The Substitution Effect of Teenagers' Smart Phone Use on Traditional Media Use

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Abstract: This study explores whether teenagers' traditional media use time has been affected by smartphone use time. Drawing on the Korean Media Panel Survey from 2011 to 2014, we specify two models—a two-stage least squares (2SLS) and a two-stage least squares with individual fixed effects (2SLS-FE)—and compare the estimates. The estimates from the 2SLS model show that teenagers' smartphone use time has a substitution effect on book reading time, computer use time, and TV watching time, while the estimates from the 2SLS-FE model show that teenagers' smartphone use time has a substitution effect on teenagers' book reading time and computer use time but no significant effect on their TV watching time.

Keywords: media substitution, smartphones, teenagers, instrumental variables, fixed effects

INTRODUCTION

Teenagers' smartphone acceptance has steadily increased in the last few years (Madden, Duggan, Cortesi, & Gasser, 2013). In Korea, people of all ages use smartphones, and teenagers have been a growing group of smartphone users since the early 2010s. As smartphones are becoming more popular among teenagers, parents worry that children's smartphone use might decrease the amount of time they spend reading books and lower academic achievement. Policy makers in Korea have tried to address concerns that have arisen over teenagers' media habits. For example, the Korean government implemented a shutdown policy in late 2011, which restricted adolescents'

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online game time at night. However, researchers find that restriction of adolescents' online game use at night has no significant effect on their total daily online game time (Sung, 2014). This study indicates that teenagers' media use patterns might be unresponsive to external interventions. Teenagers' media addictions thus remain a demanding challenge for policy makers.

Scholars have suggested that the widespread use of new media among teenagers is related to their unique characteristics, characteristics that differ from adults. Lee et al. (2013) claim that teenagers embrace the smartphone because they enjoy the mobility that it offers and because they prefer computer-mediated forms of communication (Jeffe, Lee, Huang, & Oshagan, 1995; Lee et al., 2013). Kim et al. (2012) claim that adolescents use media for many reasons and that their motives are clearer than those of adults. Son (2005) finds that teenagers' media use is concentrated in new rather than traditional media.

Previous studies have reported that adolescents tend to prefer using new media more than adults do and that adolescents' media use patterns are quite different from those of adults. However, adolescents are regarded as being more vulnerable to media addiction than adults (Kim et al., 2012). Problems associated with overuse have been reported, including a decrease in self-esteem and a loss of quality in interpersonal relationships (Young & Rodgers, 1998). Also, adolescents' cell phone addiction has a significant correlation with symptoms of mental illness such as anxiety and obsession (Kim et al. 2012). However, other studies offer a differing view. Kang, Lee, and Oh (2008) explored the extent to which individuals' personal lives were affected by the internet. The results showed that the effects of internet use vary significantly according to age, especially among teenagers. Lee (2005) analyzed the impact of internet use on traditional media use and concluded that teenagers' internet use had no effect on traditional media use while adults' internet use did. Other studies have shown that teenagers' media use patterns are not significantly influenced by new media. In sum, the extent of substitution effects vary by media type and age group.

Kim et al. (2012) claim that it is important to focus on the overall substitution effects of different media use rather than on the characteristics of individual media use when studying the side effects of media addiction, which is the approach this study adopts in investigating the substitution effect of teenagers' smartphone use on other traditional media use within the framework of a media substitution hypothesis. According to the media substitution hypothesis, teenagers' smartphone use may affect their overall media use patterns by decreasing their use of other more traditional media. However, if the relationship is complementary rather than substitutive, teenagers' smartphone use may also increase their use of traditional media. It is also possible that teenagers' smartphone use has no significant effect on their use of other media. We

can then ask whether teenagers' use of traditional media has been affected by the widespread use of smartphones among teenagers. Investigating the substitution effect of smartphone use on teenagers' other media use will provide the basis for understanding the impact of new media on existing media and teenagers' media addiction.

LITERATURE REVIEW

Media Substitution Hypothesis

A principal question in media and communication studies is whether new media use is a substitute for traditional media use. The media substitution hypothesis refers to the assumption that the use of new media will reduce the use of existing media (Lee, 2005; Shim, Kim, and Ha, 2009). The media substitution hypothesis is based on the principle of relative constancy, meaning that the amount of time spent on existing media decreases when a new medium enters the market (McCombs, 1972). The mechanism of media substitution is based on the competition between different media, and the competition stems from the limited time for media use and functional similarities among the various media. According to Kayany and Yelsma (2000), when a new medium performs the same function as existing medium, one of the two will assume a secondary position in meeting the desires of the target group. There is thus a substitutive relationship between functionally similar media and a complementary relationship between functionally different media (Lee, 2005).

The origins of the media substitution hypothesis can be traced to the Lasswell's (1948) classic study on TV and radio (Lin, Salwen, Garrison, & Driscoll, 2005). Lasswell forecasted that TV would come to substitute for radio, and his prediction was correct. Researchers have since investigated whether new media substitutes for traditional media and why people prefer using new media rather than using existing media. There are two versions of the media substitution hypothesis that are differentiated according to the relationship between different media, namely whether the relationship is one of substitution or complementation (Greenstein and Khanna, 1997). In the first, new media reduces the use of traditional media, and in the second, use of traditional media increases with the introduction of new media. Most studies report that new media substitutes for traditional media. McCombs (1972) suggests that use of the most preferred media will decrease the use of other media. Many scholars have analyzed media substitution, and their results are consistent with McCombs's (1972) suggestion. For example, Childers and Krugman (1987) find that the introduction of VCR led to a decrease in movie theater attendance, and Ferguson and Perse (2000) conclude that the

introduction of the web decreased traditional TV viewing. However, there have been debates as to whether new media use always decreases traditional media use time. Sparkes (1983) finds that video use did not affect other media use time and claims that the introduction of new media does not always affect the use of traditional media.

Other researchers such as Greenstein and Khanna (1997) suggest that the use of new media increases the use of traditional media. Drawing on the concept of substitution goods and complementary goods, they characterize the relationship between different media as substitutional or complementary. Dimmick and Rothenbuhler (1984) introduce an analysis based on niche theory and the way people rank different types of media and attempt to find some overlap between those different types of media. Albarran and Dimmick (1993) investigate the competitive relationship between TV, cable TV, and radio using niche analysis methodology. They claim that cable TV has a competitive advantage over TV and radio. Dimmick (1993) also suggests that TV, cable TV, and VCR's competitive advantage differs both cognitively and emotionally. Shim, Kim, and Ha (2009) claim that the relationship between the internet and other media has changed over time. They note that the internet replaced broadcasting in its early stages but that the relationship subsequently became complementary.

Although studies based on the media substitution hypothesis have provided a wide range of ways of understanding the relationship between media, the results vary by media type and analysis period (Kim and Park, 2016). Shim, Kim, and Ha (2009) point out that the reason for these discrepancies are methodological limitations. They argue that the effect of media substitution has been primarily measured only by media use time, which can obscure the relationship between media. Other methodologies such as the niche approach enable more diversified analyses of the way media are used, although these alternative methods are not always superior to the traditional approach based on media use time. Methodologies that depend on self-reported surveys such as the SSNIP(small but significant and nontransitory increase in price) test have been widely used in identifying the relationship between firms or broadcasting services, but these methodologies are not rigorous and are only appropriate when researchers cannot access data (Kwon, 2006). Although existing studies of the media substitution hypothesis focus on media use time and are somewhat limited in terms of robustness of measurement, these studies still significantly contribute to an understanding of the relationship between media (Lee, 2005).

The Relationship between Smartphone Use and Traditional Media Use

Identifying the relationship between smartphone and other traditional media has also been a topic of interest among researchers and policymakers. Although smartphones

have become fairly ubiquitous since the early 2010s are thought to have changed people's traditional media use patterns, there are only a few studies that investigate the effect of smartphone use on other media use within the framework of the media substitution hypothesis.

The initial study was conducted by the Korea Communications Commission (Korea Communications Commission, 2012), which analyzes whether use of a smartphone replaces other media such as computers, TV, and publications by conducting a survey of self-reported questionnaires. The results indicate that about 40% of the respondents said their computer internet use was reduced, 27.8% said their TV watching time was reduced, and 35.9% said their book/magazine/newspaper reading time was reduced. Kim et al. (2012) explore whether there is a difference between adolescents and adults when it comes to the smartphone's substitution effect. They conduct a survey with self-reported questionnaires asking whether respondents' computer internet use time has decreased since they started to use a smartphone. Of the adolescents, 66.1% responded that their internet use time had been reduced, while 44.8% of the adults responded their internet use time had decreased. Therefore, they claim that the substitution effect of the smartphone is more common among adolescents than adults. However, because these studies are based on self-reported surveys they may contain measurement errors. Although methodologies based in self-reported surveys have been widely used in identifying relationships between individuals and broadcasting services, they are not rigorous and are only appropriate when researchers cannot access actual usage data (Kwon, 2006).

Kim et al. (2013a) conduct a more structured survey asking respondents how much time they spent on media use. They investigate the effect of smartphone use on people's traditional media use with the aim of proving the media substitution hypothesis. Carrying out a logistic regression analysis, they find that smartphone use decreases traditional media use and suggest that smartphone use substitutes for traditional media use. Although it represents an important attempt to prove media substitution hypothesis, their study has some limitations. Firstly, they use cross-sectional survey data, which do not control for individuals' fixed unobserved characteristics. Secondly, an individual's media use is determined by the individual's self-selection process. However, the logistic regression does not control for bias from the individual's self-selection process, and the potential problem of reverse causality cannot be eliminated by logistic regression. We attempt to ascertain the effects of smartphone use on traditional media use when these biases are adequately controlled for.

RESEARCH DESIGN

Data and Key Features

This study uses the Korean Media Panel Survey, which was established in 2010 by the Korea Information Society Development Institute. The Korean Media Panel Survey database consists of three parts: a personal database, a household database, and a media diary database. The media diary database has been maintained since 2011 and contains a record of each person's media use over three days broken down into 15-minute intervals. The personal database documents personal characteristics, and the household database includes household information such as average monthly household income. To investigate the effect of smartphone use on teenagers' overall media use, we limit our sample to young people between the ages of 10 and 19 and use the records of the media diary database from 2011 to 2014 to construct an unbalanced panel dataset with 17,880 observations. As the media diary database documents an individual's media use information in 15-minute intervals, potential measurement errors would be smaller than those present in the studies by Korean Communications Commission (2012) and Kim et al. (2013a).

We use teenagers' smartphone use time as an independent variable to estimate the substitution effect on teenagers' traditional media use time and teenagers' book reading time, computer use time, and TV watching time as dependent variables. Books, computers, and TVs offer different content from that of smartphones, and the way these types of media are used is likewise different. Therefore, we may be able to ascertain whether the substitution effect of the smartphone on traditional media use time varies depending on the media.

This study controls for factors affecting teenagers' traditional media use. First, we take into account whether parents restrict their children's use of video games, the internet, and TV. Sung (2014) finds that such restrictions significantly reduce children's overall media use time. Parents' restrictions on access to the internet and TV may affect not only children's TV and internet use time but also children's book reading time. Second, we take into account which kinds of media devices an individual owns, which may include TVs, game consoles, desktops, laptops, and cell phones. Third, we control for household and individual characteristics. Children's media use can be affected by, for example, the fact that they live with grandparents. We use data from 16 different residential areas and take into account average monthly household income and gender makeup of households, the latter of which is regarded as one of the most important factors affecting media use (Hwang & Lee, 2009). Also, we use a school variable to take into account disruptive changes in the learning environment and in

learning time that occur when teenagers enter high school, changes that have a direct impact on teenagers' daily life habits and that also affect media usage time.

Previous studies exploring teenagers' daily life patterns generally use the time allotted for a particular activity as a variable for a life pattern. Kim et al. (2013b) use school hours, homework time, game time, book reading time, sleeping time, TV watching time, and exercise time as variables for teenagers' life patterns. Kang, Lee, and Oh (2008) use sleep time, meal time, studying time, housekeeping hours, working hours, moving time, social time, rest time, activity time, and media use time as variables for life patterns in their investigation of whether an individual's life patterns are affected by internet use. The result show that the effects of internet use vary significantly by age and that especially for teenagers the effects of internet use on both sleep and studying time are significant. In this study, studying time is included as part of book reading time, which features as a dependent variable. Therefore, we control for the sleep time variable, which might have a correlation with other media use time.

And finally, we use dummy variables for the amount of time spent using media over the course of a year, on weekends and on other special days as control variables. Measurement errors that derive from differences in survey dates can be controlled for by using a dummy variable for weekends as a control variable (Sung, 2014). Introducing a variable for unusual occasions such as exam periods, family events, and vacations can control for the different kids of media use that occur on these occasions. Table 1 presents the descriptive statistics of the key features of the observations, including teenagers' media use, personal characteristics, and household factors.

Table 1. Descriptive Statistics

Variables	2011	2012	2013	2014
mean smartphone use time (min)	15.500	49.593	76.541	89.476
mean book-reading time (min)	195.403	236.637	246.702	232.006
mean computer use time (min)	61.672	53.698	44.378	41.897
mean TV watching time (min)	56.250	50.251	50.873	55.935
mean sleep time (min)	475.315	478.912	479.828	492.545
owns smartphone	795 (15.05%)	2,254 (50.93%)	3,077 (73.37%)	3,153 (79.26%)
owns cell phone	3,211 (60.78%)	1,413 (31.93%)	478 (11.38%)	264 (6.64%)
parents' restriction of video game playing	1,911 (36.17%)	1,494 (33.76%)	1,536 (36.62%)	1,251 (31.45%)
parents' restriction of internet access	2,040 (38.61%)	1,647 (37.22%)	1,596 (38.05%)	1,389 (34.92%)

Variables		2011	2012	2013	2014
parents' restriction of TV viewing		1,671 (31.63%)	1,392 (31.46%)	1,359 (32.40%)	1,227 (30.85%)
family type	two-generation	4,551 (86.14%)	3,777 (85.36%)	3,579 (85.34%)	3,333 (83.79%)
	three-generation	504 (9.54%)	402 (9.08%)	384 (9.16%)	366 (9.20%)
owns TV		5,133 (97.16%)	4,284 (96.81%)	4,086 (97.42%)	3,900 (98.04%)
owns game console		1,611 (30.49%)	1,353 (30.57%)	1,062 (25.32%)	840 (21.12%)
owns desktop		5,034 (95.29%)	4,122 (93.15%)	3,951 (94.21%)	3,645 (91.63%)
owns laptop		1,623 (30.72%)	1,254 (38.23%)	1,269 (30.26%)	1,341 (33.71%)
male		2,727 (51.61%)	2,292 (51.80%)	2,190 (52.22%)	2,040 (51.28%)
school level	elementary	1,551 (29.36%)	1,212 (27.39%)	1,101 (26.25%)	1,083 (27.22%)
	middle	1,617 (30.61%)	1,308 (29.56%)	1,293 (30.83%)	1,191 (29.94%)
	high	1,773 (33.56%)	1,512 (34.17%)	1,446 (34.48%)	1,329 (33.41%)
	university	342 (6.47%)	393 (8.88%)	354 (8.44%)	375 (9.43%)
residential area		16 areas	16 areas	16 areas	16 areas
average monthly income		7.861	7.939	7.964	8.357
weekends		1,131 (21.41%)	973 (21.99%)	1,019 (24.30%)	1,061 (26.67)
special occasions	exam period	220 (4.16%)	167 (3.77%)	173 (4.12%)	31 (0.78%)
	family event	15 (0.28%)	24 (0.54%)	17 (0.41%)	15 (0.38%)
	vacation	30 (0.57%)	14 (0.32%)	36 (0.86%)	51 (1.28%)
observations		5,283	4,425	4,194	3,978

Note: unit of measure equals ₩500,000. (1 indicates household income below ₩500,000 and 2 indicates household income from ₩500,000 to ₩1 million. Between 2011 and 2013, 17 is the maximum value, and it indicates household income over ₩8 million. In 2014, 22 is the maximum value, and it indicates household income over ₩10.5 million.)

In 2011, the proportion of teenagers who used a smartphone was only about 15%, but that proportion rapidly increased to about 80% in 2014, and teenagers' mean smartphone use time per day also rapidly increased. In contrast, the proportion of teenagers who use a cell phone decreased from about 60% in 2011 to about 6% in 2014. These patterns indicate that the cell phone has been substituted by the smartphone, and the diffusion of the smartphone among teenagers has mainly been concentrated in the years from 2011 to 2014. Therefore, the period of this study is appropriate to investigate media substitution in teenagers.

Personal characteristics such as mean age and household characteristics such as TV ownership and desktop ownership are almost identical in all years. However, the proportion of households that have game consoles has decreased since 2012. Our dataset also contains dummy variables: whether parents restrict their children's video game playing, internet access, and TV viewing. The proportion of parents restricting their children's TV use is about 30%, and the proportion of parents restricting internet use and video game playing is slightly higher than that. Average monthly household income shows rapid growth in 2014, but this growth is an effect of the change in the way it is measured (see note in table 1). Teenagers' media use time, mean book reading time has remained study at about four hours a day since 2012, and mean TV watching time has likewise remained steady at about 50 minutes a day since 2011. However, mean computer use time steadily declined from about an hour a day in 2011 to about 40 minutes day in 2014, which may imply varying patterns of substitution effect of smartphone use on traditional media use.

Empirical Strategy

Endogeneity constitutes a major problem for estimating the effect of smartphone use on teenagers' other media use. The problem comes from the fact that smartphone use time and other media use time are determined by the same person. Thus, the independent variable may not be an exogenous variable, and the problem of simultaneity and reverse causality can lead to parameters being estimated with potential bias.

To control for reverse causality bias, we specify a two-stage least squares (2SLS) model. This study uses a dummy for smartphone ownership as an instrumental variable that directly affects teenagers' smartphone use time and also indirectly affects other media use time. Teenagers' possession of a smartphone is a cause of their smartphone use time, but teenagers' possession of a smartphone does not affect their other media use in itself; rather, it affects it through their smartphone use. Furthermore, teenagers' possession of a smartphone comes from the wide availability of smartphones across Korean society. As Bass (1969) and Rogers (1995) note, a few people adopt an innova-

tion to begin with, and then the imitation effect leads others to embrace the innovation. Therefore, diffusion of the smartphone can be regarded as an exogenous phenomenon triggered by innovators. Cho and Xu (2011) analyze Korean and Chinese consumers' reasons for purchasing a smartphone using the technology acceptance model and find that social influence is the main factor affecting smartphone purchase, which is consistent Bass's and Rogers's ideas. Therefore, smartphone ownership can be regarded as an exogenous variable in this study.

The first-stage equation of the 2SLS is as follows:

$$ST_i = \alpha_1 + \beta_1 SO_i + \gamma_1 X_i + \varepsilon_i \tag{1}$$

The independent variable ST_i is smartphone use time and the instrumental variable SO_i is a dummy for smartphone ownership. X_{it} stands for a vector of control variables that include a dummy for parents' restriction of video game playing, internet access, and TV viewing, family type, residential area, average monthly household income, TV, game console, desktop, laptop, and cell phone ownership, sleep time, gender, school level, and yearly, weekend, and special occasion use. ε_{it} is an error term. We estimate $\widehat{ST_i}$ using equation 1 to estimate β in the second-stage equation 2. Our second-stage equation is as follows:

$$Y_i = \alpha_2 + \beta_2 \widehat{ST_i} + \gamma_2 X_i + \varepsilon_i \tag{2}$$

Y_i is a vector of dependent variables that includes teenagers' book reading time, computer use time, and TV watching time. $\widehat{ST_i}$ is an estimated value of the independent variable. Unlike an ordinary least squares model, this two-stage model controls for bias generated by reverse causality. However, this model cannot control for unobserved individual characteristics.

Second, we specify a two-stage least squares model with individual fixed effects (2SLS-FE) to control potential biases from reverse causality and unobserved individual characteristics simultaneously. Consistent with the suggested two-stage equations presented in equation 1, we use a dummy for smartphone ownership as an instrumental variable. The first-stage equation is as follows:

$$ST_{it} = \alpha_3 + \beta_3 SO_{it} + \gamma_3 X_{it} + \delta_i + \varepsilon_{it} \tag{3}$$

The independent variable ST_{it} is smartphone use time and the instrumental variable SO_{it} is a dummy for smartphone ownership. X_{it} is a vector of control variables. δ_i is a vector of individual fixed effects, and ε_{it} is an error term. As with equation 2, we

estimate $\widehat{ST_i}$ to estimate β in the second-stage equation 4. Our second-stage equation is as follows:

$$Y_{it} = \alpha_4 + \beta_4 \widehat{ST_i} + \gamma_4 X_{it} + \delta_i + \varepsilon_{it} \tag{4}$$

Y_{it} is a vector of dependent variables comprising teenagers' book reading time, computer use time, and TV watching time. $\widehat{ST_i}$ is an estimated value of the independent variable. The variables used in this study are summarized in table 2.

Table 2. List of Variables

Variable Type			Variable Name
Dependent Variables			book reading time (min),
			computer use time (min),
			TV watching time (min)
Independent Variable			smartphone use time (min)
Instrumental Variable			owns smartphone
Control Variables	parental restrictions		parents' restriction of video game playing
			parents' restriction of internet access
			parents' restriction of TV viewing
	household characteristics		family type
			residential area
			average monthly income
			owns TV
			owns game console
			owns desktop
			owns laptop
	personal characteristics	personal device	owns cell phone
		life patterns	sleep time (min)
		gender	male
		school level	elementary
			middle
			high
			university
	time	ordinary	yearly
			weekends
		special occasions	exam period
			family event
			vacation

We conducted a preliminary analysis to determine whether a regression model consisting of the variables presented in this study meets the basic assumptions of an ordinary least squares model. First, we calculated variance inflation factor scores to test for potential problems due to multicollinearity. A score greater than 10.0 means that there is a serious multicollinearity problem (Kutner, Nachtsheim, & Neter, 2004). The scores in our regression models range from 1.01 to 3.77 and include parents' restriction of access to the internet (3.77), parents' restriction of video game playing (3.36), parents' restriction of TV viewing (2.47), high school (2.06), middle school (1.61), and sleep time (1.44). The mean value is 1.50. Therefore, we assume that multicollinearity is not a serious problem in our regression models. We also conducted the Breusch-Pagan/Cook-Weisberg test in order to determine whether heteroskedasticity was present (Cook & Weisberg, 1983). The results for all the three models indicate that we must reject the null hypothesis of homoskedasticity at the 0.01 significance level, which means they might contain heteroskedastic errors.[1] To address the problem of potential heteroskedastic errors, we can use robust standard errors. In particular, this study assumes that there is a heteroscedasticity between households. Thus, we use cluster-robust standard errors. As each household member is genetically and culturally similar, we attempt to relax the assumptions of a linear regression model that all observations in the dataset are independent (Wooldridge, 2002).

RESULTS

The results of our first-stage estimation are presented in table 3.

Table 3. First-Stage Estimation of the 2SLS

Independent Variable	Smartphone Use Time (min)
Instrumental Variable	
owns Smartphone	95.034*** (1.919)
Control Variables	
parents' restriction of video game playing	-6.455 (4.200)
parents' restriction of internet access	7.887** (3.958)

1. Book reading time (chi-squared: 1302.48, P-value: 0.0000), computer use time (chi-squared: 1870.39, P-value: 0.0000), TV watching time (chi-squared: 4582.52, P-value: 0.0000).

Independent Variable	Smartphone Use Time (min)
parents' restriction of TV viewing	1.469 (3.572)
family type	0.434 (2.988)
residential area	-0.100 (0.227)
average monthly income	0.002*** (0.000)
owns TV	-7.697 (5.799)
owns game console	1.657 (2.522)
owns desktop	-9.812* (5.382)
owns laptop	1.475 (2.333)
owns cell phone Own	-1.260 (0.847)
sleep time (min)	0.051*** (0.012)
male	-4.089** (1.911)
elementary school	omitted
middle school	8.613*** (1.703)
high school	17.618*** (2.800)
university	44.737*** (4.784)
yearly	3.254*** (0.815)
weekend	6.637*** (2.123)
exam period	7.879* (4.464)
family event	16.736 (11.260)
vacation	41.312 (33.104)
R-squared	0.394
observations	17,880
number of clusters	1,539
robust F-statistic	2453.37

Note: The elementary school variable is omitted because of collinearity. *p<0.1, **p<0.05, ***p<0.01. Robust standard errors clustered at the level of the household are reported in parentheses.

To test the validity of the instrument, we identify whether smartphone ownership is a weak instrument by checking the robust F-statistic value. Stock and Yogo (2005) suggest that an F-statistic value under 10 indicates that the instrument is weak and estimates are seriously biased. The robust F-statistic estimated in the first-stage regression is 2453.37, and therefore we are able to reject the null hypothesis that smartphone ownership is a weak instrument.

We estimate the effect of smartphone use time on teenagers' other media use time using estimation in the first-stage regression. The results of the second-stage estimation are presented in table 4.

Table 4. Second-Stage Estimation of the 2SLS

Dependent Variables	(1) Book Reading Time (min)	(2) Computer Use Time (min)	(3) TV Watching Time (min)
Independent Variable			
smartphone use time	-0.441*** (0.0959)	-0.120*** (0.0297)	-0.0650** (0.0310)
Control Variables			
Parents' restriction of video game playing	3.642 (13.63)	-5.431* (3.232)	2.083 (4.009)
Parents' restriction of internet access	-4.698 (14.72)	-1.842 (3.191)	-13.81*** (4.193)
Parents' restriction of TV viewing	-13.44 (12.41)	-2.304 (2.890)	-3.909 (3.503)
family type	20.15** (8.372)	2.443 (2.049)	4.004* (2.413)
residential area	9.651*** (0.894)	0.211 (0.215)	1.404*** (0.284)
average monthly income	-0.00384 (0.00485)	-0.00133 (0.00103)	0.000825 (0.00263)
owns TV	-37.04 (36.56)	-6.344 (8.420)	45.17*** (3.613)
owns game console	-20.27* (10.55)	-0.400 (2.046)	-5.622** (2.820)
owns desktop	21.75 (17.22)	32.08*** (3.439)	-7.094 (5.527)
owns laptop	-14.88 (10.32)	-6.882*** (2.054)	-15.61*** (2.579)
owns cell phone	-20.30** (9.057)	1.376 (2.441)	-0.618 (2.968)

Dependent Variables	(1) Book Reading Time (min)	(2) Computer Use Time (min)	(3) TV Watching Time (min)
sleep time (min)	-0.527*** (0.0362)	0.0942*** (0.0127)	0.0900*** (0.0143)
male	-18.719** (7.567)	15.532*** (1.817)	-3.641* (1.996)
elementary school	Omitted	Omitted	Omitted
middle school	20.84*** (7.345)	10.37*** (2.071)	-0.756 (2.916)
high school	60.91*** (10.75)	8.816*** (3.095)	-16.45*** (3.508)
university	-36.17*** (12.77)	37.83*** (4.555)	10.91** (5.332)
yearly	24.32*** (3.527)	-4.602*** (0.860)	-0.735 (1.232)
weekend	-103.9*** (5.964)	22.02*** (2.153)	41.88*** (2.855)
exam period	25.84 (19.78)	-6.018 (4.715)	-19.55*** (4.472)
family event	-20.10 (24.10)	-11.76 (8.171)	-7.077 (14.96)
vacation	-97.39*** (18.06)	-24.16*** (6.790)	-0.332 (15.36)
R-squared	0.185	0.081	0.117
observations	17,880	17,880	17,880
number of clusters	1,539	1,539	1,539

Note: The elementary school variable is omitted because of collinearity. *p<0.1, **p<0.05, ***p<0.01. Robust standard errors clustered at the level of household are reported in parentheses.

Table 4 shows that teenagers' smartphone use significantly decreases time spent using other traditional media. For each one minute increase of teenagers' smartphone use time per day, their book reading time per day is expected to decrease about 26 seconds, computer use time per day is expected to decrease about 7 seconds, and TV watching time per day is expected to decrease about 4 seconds. Since teenagers' mean smartphone use time per day in 2014 is about 89 minutes (see table 1), the estimated daily decrement of book reading time by smartphone use is about 39 minutes, the estimated daily decrement of their computer use time is about 11 minutes, and the estimated daily decrement of their TV watching time is about 6 minutes.

Teenagers with game consoles spend 20 minutes less per day reading books and 5 minutes less per day watching TV compared to those who don't. Teenagers who own

a desktop are more likely to use computers, but teenagers who own laptop are less likely to use computers than others. Teenagers with a cell phone appear to spend relatively less time reading books and watching TV. Also, males usually spend less time reading books and watching TV than females. High school students appear to spend more time reading books than other student groups, and university students tend to spend more time using computers and watching TV. On the weekend, book reading time tends to decrease greatly, while computer use time and TV watching time tend to increase. TV watching time tends to decrease during exam periods, and book reading time and computer use time tend to decrease during vacations.

The estimates presented in table 4 may be still biased due to endogeneity from omitted unobserved variables. To control for the biases from both reverse causality and unobserved omitted variables, we use two-stage least squares estimation with individual fixed effects. The results of the parameter estimation are presented in table 5.

Table 5. First-Stage Estimation of the 2SLS-FE

Independent Variable	Smartphone Use Time (min)
Instrumental Variable	
owns smartphone	82.713*** (2.915)
Control Variables	
parents' restriction of video game playing	-1.503 (5.435)
parents' restriction of internet access	0.473 (5.047)
parents' restriction of TV viewing	1.079 (4.312)
family type	-0.160 (6.559)
residential area	-1.589 (1.212)
average monthly income	-0.003* (0.001)
owns TV	1.818 (9.909)
owns game console	-3.826 (5.592)
owns desktop	-10.137 (6.427)
owns laptop	4.715 (4.311)

Independent Variable	Smartphone Use Time (min)
owns cell phone	-1.756 (2.205)
sleep time (min)	0.043*** (0.013)
male	omitted
elementary school	omitted
middle school	-0.816 (3.347)
high school	0.189 (5.887)
university	30.032*** (9.467)
yearly	8.727*** (1.443)
weekend	7.417*** (1.860)
exam period	9.138* (5.457)
family event	9.267 (10.688)
vacation	46.112 (33.910)
observations	17,880
number of clusters	1,539
Kleibergen-Paap rk Wald F-statistic	805.27
Stock-Yogo 10% maximal IV size	16.38

Note: The male variable is omitted due to an individual fixed effects inserted in this model; it is a personal characteristic that is fixed over time. The elementary school variable is omitted because of collinearity. p<0.1, **p<0.05, ***p<0.01. Robust standard errors clustered at the level of household are reported in parentheses.

We conducted the weak instrument test using the Kleibergen-Paap rk Wald F-statistic and the Stock-Yogo 10% maximal IV size estimated in the first-stage regression. If the value of the Kleibergen-Paap rk Wald F-statistic is larger than the Stock-Yogo 10% maximal IV size, the null hypothesis that the instrument is weak can be rejected (Stock & Yogo, 2005). The estimated value of the Kleibergen-Paap rk Wald F-statistic in the first-stage estimation is 805.27, larger than the estimated value of the Stock-Yogo 10% maximal IV size (16.38), and therefore, the null hypothesis that smartphone ownership is a weak instrument can be rejected.

Using the estimated value of the independent variable in the first-stage estimation,

we estimated the effect of teenagers' smartphone use time on other media use times. The results of the parameter estimation are presented in table 6.

Table 6. Second-Stage Estimation of the 2SLS-FE

Dependent Variables	(1) Book Reading Time (min)	(2) Computer Use Time (min)	(3) TV Watching Time (min)
Independent Variable			
smartphone use time	-0.202* (0.108)	-0.122*** (0.0335)	-0.0360 (0.0373)
Control Variables			
parents' restriction of video game playing	18.58 (14.65)	-4.685 (3.828)	3.666 (4.032)
Parents' restriction of internet access	-3.969 (15.64)	1.659 (3.657)	-9.796** (4.648)
parents' restriction of TV viewing	18.07 (12.79)	-2.84e-05 (3.194)	5.931 (3.744)
family type	-17.78 (17.59)	-1.556 (4.079)	-1.970 (4.040)
residential area	10.30** (4.875)	-1.685 (2.019)	1.246 (2.804)
average monthly income	0.003 (0.006)	-0.001 (0.001)	0.002 (0.004)
owns TV	12.38 (38.56)	19.73** (9.264)	37.20*** (10.55)
owns game console	-10.90 (13.04)	-4.211 (3.906)	-4.764 (4.496)
owns desktop	-20.19 (24.09)	11.05** (5.613)	-11.63 (8.046)
owns laptop	0.121 (13.84)	-3.798 (3.576)	0.707 (3.772)
owns cell phone	-15.09* (9.095)	1.703 (2.442)	1.283 (3.340)
sleep time (min)	-0.499*** (0.0336)	0.0868*** (0.0131)	0.0966*** (0.0136)
male	Omitted	Omitted	Omitted
elementary school	Omitted	Omitted	Omitted
middle school	-1.417 (11.69)	6.288* (3.307)	-3.777 (4.398)
high school	33.24* (19.93)	3.708 (5.752)	-14.83** (6.922)
university	-121.2*** (28.14)	38.73*** (8.536)	4.926 (9.925)

Dependent Variables	(1) Book Reading Time (min)	(2) Computer Use Time (min)	(3) TV Watching Time (min)
yearly	22.92*** (5.052)	-4.448*** (1.457)	-1.107 (1.778)
weekend	-122.2*** (5.851)	24.26*** (2.020)	41.48*** (2.622)
exam period	46.45** (18.80)	-8.083** (4.061)	-5.486 (4.935)
family event	-4.147 (28.63)	-6.074 (6.848)	-2.699 (11.35)
vacation	-91.72*** (24.94)	-24.58*** (7.619)	17.11 (15.74)
R-squared	0.215	0.062	0.095
observations	17,880	17,880	17,880
number of clusters	1,539	1,539	1,539

Note: The male variable is omitted due to an individual fixed effects inserted in this model; it is a personal characteristic that is fixed over time. The elementary school variable is omitted because of collinearity. p<0.1, **p<0.05, ***p<0.01. Robust standard errors clustered at the level of household are reported in parentheses.

Table 6 indicates that for each minute increase of teenagers' smartphone use time per day, teenagers' book reading time per day is expected to significantly decrease about 12 seconds, and computer use time per day is expected to significantly decrease about 7 seconds. Teenagers' smartphone use time does not affect their TV watching time. In 2014, teenagers' mean smartphone use time per day is 89.476 minutes (table 1), and therefore the estimated daily decrement of book reading time by smartphone use is about 18 minutes, and the estimated daily decrement of their computer use time is about 11 minutes.

Teenagers who own a desktop computer are more likely to use computers, and teenagers who own a cell phone appeared to spend relatively less time reading books. High school students seem to spend more time reading books and less time watching TV than other student groups, and university students tend to spend more time using computers. On the weekend, book reading time tends to decrease substantially, while computer use time and TV watching time tend to increase. Book reading time tends to increase and TV watching time tends to decrease during exam periods, and book reading time and computer use time tend to decrease during vacations.

Table 7 summarizes estimated daily decrements or increments of teenagers' traditional media use time caused by smartphone use in 2014 for the two regression models.

These results suggest that teenagers' smartphone use has a substitution effect on book reading time and computer use time. For TV watching time, the results vary depending on estimation models.

Table 7. Estimated Daily Fluctuations of Teenagers' Traditional Media Use Time Caused by Smartphone Use in 2014 for Two Regression Models (2SLS, 2SLS-FE)

	Estimated Daily Fluctuation of Media Use Time Cased by Smartphone Use (min)		
	Book Reading Time	Computer Use Time	TV Watching Time
2SLS model	-39.459***	-10.737***	-5.816**
2SLS-FE model	-18.074***	-10.916***	-3.221

Note: *p<0.1, **p<0.05, ***p<0.01.

The effects on teenagers' book reading time, and computer use time estimated from the 2SLS and 2SLS-FE models are all negative, while the effect on TV watching time from the 2SLS is negative. These different estimates suggest that the 2SLS-FE model controls for potential biases better than the 2SLS model. Therefore, the estimates supplied by the 2SLS-FE model more closely reflect the real effects than the 2SLS model.

According to our results from the 2SLS-FE model, we can conclude that the substitution effect of smartphone use on traditional media use varies across different media. Book reading time was the most substituted for out of the three media. The substitution effects of teenagers' smartphone use on book reading time and computer use time are significant, and the magnitude of the effect on book reading time is about twice the effect on computer use time. The substitution effects on TV watching time were found to be insignificant.

The results imply that smartphone has similar substitution effects as other new media in such as TV, VCR, and the web as documented in previous studies (Lasswell, 1948; Childers & Krugman, 1987; Ferguson & Perse, 2000). Although the findings of this study are consistent with those of previous studies that found that the new media use decreases other traditional media use, this study further shows the varying magnitude of the substitution effects of the new media on traditional media. This study also arrives at a different conclusion from that of the Korea Communications Commission (2012), which argues that smartphone use substitutes for TV use. However, our results are consistent with Kim et al. (2013a), which finds that TV watching through smartphone does not substitute for traditional TV watching.

CONCLUSIONS

Media substitution has been a major issue in media and communication studies. However, there is not much evidence as to whether smartphone use acts as a substitute for other traditional media use. This study estimates the effect of smartphone use on teenagers' traditional media use. By incorporating both the instrumental variable and individual fixed effects at the same time, this study attempts to control for potential biases previous studies have not controlled for. To eliminate bias from the reverse causality that arises from peoples' self-selection of media use, we use a dummy for smartphone ownership as an instrumental variable. Our findings show that the substitution effect of smartphone use on traditional media use varies across different media.

We specify two regression models using panel data from the Korea Information Society Development Institute and compare the estimates. First, estimates from the 2SLS model show that teenagers' smartphone use time decreases book reading time, computer use time, and TV watching time. Second, estimates from the 2SLS-FE model show that teenagers' smartphone use time decreases teenagers' book reading time and computer use time. We use the 2SLS-FE model to control for both individuals' unobserved characteristics and potential reverse causality bias, and therefore the estimates from the 2SLS-FE model are more unbiased than the estimates from the other two models. The estimated magnitudes of the substitution effect on book reading time and computer use time are about 12 seconds and 7 seconds respectively for each minute increase of teenagers' smartphone use time, and the total daily decrements in 2014 are about 18 minutes and 11 minutes, respectively. Therefore we can conclude that teenagers' smartphone use significantly substitutes for book reading time and computer use time, as previous studies have argued (Kim et al., 2012; Korea Communications Commission, 2012; Kim et al., 2013a). We expect that the decrements will increase as teenagers' smartphone use time increases along the S-shaped curve. Unlike previous studies, our findings suggest that teenagers' smartphone use does not significantly substitute for TV watching time.

Our results support the hypothesis that teenagers' smartphone use substitutes for teenagers' book reading and computer use (Kim et al., 2012; Korea Communications Commission, 2012; Kim et al., 2013a). However, our findings do not support the argument by Korea Communications Commission (2012) that the smartphone use substitutes for TV watching time. Instead, this finding is consistent with the argument initially made by Sparkes (1983) that new media does not always substitute for other traditional media use.

Our study may have the following policy implications. First, the Korean media market has seen the rapid diffusion of new media, and it serves as a test bed for a variety of

digital technologies. Lee et al. (2010) argue that teenagers are the ones who quickly adapt and respond to these media developments and that analyzing their media use patterns can contribute to predicting the direction the media market will go in. Likewise, Jung, Lee, and Kim (2005) note that the introduction of new media in a stagnant market creates fierce competition. From this perspective, this study may contribute to predicting the competitive edge of the future media. Second, since new media may pose a significant threat to traditional media, it is important to identify the ways the substitution effect of new media could affect policy making. To better understand the media substitution effects that occur in our society and to provide more accurate data to the relevant industries and policy makers, the Korean Communications Commission estimates the media substitution effect by conducting an audience behavior survey every year. It aims to establish a user-centered media policy, to develop a strategy for the private sector, and contribute to meeting the needs of the media user. Concerning this policy objective, our study is meaningful in identifying media substitution effects. Third, Kim et al. (2012) argue that the substitution effects of the new media may lead to addiction, particularly among adolescent groups. According to our study, smartphones are already substitute for a considerable proportion of teenagers' traditional media use. Therefore our study implies that it is necessary to review the policy to address the potential adverse effects of smartphone use, especially among adolescent groups that are considered to be more vulnerable than adults.

In conclusion, our findings indicate that the introduction of new media such as the smartphone may have a profound effect on teenagers' traditional media use and support previous studies that have argued that teenagers are vulnerable to the widespread availability of new media (Jeffe et al., 1995; Lee et al., 2013). However, this study does not account for the determinants of teenagers' vulnerability to new media. Furthermore, subsequent studies may be undertaken to empirically investigate the factors that might affect teenagers' media use.

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