings of a study not be extended to other cases, and different cases be investigated separately.

Table 1

| Characteristic                  | Percentage (%) |
|--------------------------------|----------------|
| Gender*                        |                |
| female                         | 75.67          |
| male                           | 22.67          |
| Age                            |                |
| < 20 years                     | 4.00           |
| 20-34 years                    | 50.00          |
| 35-54 years                    | 39.33          |
| 55-69 years                    | 5.33           |
| 70-84 years                    | 1.33           |
| Education                      |                |
| Less than high school          | 1.67           |
| High school                    | 7.00           |
| Some college or associate’s degree | 22.33       |
| Bachelor’s degree or higher    | 68.00          |
| # Vehicles                     |                |
| 0                              | 14.67          |
| 1                              | 34.67          |
| 2                              | 37.67          |
| ≥ 3                            | 13.00          |

Note: * there are people who prefer not to say the gender

Fig. 1. Geographical distribution of survey samples in US.

Fig. 2. Changes in employment status during COVID-19.

and Postmates, have sprung up, which have gained popularity.

The 2015 Nielsen Global E-commerce and New Retail Report surveyed more than 30,000 consumers in 60 countries in 2014, and revealed that 25% of the respondents used OGS with home delivery, 12% used OGS with pick-up service in the supermarket, and 12% and 10% used OGS with pick-up service in a drive-through and the curbside, respectively. More than half of the respondents indicated that they were willing to use OGS in the future (Nielsen, 2015). Along with the
preference during this particular time period. Li et al. (2020) studied the change in grocery shopping behavior before and during the initial stages of the COVID-19 outbreak in China when the Chinese government’s mandatory national self-quarantine campaign took place. They found that the number of online shoppers increased from 11% before to 38% during the pandemic, which led to the online shopping becoming a more popular choice. They also found that the number of shoppers of neighborhood supermarket outlets and farmers markets both decreased, while there was an increase in the shoppers of local independent small shops.

Grashuis et al. (2020) conducted an online choice experiment in the United States to elicit preferences for purchasing methods, time windows, minimum order requirements, and fees under three scenarios of an increasing, decreasing or constant number of new COVID-19 cases. They concluded that the GS preference is influenced by the trend in the number of new cases, and the relative importance of the model’s attributes decrease with a reduction in the spreading rate of the virus. Kulkarini and Barge (2020) ranked the impact of different factors, including risk of infection, touch and feel of product, variety of products, ease of comparison, convenience, instant gratification, and delivery times on online and offline grocery shopping before and during the COVID-19 pandemic in India. They found that convenience and instant gratification were the most influencing factors for both online and offline shoppers during COVID-19, respectively, while the risk of getting infected by the virus was not a driving factor for any of them.

What is missing in the literature of GS preference with respect to COVID-19 is a comprehensive study that not only considers people’s choices before and during COVID-19 pandemic but also takes the individuals’ prediction on their behavior after COVID-19 into account. Therefore, in this study two post COVID-19 periods (short-term and long-term after COVID-19) are added to the other two time periods. Further, the influence of different factors, including socio-economic and demographic characteristics, reasons for choosing online or physical grocery shopping, and frequency of grocery shopping are investigated in each of these time periods. The findings of this research provide a better insight into changes of people’s GS choice behavior between the PGS and the OGS due to the pandemic.

Survey design and data collection

An online grocery shopping survey was conducted from June to September 2020. The survey consists of the following four parts, and is shown in the Appendix section:

(I) Investigation of the socio-economic and demographic characteristics. It mainly covers respondents’ gender, age, education, household size, ethnicity, and vehicle ownership.

(II) Investigation of grocery shopping choice before the COVID-19, PGS or OGS. The considered factors mainly include respondents’ employed status, household income, preferences for PGS and OGS before occurring the pandemic.

(III) Investigation of grocery shopping choice during the COVID-19, PGS or OGS. The considered factors include respondents’ employed status, household income, preferences for PGS and OGS during the COVID-19 lockdown period.

(IV) Investigation of respondents’ adoption attitudes toward the OGS after COVID-19. Two post COVID-19 time periods are divided
into the short-term and the long-term periods. The “short-term after COVID-19” in the survey (see appendix for the survey questionnaire) was defined as the period “after lifting the stay-at-home order but before a vaccine is developed”. And the “long-term after COVID-19” refers to the period “when the vaccine is developed successfully”. Besides, adoption of automated delivery in the long-term period is also investigated in this part.

A total of 310 participants completed the survey by the end of August 2020. After excluding invalid records (e.g., contradictory responses to some questions or many unanswered questions), the data size was reduced to 302. Fig. 1 shows the geographical distribution of participants within the United States. The bigger circle size, the more participants there complete the survey. The survey covers about half of the whole states with a focus on the eastern area. 80.59% of participants came from the State of Illinois, mostly City of Chicago. Table 1 summarizes the characteristics of the survey participants. They are predominantly female (75.67%), with a bachelor’s or higher degree (68.00%), with ages from 20 to 54 years (89.33%), and having 1 to 2 vehicles (72.34%). GS in particular OGS is not a typical everyday and everybody activity. Hence, the participants’ characteristics are not expected to represent the general public. For example, having predominantly female respondents is reflective of the fact that grocery shopping is mostly carried out by a female figure in the household.
Descriptive analysis

Changes in socio-economic characteristics during COVID-19

There are four different possible changes in employment status during COVID-19 with respect to the before COVID-19 period: the two categories of no changes in status, including employment-employment and unemployment-unemployment, losing jobs during COVID-19 which is expressed as employment-unemployment, and finding jobs during COVID-19 which is expressed as unemployment-employment. Fig. 2 shows that there are no changes in the employment status of 86% of the participants (72% remain to be employed and 14% remain the unemployed status). 13% have lost their jobs during the pandemic, and the estimated unemployment rate is 15%.

The COVID-19 has affected the development of economics, which can be partially reflected by the changes in individuals’ annual household income (Fig. 3). Fig. 3(a) indicates that the proportion of incomes less than $10,000 increases significantly from 6.33% to 10.67%. The proportion of incomes between $10,000 and $24,999 has a slight increase (1.33%). However, higher incomes (higher than $25,000) have a decreasing or constant trend during COVID-19. Fig. 3(b) analyzes the changes in each income group. For example, more than 30% of people whose annual incomes are between $10,000 and $14,999 before experience a reduction during COVID-19, and about 60% of them remain unchanged. Interestingly, the results show that individuals with higher annual household income before are less affected by the virus.

| Shopper type | Grocery shopping preference before - during - after COVID-19 | Sample size |
|--------------|-------------------------------------------------------------|-------------|
| 1            | PGS-PGS-PGS                                                 | 135         |
| 2            | PGS-PGS-OGS                                                 | 56          |
| 3            | PGS-OGS-PGS                                                 | 28          |
| 4            | PGS-OGS-OGS                                                 | 68          |
| 5            | OGS-OGS-OGS                                                 | 11          |

Table 2

Grocery shopper types.

Fig. 10. Distribution of concerns about adopting automated delivery service.

Fig. 11. Distribution of annual household income before COVID-19.

Fig. 12. Distribution of frequency using OGS during COVID-19.

Fig. 13. Distribution of changes in the membership of OGS.

Fig. 14. Distribution of future adoption toward OGS.
### Table 3
Description of independent variables.

| Variables          | Type     | Description                                                                 |
|--------------------|----------|-----------------------------------------------------------------------------|
| female age         | dummy    | female: 1 if is female, otherwise 0                                            |
| age categorical    |          | There are six groups: age1: 1 if is not over 20 years old                     |
|                    |          | age2: 1 if is between 20 and 34 years                                          |
|                    |          | age3: 1 if is between 35 and 54 years                                          |
|                    |          | age4: 1 if is between 55 and 69 years                                          |
|                    |          | age5: 1 if is between 70 and 84 years                                          |
|                    |          | age6: 1 if is at least 85 years old                                            |
| education degree   | categorical | There are four groups of education degree level: education1: 1 if it is less |
|                    |          | than high school education                                                    |
|                    |          | education2: 1 if it is high school graduate                                    |
|                    |          | education3: 1 if it is college or associate’s degree                           |
|                    |          | education4: 1 if it is bachelor’s degree or higher                             |
| household size     | categorical | The number of people in a household, and four situations are considered in |
|                    |          | the survey: size1: 1 if a respondent lives alone                              |
|                    |          | size2: 1 if the household size is 2                                            |
|                    |          | size3: 1 if the household size is 3                                            |
|                    |          | size4: 1 if the household size is more than 3                                  |
| children           | categorical | The number of children in a household: children1: 1 if a household has no   |
|                    |          | children2: 1 if a household has one child                                     |
|                    |          | children3: 1 if a household has two children                                   |
|                    |          | children4: 1 if a household has more than two children                        |
| elderly            | categorical | The number of old people in a household: old1: 1 if there are no old people  |
|                    |          | old2: 1 if there are one old people in a household                            |
|                    |          | old3: 1 if there are two old people in a household                            |
|                    |          | old4: 1 if there are more than two old people in a house                      |
| vehicles           | categorical | The number of available vehicles in a household: vehicle1: 1 if the respondent |
|                    |          | has no available vehicles                                                      |
|                    |          | vehicle2: 1 if there are only one vehicle                                     |
|                    |          | vehicle3: 1 if there are two available vehicles                               |
|                    |          | vehicle4: 1 if there are more than two vehicles                               |
| employment status  | dummy    | employment: 1 if a respondent is employed, otherwise 0                       |
| annual income      | categorical | There are nine groups of annual household income: income1: 1 if the income is |
|                    |          | less than $10,000                                                             |
|                    |          | income2: 1 if the income is between $10,000 and $14,999                       |
|                    |          | income3: 1 if the income is between $15,000 and $24,999                       |
|                    |          | income4: 1 if the income is between $25,000 and $34,999                       |
|                    |          | income5: 1 if the income is between $35,000 and $49,999                       |
|                    |          | income6: 1 if the income is between $50,000 and $74,999                       |
|                    |          | income7: 1 if the income is between $75,000 and $99,999                       |
|                    |          | income8: 1 if the income is between $100,000 and $149,999                    |
|                    |          | income9: 1 if the income is $150,000 or more                                 |
| mode of PGS        | categorical | Eight kinds of modes for PGS are investigated: car: 1 if the primary mode of |
|                    |          | PGS is private car                                                          |
|                    |          | transit: 1 if go to PGS by transit                                            |
|                    |          | metro: 1 if go to PGS by metro                                               |
|                    |          | taxi: 1 if go to PGS by taxi                                                  |
|                    |          | bicycle: 1 if go to PGS by bicycle                                            |
|                    |          | walk: 1 if go to PGS by walking                                               |
|                    |          | ridesourcing: 1 if go to PGS by e-hailing ride services                      |
|                    |          | ormode: 1 if go to PGS by other modes                                          |
| reasons for PGS    | categorical | There are six reasons for using PGS in the survey: enjoy: 1 if a participant  |
|                    |          | enjoys the process of PGS                                                     |
|                    |          | quality: 1 if the physical stores are close to a                              |
|                    |          | participant: 1 if thinks physical stores have abundant goods                  |

### Table 3 (continued)

| Variables          | Type     | Description                                                                 |
|--------------------|----------|-----------------------------------------------------------------------------|
| frequency for      | categorical | The general frequency of PGS/OGS for a respondent: frequency1: 1 if is more  |
| PGS/OGS            |          | than once a week                                                            |
|                    |          | frequency2: 1 if is once a week                                              |
|                    |          | frequency3: 1 if is once every two weeks                                      |
|                    |          | frequency4: 1 if is once a month                                             |
|                    |          | frequency5: 1 if is less than once a month                                    |
| OGS experience     | dummy    | OGSexp: 1 if has the OGS experiences, otherwise 0                            |
| reasons for OGS    | categorical | There are seven reasons for using OGS in the survey: COVID-19: 1 if uses   |
|                    |          | OGS because of the pandemic                                                   |
|                    |          | convenience: 1 if the reason is the convenience of OGS                       |
|                    |          | mobility: 1 if uses OGS because of the mobility limitation                   |
|                    |          | timesav: 1 if thinks the OGS mode is time saving                            |
|                    |          | health: 1 if uses OGS because of health constraints                          |
|                    |          | weather: 1 if uses OGS because of adverse weather                            |
| types of OGS       | categorical | There are three kinds of OGS services: service1: 1 if the grocery stores are |
|                    |          | existed only online                                                          |
|                    |          | service2: 1 if online stores are authorized by physical stores               |
|                    |          | service3: 1 if stores are authorized by third party services                 |
|                    |          | delivery: 1 if chooses home-delivery service, otherwise 0                    |
|                    |          | membership: 1 if purchases the online membership                            |
| role of OGS        | categorical | There are three potential roles for the OGS: primary: 1 if regards OGS as a |
|                    |          | role in the future                                                           |
|                    |          | supplementary: 1 if regards OGS as a supplementary role                      |

### Changes in GS preference

Fig. 4 compares the distribution of participants’ primary GS mode before and during COVID-19. Although PGS is dominant in both time periods, the outbreak of COVID-19 increases the popularity of OGS from 5.00% to 36.67%. The transfer intensity from PGS to OGS is about 33.33%. Considering the situation that people who chose PGS as the primary mode may or may not have the OGS experience, Fig. 5 analyzes the distribution of experiencing OGS in different time periods. Although only 5.00% of participants prefer OGS as the primary mode before, 36.33% of them in fact have experienced OGS already, and the percent increases to 60.67% during the pandemic. After COVID-19, there is a reported decreasing trend in OGS use, however, it is still larger than that of before, which may indicate that the pandemic has lasting effects on using and adopting the OGS.

The reasons for using PGS and OGS in different time periods are shown in Fig. 6. For the traditional PGS mode, people chose PGS before mainly because they have a high demand for food quality (62.11%) and enjoy the process (59.65%), followed by the cost saving attribute (54.39%). During COVID-19, the main reasons were high quality (54.74%) and cost saving (52.63%), while enjoy the PGS process has the highest decrease in its popularity. For the OGS mode, Fig. 6(b) presents that convenience and time saving are the most two important reasons for using OGS before COVID-19. With the influence of COVID-19, the most
Without any significant changes to the structure, the proportion of people suffering from COVID-19 is significantly reduced in the long-term after COVID-19. This reason again, COVID-19 is still a major drive by taking the second rank, followed by the time saving. Fig. 6(b) shows that the concern about the PGS-PGS-OGS, as an example, it represents shoppers who prefer the PGS before and during COVID-19, and prefer the OGS in the long-term after COVID-19. Figs. 11–14 describe some characteristic distributions among these five shopper types in order to distinguish them, including the annual household income before COVID-19, frequency to use OGS during COVID-19, the ownership of OGS membership, and the attitudes toward OGS. For example, shoppers who always prefer the OGS in the three time periods in general have more than $35,000 income before the pandemic. During COVID-19, most shoppers of type 1 who always prefer the PGS have less frequency of OGS, less than once a month. Instead, most shoppers who are interested in the online shopping have once a week or once every two weeks frequency of OGS. For the ownership of OGS membership, Fig. 13 finds that except for the type 5 shoppers remain the highest membership rate (54.55%), and 69.12% of shoppers of type 4 have membership during the special time period, other three types of shoppers are more likely not to buy the OGS membership neither before nor during COVID-19. For the role of OGS in the future, 63.64% of type 5 shoppers who prefer to use OGS in different time periods would regard it as a primary mode, over 60% of type 2 and type 4 shoppers think it should play a supplementary role, while more than half of type 1 and type 3 shoppers who would go back to traditional PGS after COVID-19 think the OGS is an occasional mode.

**Distinction of various shopper types**

By investigating the trends in GS preference during time with regard to COVID-19 (before, during, and long-term after), five different shopper types can be defined, which are presented in Table 2. Taking the type 2, PGS-OGS-OGS, as an example, it represents shoppers who prefer the PGS before and during COVID-19, and prefer the OGS in the long-term after COVID-19. Hypothesis 1: Income and vehicle ownership some socio-economic characteristics and advantages of OGS would change people’s GS choice from the PGS to the OGS mode during COVID-19. Table 3 describes all used independent variables in models. The dependent variable has two values: 1 represents that a participant chooses OGS during COVID-19 instead of remaining the GS mode chosen before the pandemic, and 0 represents the participant remains the GS mode during the period. And estimation of the binary logit model is presented in Table 4. In general, gender, vehicle ownership, employment status, annual household income, primary mode of PGS, frequency of OGS and PGS, and attributes of OGS are significant factors. Women, people who go to PGS once a month before COVID-19, are employed, have more than $35,000 income, do OGS frequently, or have health related constraints during the pandemic are more likely to choose

### Table 4

| Variable | Coefficient | Odds ratio | p value |
|----------|-------------|------------|---------|
| female2  | 1.382       | 3.983      | 0.026** |
| size4    | -1.034      | 0.356      | 0.096*  |
| vehicle2 | 1.815       | 6.141      | 0.034** |
| emchance | 1.914       | 6.780      | 0.048** |
| incomeincrease | -2.443 | 0.087 | 0.020** |
| BC_car   | -2.527      | 0.072      | 0.002***|
| BC_quality | -1.077     | 0.341      | 0.054*  |
| BC_OGS_frequency4 | 2.283 | 9.806 | 0.097** |
| BC_convenience | -1.438 | 0.237 | 0.011*** |
| DC_employment | 1.280 | 3.597 | 0.056*  |
| DC_income5 | 4.569 | 0.010 | 0.014**** |
| DC_income5 | 2.775 | 16.039 | 0.029** |
| DC_OGS_frequency2 | 1.947 | 7.008 | 0.022** |
| DC_OGS_frequency3 | 1.995 | 7.352 | 0.009*** |
| DC_OGS_frequency4 | 3.890 | 48.911 | 0.000**** |
| DC_OGS_frequency4 | 4.021 | 55.757 | 0.000**** |
| DC_OGS_frequency4 | 3.609 | 36.929 | 0.000**** |
| DC_COVID-19 | 5.171 | 176.091 | 0.000**** |
| DC_convenience | 1.537 | 4.651 | 0.024** |
| DC_income9 | -1.657 | 0.191 | 0.018** |
| DC_income8 | 1.381 | 3.979 | 0.006** |
| constant | -6.916     | 0.000     | 0.000*** |

Note: BC and DC stand for before and during COVID-19, respectively.

| Variable                  | Coefficient | Odds ratio | p value |
|---------------------------|-------------|------------|---------|
| Pseudo R-squared          | 0.687       |            |         |
| Log-Likelihood             | -57.153     |            |         |
| No. Observations          | 285         |            |         |

This study also investigates the popularity of three types of OGS services (Fig. 8). Participants are able to select more than one type. Results show that the three kinds of services had almost equal shares before the pandemic. However, the third-party service and the online service provided by a physical store attract more during COVID-19.
## Table 5

Estimation results of BL models for using OGS in different time periods.

| Variable                  | Before COVID-19 |          | During COVID-19 |          | short term after COVID-19 |          | long term after COVID-19 |          |
|---------------------------|-----------------|----------|------------------|----------|---------------------------|----------|--------------------------|----------|
|                           | Coef            | p value  | Coef             | p value  | Coef                       | p value  | Coef                      | p value  |
| female                    | 1.578           | 0.011**  | 1.632            | 0.007*** |                           |          |                          |          |
| age2                      | 1.480           | 0.018**  |                  |          |                           |          |                          |          |
| age4                      | −2.183          | 0.024**  |                  |          |                           |          |                          |          |
| age5                      | 3.481           | 0.048**  |                  |          |                           |          |                          |          |
| education2                | −1.279          | 0.055*   |                  |          |                           |          |                          |          |
| education3                | 3.155           | 0.059**  |                  |          |                           |          |                          |          |
| education4                | 2.674           | 0.005**  |                  |          |                           |          |                          |          |
| size1                     | −2.137          | 0.014**  |                  |          |                           |          |                          |          |
| children2                 | 1.260           | 0.020**  |                  |          |                           |          |                          |          |
| old1                      |                |          |                  |          |                           |          |                          |          |
| old2                      |                |          |                  |          |                           |          |                          |          |
| vehicle1                  | 2.239           | 0.032**  |                  |          |                           |          |                          |          |
| vehicle4                  | 1.567           | 0.045**  |                  |          |                           |          |                          |          |
| BC_employment             | −1.604          | 0.021**  |                  |          |                           |          |                          |          |
| BC_income1                | −4.971          | 0.003*** |                  |          |                           |          |                          |          |
| BC_income5                | −3.523          | 0.009*** |                  |          |                           |          |                          |          |
| BC_income6                | −0.920          | 0.030**  | −3.968           | 0.002**  |                           |          |                          |          |
| BC_income7                | 2.877           | 0.001*** |                  |          |                           |          |                          |          |
| BC_income9                | 1.103           | 0.070**  |                  |          |                           |          |                          |          |
| BC_car                    | −3.518          | 0.001*** | 3.677            | 0.001*** |                           |          |                          |          |
| BC_transit                | −3.826          | 0.001*** |                  |          |                           |          |                          |          |
| BC_bicycle                | −4.273          | 0.008*** |                  |          |                           |          |                          |          |
| BC_walk                   | −3.554          | 0.003*** |                  |          |                           |          |                          |          |
| BC_PGS_frequency1         | −0.773          | 0.005*** |                  |          |                           |          |                          |          |
| BC_PGS_frequency2         | 1.091           | 0.007*** |                  |          |                           |          |                          |          |
| BC_PGS_frequency3         | −1.646          | 0.043**  |                  |          |                           |          |                          |          |
| BC_employment             | −1.202          | 0.048**  |                  |          |                           |          |                          |          |
| BC_income1                | 2.319           | 0.012**  |                  |          |                           |          |                          |          |
| BC_income5                | −1.378          | 0.042**  |                  |          |                           |          |                          |          |
| BC_income6                | −2.438          | 0.001*** |                  |          |                           |          |                          |          |
| incomeincrease            | 3.148           | 0.019**  | −1.351           | 0.083*   |                           |          |                          |          |
| DC_income1                | 1.291           | 0.037**  |                  |          |                           |          |                          |          |
| DC_income2                | 2.040           | 0.065*   |                  |          |                           |          |                          |          |
| DC_income3                | 3.426           | 0.064*   |                  |          |                           |          |                          |          |
| DC_income4                | 3.753           | 0.094*   | 3.023            | 0.003*** |                           |          |                          |          |
| DC_income5                | 2.707           | 0.017**  | −2.147           | 0.001*** |                           |          |                          |          |
| DC_income6                | 4.300           | 0.000*** |                  |          |                           |          |                          |          |
| DC_income7                | 3.734           | 0.014**  |                  |          |                           |          |                          |          |
| DC_timesav                | 2.931           | 0.000*** |                  |          |                           |          |                          |          |
| DC_vehicle                | −2.053          | 0.008**  |                  |          |                           |          |                          |          |
| DC_mobility               | −1.388          | 0.000*** |                  |          |                           |          |                          |          |
| DC_PGS_frequency1         | −2.053          | 0.008**  |                  |          |                           |          |                          |          |
| DC_PGS_frequency2         | −3.205          | 0.000*** |                  |          |                           |          |                          |          |
| DC_PGS_frequency3         | −0.946          | 0.065*   | −2.523           | 0.003*** |                           |          |                          |          |
| DC_child                  | 2.438           | 0.001*** |                  |          |                           |          |                          |          |
| DC_GOS_frequency1         | 1.372           | 0.087*   | 1.931            | 0.022**  |                           |          |                          |          |
| DC_GOS_frequency5         | 2.040           | 0.002*** | 1.600            | 0.006**  |                           |          |                          |          |
| DC_COVID-19               | 2.135           | 0.000*** |                  |          |                           |          |                          |          |
| DC_convenience            | 4.025           | 0.002*** |                  |          |                           |          |                          |          |
| DC_mobility               | 2.072           | 0.002*** |                  |          |                           |          |                          |          |
| DC_timesav                | 1.265           | 0.032*** |                  |          |                           |          |                          |          |
| DC_vehicle                | 1.925           | 0.000**  |                  |          |                           |          |                          |          |
| DC_PGS_frequency1         | 3.134           | 0.000*** |                  |          |                           |          |                          |          |
| DC_PGS_frequency2         | 1.418           | 0.021**  |                  |          |                           |          |                          |          |
| DC_PGS_frequency3         | 4.749           | 0.000*** |                  |          |                           |          |                          |          |
| DC_PGS_frequency4         | 3.423           | 0.000*** |                  |          |                           |          |                          |          |
| DC_PGS_frequency5         | 2.825           | 0.002*** |                  |          |                           |          |                          |          |
| DC_PGS_frequency6         | −5.923          | 0.000*** |                  |          |                           |          |                          |          |
| DC_PGS_frequency7         | −4.490          | 0.000*** |                  |          |                           |          |                          |          |
| DC_PGS_frequency8         | 0.171           | 0.075**  | 0.670            | 0.615    |                           |          |                          |          |
| DC_PGS_frequency9         | −66.717         | −79.593  |                  |          |                           |          |                          |          |
| DC_PGS_frequency10        | 300             | 300      | 300              | 300      |                           |          |                          |          |
OGS as the primary GS mode with the influence of the COVID-19. However, people who mainly go to PGS by private car, and have higher requirements for products quality are less likely to choose OGS as the primary mode. The increasing household size also decreases the probability. Interestingly, the convenience of OGS does not increase the probability to choose OGS before but works significantly during COVID-19, this could be due to a change in definition of convenience because of the occurrence of the pandemic.

The odds ratio estimates that the changes in the predicted odds of choosing OGS as the primary mode during COVID-19 when an independent variable is 1 and 0. Taking the female as the example, 3.983 indicates that the predicted odds of choosing the OGS mode during COVID-19 for female is 298% higher than the odds for male, which has the consistent explanation by the coefficient that females are more likely to choose OGS than male. For the household size, the odds ratio means that the odds of choosing OGS for household with three or more members is 64% lower than the odds for household with less three members. Above all, the binary logit model enables to validate the Hypothesis 1 significantly.

Choice behavior of experiencing/using OGS before, during, and after COVID-19

As shown in Fig. 5, the distributions of any OGS before, during, and after COVID-19 (including the short-term and long-term after the pandemic) are different. This may be due to some changes in important influencing factors and the related effects. This section, therefore, tests another hypothesis by series of binary logit models:

Hypothesis 2: The important factors that influence people to experience OGS, even though may not choose OGS as the primary mode, before, during, and after COVID-19 periods are different.

There are two classes for the dependent variable: 1 represents yes on OGS experiences, and 0 refers to no OGS experience. Table 5 shows the estimation results of binary logit models for different time periods. With the influence of COVID-19, the ownership of available vehicles, higher household income, and having OGS experiences not only are important factors for choosing OGS as the primary mode during COVID-19 but also increase the probability of experiencing the OGS mode in the four time periods. Additionally, the preference of home-delivery service for OGS, and regarding OGS as a primary or supplementary mode make people more interested in using OGS. However, the same level of household income in different time periods has different effects on using OGS, which is shown by the negative coefficient of BC_income4 and the positive value of DC_income4 during the pandemic. The coefficient of the age variable find that people aging between 20 and 54 years are more likely to experience OGS before COVID-19, but people aging between 70 and 84 years show more tendency to use OGS after COVID-19.

In some cases, even for the same influencing factors, the effects vary before, during, and after COVID-19. Lower education level, conducting PGS by walking, and frequent PGS prior to COVID-19 decrease the likelihood to use OGS before the pandemic, but increase that likelihood after COVID-19. PGS by private car makes shoppers less likely to use OGS before and after COVID-19, but more likely to use OGS nonetheless during the pandemic. Interestingly, people having children, or having a household income between $25,000 and $34,999 are less interested in OGS during the pandemic, but show greater interest in OGS after the pandemic. Besides, the coefficient of the convenience of OGS before is positive during, while becomes negative after the pandemic.

Obviously, the influencing factors for using OGS vary in different time periods, which tests the Hypothesis 2 significantly. For example, after the COVID-19, gender becomes an important factor and female is more likely to use the OGS mode. However, living alone and the household has no elderly reduce the probability. If there is an increase in income during, it increases the probability of using OGS only during the pandemic.

Conclusions

COVID-19 has affected people’s GS preference, in particular after implementing the stay-at-home order. This research therefore aims to analyze individual’s GS choice between PGS and OGS with the influence of COVID-19. An online survey was designed to collect data, including participants’ social economic characteristics, GS preference and reasons before, during, in the short-term and the long-term after COVID-19. Firstly, descriptive analysis is conducted and finds that the pandemic indeed makes certain people lose jobs, while most people remain employment status unchanged. The proportion of participants having low level of income increases significantly. Even though PGS remains the dominant GS mode at all time, the OGS mode becomes more popular during and after COVID-19. The main reasons for choosing OGS during and in the short-term after the pandemic are the concern over virus, convenience and time saving attributes of OGS. After the vaccine is produced, most people think OGS would play a supplementary and an occasional role. Overall, the attitude towards the automated delivery service is considerable.

Based on the utility maximization theory, series of binary logit models are then estimated to analyze what factors and how they influence people to use the OGS mode (as their primary GS mode) in different time periods. The pandemic has increased the popularity of OGS even though not choose it as the primary GS mode. In general, female, vehicle ownership, higher income, the health constraint, and the concern of COVID-19 would increase the likelihood to choose OGS as a primary mode during COVID-19, and continue to experience the mode after COVID-19. Besides, with the influence of COVID-19, old people, or people who have high frequency of PGS before, high frequency of OGS during COVID-19, or regard OGS as a primary or supplementary mode are also more likely to use it. While people who often go to physical stores by private car before, or have high requirements on product quality show less tendency to choose it after the pandemic.

There are limitations in this study. Firstly, the limited sample size. Because most participants come from Chicago city, so the findings in this study are not representative of the entire United States. Secondly, we are now in the long-term after COVID-19, and it is necessary to continue the survey and investigate the real situation of OGS. In addition, this study is limited by the binary logit model, it is possible to explore multiple approaches to model the impact of the pandemic. Except for focusing on grocery shopping behaviors in different time periods, quantitatively analyzing what kinds of people would keep using PGS all the time, who are willing to shop online only during the pandemic but reverted to PGS after COVID-19, and who would use OGS not only during but also after COVID-19 is also interesting.

In conclusion, during COVID-19 the advantages of OGS have been recognized, and OGS is likely to remain popular if not more even after the pandemic. In particular, the third-party service type dominates among three different service types. The effect of OGS is likely to last after the population is largely vaccinated.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests.
interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

We thank Michelle Lemus Alvarez for her help in recruiting survey participants and initial data cleaning.

Data availability statement

Some or all data, models, or code that support the findings of this study are available from the corresponding author upon reasonable request.

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