

AN EMPIRICAL ANALYSIS OF USAGE BEHAVIOR BY CONTENT TYPE AND BEHAVIORAL ORIENTATION ON A MOBILE MUSIC APP

Completed Research Paper

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Abstract

Recently, many mobile apps have made viable new business models such as in-app purchase. In this paper, we quantify how mobile app usage relates to the unique characteristics of behavioral orientations and content types, focusing on the interrelationship among content usage in the context of in-app purchase. Using a large-scale dataset of individual content usage in a particular music mobile app, we build a simultaneous equation panel data model to examine dynamic interdependent usage of mobile app. We find a positive temporal effect of self-oriented content usage (download) on other-oriented content usage (gift), based on behavioral orientation, and also a temporal interdependence between external (ringtone) and internal usage (mp3) based on types of content. We also find that the 4G communications standard increases content usage in this mobile app. These findings provide useful insights for mobile app developers, mobile network operators, content providers, and mobile device manufacturers.

Keywords: Mobile apps, music content, usage behavior, behavioral orientation, content type

Introduction

Recent academic studies have pointed out that it is necessary to give attention to the impact of mobile computing on users (Vodanovich et al. 2010; Yoo 2010). The explosive growth of the mobile computing over the last few years has made mobile phone a must-have part of everyday life for many people worldwide. In particular, mobile applications (or apps) have played a significant role in this phenomenal growth, and even in improving sales for firms in this field (Brousell 2012; Perlroth 2012). A recent report mentions that the amount of time U.S. consumers spent using mobile apps in December 2012 beat the amount of time spent in December 2011 by 35% (127 minutes a day, from 94), and this suggests that mobile apps are becoming as popular as TV (Khalaf 2012).¹ Moreover, overall mobile app revenue hit \$8.5 billion in 2011; moreover, by 2016, total global mobile application revenues will reach an estimated \$46 billion (Beccue 2012).

Users, of course, prefer free apps by a wide margin. Free apps will account for nearly 90% of total mobile app store downloads in 2012, and user preference for free apps is expected to grow and 93% of mobile app downloads are expected to be free by 2016 (Shen and Blau 2012). From the business model perspective, mobile apps produce profit mainly from pay-per-download, in-app purchases, subscriptions, and advertising, in particular, the number of people making in-app purchases will grow significantly (Beccue 2012). In-app purchase refers to the ability of a mobile device to facilitate the sale of products and services within apps. Many in-app purchases occur in music and games, where users are able to purchase goods for the music and game through the app itself.

In the present study, we focus on in-app purchases, thereby identifying effective operational strategies for apps in a particular niche to survive amid keen competition. Although growth in the apps market and in app usage provide a great opportunity for researchers, little empirical research has been conducted on the dynamics of mobile apps (Boudreau 2012; Garg and Telang 2012). Some of what recent research there has been estimates the demand for both paid and free apps using public ranking data (Garg and Telang 2012). This attempt provides insight into what makes apps effective, on the basis of market ranking. However, even as new apps are being developed, many are falling behind in the market. In this sense, we consider that continuous profit from certain sources (e.g., sales from in-app purchases) are crucial for the sustainability of an app, and feel that it is necessary to examine the interrelationship between the various kinds of content usage activities (e.g., Ghose and Han 2011; Xia et al. 2012) for such sustainability, in the context of mobile apps.

Unlike the prevalent situation in mobile commerce (Li et al. 2012; Wang and Li 2012), a mobile app selling content specific to itself causes users to focus on the transaction of content within the boundaries of its system. That is, to our knowledge, the usage of mobile apps requires higher involvement of users comparing to that of the mobile internet in general. It can be said that every moment when users run an app reflects their sense of purpose (e.g., to listen to music, buy certain content, or play a game). For these reasons, it seems necessary to examine the underlying mechanism of content transactions within apps in order to provide effective development, management, and marketing strategies for them. Notably, we examine music content in the research because music content is popular and widely downloaded through music apps (e.g., ringtones or mp3 files for listening).²

Most importantly, we have a limited understanding of how users simultaneously consume multiple contents in mobile apps and what the interrelationship between such contents is of such an outcome

¹ At the end of 2012, there are over 700,000 iOS applications in the Apple iTunes App Store, and competing platforms have seen similar trends: Google's Android platform now has as many apps as iOS, while the Windows Phone Store has only 120,000 apps, but it's also growing quickly (Zibreg, 2012).

² Mobile apps can be grouped in ten main categories, as follows: utilities apps, entertainment apps, games apps, news apps, productivity apps, search tool apps, social networking apps, sports apps, travel apps, and weather apps, in addition, 80% of total time spent on mobile apps is on gaming, social networking, or entertainment (Khalaf, 2012). Recently, the music category has been the fifth-most popular app category after games, weather, social networking, and map/navigation (Kuang, 2012). Games are the most popular mobile app category; however, in-app purchases in this category are very heterogeneous, since the characteristics of games, and of their users and usage, can vary widely. Thus, we turn our attention to the music category to more easily capture the empirical consumption of mobile digital content.

through mobile apps. Prior studies have generally examined the dynamics of contents consumption in the mobile context (Ghose and Han 2011; Kim et al. 2010), without taking into account which type of contents are differently consumed depending on both its nature and consumers' behavioral intentions. Thus, to fill this gap, the present research examines the temporal interdependence between the various types of contents over time, by content type and behavior orientation. Our data set consists of mobile app data across a panel of users, encompassing the four types of contents usage in a music app such as mp3 download, mp3 gift, ringtone download, and ringtone gift. That data set consists of 257,000 individual-level mobile app data records across 150,000 users and data on mobile device-specific characteristics (e.g., 4G support, Tablet, Handset age).

Drawing on the altruism (Lampel and Bhalla 2007), reciprocity (Butler et al. 2007; Connolly and Thorn 1990), and economic behavior under resource constraints (Jacoby et al. 1976), we first classify contents usage into self-oriented usage (contents download) and other-oriented usage (contents gifting) by the behavioral orientations of contents usage. Next, we identify different types of music contents (mp3 and ringtone) by disaggregating contents usage into external usage (ringtone) and internal usage (mp3). Keeping this framework in mind then, in this paper we focus on a temporal interdependence between the four types of usage activities and impact of the performance of a mobile device (e.g., 3G or 4G services) on music app usage.

We thus empirically examine such interrelationship between various kinds of content usage in music apps using a fair-sized panel dataset, to understand the underlying mechanism of usage in apps and give an insight to manage apps efficiently. The objective of this study was to address the following questions: (1) With respect to behavioral orientations of contents usage, is self-oriented contents usage temporally proximal to other-oriented contents usage? (2) With respect to types of contents, is there a positive or negative interdependence between external and internal contents usages? (3) What are the implications of these temporal interrelationships among content usage activities? (4) Does the performance of a mobile device promote an increment in the usage of mobile apps on that device? (4) Is there complementarity between content usage activities in an app and the characteristics of the mobile device such as handset size and age? We examine these questions by utilizing simultaneous equation models as well as GMM-based dynamic panel models for robustness checks.

Using a large-scale dataset of individual content usage in a particular music mobile app, we find a positive temporal effect of self-oriented content usage on other-oriented content usage, based on behavioral orientation, and also a temporal interdependence between external and internal usage, based on types of content. Obviously, we also find that faster networks such as 4G communications standard increases content usage in general. The findings of this study contribute to the literature on the online contents usage, and its dynamics. Also, our findings can provide useful insights for mobile app developers, mobile network operators, content providers, and mobile device manufacturers.

In the following section, we first discuss the related literature. We then discuss interdependent usage activities related to music content with research hypotheses. Next, we describe our data, note some basic patterns, and explain our econometric model. We then present our results and evidence of robustness, and finally, present conclusions, implications, and limitations.

Literature Review

This study is related to a small group of literature that explains the interplay between online contents usages (e.g., downloading and gifting) and the characteristics of music content (e.g., mp3 and ringtone). First, this study relates the dynamic interdependence between online contents usage. The prior research in online content sharing (e.g., peer-to-peer or P2P sharing) suggests that the more benefit users get from a network, the more likely they are to create and share content (Xia et al. 2012). This research shows positive temporal interdependence between content sharing and content usage over time (particularly in P2P networks), but there have also been contrary results seen showing a negative temporal interdependence (particularly on the mobile internet) between content usage and content generation (Ghose and Han 2011). Thus, they produce mixed results in different contexts.

The second stream of research investigates the characteristics of online music contents. Without a doubt, music content is an "experience good," whose real value is revealed only after its consumption (Nelson

1970). It is often considered to be fashion-oriented content, where user preferences can change quickly and can be influenced by other users who have or have not enjoyed it (Bhattacharjee et al. 2007). Music content and its surrounding environments have received much attention in various contexts, including peer to peer (Asvanund et al. 2004; Bhattacharjee et al. 2007; Johar et al. 2012; Johar et al. 2011), and blogging (Dewan and Ramaprasad 2012). However, changes in the situation described in this literature may be emerging as recently developed mobile apps under a fast wireless environment enable users to more easily and actively enjoy and exchange music content with others.

Third, it deserves mention that previous literature adopts various concepts of “usage activity,” which designates the behavioral orientation related to digital content. Content usage and generation have mainly been investigated on the mobile internet (Ghose and Han 2011), content downloading and sharing mainly in relation to P2P networks (Bhattacharjee et al. 2007; Johar et al. 2011), and content sampling and blogging mainly in in online communities (Dewan and Ramaprasad 2012). In this study, we suggest that all these activities can be largely categorized either as “self-oriented usages” (e.g., downloading and consumption) or “other-oriented usages” (e.g., gifting, sharing, generating, and sampling) by its behavioral orientations (Dreu and Nauta 2009). That People are driven by both self-oriented and by other-oriented is an issue that social scientists have pondered for many centuries (Cropanzano et al. 2005; Korsgaard et al. 1996). In this view, self-oriented usage such as contents download can be characterized by one’s enjoyment maximization, whereas other-oriented usage such as contents gift can emphasize principles such as selflessness, cooperation, and concern for the enjoyment of others. Inter alia, gifting is notable for its one-to-one nature, as opposed to the one-to-many or many-to-many nature of online sharing. Online gift giving (i.e., gifting) nevertheless has a public aspect in the form of promotional gift coupons for consumers (Skageby 2007); however, in our theorizing, we consider music content gifting as a one-to-one process taking place in a user’s social network in terms of the other-oriented dimension of usage. Additionally, we treat music content downloading as a self-oriented usage dimension.

Fourth, there are various types of music content online. Mp3 files have been used widely in many service platforms, including P2P networks (Peitz and Waelbroeck 2005); however, mobile platforms provide additional types of music content, such as ringtones and ringback tones (Belo and Ferreira 2012; Ma et al. 2010). Recently, many apps enabling users to create ringtones from their own music files have been registered in apps markets (e.g., Ringtone Designer and Ringtone Converter for the iPhone). We focus on the ringtone’s use as an expression of the user’s current status (e.g., changing one’s ringtone to mirror one’s feelings) and as a way to identify the person calling (e.g., setting different ringtones for one’s family) because they show that contrary to mp3s, which are usually for the user’s private consumption, the ringtone has external and expressive features (Andersson and Rosenqvist 2006; Kumar and Thomas 2006; May and Hearn 2005). Thus, we can examine different types of music content (mp3 vs. ringtone) by disaggregating usage activities into external and internal usage.

Theoretical Framework and Research Hypotheses

Interdependence of usage activities for music content

In this section, we present theoretical framework and research hypotheses regarding the temporal interdependence of usage activities based on the literature of the altruism (Lampel and Bhalla 2007), reciprocity (Butler et al. 2007; Connolly and Thorn 1990), and economic behavior under resource constraints (Jacoby et al. 1976). Our framework for investigating content usage in mobile apps, as discussed above, has two-way dimensions; behavioral orientation and content type.

The one dimension allows us to distinguish behavioral orientation of content usage into self-oriented usage (e.g., downloading) and other-oriented usage (e.g., gifting). According to social psychologists, in contrast to impersonal exchange relationships involving strangers and casual acquaintances, individuals’ communal relationship involving friends and family members are founded on selflessness and a concern for the needs of the other (Clark et al. 1986; Clark et al. 1987). In the context of mobile apps, users consume simultaneously several types of contents in terms of behavioral orientation (e.g., one could either download contents for their own enjoyment or gift it to their friends). Echoing these behavioral-oriented characteristics, we conceptualize the content download as the self-oriented usage, while the content gifting as the other-oriented usage.

Another dimension indicates the purpose of content type by labeling usage as either internal (“own”) or external (“expressive”) usage. Remarkably, among various types of music content, the mp3 as a standard encoding format for digital audio has further enhanced the opportunities to download, share, and listen to music (Heye and Lamont 2010), and the most successful purely mobile entertainment content has been the ringtone (Srivastava 2005). Focus on these two types of content, we conceptualize the usage of mp3s as an internal usages, which is usually for the user’s private consumption, but the usage of ringtone as an external usages because it has external and expressive features (Andersson and Rosenqvist 2006; Kumar and Thomas 2006; May and Hearn 2005).

Specifically, the mp3 download has self-oriented and internal trait, however the ringtone gift can be regard as the other-oriented and external content usage. Because our goal is to understand users’ interdependent activities, within this framework, we need to first look for evidences on interdependence between four types of mobile apps usage as following two dimensions of content usage (behavioral orientation; self-oriented vs. other-oriented, and content type; internal vs. external).

First, to understand the temporal relationship between self-oriented usage and other-oriented usage, specifically, to develop the following hypothesis, we draw on gifting and reciprocity literature. Based on the linkage between gifting behavior and personal value, previous studies suggest that the primary reason for gifting is to give or obtain pleasure (Beatty et al. 1991; Lowes et al. 1971), and mention that altruism (e.g., other-orientation) is a key motive for online gift-giving (Lampel and Bhalla 2007). The concept of reciprocity can explain such gifting behavior (Connolly and Thorn 1990), that when people expect to receive gifts from one another, they tend to have the incentive to offer gift as well. In a one-to-one relationship, people gift or contribute because they expect to personally benefit (e.g., pleasure) from their friend, and the more benefits they receive from friends, the more they would like to gift or contribute to an online network (Butler et al. 2007). In a mobile music app, users take on dual roles of consumers and providers of resources as similar in P2P networks (Asvanund et al. 2004). Thus, positive network externalities arise when users who enjoy downloaded music in a previous period gift music content to their friends in the current period. In the same vein, the prior work in a P2P network, suggest the more benefits from the contributions of other users, the more that user is willing to share content (Xia et al. 2012). Based on this stream of work, we expect a positive temporal effect of self-oriented usage on other-oriented usage. Furthermore, we examine this positive temporal impact of users’ enjoyment via downloading on gifting regardless of content type. Therefore, we hypothesize as follow.

Hypothesis 1: The more self-oriented content a user consumes, the more likely she is to continue other-oriented usage.

To derive our second group of hypotheses, specifically, a temporal interdependence between usage of external and of internal contents, we focus on psychic rewards such as satisfaction and enjoyment which are associated with both internal and external exchange of goods (Lusch et al. 1992). This hints that the psychic rewards of external content might extend to internal content, and more external contents usage will make users more likely to continue internal contents usage for continuous value of music contents (Frith 1998). We thus anticipate that usage of external content will have a positive temporal effect on usage of internal content usage due to psychic rewards (e.g., enjoying whole music whenever he/she likes) and intangible return (Wasko and Faraj 2000). However, from a user’s perspective, the user can drive less psychic reward from the expansion of internal contents to external contents because they already are likely to achieve intrinsic satisfaction and self-actualization (Wasko and Faraj 2000) through internal contents consumption. Rather than, due to resource constraint (Jacoby et al. 1976), when a user consumes internal contents, she has less incentive to consume external contents additionally over time. Therefore, we hypothesize the following.

Hypothesis 2(a): The more external contents a user consumes (i.e., ringtone download and gift), the more likely she is to continue internal contents usage (i.e., mp3 download and gift).

Hypothesis 2(b): The more internal contents a user consumes, the less likely she is to continue external contents usage.

Moreover, in mobile app settings, users need to allocate their resources such as time and contents charge among various types of usages. The prior study on the mobile internet suggests the there is a negative temporal interdependence between content generation and content usage activities over time (Ghose and Han 2011). Especially, in this study, we expect negative temporal interdependence between usage

activities which are entirely different in terms of both behavioral orientation and content type (e.g., self-oriented external usage and other-oriented internal usage, or self-oriented internal usage and other-oriented external usage) due to both resource constraints, on the basis of the literature on economic behavior under resource constraints (e.g. Becker 1965; Jacoby et al. 1976). Therefore, we have the following hypotheses.

Hypothesis 3(a): The more ringtone (mp3) a user downloads, the less likely she is to continue mp3 (ringtone) gifting.

Hypothesis 3(b): The more mp3 (ringtone) a user gifts, the less likely she is to continue ringtone (mp3) downloading.

Mobile applications and supporting environments

As an emergent example of ubiquitous information systems (UIS), mobile devices and their environments tend to be smart, enabling very interactive relationship between users and mobile device (Poslad 2009; Vodanovich et al. 2010). A significant reason for this is the fast speed of wireless broadband and the broad availability of mobile apps. The former is generated by telecommunication companies to provide a better service for their subscribers, while the latter enables developers to sell their products to a large market through various store platforms (e.g., the iTunes app store, and the Android market).

Prior research suggests that complementarity between applications and services is crucial to foster platform migration to new mobile service platforms such as wireless broadband among consumers (i.e., from 2G to 3G) (Xu et al. 2010). Recently, mobile service providers are scrambling to implement 4G (also LTE, for “long-term evolution”) networks to meet the growing demand for faster networks to support rich multimedia content. With the acceleration of 4G networks, carrier and app developer focus has rightfully shifted from delivering speed alone to better user experiences and business models as well, as this ecosystem evolves (Campbell 2012). 4G networks are now present in many places and on the way in most. Faster networks and more apps are just the first steps in generating consumer excitement, but customer satisfaction, and new revenues. It is thus highly probable that complementarity between mobile apps and the fourth generation (4G) platform in the mobile communication market will even more effectively promote the use of mobile apps under the new, faster network speed. Therefore, we hypothesize the following.

Hypothesis 4: The faster a user’s download speed in using the wireless network, the more likely she is to continue using a mobile app.

Empirical Analysis

In this section, we provide an overview of mobile apps found in our dataset, from a large app service provider in South Korea, and show basic patterns seen in those data that are relevant to our research framework. We then present the econometric model estimating an individual-level simultaneous equations panel data to test our hypotheses.

Data

Our data consists of records of 257,000 mobile music apps from around 150,000 mobile users who downloaded the apps from a particular mobile network operator (MNO) in Korea between January 30 and April 15, 2012. From July 2011, South Korean MNOs have implemented 4G services, which had about 5 million subscribers in the country in April 2012 (and over 10 million by the end of 2012). Under 4G, it just a few minutes to download a large video file; music downloads take only a few seconds, facilitating the download and exchange of digital content. Thus, many MNO companies provide their own mobile apps to support and retain their subscribers. Our data are for a music app provided by one of the largest Korean MNOs; this is the second-most popular free app in Korea, after a particular game. This app enables user to purchase music contents legitimately, thus users can download or gift music contents for their friends with a few touch clicks. The users are charged it on their mobile phone bill. Like many music apps, it provides the latest music charts, classification by genre, and a facility for checking spelling.

Our data consist of individual information on download and gifting of ringtones and mp3s (thus, four specific activities). We aggregate the level of activity based on weekly activity for each user. In the app under study, users are charged a fee based on amount of activity of about \$0.60 per mp3 download or gift and about \$0.8 per downloading or gift of ringtone. We consider user expense for both download and gifting of both ringtones and mp3s.

We also gather data on mobile device characteristics for each user. Notably, the proportion of users who have a 4G-supporting device is 65%, and only 1% users have a tablet device (one with a display larger than seven inches). Handset age is measured from the time the handset was launched. It should be noted that this measure does not suggest the performance of handset devices because handset manufacturers continuously launch products with varying characteristics based on their market strategies, but this approach does enable us to capture users' familiarity with their devices. In addition, since we don't have data on demographic variables like age and gender, we employ appropriate econometric models to control unobservable user-specific errors. The summary statistics of our key variables are provided in Table 1.

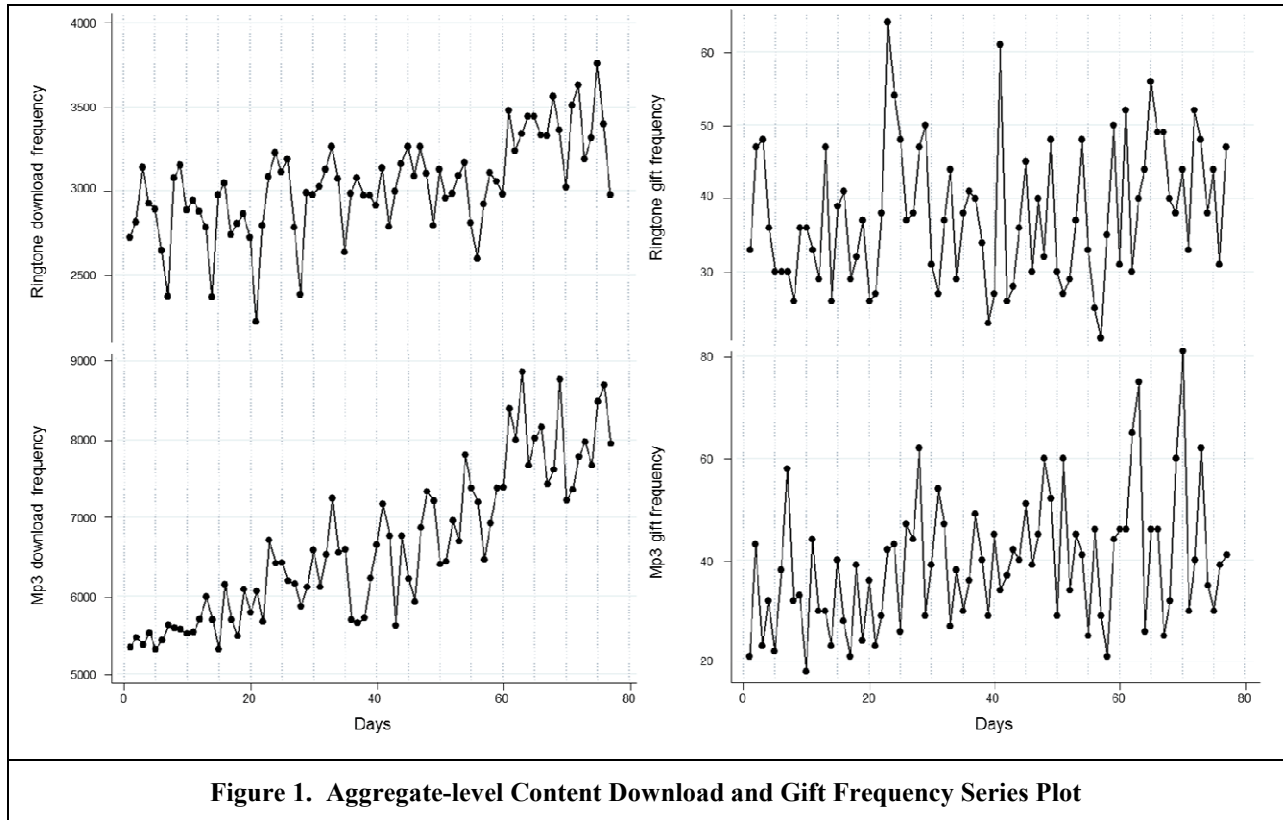
Table 1. Summary Statistics				
Variable	Observations	Mean	Std. dev.	Max
Weekly, user-specific content activity data				
Number of Mp3 Downloading	257,961	1.82	1.11	1021
Number of Ringtone Downloading	257,961	0.90	5.55	101
Number of Mp3 Gifting	257,961	0.09	0.53	100
Number of Ringtone Gifting	257,961	0.01	0.14	13
Mobile device-specific characteristics				
4G (LTE) Support (1=yes, 0=no)	148,562	0.65	0.46	1
Tablet (1=yes, 0=no)	148,562	0.01	0.08	1
Handset Age (months)	148,562	6.47	4.14	59.83
Weekly, user-specific content expense data				
Expense of Mp3 Downloading (\$)	257,961	1.09	1.41	612.60
Expense of Ringtone Downloading (\$)	257,961	1.15	3.33	130.70
Expense of Mp3 Gifting (\$)	257,961	0.11	0.58	60.00
Expense of Ringtone Gifting (\$)	257,961	0.02	0.18	16.90

Patterns in the data

Before discussing our econometric model in detail, we first describe general patterns found in the data. Generally, consumers use their mobile devices, including for internet surfing, more during the week than on weekends (Baye et al. 2009; Ghose and Han 2011). In our sample, over 11 weeks, we see this strong weekly cycle for all types of mobile app usage (see Figure 1). Users download ringtones more on weekdays than on the weekend. With regard to mp3s, while users in our sample steadily increased the number of mp3s they downloaded, this weekly cycle was still seen. We controlled these time-variant increasing effects by using time-period dummies. Finally, there was little gifting of either type of file compared to downloading (thousands vs. dozens), but a weekly cycle could still be seen for gifts.

To more clearly understand our data, we look at individual app usage patterns of random users. Figure 2 presents weekly frequency patterns by both action type and content type. This plot gives us some insight into the simultaneous relationship between types of usage. For example, for one particular user, irrespective of content type, gifting frequency correlates highly with downloading frequency. As noted above, in this interrelationship between gift and download we can see to a degree the interdependence

between other- and self-oriented action. In addition, with respect to content type, regardless of behavioral orientation, mp3 usage frequency correlates highly with ringtone usage frequency for this user. Likewise, the basic patterns in our data show interdependent relationships between own content for internal usage and expressive content.



Empirical modeling

We employed 3SLS estimation for a simultaneous equations panel data model to analyze mobile app usage. The 3SLS procedure is used to derive the parameters of the full system because endogenous variables in some equations of the model are used as explanatory variables in other equations. It combines two-stage least squares (2SLS) and seemingly unrelated regression (SUR) methods to take into account the cross-equation correlation of errors among different dependent regressors. As we have observed simultaneity in mobile app usage, simultaneity bias makes OLS estimation inappropriate. To improve robustness of our analysis, we further conduct generalized method of moments (GMM)-based dynamic panel data estimation (Arellano and Bover 1995; Blundell and Bond 1998). Before building the main equations, however, there are several econometric issues that we need to control. First, we see that there is an initial conditions problem for each user, and thus the first week's observation in our data is not likely to show real initial usage. Second, individual users generally have different preferences and tendencies toward content type and behavioral orientation. Finally, our results may be influenced by unobserved user heterogeneity (e.g., age, gender) and/or by the characteristics of the music content (e.g., chart rank, recency, and genre, etc.). We control these econometric issues in order to focus on our research goal.

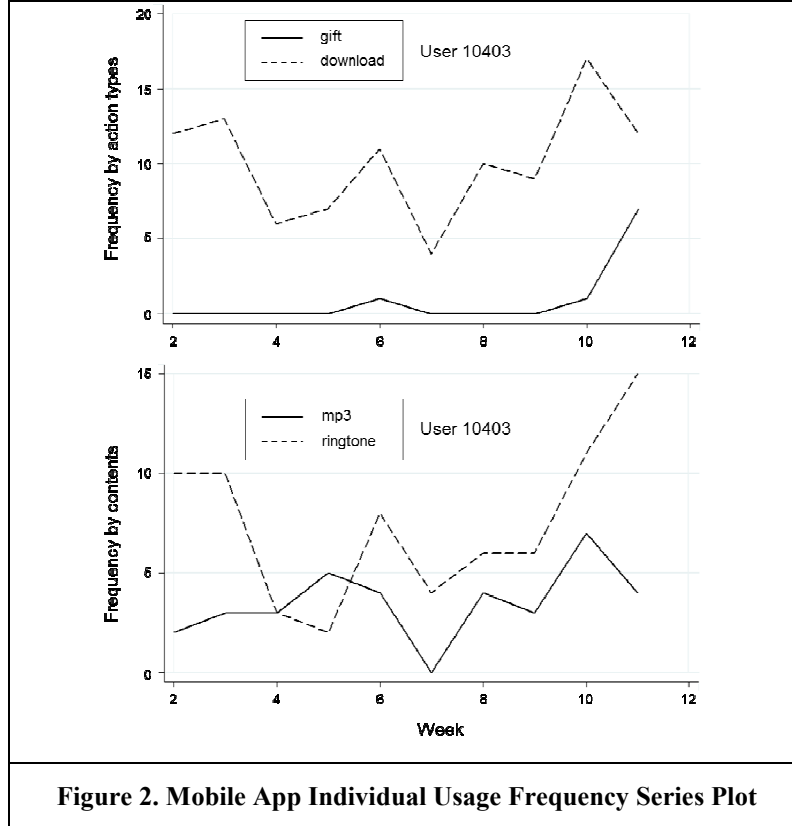


Figure 2. Mobile App Individual Usage Frequency Series Plot

Our panel data consists of a total of eleven temporal observations. To analyze content downloading and gifting, we include lagged variables in each equation to incorporate temporal interdependence. Then, we take the natural logarithm of these variables to control their skewedness and the different absolute frequency. Moreover, to control sample bias due to a lagged endogenous variable, we employ a first-differencing transformation on each variable in our model (Wooldridge 2002). Similar to previous literature on music sharing (Liebowitz 2008), this first-difference 3SLS enables us to alleviate unobserved user-specific, content-specific factors (e.g., age, gender, music genre, music sales). Equations for frequency of both content usage and content exchange are specified; moreover, we specified another set of simultaneous equations for content type, as follows: for $t = 2, 3, \dots, T$:

$$\Delta \ln(\text{Download}_{i,t}) = \beta_1 \Delta \ln(\text{Gift}_{i,t-1}) + \Delta \gamma_t + \Delta \delta_{i,t}, \quad (1)$$

$$\Delta \ln(\text{Gift}_{i,t}) = \beta_2 \Delta \ln(\text{Download}_{i,t-1}) + \Delta \eta_t + \Delta \theta_{i,t}, \quad (2)$$

$$\Delta \ln(\text{Mp3}_{i,t}) = \beta_3 \Delta \ln(\text{Ringtone}_{i,t-1}) + \Delta \kappa_t + \Delta \lambda_{i,t}, \quad (3)$$

$$\Delta \ln(\text{Ringtone}_{i,t}) = \beta_4 \Delta \ln(\text{Mp3}_{i,t-1}) + \Delta \mu_t + \Delta v_{i,t}, \quad (4)$$

where γ_t , η_t , κ_t , and μ_t are time-period dummies, and $\delta_{i,t}$, $\theta_{i,t}$, $\lambda_{i,t}$, and $v_{i,t}$ are user and time-specific error terms.

Although we specified simultaneous equation by users' action (download and gift), and by content type (mp3 music and ringtone music), we need to analyze the actual nature of app usage, incorporating all types of app usage considered in the model. Therefore, we specified the full model equations as follows, $t = 2, 3, \dots, T$:

$$\begin{aligned} \Delta \ln(\text{RingtoneGift}_{i,t}) &= \beta_5 \Delta \ln(\text{RingtoneDownload}_{i,t-1}) \\ &+ \beta_6 \Delta \ln(\text{Mp3Gift}_{i,t-1}) + \beta_7 \Delta \ln(\text{Mp3Download}_{i,t-1}) + \Delta \psi_t + \Delta \omega_{i,t}, \end{aligned} \quad (5)$$

$$\begin{aligned} \Delta \ln(\text{Mp3Download}_{i,t}) &= \beta_8 \Delta \ln(\text{RingtoneDownload}_{i,t-1}) \\ &+ \beta_9 \Delta \ln(\text{Mp3Gift}_{i,t-1}) + \beta_{10} \Delta \ln(\text{RingtoneGift}_{i,t-1}) + \Delta \rho_t + \Delta \pi_{i,t}, \end{aligned} \quad (6)$$

$$\begin{aligned} \Delta \ln(\text{RingtoneDownload}_{i,t}) &= \beta_5 \Delta \ln(\text{Mp3Download}_{i,t-1}) \\ &+ \beta_6 \Delta \ln(\text{RingtoneGift}_{i,t-1}) + \beta_7 \Delta \ln(\text{Mp3Gift}_{i,t-1}) + \Delta \rho_t + \Delta \nu_{i,t}, \end{aligned} \quad (7)$$

$$\begin{aligned} \Delta \ln(\text{Mp3Gift}_{i,t}) &= \beta_{14} \Delta \ln(\text{RingtoneGift}_{i,t-1}) \\ &+ \beta_{15} \Delta \ln(\text{Mp3Download}_{i,t-1}) + \beta_{16} \Delta \ln(\text{RingtoneDownload}_{i,t-1}) + \Delta \sigma_t + \Delta \varphi_{i,t}, \end{aligned} \quad (8)$$

where ρ_t , ω_t , ψ_t , and σ_t are time-period dummies, and $\nu_{i,t}$, $\pi_{i,t}$, $\omega_{i,t}$, and $\varphi_{i,t}$ are user and time-specific error terms.

Results

Results on content usage behavior

We begin our analysis by estimating the interdependency between content download and gifting, per Eq. (1) and (2). Table 2 presents 3SLS estimation results on our models. We first check that there is a significantly negative effect of download in a previous period on gift in the current period ($\beta = -.0053$, $p < .001$). This result also implies that the effect of gift in a previous period is negative on download in the current period ($\beta = -.0054$), but the result is not statistically significant because of its high standard error (0.0188). As we seen from Figure 2, gift frequency has large volatility in our data, which may cause a high standard error. This finding implies that people give music infrequently.

We find a temporal relationship between content types from Eq. (3) and (4). This implies that an increase in mp3 in a previous period is associated with a decrease in ringtone usage in the current period ($\beta = -.0091$, $p < .001$). This finding shows that past usage of internal content can be transformed negatively into current usage of external content. We also find that an increase in ringtone in a previous period is associated with an increase in mp3 usage in the current period ($\beta = .0119$), however, the ringtone usage pattern may induce a higher volatility (see Figure 2), this result was not significant (standard error 0.0122). This result largely indicates some clues that the effect of external content usage in a previous period is positively associated with internal content usage in the current period. In sum, our aggregate metric for activities and content types cannot explain fully explain mobile app usage, and so these results suggests the need for the use of a full model reflecting all types of usage behavior.

We next introduce usage of four types of mobile apps into the simultaneous equations from Eq. (5) to Eq. (8). First, we find temporal relationship between usage of other-oriented content (i.e., gifting) and usage of the other types of content. Specifically, the result of Eq. (5) implies that ringtone gifting in the current period is positively associated with ringtone download in a previous period ($\beta = .0069$, $p < .001$). This finding supports our prediction that users tend to share their impressions of music with others by means of ringtone gifting. However, the result of Eq. (8) implies that mp3 gifting in the current period is not statistically associated with mp3 download in a previous period. This result attenuates Hypothesis 1, but implies the boundary condition of a positive temporal effect of self-oriented usage on other-oriented usage. According to our results, a positive temporal association between self-oriented usage and other-oriented usage is only valid in external contents, but not in internal contents. Thus, Hypothesis 1(a) is partially supported.

Table 2. 3SLS Estimation Results on Research Model

Model	Dependent variable	Explanatory variables	Coefficient	Model fit
(1)	Log music download (<i>t</i>)	Log music gift (<i>t-1</i>)	-0.0054 (0.0188)	$\chi^2=22.9^{***}$ Adj. R ² =0.05
(2)	Log music gift (<i>t</i>)	Log music download (<i>t-1</i>)	-0.0053 (0.0018) ^{***}	$\chi^2=149.3^{***}$ Adj. R ² =0.16
(3)	Log mp3 usage (<i>t</i>)	Log ringtone usage (<i>t-1</i>)	0.0119 (0.0122)	$\chi^2=213.4^{***}$ Adj. R ² =0.09
(4)	Log ringtone usage (<i>t</i>)	Log mp3 usage (<i>t-1</i>)	-0.0091 (0.0027) ^{***}	$\chi^2=78.3^{***}$ Adj. R ² =0.02
(5)	Log ringtone gift (<i>t</i>)	Log ringtone download (<i>t-1</i>)	0.0069 (0.0013) ^{***}	$\chi^2=39.7^{***}$ Adj. R ² =0.12
		Log mp3 gift (<i>t-1</i>)	-0.0056 (0.0022) ^{**}	
		Log mp3 download (<i>t-1</i>)	-0.0008 (0.0006)	
(6)	Log mp3 download (<i>t</i>)	Log ringtone download (<i>t-1</i>)	0.0279 (0.0124) ^{**}	$\chi^2=27.4^{***}$ Adj. R ² =0.11
		Log mp3 gift (<i>t-1</i>)	0.0073 (0.0212)	
		Log ringtone gift (<i>t-1</i>)	-0.0156 (0.0583)	
(7)	Log ringtone download (<i>t</i>)	Log mp3 download (<i>t-1</i>)	-0.0082 (0.0026) ^{**}	$\chi^2=33.5^{***}$ Adj. R ² =0.20
		Log ringtone gift (<i>t-1</i>)	0.0422 (0.0274)	
		Log mp3 gift (<i>t-1</i>)	-0.0344 (0.0096) ^{***}	
(8)	Log mp3 gift (<i>t</i>)	Log ringtone gift (<i>t-1</i>)	-0.0123 (0.0162)	$\chi^2=156.4^{***}$ Adj. R ² =0.23
		Log mp3 download (<i>t-1</i>)	-0.0018 (0.0016)	
		Log ringtone download (<i>t-1</i>)	-0.0317 (0.0033) ^{***}	

Standard errors in parentheses. *significant at 10%; ** significant at 5%; *** significant at 1%. Time-fixed dummies are included, but not reported for brevity.

Second, we find a positive and significant temporal effect of ringtone download on mp3 download from results of Eq. (6). Specifically, an increase in ringtone download in a previous period is associated with an increase in mp3 download in the current period (in Eq. 6; $\beta = .0279$, $p < .05$). Consistent with Hypothesis 2(a), we see changes in the usage of self-oriented content from external to internal over time. On the other hand, we find that the negative effect of mp3 gifting in a previous period on ringtone gifting in the current period are derived from a monetary constraint and a less incentive to consume (in Eq. 5; $\beta = -.0056$, $p < .05$). Combined with the results of Eq. (7), we find temporal interdependence between ringtone download and mp3 download. With respect to external and self-oriented content usage (i.e., ringtone download) in the current period, we see a negative and significant temporal effect of mp3 downloading (in Eq. 7; $\beta = -.0082$, $p < .05$). These results indicate that an increase in internal contents usage (mp3 gifting and downloading) in a previous period promotes a decrease in external contents usage in the current period (ringtone gifting and downloading), and support Hypothesis 2(b).

Finally, we find a negative temporal interdependence between two contrary usages from the results of Eq. (7) and (8). For example, ringtone download has an external and self-oriented character, but mp3 gifting has an internal and other-oriented character. Our simultaneous results imply that an increase in ringtone download in the previous period is associated with a decrease in mp3 gifting in the current period and vice versa ($\beta = -.0317$, $p < .01$; $\beta = -.0344$, $p < .01$, respectively). Due to relative high standard error, results indicate that there is not a significant temporal interdependence between mp3 download and ringtone gift. These results partially supports Hypotheses 3(a) and 3(b), and suggests that content usages that have completely different behavioral properties (self-oriented vs. other-oriented) and content-specific properties (external vs. internal) can be impediments to each other.

Robustness checks and results using the performance of mobile device

To check the robustness of our results, we re-estimated our main equations separately with a lagged dependent variable using GMM-based dynamic panel data estimation. We estimated our models using the *xtdpdsys* procedure in STATA, employing only a log transformation of variables (i.e., not take a first-differencing transformation). Moreover, we incorporate variables representing the performance of the mobile device (e.g., broadband speed, screen size, and handset age). As shown in Table 3, the overall results based on GMM-based estimations are qualitatively the same as our 3SLS estimation results.

In addition, we estimated our main equations using metrics for expense of activity instead of frequency metrics.³ We find that these results are qualitatively similar to our 3SLS and GMM-based estimation results. As we ran our models using first-differencing 3SLS, we controlled unobservable user-specific characteristics such as performance of mobile devices. In our GMM-based estimation, we incorporate these variables into our models; through these works, we can draw both robust results and the effects of the mobile device's performance on app usage to test Hypothesis 4.

First, we find that faster mobile wireless speed under 4G promotes mobile app usage significantly (all coefficients of 4G support across all models are statistically significant). Specifically, users who have a device supporting 4G service (in our sample, 168,708 users) more frequently use music app than those who don't (2G or 3G; 89,253 users). This finding conforms to the common view that system quality, measured in terms of system speed, is positively related to system usage (Rai et al., 2002), and also that the efforts of MNO companies to provide faster broadband have had an accelerative effect on their subscribers. Therefore, these findings support our Hypothesis 4. Users who have a 4G device may perceive a lower psychological barrier to using their mobile app due to the short wait time. Second, we test the effect of platform (e.g., handset, tablet) on mobile app usage. Since tablet, generally defined as having a display of seven inches or larger are not yet used widely in the Korean market, recall that only about 1% of users in our sample (1023 of 147,574 users) use a mobile app through a tablet. However, our results show that the use of big-screen mobile platforms which enable users to seek a variety of content, increase the amount of content downloaded ($\beta = .8339, p < .05$ in model 1), but decrease the gifting of content ($\beta = -.5962, p < .01$ in model 2). This finding shows us that users of large-screen mobile platforms utilize their devices by downloading various kinds of content, but that two-handed mobile platforms, because of their large form factor, are inadequate for gifting content, and tablets are mainly used for content consumption (such as downloading). Because of the small number of observations for tablets, we don't find consistent effects of tablet usage on any of the four usages.

Finally, we find that handset age increases ringtone usage ($\beta = .0107, p < .05$; $\beta = .0197, p < .01$; $\beta = .0109, p < .05$, in models 4, 5, and 7, respectively). This finding implies that users who have a relatively old handset may want to renew their device psychologically by changing its ringtone.⁴ Moreover, users who have a superannuated handset prefer expressive content for external usage to own content for internal usage, following the fashion.

³ Note that due to multicollinearity, we cannot include both content price and content frequency in the main model.

⁴ We also incorporated the quadratic terms for handset age in the model to validate our interpretation. The results indicate that there are still significant effects for ringtone usage, thus we can conclude that consumers with older handsets purchase more ringtones to renew their device psychologically.

Table 3. System GMM-Based Dynamic Panel Data Estimation Results on Research Model

Model	Dependent variable	Explanatory variable	Coefficient	Wald χ^2
(1)	Log music download (<i>t</i>)	Log music download (<i>t-1</i>)	0.0283 (0.0067)***	377.18***
		Log music gift (<i>t-1</i>)	-0.0300 (0.0214)	
		4G support	0.7376 (0.1317)***	
		Tablet	0.8339 (0.4253)**	
		Handset Age	-0.0014 (0.0259)	
(2)	Log music gift (<i>t</i>)	Log music gift (<i>t-1</i>)	0.0136 (0.0056)**	1262.68***
		Log music download (<i>t-1</i>)	-0.0085 (0.0020)***	
		4G support	0.1567 (0.0405)***	
		Tablet	-0.5962 (0.1303)***	
		Handset Age	0.0047 (0.0035)	
(3)	Log mp3 usage (<i>t</i>)	Log mp3 usage (<i>t-1</i>)	0.0250 (0.0069)***	568.48***
		Log ringtone usage (<i>t-1</i>)	-0.0082 (0.0133)	
		4G support	0.5390 (0.1390)***	
		Tablet	0.0317 (0.4484)	
		Handset Age	0.0096 (0.0123)	
(4)	Log ringtone usage (<i>t</i>)	Log ringtone usage (<i>t-1</i>)	0.0548 (0.0068)***	142.74***
		Log mp3 usage (<i>t-1</i>)	-0.0067 (0.0031)**	
		4G support	0.1959 (0.0668)**	
		Tablet	0.1758 (0.2158)	
		Handset Age	0.0107 (0.0059)**	
(5)	Log ringtone gift (<i>t</i>)	Log ringtone gift (<i>t-1</i>)	-0.0348 (0.0058)***	752.03***
		Log ringtone download (<i>t-1</i>)	0.0071 (0.0014)***	
		Log mp3 gift (<i>t-1</i>)	-0.0084 (0.0024)**	
		Log mp3 download (<i>t-1</i>)	-0.0001 (0.0007)	
		4G support	0.0414 (0.0138)**	
		Tablet	-0.5429 (0.0440)***	
		Handset Age	0.0197 (0.0012)***	
(6)	Log mp3 download (<i>t</i>)	Log mp3 download (<i>t-1</i>)	0.0299 (0.0069)***	389.25***
		Log ringtone download (<i>t-1</i>)	0.0413 (0.0139)**	
		Log mp3 gift (<i>t-1</i>)	-0.0123 (0.0243)	
		Log ringtone gift (<i>t-1</i>)	0.0417 (0.0656)	
		4G support	0.7137 (0.1382)***	
		Tablet	0.1901 (0.4453)	
		Handset Age	0.0104 (0.0123)	
(7)	Log ringtone download (<i>t</i>)	Log ringtone download (<i>t-1</i>)	0.0500 (0.0070)***	204.55***
		Log mp3 download (<i>t-1</i>)	-0.0039 (0.0031)*	
		Log ringtone gift (<i>t-1</i>)	0.0419 (0.0315)	
		Log mp3 gift (<i>t-1</i>)	-0.0964 (0.0106)***	
		4G support	0.1682 (0.0660)**	
		Tablet	0.6152 (0.2128)**	
		Handset Age	0.0109 (0.0028)**	
(8)	Log mp3 gift (<i>t</i>)	Log mp3 gift (<i>t-1</i>)	0.0537 (0.0061)***	1487.61***
		Log ringtone gift (<i>t-1</i>)	-0.0222 (0.0186)	
		Log mp3 download (<i>t-1</i>)	-0.0029 (0.0018)	
		Log ringtone download (<i>t-1</i>)	-0.0646 (0.0038)***	
		4G support	0.1899 (0.0392)***	
		Tablet	-0.1102 (0.1259)	
		Handset Age	-0.0144 (0.0034)*	

Standard errors in parentheses. *significant at 10%; ** significant at 5%; *** significant at 1%; Time-fixed dummies are included, but not reported for brevity.

Discussions

When the Apple iPhone first debuted in early 2007, there were only a few apps available for the device; however, mobile apps are now one of the fastest-growing internet-related services. Despite the current worldwide interest in apps, very little is known about the internal mechanism of content usage in mobile apps. To examine interdependence in usage of mobile apps, we suggest a general research framework for music content usage behavior in apps and analyze it using a large-scale panel dataset consisting of various types of content usage behavior and mobile device's performance.

The insights from our results also have theoretical implications. First, this research can broaden the boundaries of research on music content, as considered in several previous studies (Asvanund et al. 2004; Bhattacharjee et al. 2007; Dewan and Ramaprasad 2012; Liebowitz 2008). Music content gifting implies the transfer of the user's experience (in the sense that music content is an experience good) (Nelson 1970). We reorganized various concepts of usage activities involved in exchanging digital content by classifying usage into either self- or other-oriented based on multiple concepts related to digital content from previous studies (Boudreau 2012; Dewan and Ramaprasad 2012; Johar et al. 2012). Through these works, we find a positive temporal effect of self-oriented usage on other-oriented usage, and our results empirically support that the reason for other-oriented behavior such as gift giving is to give or obtain pleasure over time (Beatty et al. 1991) and the positive network externalities of music content (Asvanund et al. 2004). Thus, our study provides additional evidence of the reciprocity stemming from social exchange theory (Connolly and Thorn 1990; Homans 1958; Xia et al. 2012).

Second, this research examines usage of specific types of music content—mp3s and ringtones—by theoretically classifying them as external or internal content usage, and finds a temporal interdependence between external and internal usage. Specifically, we find changes in the usage of self-oriented content from external to internal overtime by increasing psychic rewards (Lusch et al. 1992), but the negative temporal effect of internal contents usage on external contents usage due to a monetary constraint and a less incentive to consume (Jacoby et al. 1976; Wasko and Faraj 2000). Furthermore, on the basis of the literature on economic behavior under resource constraints (e.g. Becker 1965; Ghose and Han 2011), we also find that there is a negative temporal interdependence between usage activities which are entirely different in terms of both behavioral orientation and content types, and an evidence that these contents usages can be impediments to each other. Thus, this study contributes to online contents usage literature by providing a potential explanation for a temporal interdependence among contents usage activities (Ghose and Han 2011; Xia et al. 2012), in the context of mobile apps.

Finally, our finds suggest that the faster the download by 4G platform, the more likely users are to increase mobile apps usage. Our findings provide substantial support for a complementarity between applications and services (Xu et al. 2010). Moreover, this study empirically finds that users who have older mobile devices are likely to prefer external over internal usage. From this result, we additionally observe complementarity between handset age and external content such as music ringtones.

Our data come from a setting where users download a free mobile app and purchase music content in-app in patterns based on frequency. Recent market research has shown that paid apps have been profitable for a select few but that in-app purchases and ad-supported models are gaining popularity (Beccue 2012). Our results, based on in-app purchase data, can provide useful managerial insights for mobile app developers, mobile network operators, content providers, and mobile device manufacturers. First, our results imply that mobile app developers should consider the interdependence between different types of in-app purchase activity. Specifically, the negative temporal interdependence between diametrically opposed usage activity such as ringtone downloading and mp3 gifting can lead to a loss of sales and may promote the weeding out of the app from the app market. On the other hand, both the positive temporal impact of ringtone download on mp3 download and the positive temporal impact of ringtone download on ringtone gifting can give insight to increase content sales. Hence, mobile app developers could consider ways to provide synergistic usage features and simplify content purchase procedures for mobile apps. Second, for mobile network operators (MNOs), our results imply that the 4G service platform, which promises faster speeds and reliable connectivity, has a positive effect on the growth of mobile app usage. Third, our study gives the insight that content providers can collaborate with mobile app developers and take advantage of 4G by delivering richer content to the user through dedicated mobile apps. Finally, our results imply that content gifting via a tablet, which has a large display, requires more effort and resources

than does a handset. This impact of form factor size on content usage can provide mobile device manufacturers with new ideas regarding easy-to-use content UI/UX (user interface/user experience) for self-oriented versus other-oriented usage and can increase the utility of the mobile device for users.

Conclusions and Directions for Future Research

This study has some limitations and provides directions for future research. First, we only examined data for a certain music app, and given the pervasiveness of contents usage in this study and empirical support for the proposed hypotheses, we expect the results to hold for many other mobile apps (e.g., social games such as Farmville). However, focusing on a single mobile app does not compromise the generalizability and external validity of the results. Thus we call for future research that examines several categories of mobile apps (e.g., game apps, sports apps, and travel apps) to clarify their relevant characteristics.

Second, of a number of different revenue models, we examined in-app purchase only. For the generalization of our results, future research on paid and ad-supported apps can be conducted. Lastly, limitations arise from the lack of data. For example, we do not have information about user demographic variables such as age, gender, or location. However, we controlled unobserved user-specific differences by using appropriate econometric specifications. Moreover, recent mobile apps that sell in-system digital content tend to have scarcer user information than mobile network operators or apps markets, because the intermediation of these institutions means that it is highly probable that mobile apps do not include customer information. Nevertheless, future work could examine this user information.

In conclusion, this study strengthens our knowledge of the dynamics of content usage in mobile apps, and we hope that this study will generate further interest in and attention to the economics of mobile apps and mobile commerce.

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