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Effects of mobile networks and Covid-19 on mobile shopping sales in South Korea

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ABSTRACT

Covid-19 has driven us abruptly to a new world of contactless society. It also compelled us to use online shopping, especially mobile shopping in South Korea, where the dominant mode of wireless communication was already 4G services when Covid-19 broke out. This paper examines the different roles of mobile networks and the Covid-19 pandemic in transforming mobile shopping submarkets in South Korea by estimating the long-term and short-term effects of these two factors on mobile shopping sales. We used a cointegration and an error correction model to estimate long-term and short-term effects separately. This paper finds that Covid-19 was a major short-term factor affecting sales in mobile shopping submarkets, while mobile network subscribers were a key long-term driving factor of mobile shopping sales growth.

1. Introduction

Various factors, including new technologies and the Covid-19 pandemic, have reshaped the online shopping landscape worldwide (Grewal et al., 2017; Lamberton & Stephen, 2016). Mobile phones, especially smartphones, supported by anywhere and anytime wireless connections to the internet, have enhanced the convenience of online shopping (Spaid & Flint, 2014; Zhongmei et al., 2020).

Although online shopping dates back to telephone shopping (Cox & Rich, 1964), the focus of this research is limited to shopping via wireless internet. This paper defines internet shopping as shopping via fixed internet and mobile shopping as shopping through mobile applications (apps) and webs mainly because Statistics Korea collects online shopping data based on those definitions. Often customers use desktop computers for internet shopping and smart devices, including smartphones and tablets, for mobile shopping. Our definition of mobile shopping here does not mean literally shopping on the go and includes the usage of smartphones for shopping, even at homes and offices.

As summarized in the literature review section, two key factors driving both internet and mobile shopping are convenience and perceived risk. Online shoppers choose shopping online over offline mainly for convenience in shopping, and they also increased online purchases as various perceived risks had decreased over time with safer online payments, easier return policies, and the introduction of improved return systems. Online shopping in South Korea increased by a factor of five in the 2010s, and the sales value of mobile shopping in South Korea surpassed that of internet shopping in 2016. As of the end of 2020, sales of mobile shopping were...
greater than that of internet shopping by a factor of two. Between 2013 and 2020, mobile shopping sales increased by a factor of 16, while internet shopping sales increased by a factor of 1.6. These structural changes in online shopping markets were similarly observed in other advanced countries, including the United States and Europe (Chopdar & Balakrishnan, 2020; Eurostat, 2020; Evans, 2021).

Recently, the structural change toward mobile shopping in online shopping channels has become more pronounced, domestically and globally, due to the Covid-19 pandemic (Evans, 2021; WHO, 2020). Covid-19 has driven us abruptly to a new world of contactless shopping. At various points in time since the onset of Covid-19, local and national governments have imposed travel restrictions on domestic travel and travel abroad, regulated gatherings in public and private places and have also periodically changed these regulation rules. These changing regulations have generated short-term variations in mobile shopping, allowing us to identify the different impacts of mobile networks and Covid-19 on mobile shopping sales. Whereas mobile network expansion or increased subscription to the mobile internet generally tended to grow gradually, resulting in more long-term impacts on mobile shopping across products, Covid-19 brought forth short-term variations in mobile shopping due to erratic changes in regulation over time and across products. In other words, the effects of Covid-19 on mobile shopping sales are likely to be uneven across products and over time, while the growth of mobile subscriptions generates a general increase in mobile shopping across products.

This paper examines how these two factors—Covid-19 and mobile networks—affected differently mobile shopping sales (consumptions) in submarkets. In order to attain this objective, this research uses the data from 21 submarkets of Korean mobile shopping and draws on a cointegration model and an error correction model of time-series analysis. This paper finds that Covid-19 was a major short-term factor affecting sales in mobile shopping submarkets, while the growth in mobile network subscribers was a key long-term driving factor of sales growth in mobile shopping. Without Covid-19, a quasi-experiment, and monthly data, it would not be feasible to estimate the long-term economic effects of mobile networks and the short-term effects of Covid-19 on mobile shopping sales. This paper’s contribution to the internet literature is to empirically estimate the effects of mobile network subscription growth on a mobile service, specifically mobile shopping. In this respect, this paper is different from previous macro-level analyses examining the impact of communication network infrastructure on economic growth. Another contribution is to extend online shopping research to the market-level study. As section 3 summarizes, the literature on online and mobile shopping has traditionally focused on consumer attitudes and purchase intentions to help develop firms’ marketing strategies. Practically, this research will also be helpful for businesses to predict the changes in mobile shopping in the short term with the error correction model and the effects of similar shocks that are likely to come in the future.

The remaining structure of this paper is as follows. The next section overviews the developments and changes in the Korean internet and mobile shopping submarkets over the past four years and nine months. During that period, the core of Korean online shopping shifted from the internet to mobile shopping. Section 3 reviews the literature on online shopping and the effects of Covid-19 on retail businesses and derives the research questions of this study. Section 4 explores the characteristics of our data and introduces the econometric estimation models of this study, and section 5 reports and discusses the outcomes of the analyses. Section 6 concludes the paper with a brief discussion of its implications and limitations.

2. Recent developments in the Korean online shopping submarkets

2.1. Overall changes in the Korean online shopping

Statistics Korea, the Korean statistical office, publishes monthly online shopping sales data by 23 commodity and service groups, termed submarkets here, for internet and mobile shopping. The online shopping sales data are collected by Statistics Korea from 1077 online shopping malls sampled from a population of 19,087 B2C online shopping malls. This population includes online-only malls and mixed malls using both online and offline distribution channels, and sales values comprise sales to both domestic and foreign consumers. Internet shopping sales are the sales from pc-based online transactions, and mobile shopping sales are from the mobile app or the mobile web. In other words, the sales from mobile shopping are also separately counted and collected, so total online shopping sales are simply the addition of the two types of sales. This paper uses the data of 21 submarkets out of 23 submarkets, and Table 1 presents these 21 submarkets and their main sale items. The two other submarkets, “miscellaneous services” and “others,” are not used for analyses because their unknown heterogeneous compositions of sale items hinder our understanding and explanation of the submarket data.

For the past three years and nine months, the year-over-year growth rates of mobile shopping have recorded, on average, 27.4% per year, while those of internet shopping have remained at 7.7%. Owing to the persistent and strong growth of mobile shopping, the aggregated sales of internet and mobile shopping have grown 19.8% per year for the same period as the year-over-year growth rate,

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3 Authors’ own calculations (Statistics Korea: Wholesale & Retail Trade and Service Industry).

4 We downloaded online shopping sales data from Statistics Korea.

5 Those with sales less than 24 million Korea Won (1$ = about 1100 Korea Won) are excluded from the population but their aggregated sales cover only 0.04% of the total Korean online shopping sales.

6 In collecting sales data for mixed malls, Statistics Korea counts only online shopping sales by excluding offline sales.

7 This definition of mobile shopping was also used in the previous studies (Einav et al., 2014).

8 Four years and nine months monthly data are used for the year-over-year growth rate, so the calculated growth rates exist for only three years from January 2018 to September 2021.
Table 1

Online shopping commodity and service groups and their major items.

| Groups (Abbreviation) | Major items |
|-----------------------|-------------|
| Fashion items and accessories (Accessory) | Hats, caps, gloves, scarfs, watches, rings, earrings, and other accessories |
| Agro-fishery-livestock products (Agrofishery) | Grain, meat, corn, fish, vegetables, fruits, etc. |
| Automobiles and parts (Autoparts) | Cars, motorcycles, driving guide system, vehicle black box camera, engine oil, windshield wiper fluid, other auto parts and supplies |
| Bags (Bags) | Purses, suitcases, backpacks, etc. |
| Books (Books) | Books except for e-books |
| Clothing (Clothing) | Clothing for men and women, sportswear, etc. |
| Computers and parts (Computers) | Personal computers, notebook computers, printers, speakers, software, etc. |
| Cosmetics (Cosmetics) | Cosmetics, perfumes, miscellaneous items for makeup |
| Culture services (Culture) | Film, opera, musical, ballet, cinema reservation services |
| E-coupon services (eCoupon) | All kinds of gift cards or coupons |
| Home appliances and Electronics (Electronics) | TV, refrigerator, air conditioner, washer and dryer, digital camera, cellphone, etc. |
| Food and beverages (Food) | Coffee, tea, water, cereal, beverages, sugar, cooking oil, kimchi, canned food, etc. |
| Food services (FoodServ) | Cooked and delivered food (pizza, chicken, etc.) services |
| Furniture (Furniture) | Desks, chairs, tables, beds, etc. |
| Goods for kids and infants (Kids) | Diapers, strollers, baby walkers, beds and car seats for babies, dolls and toys, etc. |
| Daily necessities (Necessities) | Cooking appliances, bedding, soap, shampoo, toilet paper, detergent and cleanser, flowers, vases and flower pots, etc. |
| Pet supplies (PetSupp) | Pet food, cleaning supplies, pet toys, pet shoes, and clothing, etc. |
| Shoes (Shoes) | All kinds of shoes, sandals, slippers, etc. |
| Sports and leisure items (Sports) | Sports and outdoor items, hiking items, miscellaneous items for leisure activities |
| Stationary (Stationery) | Office supplies, stationery, papers, pencils, etc. |
| Travel and transportation service (Travel) | Bus and train tickets, airline ticketing and reservation, rental car, hotel, and accommodations, etc. |

* Source: Online shopping survey (Statistics Korea).

and the share of mobile shopping in online shopping has increased from 53.6% in January 2017 to 72.3% in September 2021. Fig. 1 illustrates this drastic structural change in the Korean online shopping industry. This big picture of online shopping does not reveal the ups and downs of submarkets in Korean online shopping between 2017 and 2021, which fluctuations are investigated in detail in the following subsection.

2.2. Changes in the composition of Korean online shopping submarkets

This subsection reports several notable changes in the Korean online shopping industry over the past four years and nine months, a time period encompassing both the initial pre-Covid period and the subsequent post-Covid period. Over this entire period of time, as shown in Tables 2 and 3, the Korean online shopping industry has experienced ups and downs in the growth rates and the rankings of internet and mobile shopping submarkets. Table 2 presents the average monthly sales growth rates of 21 submarkets for the two time periods distinguished by the Covid-19 pandemic and the average sales of the submarkets. First, over the whole period, as shown in the group mean of Table 2, the monthly growth rates of mobile shopping in most submarkets exceeded, on average, those of internet shopping, which resulted in the widening gap between the internet and mobile shopping shown in Fig. 1.

Second, from the different growth rates in sales shown in Table 2, we can also see that the 21 submarkets have been differentially affected by the Covid-19 pandemic. In order to explore the substitution of mobile shopping for internet shopping, we categorize the 21 submarkets into two groups: mobile shopping substitutes for internet shopping (MsI) and, inversely, internet shopping substitutes for mobile shopping (IsM). In examining mobile conversion in online shopping, we can use two approaches: one is to compare the ratios of mobile shopping sales to internet shopping sales calculated for submarkets for the two points in time between January 2017 and January 2021, and the other is to calculate and compare growth rates of mobile and internet shopping sales for submarkets and sub-periods. While it is easy to show the mobile shopping conversion in the former approach, that approach ignores the transition process between the two time periods. As shown in Fig. 2, the ratios of mobile shopping sales to internet shopping sales in “Cosmetics” and “Shoes” submarkets have declined, implying that they are IsM cases. “Shoes,” however, can be seen as an MsI case because its ratios at the two points of time were greater than 1. Looking at the ratio, we can consider “Computers” as a case of IsM because its values were also less than 1, even though the ratio has become larger between the two points of time. In terms of the latter approach, MsI is the case in which mobile shopping average growth rates are greater than internet shopping average growth rates in a given period, and IsM is the opposite, i.e., mobile shopping average growth rates are less than or equal to internet shopping average growth rates. Growth rates in bold fonts in Table 2 stand for IsM cases, and all others are MsI. We can easily observe that MsI was found in 16 submarkets before Covid-19 and was found in 18 submarkets after the onset of the pandemic. For the entire period of time, IsM has continued in only two submarkets, “Cosmetics” and “Autoparts,”. To sum up, regardless of the ways of measuring mobile conversion, MsI has occurred widely and consistently in the Korean online shopping industry.

Third, during the Covid-19 pandemic (After Covid in Table 2), mobile shopping substitution for internet shopping was most striking

9 We used January data in comparison in order to prevent possible monthly seasonal effects.
in those submarkets in which the growth rates of mobile shopping submarkets exceeded those of internet shopping submarkets. We calculated the growth rate gaps by subtracting internet shopping growth rates from mobile shopping growth rates for each submarket during the Covid-19 pandemic period in order to identify the submarkets where mobile conversion was most significant. They are “Culture,” “FoodServ,” “Sports,” “PetSupp,” “Electronics” and “Kids” submarkets.

Fourth, travel and transportation services (“Travel”) had been the largest submarket in terms of sales in both internet and mobile shopping markets, but after Covid-19 broke out, their monthly sales fell drastically in both markets, as shown in Fig. 3. Because of domestic and international lock-downs, the travel industry was hit hardest globally among the submarkets. Covid-19 also severely negatively impacted the “Culture” and “Clothing” submarkets. “Culture” submarkets, representing online reservation services for artistic performances, such as films, operas, musicals, and ballets, ranked eleventh and sixteenth in January 2017 in internet and mobile shopping, respectively. As cinemas and theaters were forced to close after Covid-19, “Culture” submarkets’ rankings fell to the lowest rank in January 2021, 21st of the 21 submarkets. The internet and mobile shopping submarkets for “Clothing,” which ranked

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**Table 2**

Average monthly sales and growth rates of 21 submarkets by sub-periods.

| Units       | Internet Shopping |                      | Mobile Shopping |
|-------------|-------------------|----------------------|-----------------|
|             | Average Sales     | Before Covid         | After Covid     | Average Sales     | Before Covid         | After Covid     |
|             | Million Korea Won | Monthly Average (%)  | Monthly Average (%) | Million Korea Won | Monthly Average (%)  | Monthly Average (%) |
| Accessory   | 60,433            | 0.961                | −0.432          | 131,776          | 2.366                | 0.519            |
| Agrofishery | 112,321           | 3.846                | 3.455           | 260,525          | 3.043                | 4.155            |
| Autosparts  | 70,776            | 5.021                | 55.333          | 72,257           | 1.532                | 4.075            |
| Bags        | 50,833            | 1.030                | 0.212           | 157,799          | 1.979                | 1.652            |
| Books       | 97,181            | 1.234                | 2.095           | 72,416           | 2.931                | 3.072            |
| Clothing    | 438,407           | 2.136                | 2.845           | 725,072          | 3.739                | 3.141            |
| Computers   | 314,563           | 1.068                | 1.979           | 209,826          | 2.065                | 2.101            |
| Cosmetics   | 422,910           | 2.450                | 0.579           | 489,313          | 1.946                | −0.060           |
| Culture     | 63,195            | 1.228                | 10.009          | 77,482           | 3.916                | 14.747           |
| eCoupon     | 36,027            | 4.969                | 3.051           | 232,097          | 4.895                | 3.173            |
| Electronics | 500,929           | 2.619                | 1.640           | 718,197          | 3.591                | 3.570            |
| Food        | 372,127           | 1.737                | 2.337           | 857,786          | 2.767                | 2.963            |
| FoodServ    | 52,139            | 2.842                | 0.260           | 894,562          | 5.825                | 4.431            |
| Furniture   | 107,279           | 0.961                | 1.852           | 216,383          | 2.444                | 2.509            |
| Kids        | 83,013            | 1.924                | 0.371           | 265,233          | 2.310                | 2.085            |
| Necessities | 299,332           | 0.867                | 2.241           | 632,196          | 1.965                | 2.355            |
| PetSupp     | 22,434            | 0.537                | −0.255          | 58,130           | 2.492                | 1.909            |
| Shoes       | 72,443            | 3.582                | 1.584           | 122,274          | 3.298                | 2.606            |
| Sports      | 142,921           | 1.716                | 2.832           | 227,138          | 3.421                | 5.000            |
| Stationery  | 40,812            | 1.438                | 1.266           | 37,099           | 4.212                | 1.888            |
| Travel      | 440,595           | 0.685                | 1.050           | 679,075          | 1.759                | 0.598            |
| Average     | 180,984           | 1.063                | 0.732           | 339,849          | 2.381                | 1.936            |
second in January 2017, fell to sixth in internet shopping and fifth in mobile shopping in January 2021. In addition, “Bags” and “Accessory” submarkets also experienced declines in their rankings in both internet and mobile shopping markets. These significant changes in online shopping after Covid-19 were similarly observed in other countries (Deloitte, 2021; OECD, 2020; Statista, 2021).

Fifth, Table 3 also reveals that ranking rises in mobile shopping were most apparent in “FoodServ” and “eCoupon” submarkets and moderately conspicuous in “Electronics,” “Agrofishery” and “Books.” In internet shopping, ranking rises were most striking in “eCoupon,” “FoodServ,” “Furniture” and “Cosmetics” submarkets and moderately conspicuous in “Shoes,” “Food,” “Electronics,” “Necessities” and “Kids” submarkets. The big strides of those submarkets in the rankings of mobile and internet shopping did not share common causes. The mobile “FoodServ” submarket, providing cooked food such as pizza and chicken, for example, continued to have strong growth over the past four years, not just in the period of Covid-19, whereas the internet “FoodServ” submarket barely grew at all.

Fig. 2. Online shopping conversion to mobile shopping between 2017 and 2020 in Korea

* “FoodServ” submarket is not shown in Fig. 2, because its M-sales/I-Sales ratio changed drastically from 4.6 to 28.7 between Jan. 2017 and Jan. 2021.

Table 3

| Group | Abbr. | Mobile sales of 2021.01 (Bil. Won) | Rank by mobile sales of 2021.01 | Rank by mobile sales of 2017.01 | Rank by internet sales of 2021.01 | Rank by internet sales of 2017.01 |
|-------|-------|----------------------------------|-------------------------------|-------------------------------|----------------------------------|-------------------------------|
| FoodServ | 1956.0 | 1 | 8 | 14 | 19 |
| Food | 1591.6 | 2 | 3 | 3 | 5 |
| Electronics | 1175.7 | 3 | 6 | 1 | 3 |
| Necessities | 951.2 | 4 | 5 | 5 | 7 |
| Clothing | 745.2 | 5 | 2 | 6 | 2 |
| Agrofishery | 537.2 | 6 | 9 | 7 | 8 |
| Cosmetics | 501.4 | 7 | 4 | 2 | 6 |
| Travel | 405.5 | 8 | 1 | 12 | 1 |
| eCoupon | 383.7 | 9 | 15 | 15 | 21 |
| Furniture | 348.9 | 10 | 11 | 8 | 12 |
| Computers | 342.9 | 11 | 10 | 4 | 4 |
| Kids | 327.4 | 12 | 7 | 11 | 13 |
| Sports | 260.2 | 13 | 13 | 9 | 9 |
| Bags | 181.1 | 14 | 12 | 17 | 15 |
| Books | 131.2 | 15 | 18 | 10 | 10 |
| Accessory | 129.0 | 16 | 14 | 16 | 14 |
| Shoes | 116.0 | 17 | 17 | 13 | 16 |
| Autoparts | 110.1 | 18 | 19 | 18 | 18 |
| PetSupp | 82.1 | 19 | 20 | 20 | 20 |
| Stationery | 59.0 | 20 | 21 | 19 | 17 |
| Culture | 21.8 | 21 | 16 | 21 | 11 |
during the Covid-19 period, implying that Covid-19 and mobile technologies differentially affected internet and mobile shopping.

In summarizing the structural changes of submarkets in the Korean internet and mobile shopping industries, we can highlight the following three points. First, mobile substitution for internet shopping has progressed in a large share of submarkets before Covid-19, and that mobile substitution has been continuing in most Korean submarkets of online shopping. We can presume that contactless consumption due to Covid-19 boosted mobile shopping sales as mobile networks and smart devices have been upgraded. Second, most of the dramatic structural changes in the Korean online shopping industry took place after the Covid-19 outbreak, resulting in large fluctuations in the rankings of submarkets. Third, as can be seen in Table 2, even though several submarkets such as “Culture,” “Clothing,” “Accessory” and “Kids” were hit hard by Covid-19, the damages to those submarkets were relatively less in mobile shopping than in internet shopping. Considering these three points, we believe it is reasonable to postulate that Covid-19 accelerated the short-term structural changes.

3. Literature review and research questions

3.1. Literature review on online shopping and the effects of Covid-19 on retail business

Over the past two decades, research papers on online shopping and marketing proliferated, and their research concerns have covered various dimensions of online shopping (Grewal et al., 2017; Lamberton & Stephen, 2016). Here, this literature review on online shopping focuses on the areas related to our research question development and is, therefore, neither a complete nor comprehensive review of online shopping and marketing as a whole. As discussed earlier, technologies were the main driver of structural changes in online shopping. Conversion to mobile shopping from internet shopping is facilitated by the flexibility of wireless connections in space and time dimensions (Luo et al., 2014). At the dawn of the twenty-first century, when 2G mobile networks were full-blown, academic research on mobile commerce began to emerge (Zhongmei et al., 2020). Balasubramanian et al. (2002) formally conceptualized mobile commerce, illustrating how traditional commerce activities would evolve in a space-time matrix. They predicted that mobile commerce would bring forth rapid innovation in location-specific and time-critical commerce activities. Comparing internet and mobile shopping, Ghose et al. (2013) argued that search costs were higher in mobile shopping because of the small screen size, and thus ranking effects of mobile ads were more significant on mobile phones than on desktop computers. In addition, they argued that mobile shopping could be more complementarily used for local offline shopping than for online shopping from distant stores. As the studies above predicted, wireless internet reduced space and time constraints and enhanced flexibility in the retail business for sellers and buyers. Xu et al. (2016) conducted empirical research supporting mobile conversion in online shopping and reported that tablets functioned as a substitute for the PC channel but as a complement for the smartphone channel.

The most popular research subject on online shopping has been behavioral studies on user adoption and the customer experience in online shopping. Bhatnagar et al. (2000) proposed two constructs, convenience and risk, based on the consumer theory of micro-economics to investigate who uses and who does not use online shopping. As Bhatnagar et al. (2000) stated, the two constructs were not new ones but were identified in earlier research by Cox and Rich (1964) on telephone shopping. Bhatnagar et al. (2000) found that the two constructs affected consumers’ purchase behavior, and these effects varied with product categories and demographic variables. Since Bhatnagar et al. (2000) was published, extensive research papers on consumer behavior in online shopping, especially on consumer attitudes and purchase intentions, have been published in the literature: some prominent studies are Bart et al. (2014), Chopdar and Balakrishnan (2020), Forsythe and Shi (2003), Kim et al. (2021), Lee and Tan (2003), Li et al. (2020), Nysveen et al.
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The Covid-19 pandemic, which started in Korea on January 20, 2020, drove people to prefer online shopping over offline shopping. Consumers chose online shopping because they could buy goods and services without contacting salespersons and other consumers and could also avoid various space and time constraints placed on consumption by governments. After Covid-19 broke out, consumers’ consumption sets were constrained by various local and global regulations. For example, traveling within and between countries was sometimes prohibited, gatherings of people in public and private places and shopping in offline stores were regulated, and shop opening hours were also controlled by governments worldwide (WHO, 2020). In addition, employees and students began to work at home and take online classes, which also changed purchase intentions by forcing them to stay home. Covid-19 truly strengthened the advantage of online shopping over offline shopping, freeing consumers from space and time constraints. In addition, Covid-19 is likely to favor mobile shopping because mobile apps and connection technologies supporting online consumption have improved continuously. As summarized in the previous section, the sales of some submarkets have increased dramatically after Covid-19, while those of

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others have declined. The spread of Covid-19 in Korea, as shown in Fig. 4, has not remained even over time but went through five bursts and four troughs over the past twenty-one months. This implies that there have been variations in Covid-19’s effects on the internet and mobile shopping over time. These variations across submarkets over time enable us, we believe, to estimate the differential effects of Covid-19 on the sales of mobile shopping submarkets in Korea and, indirectly, the long-term impact of mobile network subscriptions on mobile shopping.

Covid-19 in Korea is likely to facilitate mobile shopping because shopping through mobile internet is more convenient for users with always-on smart devices than wired internet. However, the transition is likely to be heterogeneous across mobile shopping submarkets because, according to the literature review, consumers have different attitudes toward adopting mobile shopping, especially when the products are expensive and the risk level is higher in the transaction. An illustrative example is the “Autoparts” submarket, including cars, motorcycles, and automobile parts. Thus, the research question is to estimate the differential effects of Covid-19 on mobile shopping to provide a better understanding of how consumers respond to an external shock such as Covid-19. In addition, as discussed later, we also evaluate the long-term effects of mobile network subscriptions on mobile shopping. This research, however, is somewhat explorative because we can not explain why such differential effects occurred in submarkets. More specific hypotheses of this study are enumerated in subsection 4.2, where we introduce the analytical models.

4. Data and the model

4.1. Data and descriptive statistics

This paper drew on monthly sales data from January 2017 to September 2021 for 21 submarkets of mobile shopping. Submarket sales data of mobile shopping are used as dependent variables, and the explanatory variables are mobile internet subscriber lines (MSL), Covid-19 confirmed cases (Covid), income (I: credit card payments were used as a proxy variable), and the number of employees (Emp). Nominal monetary values, sales values and credit card payments, were deflated by CPI (consumer price index) in order to remove common inflation effects. All variables are monthly data, which constrains our choice of explanatory variables because some data related to mobile shopping is not collected monthly. All dependent and independent variables are checked to see if they have monthly seasonal effects by running regressions with only month dummies. Only clothing, income, and employment variables have monthly seasonality, and they were deseasonalized before analyses. The reason for using data from 2017 in this paper is that Statistics Office adopted new data collection methods for online shopping in 2017. Descriptive statistics of independent variables and their correlation coefficients matrix are reported in Table 4. In most cases, correlation coefficients are not high, so we expected that the multicollinearity problem would not be serious even though pairwise coefficient checking is insufficient to avoid that problem. The descriptive statistics of dependent variables are not presented in Table 4 because they were already introduced in the previous Tables and Figures.

4.2. Analytical models

Each submarket of online shopping is a collection of commodities and services, so the sales values of submarkets are aggregated sales of individual commodities and services within each group. Given that all dependent and independent variables are monthly time-series data, we first checked whether they are stationary or not because monthly time-series data are often non-stationary. As expected, all dependent and independent variables turned out to be non-stationary, and when we checked the possibility of trend stationarity, only “Clothing,” “Shoes,” “Accessory,” and “Emp” were also identified as trend stationary. After the first differencing, we were able to ascertain that all the variables are stationary. Thus, they are difference stationary and I (1) series. To identify the long-term effects of Covid-19 on submarket sales of mobile shopping, this paper utilized reduced form linear regression models, as shown in Equation (1). Real sales values (market equilibrium quantities), $Y_i$, are a function of exogenous variables, which are composed of four explanatory variables. In the regression analyses based on Equation (1), the endogeneity problem is not likely to exist between the dependent variables and the four independent variables because mobile shopping submarkets are only a small part of the Korean national economy, but all dependent variables are measured at the national level. In other words, there is no possibility of reverse causality such that dependent variables affect independent variables.

$$Y_i = \alpha_i + \beta_{i1} \text{MSL}_i + \beta_{i2} \text{Covid}_i + \beta_{i3} I_i + \beta_{i4} \text{Emp}_i + \epsilon_i$$  \(1\)

where $Y_i$ is a dependent variable with a submarket index $i = 1, \ldots, 21$, $\alpha_i$ is constant, $\beta$’s are regression coefficients, and $t$ is the time

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10 We collected credit card payments and employment data from the homepage of Statistics Office, and downloaded Covid confirmed cases data from the Korean government’s public data portal, https://www.data.go.kr/en/index.do.

11 To obtain a deseasonalized variable, we first ran the OLS regression of the three variables on only eleven monthly dummies. We then extracted residual values and the value of constant term from the regression results and added the constant-term value to residual values to obtain the deseasonalized variables.

12 We also obtained the variance inflating factor (VIF) values for the independent variables of the regression model and report here only the case with “Computers” as a dependent variable. They are 7.1, 1.6, 10.7, and 3.2 for MSL, Covid, I and Emp, respectively, implying that multicollinearity is not a problem.

13 We thank anonymous reviewers for suggesting this issue.
index which ranges from January 2017 to September 2021. The independent variables do not have an i submarket index because there are no submarket-specific independent variables used in the regressions. As the same independent variables are used for explaining submarkets sales, we ran regressions separately for individual submarkets: 21 regressions of real mobile shopping sales on explanatory variables.

All regressions are time-series analyses with level values of I (1). After running the regressions for 21 submarkets, we also executed the cointegration test with the residuals of the regressions and found all residual variables are stationary. This suggests that there are long-term relationships between the dependent and independent variables in each submarket. While checking the cointegration regression models, we also checked autocorrelation in residuals. When autocorrelation was detected, we corrected standard errors with autocorrelation robust standard errors based on the Newey-West method, provided in R, in calculating t-statistics and p-values. Table 5 reports the outcomes of mobile shopping submarket sales regressions, and these results are discussed in the following section.

As is well-known, however, the results from the cointegration regression models do not deliver short-term relationships between the dependent and independent variables. To investigate the short-term effects of the regressors on the dependent variables, we ran an error correction model, shown in Equation (2), for each submarket with the first difference values. The model of Equation (2) is different from Equation (1) in two aspects: one difference is its use of the first difference data, not level data; the other is that Equation (2) includes the error correction term, Ect, in regression. The error correction term is the residuals from the regressions of Equation (1) and its coefficient β should be negative and less than 1 in absolute value (Guajari & Porter, 2009; Hamilton, 1994). These conditions of the error correction term imply that the short-term variations (errors) have a reverting tendency to the long-term relationship among the independent and dependent variables. As reported in the following section, the two conditions are satisfied in all submarket regressions.

\[
Y_t = \alpha + \beta_1 MSL_t + \beta_2 Covid_t + \beta_3 I_t + \beta_4 Emp_t + \beta_5 Ect_t + \epsilon_t 
\]

(2)

\[\text{When not deseasonalized, level data are just original data but when deseasonalized, level data are deseasonalized data.}\]

Table 4

Descriptive statistics and correlation coefficients of independent variables.

|          | MSL  | Covid | I     | Emp  |
|----------|------|-------|-------|------|
| mean     | 67.146 | 5.504 | 50.561 | 26.936 |
| min      | 61.518 | 0     | 41.966 | 25.818 |
| max      | 72.009 | 60.317 | 56.882 | 27.683 |
| count    | 57   | 21    | 57    | 57   |

Correlation coefficients

|          | MSL | Covid | I | Emp |
|----------|-----|-------|---|-----|
| MSL      | 1   |       |   |     |
| Covid    | 0.589 | 1 |   |     |
| I        | 0.760 | 0.433 | 1 |     |
| Emp      | 0.422 | 0.325 | 0.638 | 1   |

Fig. 4. Monthly confirmed Covid-19 cases in South Korea.
Table 5
Regression results of the cointegration models.

| Submarkets    | Coefficients and p-values of independent variables (dependent variable: real values of mobile shopping submarket sales) |
|---------------|------------------------------------------------------------------------------------------------------------------|
|               | MSL      | Covid | I         | Emp      | Adjusted R² |
|---------------|----------|-------|-----------|----------|-------------|
| Accessory (p-value) | 0.914 | −0.313 | 2.495     | 21.392   | 0.545       |
|               | (0.504) | (0.062) | (0.099)   | (0.102)  | 1.412 (0.003)|
| Agrofishery (p-value) | 35.901 | 3.591 | −1.342    | −100.119 | 0.898       |
|               | (0.000) | (0.000) | (0.836)   | (0.144)  | 1.046 (0.000)|
| Autoparts (p-value)   | 8.403  | 0.678 | −1.841    | −15.286  | 0.888       |
|               | (0.000) | (0.000) | (0.0359)  | (0.009)  | 0.920 (0.000)|
| Bags (p-value)        | 5.536  | 0.007 | 4.328     | −8.008   | 0.915       |
|               | (0.000) | (0.958) | (0.001)   | (0.481)  | 1.617 (0.027)|
| Books (p-value)       | 6.725  | 0.434 | −0.101    | −25.597  | 0.736       |
|               | (0.005) | (0.035) | (0.973)   | (0.269)  | 1.155 (0.000)|
| Clothing (p-value)    | 16.179 | −0.090 | 24.235    | −90.584  | 0.916       |
|               | (0.000) | (0.724) | (0.000)   | (0.000)  | 1.780 (0.098)|
| Computers (p-value)   | 14.507 | 0.877 | 4.299     | −71.168  | 0.770       |
|               | (0.016) | (0.099) | (0.555)   | (0.226)  | 0.701 (0.000)|
| Cosmetics (p-value)   | −5.345 | 1.958 | 15.411    | 210.244  | 0.698       |
|               | (0.402) | (0.028) | (0.024)   | (0.001)  | 0.824 (0.000)|
| Culture (p-value)     | −11.986 | 0.770 | 8.790     | 37.899   | 0.417       |
|               | (0.002) | (0.064) | (0.036)   | (0.298)  | 0.829 (0.000)|
| eCoupon (p-value)     | 30.745 | 1.318 | 3.086     | −3.581   | 0.961       |
|               | (0.000) | (0.000) | (0.290)   | (0.862)  | 1.175 (0.000)|
| Electronics (p-value) | 70.722 | 5.648 | 6.971     | −173.128 | 0.931       |
|               | (0.000) | (0.000) | (0.395)   | (0.007)  | 1.740 (0.074)|
| Food (p-value)        | 115.986 | 7.509 | −5.74     | −231.659 | 0.943       |
|               | (0.000) | (0.000) | (0.682)   | (0.104)  | 0.936 (0.000)|
| FoodServ (p-value)    | 175.315 | 16.609 | 4.413     | −305.816 | 0.862       |
|               | (0.000) | (0.000) | (0.019)   | (0.021)  | 0.425 (0.000)|
| Furniture (p-value)   | 23.617 | 0.617 | 0.723     | 23.612   | 0.919       |
|               | (0.000) | (0.110) | (0.058)   | (0.006)  | 0.771 (0.000)|
| Kids (p-value)        | 16.476 | 0.842 | 1.356     | −6.866   | 0.793       |
|               | (0.000) | (0.104) | (0.670)   | (0.755)  | 1.401 (0.003)|
| Necessities (p-value) | 77.406 | 2.859 | −13.007   | −92.591  | 0.938       |
|               | (0.000) | (0.007) | (0.184)   | (0.270)  | 1.016 (0.000)|
| PetSapp (p-value)     | 4.628  | 0.246 | −0.035    | −6.079   | 0.954       |
|               | (0.000) | (0.000) | (0.933)   | (0.033)  | 1.383 (0.002)|
| Shoes (p-value)       | 7.440  | −0.336 | 0.469     | −2.791   | 0.632       |
|               | (0.000) | (0.038) | (0.787)   | (0.885)  | 1.374 (0.002)|
| Sports (p-value)      | 21.741 | 1.148 | 1.049     | −60.693  | 0.815       |
|               | (0.000) | (0.009) | (0.857)   | (0.304)  | 0.971 (0.000)|
| Stationery (p-value)  | 4.080  | −0.002 | 0.255     | −8.415   | 0.821       |
|               | (0.000) | (0.989) | (0.748)   | (0.310)  | 0.920 (0.000)|
| Travel (p-value)      | −58.183| −5.128 | 38.271    | −304.479 | 0.493       |
|               | (0.021) | (0.025) | (0.172)   | (0.113)  | 0.628 (0.000)|
| D.W (p-value)         |       |       |         |          |             |

In the above long-term and short-term models, the three coefficients, $\beta_1$, $\beta_2$, and $\beta_4$, are expected to be positive because, other things being equal, they are expected to boost consumption in microeconomics consumer theory if commodities are normal goods. As discussed earlier, the sign of $\beta_2$ measuring the effect of Covid-19 on mobile shopping can be either positive or negative across submarkets. Table 6 reports the results from the error correction models. In the last columns of Tables 5 and 6, we also report the coefficients of determination and the Durbin-Watson statistic. For the sake of readability, we provided p-values, based on autocorrelation robust standard errors, of regression coefficient estimates instead of standard error or t-statistic. All analyses were done with the R statistical program. The coefficients in bold font in Tables 5 and 6 are those statistically significant at the 5 percent level of significance, and those that are underlined are significant at the 10 percent level of significance.

5. Outcomes and discussion

As discussed earlier, the development of mobile communication technologies and the rapid global spread of the Covid-19 pandemic facilitated the adoption of mobile shopping, resulting in the rapid growth of mobile shopping sales. In the previous section, we ran two time-series regressions to estimate the effects of Covid-19 on mobile shopping: One is the cointegration model, and the other is the error correction model. The key findings of our analyses are next discussed.

We found a long-term relationship between dependent and independent variables from the cointegration model, estimating a reduced form demand function. As can be observed in Table 5, the mobile communication subscriber lines (MSL) turned out to be statistically significant in 19 markets out of 21 mobile shopping submarkets and contributed positively to the growth of 17 mobile
platforms, shrank abruptly after Covid-19 due to the international distribution network bottlenecks.

Mobile shopping market was hit severely by Covid-19, probably because foreign consumption of cosmetics, transacted through mobile webs and apps, measured by mobile subscriber lines, is the critical factor contributing to the growth of mobile shopping in general. This finding reconfirms the previous finding that mobile communication infrastructure, including networks, are similar to retail submarkets, probably because fashion items and accessories are experience goods and still are predominantly consumed offline. The other two submarkets, "Travel" and "Culture," where the coefficients are negative even though they are statistically significant, are similar to "Cosmetics" in that their sales decreased abruptly after Covid-19.

As shown in Fig. 5, the "Cosmetics" mobile shopping market was hit severely by Covid-19, probably because foreign consumption of cosmetics, transacted through mobile platforms, shrank abruptly after Covid-19 due to the international distribution network bottlenecks. Considering this, we presume that the regression result does not demonstrate the ineffectiveness of MSL in cosmetics sales and believe that the mobile subscription will positively affect cosmetics sales after Covid-19. "Accessory" is thus the only market where mobile shopping is not popular, probably because fashion items and accessories are experience goods and still are predominantly consumed offline. The other two mobile shopping submarkets, "Travel" and "Culture," where the coefficients are negative even though they are statistically significant, are similar to "Cosmetics" in that their sales decreased abruptly after Covid-19. Considering that before Covid-19, the mobile shopping sales in the two submarkets have grown continuously, we anticipate that the sales in both markets will resume their previous growth pattern after Covid-19. In conclusion, these analytical outcomes show that mobile subscription has led to the expansion of mobile shopping, and we can expect that, as mobile communication networks upgrade to 5G services, mobile shopping after Covid-19 will grow as strongly as before Covid-19.

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**Table 6**
Regression results of the error correction models.

| Submarkets | Coefficients and p-values of independent variables (dependent variable: first difference in real values of mobile shopping submarket sales) |
|------------|----------------------------------------------------------------------------------------------------------------------------------|
|            | (The number of samples: 56)                                                                                                                                                           |
|            | MSL     Covid 1 I Emp Ect Adjusted R² D.W (p-value)  |
| Accessory  (p-value) | –1.095 (0.952) 0.294 (0.360) 1.878 (0.164) 7.410 (0.544) –0.623 (0.000) 0.296 (0.000) 1.857 (0.269)  |
| Agro/food  (p-value) | –36.417 (0.547) 1.842 (0.083) 2.349 (0.599) –101.184 (0.016) –0.548 (0.000) 0.349 (0.000) 2.094 (0.600)  |
| Autoparts  (p-value) | 6.726 (0.569) 0.590 (0.007) –0.912 (0.301) –0.863 (0.914) –0.365 (0.003) 0.163 (0.000) 2.055 (0.533)  |
| Bags  (p-value) | 26.890 (0.072) 0.349 (0.165) 2.806 (0.011) 2.752 (0.777) –0.802 (0.000) 0.395 (0.000) 1.845 (0.264)  |
| Books  (p-value) | –5.645 (0.770) 0.746 (0.032) 1.003 (0.480) –35.847 (0.008) –0.571 (0.000) 0.354 (0.000) 1.962 (0.410)  |
| Clothing  (p-value) | –45.557 (0.420) 0.510 (0.601) 27.713 (0.000) –110.546 (0.005) –0.923 (0.000) 0.614 (0.000) 2.079 (0.600)  |
| Computers  (p-value) | –62.078 (0.105) 0.767 (0.251) 1.877 (0.499) –47.777 (0.071) –0.340 (0.003) 0.207 (0.000) 1.982 (0.425)  |
| Cosmetics  (p-value) | 62.239 (0.026) 1.539 (0.195) 15.433 (0.000) 45.336 (0.497) –0.168 (0.023) 0.368 (0.174) 1.774 (0.166)  |
| Culture  (p-value) | –72.603 (0.025) –1.493 (0.009) 0.932 (0.706) 41.878 (0.054) –0.250 (0.025) 0.217 (0.000) 1.834 (0.226)  |
| eCoupon  (p-value) | –37.418 (0.708) 0.216 (0.353) 2.316 (0.485) –15.864 (0.266) –0.611 (0.000) 0.299 (0.000) 2.053 (0.544)  |
| Electronics  (p-value) | 52.266 (0.667) 7.260 (0.001) 6.681 (0.455) –82.646 (0.323) –0.883 (0.000) 0.381 (0.000) 1.924 (0.373)  |
| Food  (p-value) | 19.791 (0.876) 5.343 (0.018) 7.031 (0.459) –210.347 (0.017) –0.437 (0.000) 0.267 (0.000) 2.297 (0.843)  |
| FoodServ  (p-value) | –24.984 (0.794) 16.194 (0.000) 0.648 (0.927) –118.773 (0.055) –0.166 (0.004) 0.470 (0.004) 1.534 (0.028)  |
| Furniture  (p-value) | 42.884 (0.116) 0.942 (0.047) 2.503 (0.210) –55.528 (0.004) –0.298 (0.010) 0.202 (0.000) 1.984 (0.425)  |
| Kids  (p-value) | –40.740 (0.349) 1.866 (0.015) 0.830 (0.790) –19.716 (0.493) –0.723 (0.000) 0.401 (0.000) 1.782 (0.190)  |
| Necessities  (p-value) | 26.132 (0.729) 4.534 (0.001) –0.756 (0.895) –42.988 (0.414) –0.367 (0.007) 0.221 (0.000) 2.173 (0.701)  |
| PetSapp  (p-value) | 9.578 (0.080) 0.293 (0.002) 0.577 (0.150) –6.035 (0.099) –0.614 (0.000) 0.352 (0.000) 2.084 (0.606)  |
| Shoes  (p-value) | 20.536 (0.304) 0.074 (0.905) 0.070 (0.948) 7.618 (0.617) –0.709 (0.000) 0.330 (0.000) 1.680 (0.103)  |
| Sports  (p-value) | 97.464 (0.028) 1.302 (0.080) 2.907 (0.302) –25.869 (0.509) –0.431 (0.000) 0.218 (0.000) 1.518 (0.028)  |
| Stationery  (p-value) | –1.886 (0.813) 0.338 (0.019) 0.577 (0.311) –5.888 (0.264) –0.389 (0.002) 0.257 (0.000) 1.936 (0.364)  |
| Travel  (p-value) | –113.671 (0.456) –3.197 (0.033) –3.197 (0.066) –206.911 (0.031) –0.245 (0.002) 0.248 (0.002) 1.583 (0.044)  |

When we calculate the share of foreign sales in total online cosmetics sales in 2020 in Korea by collecting foreign sales data from the web (www.cmnc.co.kr/mobile/sub_view.asp?news_idx=36759), the share was about 34%.
Because the error correction models use the first difference data of variables, we lose one observation, and the adjusted R

Furniture, “” variable shows that employment increases the consumption of cosmetics while reducing the consumption of

metics, “” “” Accessory.

with family. Covid-19, on the other hand, had a severe impact on those markets such as

tronics, “” “” Computers.

increased only the sales of

Bags, “” “” Cosmetics.

variations of Covid-19.

Clothing, “” “” Computers, “” “” Shoes.

increased in 12 submarkets and reduced them in

submarkets except for

Bags, “” ” “” Clothing.

The submarket number increases to the numbers in parentheses when we use the 10 percent significance level.
6. Conclusion

Covid-19 abruptly drove us to a new world of contactless society. It also compelled us to use online shopping, especially mobile shopping in South Korea, where the dominant mode of wireless communication was already 4G services when Covid-19 broke out (Jung & Kwon, 2015). When Covid-19 started in South Korea, the share of 3G, 4G, and 5G service subscriptions in total wireless subscriptions was already 98.7 percent. This implies that Covid-19 would not have facilitated upgrades in mobile subscriptions or mobile subscription growth in South Korea. We therefore do not think there was an interaction effect between mobile subscription and Covid-19, and when we put the interaction term in the error correction model, the interaction variable was not statistically significant in any submarkets.

This paper finds that Covid-19 was a major short-term factor affecting sales in mobile shopping submarkets, while mobile network subscribers were a key long-term driving factor of sales growth. These findings suggest that mobile networks have generally boosted the increase in mobile shopping markets over time, and the changes in Covid-19 confirmed cases mainly generated variations in short-term mobile sales. In addition, the effects of Covid-19 on mobile shopping sales were ambiguous in the long term, compared to the impact of the mobile service subscription variable. Based on our findings, we cannot assert that the better wireless communication networks helped South Korea overcome the Covid-19 pandemic with smaller costs. We do think, however, that it is at least highly possible that the better wireless communication infrastructure reduced inconvenience in shopping during self-isolation periods and thereby indirectly improved social welfare during Covid-19.

This paper has a few limitations that we hope to overcome in future research. One limitation is that the number of samples collected after Covid-19 is small, suggesting that we need to be cautious in generalizing the outcomes of the research. This problem, however, will be resolved over time because the sample size grows with time. Another is that this study utilizes only Korean online shopping sales data, further limiting generalizing research outcomes.

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Data availability

Data will be made available on request.

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