

The impact of online grocery shopping on stockpile behavior in Covid-19

Online grocery shopping on stockpile behavior

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Abstract

Purpose – This research is to examine the impact of online channels on food stockpile behavior.

Design/methodology/approach – In this study, we use bivariate probit models to empirically investigate the impact of online purchasing channels on Chinese urban consumer food hoarding behaviors with random survey samples.

Findings – Results show that fresh food e-commerce channels are more likely to be associated with panic stockpile behaviors due to higher likelihood of supply shortages than offline channels with government assistance in logistic management. In contrast, community group buy, another format of e-commerce, appears superior in satisfying the consumer needs and easing the panic buying perception.

Practical implications – It suggests that online channels may have diverse impacts on consumers' panic stockpiling behaviors during the extreme situations. Online channels need to develop efficient supply chains to be more resilient to extreme situations and the government shall recognize the increasing share of the online channels together with traditional offline channels when implementing supporting policies.

Social implications – With ever increasing share of online channels, it is imperative in terms of policy implications to understand how would online channels affect hoarding behavior.

Originality/value – We are the first study in online shopping's impact on food stockpile during pandemics using a random sample. Although food stockpile behavior at times of emergency have been investigated in many literature, there are no empirical studies on the impact of online channels on stockpile behaviors under extreme situations. Unlike disasters that immediately impact every entity in supply chains covering producers, vendors, distribution centers and retailers, pandemics did not render supply chains affected immediately, but rather increase consumers' willingness to shop online to avoid virus. Thus, Covid-19 provides a natural experiment to investigate the online channels' impact on stockpile behavior.

Keywords Community group buy, Fresh food e-commerce, Pandemics, Stockpile

Paper type Research paper

1. Introduction

The active outbreak of Covid-19 first observed in Wuhan, China in December 2019, soon became a pandemic in the country and spread to the entire world in the following months, striking densely populated large cities most severely. Quarantine, shelter-in-home and lockdown are measures taken by all major infected regions worldwide, including Chinese top tier metropolitans, Beijing, Shanghai and Guangzhou as the first responsive cities together



with Wuhan. Because of the shelter-in-home order, food rush and hoarding occurred universally (Lufkin, 2020).

Although food stockpile behavior at times of emergency have been investigated in many literature (e.g. Hori and Iwamoto, 2014; Abe *et al.*, 2014), there are no empirical studies on the impact of online channels on hoarding behaviors. Disasters such as earthquake, Hurricane and tsunami would immediately impact every entity in supply chains covering producers, vendors, distribution centers and retailers. In contrast, during the pandemics, supply chains are less immediately affected than those disasters, but rather consumers' willingness to shop online to avoid virus has increased. Thus, the research on food stockpile behaviors in pandemics will be of potential value in contributing to existing literature by adding a new perspective. Besides, with ever increasing share of online channels, it is imperative in terms of policy implications to understand how would online channels affect hoarding behavior. Therefore, this research is to examine the impact of online channels on food stockpile behavior.

Online purchasing channels are considered to help alleviate food hoarding panic by providing a convenient shopping venue eliminating consumers' risk of getting infected with crowds in stores. Thus, e-commerce businesses are highly commended and have received good credits for its contribution in food distribution (Yao, 2020; Guo *et al.*, 2020). Sales on fresh food e-commerce platforms in Shanghai boomed up by 167% and orders increased by 80% from January to March 2020. Meanwhile, daily active user number increased by 127.5%, and order per transaction increased from 40 yuan to more than 100 yuan. Daily transaction volumes were as high as 150 tons of pork and 500 tons of vegetable (Sheng, 2020). However, at the same time, it was reported that fresh food e-commerce, such as Daily Fresh or Meiriyouxian, was hit by heavy food rush. Many shoppers complained that they had to rush to the app for food and still ended in vain.

Although China witnessed some panic buying when its outbreak began in January, the rush for essential goods was comparatively short (People.cn, 2020), as local governments tried hard to mobilize employees, volunteers and couriers to ensure supplies of daily necessities, from food to cleaning products through grocery store chains. Because of these government efforts to facilitate and enhance food supply chains during the disruption, offline grocery stores were quickly restocked which avoided the spread of food shortage fear.

In contrast, online e-commerce platforms were established by private enterprises hosting a large number of small vendors and hardly receive any government support during the supply chain disruption because it is fragmented and not considered essential by governments. However, during the pandemics, consumers rushed to the e-commerce platforms for food. If they failed to place the orders, they could not easily switch to offline channels, which may aggravate their panic of food rush. Their panic of food hoarding may even be amplified by the transparency of e-commerce platforms, because they could see it clearly when there was a food rush in apps the next minute the food was sold out.

Aside from common fresh food e-commerce that consumers individually buy from online stores such as Jingdong or Taobao, WeChat community group buy (WCGB), a new type of location-based social model through the popular social media WeChat, is emerging during the pandemics. In most cases, a community leader initiates a purchase, and gathers orders placed by his/her WeChat group friend members who are residents living in the same neighborhood without charging service fees. Once the leader submitted the total order to a regular online store or an offline supermarket that offers web-order and delivery service, the seller would fill the order and ship to the community leader's address. Each member then picks up his/her own order from the community leader's address (Chen, 2019). WCGB provides several benefits, including free shipping exclusively for large orders and higher priority to be filled by the sellers during shortage. Also WeChat users with no experience of ordering groceries online can easily place orders in the

WeChat groups, which is usually the case for the elderly people. WCGB is especially popular during the pandemic when people are more willing to sacrifice privacy and individual free choices in exchange for reduced shopping trips and risks of canceled orders. Some platforms such as Pinduoduo even provides special Apps for community WCGB to help the leaders handle payments conveniently. WCGB works as a bridge between online vendors and individual shoppers, while itself not in charge of distribution or supply. Consumers gathered in WCGB have constituted a large purchasing power that no profit-driven e-commerce firms or community workers employed by governments could simply ignore. Thus it is expected that WCGB may perform better than fresh food e-commerce in terms of stemming food panic buying. However, it is also possible that a consumer's buying desire is aroused by others in the WeChat group to hoard more.

Thus what is the role of e-commerce playing during the pandemics? Do online channels mitigate the panic food stockpile better than offline channels? Do WCGB and fresh food e-commerce platforms have different impacts? While there are plenty of existing biomedical, medical and epidemiological studies on novel Covid-19, there exist few economic studies on panic stockpiling and no quantitative study on the impact of e-commerce. Now that such food rush and online food ordering are emerging in many countries in the world following the spread of the virus and the shelter-in-home orders, studies of these phenomena may be of global value. In order to bridge this gap in the existing literature, we employ a unique dataset that was collected during the period in Beijing, Shanghai and Guangzhou exclusively for this study and investigate how households protect their livelihoods against an unexpected negative shock caused by Covid-19. This study will also attempt to assist future disaster management plans by investigating the impact of e-commerce on panic stockpiling behavior.

2. Sampling method and statistics

A survey of consumers in Chinese top tier cities of Beijing, Shanghai and Guangzhou, all of which were affected by the virus, was conducted in February 2020. Better than many studies using convenience samples from surveys through personal connections over social media that may result in biased samples, we enlisted a credible online surveying company who recruited random participants from its existing huge national panel of online consumers.

We collected 540 observations, 1/3 in each city, covering grocery shoppers 18 yrs or older with an average age of 31.6. Although the online surveys include more young people than offline grocery shoppers where retired people tend to be the major category, it is appropriate in that during the shelter-in-home time when younger people tend to handle the grocery shopping more than the elderly people, especially in online channels. In the survey, we asked questions about consumers' food purchasing behavior, their psychological status, their health status regarding to the Covid-19 virus and other socio-economic variables. We use two food categories, vegetables and instant noodles, to study the food hoarding phenomena. The former is perishable and essential for everyday food consumption, and the latter is a non-perishable food product and is consumed more by busy working populations (Ho *et al.*, 2019) [1]. The survey questions related to food purchasing behavior and Covid-19 factors are listed in Table 1.

The descriptive statistics show that 60% of respondents agree that it is necessary to hoard vegetables. 73% of them have stored vegetables at home sufficient for 3-day consumption. This volume is quite high compared to Chinese shopping culture that a good share of families are accustomed to do daily vegetable shopping for freshness (Shi, 2020). Keeping a 3-day supply is the maximum they can do [2]. On the contrary, only 16% agree that it is necessary to hoard instant noodles, while 62% have had instant noodles enough for one-week use. With shelter-in-home orders, most people have more time to cook. 53% of respondents have bought fresh food on e-commerce platforms, and 38% have used WCGB. There are quite some overlap of people using both.

We found 3% of the respondents in these three cities either are confirmed or formally suspected to get Covid-19 virus infection themselves or having a close relative or a close

Table 1.
Survey questions and
variable explanation

Survey question	Variable	Description	Statistic
Do you think it is necessary to keep hoarding vegetable?	Vegneed	{ 1, if yes 0, otherwise	1 : 60% 0 : 40%
Do you have enough vegetables for three days?	Veg	{ 1, if yes 0, otherwise	1 : 73% 0 : 27%
Do you think it is necessary to keep hoarding instant noodle?	Instantneed	{ 1, if yes 0, otherwise	1 : 16% 0 : 84%
Do you have enough instant noodles for one week?	instant	{ 1, if yes 0, otherwise	1 : 62% 0 : 38%
Have you used WCGB in purchasing food?	WeChat	{ 1, if yes 0, if no	1 : 38% 0 : 62%
Have you used fresh food e-commerce?	ffecom	{ 1, if yes 0, if no	1 : 53% 0 : 47%
Have you used either WCGB or fresh food e-commerce?	online	{ 1, if yes 0, if no	1 : 67% 0 : 33%
What is your health status regarding to Coronavirus?	Condition	{ 2, if you or your relatives/friends are confirmed or suspected 1, if there are confirmed or suspected cases near your residence 0, otherwise	2 : 3% 1 : 40% 0 : 57%
Are you a doctor or is any of your close relatives or close friends a doctor?	Doc	{ 1, if yes 0, if no	1 : 43% 0 : 57%
Is your profession related with medication?	Med	{ 1, if yes 0, otherwise	1 : 6% 0 : 94%
To what degree do you feel anxious about the outbreak?	anxiety	{ 2, very much 1, a little 0, not at all	2 : 19% 1 : 72% 0 : 9%
Are you worried that there will be a shortage of vegetables?	worryveg	{ 1, if yes 0, if no	1 : 38% 0 : 62%
Are you worried that there will be a shortage of instant noodles?	worryinstant	{ 1, if yes 0, if no	1 : 14% 0 : 86%
What is your gender?	Male	{ 1, if yes 0, if no	1 : 50% 0 : 50%
How many years of school have you attended?	Edu (years schooling)	Mean 16, Std. dev. 1.72	
What is your family annual income?	Income (thousand yuan)	Mean 167.5, Std. dev. 3.01	
Which year were you born?	Age (years)	Mean 31.6, Std. dev. 7.21	

friend confirmed or formally suspected. It is rather devastating for people in this situation during February because the death rate was reported to be quite high in the initial stage of the pandemics. 40% of respondents have confirmed or formally suspected cases nearby in the neighborhood. This means going out for shopping trips is risky for them as most people in these cities living in densely populated buildings sharing with many in small elevators, narrow stairways and hallways and crowded grocery store isles.

About 43% of respondents are either medical doctors or having a relative who is a doctor. Doctors are extremely busy during this period to either treat patients directly or support their colleagues in hospitals. Thus they are perceived to be under the highest risk of getting infected after the depressing January statistics from Wuhan. However, only 6% of the respondents whose own profession (or major if college students) is medical related. Comparing these two statistics, we know that very few respondents are doctors themselves, but many have a relative who is 91% of our respondents feel somewhat or very much anxious about the spread of Covid-19, which represents the situation at that time. 38% of them are scared about the possibility of vegetable shortage, while only 14% are scared about the possibility of instant noodle shortage. It is interesting to see that commodities under shortage in China and in other countries are different. In the United States, it is more of non-perishable food like canned soup and boxed pasta that aroused the highest shortage alert, and in Japan and Hong Kong it is toilet paper.

In terms of social and economic issues, the average education level is 16 yrs of schooling which is equivalent to a college degree, including 10% of respondents graduated from high school (including secondary school) and below, 80% from junior college and higher vocational education, 8% in university bachelor program and 2% from graduate program.

We also asked whether the residential complex is closed or not during the time of survey and if so, whether the respondents were prepared well before it was closed. In these cities, the lockdown or close means the entire complex is gated with often only one exit under check. Residents need to wear masks, hold specially issued passes and get body temperatures measured at the gate to go through, and non-residential guests without the passes are not allowed to enter. It becomes very inconvenient for residents to go out shopping when the community is closed. Figure 1 shows the distribution between unprepared and close. Among them, close is a dummy variable, with 1 representing that the residential complex has been closed for management, 0 otherwise. Similarly, unprepared is also a dummy variable,

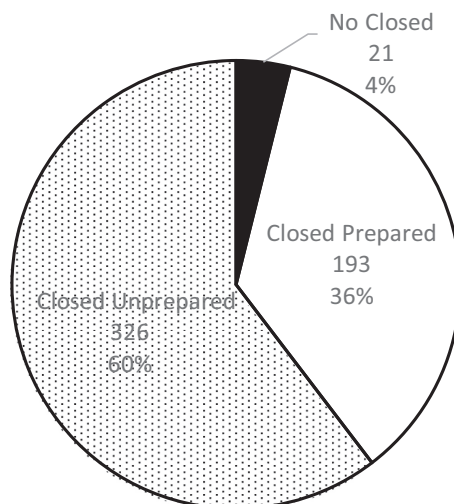


Figure 1. Distribution of closed community and unprepared residents

1 representing that the residents did not prepare well before the community was lockdown. It can be seen from the table that the portion of lockdown community constituted for 96%, which is consistent with what is reported on the news that the government forced the cities to implement lockdown community policy. Of the lockdown community, residents who prepared well account for 36% of all the respondents while who did not prepare well 60%, meaning most people did not prepare well before the community lockdown.

3. Empirical model

To examine the influence that e-commerce brings to food stockpile behavior in terms of both fresh food and shelf-stable food, we consider the following bi-probit model using vegetable as an example of fresh food and instant noodle as an example of the shelf-stable food, allowing the two categories of food to be correlated to one another when the shopping decisions are made together:

$$Y_1^* = X_1\beta_1 + \varepsilon_1, \text{ if } Y_1^* > 0, \text{ then } Y_1 = 1 \text{ otherwise } = 0$$

$$Y_2^* = X_2\beta_2 + \varepsilon_2, \text{ if } Y_2^* > 0, \text{ then } Y_2 = 1; \text{ otherwise } = 0$$

and

$$\begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \end{pmatrix} | X \sim \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_1^2 & \rho \\ \rho & \sigma_2^2 \end{pmatrix}$$

where Y_i is the observed food i , $i =$ vegetable and instant noodle, stockpile behavior and perceptions in alternative models. X_i is the associated vector of all explanatory variables for food i , and β_i is the corresponding coefficient vector. Y_i^* is the latent variable represent the consumer's utility level, when it is greater than zero, then a decision of $Y_i = 1$ will be observed. The two error terms, ε_1 and ε_2 are allowed to be correlated in the bivariate probit model.

$$\text{Prob}(Y|X) = \iint \varphi(\varepsilon|X\beta) d\varepsilon_1 d\varepsilon_2$$

where $\phi()$ is the density function of joint bivariate normal distribution. The maximum log likelihood estimation cannot directly estimate ρ , but $\text{ath } \rho, \text{ ath } \rho = \frac{1}{2} \ln \left(\frac{1+\rho}{1-\rho} \right)$.

We will use this model to study the stockpile behaviors using three dependent variables separately. They are whether the consumer has enough food (*veg, instant*), whether they feel they need more hoarding (*vegneed, instantneed*), and whether they worry about shortage (*worryveg, worryinstant*). The explanatory vector X includes the following variables:

$$X = \begin{pmatrix} \text{close, unprepared, online, wechat, ffecom, Affec}_{\text{nearby}}, \text{Affect}_{\text{selfcloseot}}, \text{anxious}_{\text{alittle}}, \\ \text{anxious}_{\text{very}}, \text{docs, med, other control variables} \\ \delta \end{pmatrix},$$

where close, unprepared, online, WeChat, ffecom, doc and med are dummy variables defined in Table 1 and Figure 1. $\text{Affect}_{\text{nearby}}$ and $\text{Affect}_{\text{selfcloseot}}$ are also dummy variables derived from the values of condition in Table 1, with $\text{Affect}_{\text{nearby}} = 1$ if condition = 1; $\text{Affect}_{\text{selfcloseot}} = 1$ if condition = 2; otherwise they both = 0. Stating anxious toward the pandemics respectively. $\text{Anxious}_{\text{afflittle}}$ and $\text{Ancious}_{\text{very}}$ are two dummy variables derived from anxiety in Table 1, denoting different levels, a little bit or very much, of feeling anxious about the pandemics.

The major hypothesis is that online grocery shopping may aggravate the pressure of feeling the need for food stockpiling thus increasing the likelihood of food hoarding behavior. We also hypothesize that the WCGB may ease the pressure and reduce the likelihood of food hoarding behavior.

There are additional hypotheses concerning the directions of the exogenous variable impacts. Having a profession in medical fields and working as a doctor may play a role in explaining stock-up behavior. The medical professionals and doctors have a better sense on the severity of the diseases and thus may tend to stockpile more than others. However, the lack of information of judgment about the situation for other people may also tend to stockpile too much due to panic effects. Also, doctors are probably the busiest group during the pandemics that they work longer than other groups, thus may need instant noodles more than other groups. Whether the respondents themselves close friends, or relatives are being affected may also play an important role in impacting stockpiling behaviors. When they themselves or their close others are affected, they will feel more threatened by the diseases, and thus raise alert toward the disease.

4. Results

Results of the stockpile behavior are listed in Table 2. The ath ρ is significant at the 1% level in both regressions, meaning the null hypotheses of independence of equations in the bivariate probit model are rejected. The hoarding behaviors for the two different foods are interdependent. Results from two alternative specifications of bi-probit regressions are then listed in Table 2. The Wald Chi-square tests of the two bi-probit regressions indicate significant explanatory variables at the 5% level and 1% level separately.

The difference of the two specifications in model (1) includes the *online* variable representing people shopping in either e-commerce stores or WCGB, while model (2) includes the two variables of *WeChat* and *ffecom* separately. The variable *online* in (1) is significantly positive for both vegetable and instant noodle, meaning people shop at either online channels tend to have stored enough foods at home relative to those who only buy groceries offline. Then, when we further categorize online channels to fresh food e-commerce and WCGB, we

Variables	(1)		(2)	
	Veg	Instant	Veg	Instant
Close	0.107 (0.339)	-0.090 (0.324)	0.034 (0.346)	-0.065 (0.326)
Unprepared	-0.278** (0.131)	-0.399*** (0.124)	-0.285** (0.133)	-0.394*** (0.125)
Online	0.207* (0.125)	0.239** (0.120)		
WeChat			0.431*** (0.130)	0.127 (0.119)
Ffecom			-0.058 (0.124)	0.147 (0.116)
Affec_nearby	0.149 (0.127)	0.016 (0.120)	0.134 (0.128)	0.010 (0.120)
Affec_selfcloseot	0.099 (0.360)	0.126 (0.348)	0.000 (0.362)	0.098 (0.350)
Male	-0.140 (0.124)	-0.056 (0.117)	-0.138 (0.125)	-0.061 (0.117)
Edu	-0.002 (0.038)	-0.008 (0.035)	0.004 (0.038)	-0.005 (0.036)
Shanghai	0.122 (0.147)	-0.056 (0.140)	0.124 (0.148)	-0.069 (0.140)
Guangzhou	0.051 (0.149)	-0.070 (0.142)	0.041 (0.150)	-0.076 (0.143)
Middle_income	0.321 (0.228)	0.048 (0.221)	0.292 (0.230)	0.054 (0.222)
High_income	0.287 (0.235)	0.165 (0.228)	0.301 (0.237)	0.168 (0.229)
Agen	-0.011 (0.008)	0.001 (0.008)	-0.010 (0.008)	0.000 (0.008)
Doc	0.147 (0.129)	0.249** (0.122)	0.141 (0.131)	0.238** (0.123)
Med	0.331 (0.293)	0.330 (0.265)	0.339 (0.298)	0.341 (0.266)
Little-anxiety	-0.040 (0.220)	0.140 (0.205)	-0.044 (0.223)	0.153 (0.205)
Very-anxiety	-0.418* (0.249)	-0.088 (0.235)	-0.424* (0.251)	-0.075 (0.236)
_cons	0.516 (0.739)	0.318 (0.701)	0.204 (0.909)	0.833 (0.944)
/athrho	0.402*** (0.078)		0.414*** (0.079)	
Wald Chi ²	50.85**		57.44***	

Note(s): standard errors are reported in (.), *, ** and *** denote the coefficient estimates are statistically significant at 1%, 5% and 10% levels

Table 2. Bi-probit results of stockpile status

find that WCGB channel is more likely to be associated with vegetable stock-up behavior, while fresh food e-commerce is not. The reasons could be that WCGB channel has better supply availability than e-commerce stores and offline stores and/or WeChat group purchasers are influenced by each other to have higher hoarding desires than offline shopping or private shopping at online stores. The positive contribution of online to stockpile comes primarily from the WCGB. It seems to contradict to the belief that online channels provide additional no-contact source so as to reduce the need of stockpiling due to the fear of virus infection through shopping trips or out-of-stock in local stores, is indeed consistent to this rationale that it contributes to the food at hand positively from the WeChat group purchase channel, not the need to buy furthermore.

To further examine whether it is because WeChat group purchasers are more willing to stockpile, we run another bi-probit regression for perception variables. Other than the same explanatory variables used in the behavior equations, we include an additional variable representing whether the consumer worry about the shortage of a food in its the corresponding question. Results are shown in Table 3.

According to Table 3, WCGB channel is significantly negative in the vegetable equation, which says it is less likely to be associated with the perception of stockpiling more vegetable than offline channel. This result suggests that WeChat group purchasers are less willing to purchase vegetable, thus the higher impact of WCGB on vegetable stockpile can only be explained by more supply availability on the channel than others. Because WCGB receives higher order filling priorities than individual consumers and also because the WCGB leaders have done homework to secure the right sellers, group purchasers may feel more secure with the food supply.

In contrast, according to the results, fresh food e-commerce channels are more likely to be associated with higher perception of the need for both more vegetable and instant noodles

Variables	(1)		(2)	
	Vegneed	Instantneed	Vegneed	Instantneed
Close	0.073 (0.298)	-0.443 (0.304)	0.105 (0.299)	-0.410 (0.317)
Online	0.036 (0.123)	0.292** (0.119)		
WeChat			-0.203* (0.122)	0.131 (0.140)
Ffecom			0.204* (0.120)	0.215* (0.114)
Affec_nearby	0.187 (0.121)	0.067 (0.140)	0.187 (0.121)	0.057 (0.140)
Affec_selfcloseot	0.318 (0.358)	0.248 (0.360)	0.352 (0.361)	0.206 (0.363)
Male	-0.145 (0.119)	-0.001 (0.139)	-0.146 (0.120)	-0.004 (0.139)
Edu	-0.077** (0.037)	-0.033 (0.034)	-0.085** (0.037)	-0.002 (0.045)
Shanghai	0.052 (0.145)	-0.059 (0.168)	0.066 (0.145)	0.047 (0.167)
Guangzhou	-0.039 (0.144)	-0.069 (0.169)	-0.020 (0.145)	0.068 (0.169)
Middle_income	-0.126 (0.221)	0.233 (0.219)	-0.088 (0.222)	-0.041 (0.286)
High_income	-0.131 (0.229)	0.348 (0.223)	-0.123 (0.230)	0.363* (0.225)
Agen	0.015** (0.008)	-0.002 (0.008)	0.014* (0.008)	-0.003 (0.010)
Doc	0.166 (0.125)	0.271** (0.119)	0.185 (0.126)	0.278** (0.119)
Med	-0.564** (0.248)	0.580** (0.264)	-0.551** (0.249)	0.592** (0.264)
Little-anxiety	0.212 (0.198)	0.081 (0.234)	0.212 (0.199)	0.093 (0.234)
Very-anxiety	0.668*** (0.244)	-0.128 (0.271)	0.689*** (0.246)	-0.108 (0.273)
Worryveg	0.728*** (0.128)		0.715*** (0.130)	
Worryinstant		0.050 (0.160)		0.062 (0.160)
_cons	0.462 (0.693)	-2.422 (0.865)	0.538 (0.697)	-2.421*** (0.869)
/athrho	-0.008 (0.078)		-0.012 (0.073)	
Wald Chi2	95.94***		98.30***	

Table 3. Bi-probit model results for the perception of food hoarding

Note(s): standard errors are reported in (.). *, ** and *** denote the coefficient estimates are statistically significant at 1%, 5% and 10% levels

than offline channels. Coupled with results shown in Table 2, it suggests that individual consumers shopping directly from e-commerce stores may have demand left unsatisfied, as they are less likely to have enough stock at home while expressing higher need for food stockpiling. Demand created by individual orders placed on fresh food e-commerce platforms exceeds the supply capacity during this pandemic, which has been reported in the news report. Many fresh food e-commerce vendors had a food rush and consumers strived for food but ended in vain.

As a cross check, we run another regression of whether consumers are concerned of food shortage. The results are listed in Table 4. Results confirmed that fresh food e-commerce are more likely to contribute to the concerns over a vegetable shortage. It suggests that fresh food e-commerce amplify the panic of food shortage due to its limited supply capacity. The positively and significantly *online* variable is mostly contributed by the e-commerce channel.

In terms of instant noodle, either e-commerce or WeChat group buy shows limited difference in terms of impacting the stockpile behavior (Table 2) and whether being concerned of food shortage (Table 4). It could be explained by the fact that instant noodle is shelf-stable food. Both online and offline sellers can easily store instant noodles and manage the distribution much easier than they store and deliver fresh vegetable. The results indicate the food supply capacity is the dominating factor.

We also learn some interesting stories from the control variables. They perform quite consistently across the three models in that the city dummies are insignificant because all these three cities have experienced similar impacts by the virus and taken similar measure. The variable, *close*, representing the lockdown is mostly insignificant, which can be the result of the lack of variability of our data. 96% of respondents live in communities that have been lockdown. The variable, *unprepared*, give the significant and correct signs in all models.

The more anxious consumers feel about the pandemics, the less likely they are to stockpile enough food, but the more likely to feel the need to stockpile and to be concerned over food

Variables	(1)		(2)	
	Worryveg	Worryinstant	Worryveg	Worryinstant
Close	-0.249 (0.313)	-0.626* (0.350)	-0.101 (0.323)	-0.607* (0.348)
Unprepared	0.112 (0.127)	0.287* (0.159)	0.120 (0.128)	0.282* (0.159)
Online	0.234* (0.126)	0.101 (0.153)		
WeChat			-0.021 (0.123)	0.020 (0.148)
Ffecom			0.292** (0.120)	-0.036 (0.144)
Affec_nearby	0.074 (0.123)	-0.001 (0.149)	0.073 (0.123)	0.002 (0.149)
Affec_selfcloseot	0.454 (0.333)	-0.126 (0.424)	0.443 (0.336)	-0.111 (0.424)
Male	0.113 (0.120)	-0.223 (0.147)	0.103 (0.121)	-0.232 (0.147)
Edu	-0.005 (0.036)	0.016 (0.047)	-0.005 (0.037)	0.019 (0.048)
Shanghai	0.121 (0.143)	0.158 (0.170)	0.113 (0.143)	0.149 (0.170)
Guangzhou	-0.068 (0.147)	-0.103 (0.181)	-0.093 (0.148)	-0.108 (0.182)
Middle_income	0.511** (0.256)	0.372 (0.357)	0.529** (0.256)	0.363 (0.356)
High_income	0.715*** (0.260)	0.703** (0.359)	0.700*** (0.260)	0.705** (0.357)
Agen	-0.032*** (0.009)	-0.020* (0.011)	-0.034*** (0.009)	-0.019* (0.011)
Doc	0.133 (0.126)	0.020 (0.152)	0.128 (0.128)	0.020 (0.153)
Med	-0.169 (0.254)	0.019 (0.305)	-0.139 (0.259)	0.013 (0.306)
Little-anxiety	0.471** (0.232)	0.524 (0.329)	0.481** (0.232)	0.516 (0.327)
Very-anxiety	1.284*** (0.261)	0.971*** (0.353)	1.346*** (0.268)	0.952*** (0.351)
_cons	-0.575 (0.719)	-1.381 (0.931)	-0.499 (0.720)	-1.326 (0.932)
/athrho	0.148* (0.089)		0.153* (0.089)	
Wald Chi ²	88.55***		90.49***	

Note(s): standard errors are reported in (.), *, ** and *** denote the coefficient estimates are statistically significant at 1%, 5% and 10% levels

Table 4. Bi-probit model results for expecting supply shortages

shortage. This is consistent to the psychology literature like (Segerstrom *et al.*, 1998) that when people are under pressure and having anxiety, they are pessimistic. Also the negative effect on stockpile status is a result of their being inactive in action.

Results also show that consumers with higher income tend to concern more about the food shortage and have stronger will to stockpile. However, they are less likely to stockpile enough food relative to others. It may indicate that price signal failed to work during the pandemics that it did not reflect high demand created by consumers with high income. People with higher demand and higher income did not get food more than people with less income did. It is consistent with what we expected that government make every effort in stabilizing the food price. Also, vegetable and instant noodles are necessities, their costs consist a small share in overall household budget for most people in these three cities, people are not sensitive to the monetary measurement related to food purchasing especially during the pandemic period. Furthermore, stores may have restricted the quantities each shopper can buy, which widens the gap between targeted sufficient level and the actual acquired level for the higher income consumers to feel sufficient.

Age is insignificant in both stockpile equations, positive in vegetable need equations but negative in both worry equations. This shows that older people tend to feel they need more vegetables, although they have stockpiled the same as younger people, because they consider vegetables more important in diets. However, they trust the system better than younger people for providing their needs so that they worry less.

Another interesting result is that doctors and medical-related professionals are more likely to feel the need of instant noodles. It may suggest that the people who had more relevant knowledge may consider the pandemics more severe than other people and thus are more likely to store instant noodle for long-run preparation.

5. Conclusions and policy implications

E-commerce was highly commended for playing an important role in alleviating panic stockpiling behavior (Yao, 2020; Guo *et al.*, 2020). As a first attempt in providing empirical evidence for how e-commerce impact food purchasing behavior, this research sheds light on the downside that e-commerce may bring to the society when e-commerce platforms has a food run under extreme situations. Most of the current literature analyze under normal condition how e-commerce enhanced well-being of consumers with its compelling advantages including lower cost structure, greater flexibility, broader scale and scale of services, greater transparency and faster transactions (Kabango and Asa, 2015; Zheng *et al.*, 2020). Limited if any literature analyzes when demand exceeds the supply on e-commerce platforms, how will the e-commerce play under extreme situations. This makes it difficult to develop constructive guidance in launching an efficient implementation against panic stockpile in extreme situations.

Survey data show that 60% of our respondents are not prepared well when their residential community is locked down. This unpreparedness is also highly associated with the worries and stockpile pressure. It calls for governments' quick organization to ensure the basic food supply when issuing the lockdown orders.

Employing bi-probit models, we found that individual consumers on fresh food e-commerce channel may have demand that has not been satisfied. Demand created by individual orders placed on fresh food e-commerce platforms exceeds the supply capacity of e-commerce business. It suggests that fresh food e-commerce amplify the panic of food shortage due to its limited supply capacity. In contrast, because community group buy has larger purchasing power than individual consumers and it saves risk of getting affected in supermarkets and grocery stores, group buyers may feel more secure with the food supply. Furthermore, peer influence in WeChat group is a strong factor for stockpiling. Families who

buy grocery in WeChat group get their own needs satisfied better. Results indicate fresh food e-commerce are associated with the likelihood of more panic stockpile than offline channels. The results also indicate the food supply capacity is the dominating factor.

These results have some implications for both the industry and public policy. First, it calls for the government to consider proper arrangements for people's livelihood when issuing drastic orders like lockdown. Second, online businesses as a growing new channel for grocery should develop their supply chain to make it more resilient to extreme situations, so that when other extreme situations happen, e-commerce could play an important in mitigating the panic shortage. Governments should not ignore the ever growing online grocery stores while assisting the supply chain of traditional offline channels. Third, results suggest that governments have done a good job to convince older people and reduce their worries about food shortage likely through the traditional public media, however, younger people worry more. Many young urban citizens depend on cafeteria, restaurants and online food deliver services for their meals before the pandemic, and their lives are affected more by the lockdown. Thus it calls for governments' attention to the changing lifestyle of urban dwellers when providing public services and policies under special situations instead of focusing all on traditional lifestyle.

Notes

1. We also examined meat as another fresh food and frozen food as another shelf-stable food as a robustness check and all the general results about online still hold.
2. Because of the daily fresh food shopping tradition and the small size refrigerator constraint, keeping a 3-day vegetable supply is considered stockpile. However, such a stockpile is quite likely rational for the consideration of reduced shopping trips to avoid virus infection.

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