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Exploring the interplay between social distancing, innovation adoption, and privacy concerns amid the COVID-19 crisis

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Using the case of coronavirus disease-2019 (COVID-19) as a natural experiment, this study discusses how innovation policy should be designed in times of crisis when public interest and privacy concerns collide. For this purpose, the causal relationship between social distancing enforcement and innovation adoption in consideration of privacy concerns is explored by using national-level survey data. Our key findings from econometric analysis are as follows: first, the implementation of social distancing policies leads to an increase in the adoption of wearable devices. Second, the strengthening of social distancing has caused a decrease in individual privacy concerns. Finally, a decrease in individual privacy concerns leads to an increase in wearable device adoption. Social distancing during the COVID-19 not only accelerated innovation adoption but also led a decrease in privacy concerns. Our results suggest that government should play a role in safe guarding public privacy when individuals may let their guard down during times of crises.

Keywords: COVID-19; crisis; innovation adoption; privacy concerns; social distancing.

1. Introduction

The impact of coronavirus disease-2019 (COVID-19) and its ripple effects is one of the most significant events in human history. Its reach devastated many existing services, making them nearly inoperable (Orlikowski and Scott 2021; Reale 2021), because social-distancing policies disrupted business operation and daily activity. During the global pandemic, there were many people who voluntarily isolated at home and limited contact with others. When they did venture into public spaces, their interactions were interrupted by social-distancing policies, which are community-level actions to mitigate the spread of an airborne infectious disease and national crisis. Social- distancing policies include restrictions on public transportation, limiting the number of people in certain venues (e.g., school closures), masking policies, and surveillance such as track-and-trace programs. Among the government acts implemented to control the pandemic, social distancing was recognized as an effective method to prevent the spread of COVID-19 (Thu et al. 2020), but this forced people to seek alternative or sometimes innovative services (Gkeredakis, Lifshitz-Assaf, and Barrett 2021).

Consequently, the use of digital technologies increased and allowed previous socio-economic activities to resume. Digital technologies enabled the resumption of employment and education activities through work-from-home and remove learning initiatives. From an innovation theory perspective, especially when the adoption of digital innovation is discussed, the issue of privacy concerns should be considered (Quach et al. 2022). The pattern of privacy concerns changed over generations along with the changes in technological environments and the adoption of new media technologies (McLuhan 1964). Especially in the digital era, people constantly find themselves in digital environments tied to their digital personal data, increasing their exposure to privacy issues (Goldfarb and Tucker 2012). For instance, privacy concerns in the digital age are mostly affected by the one's social network service usage behavior, generation, and cultural background (Zhong et al. 2024). Where social distancing and digitalization coexist, however, how social distancing influences innovation adoption and how policy should intervene is left unknown.

In the context of the special issue, vulnerabilities may arise as a result of the shift in national innovation systems to respond to COVID-19, creating unintended consequences (editors, this issue). Social-distancing policies may have effects on privacy concerns that can also affect innovation. In this case, government policy may play a role in mitigating the impact between social-distancing and innovation policies. This study considers the distinct cultural factors in South Korea that may influence perceptions of technology and privacy. The country is a global testbed in technology adoption, underpinned by a societal emphasis on efficiency and innovation. South Koreans are generally more willing to embrace new technologies, often facilitated by robust national policies geared toward technological advancement (Im et al. 2014). When it comes to privacy concerns, they generally display lower levels of apprehension compared to populations in other countries (Kim and Kwan 2021). These traits not only set the stage for rapid technological integration but also shape the way privacy is perceived and negotiated.

Using the COVID-19 crisis as a natural experiment, this study discusses how policy should be designed in times of crisis when public interest and privacy concerns collide. For this purpose, the causal relationship between social distancing enforcement, privacy concerns, and innovation adoption is explored using both descriptive and econometric approaches. Both empirical approaches were applied to the Korean Media Panel (KMP) data, a national-level survey data provided by Korea Information and Communication Policy Research Institute (KISDI). The data collection period provides a natural experiment by dividing the periods before and after COVID-19 struck and when increasing levels of social-distancing policies were adopted. The surveys in 2018 and 2019 were conducted before the pandemic; the 2020 and 2021 surveys were differentiated by the social distancing policies that were adopted in the Greater Seoul Metropolitan Area and in other parts of the country. Thus, this study attempted to infer a causal relationship between strengthening social distancing policy and privacy concerns by using these temporal and regional differences applying a difference-in-difference (DID) approach.

2. Literature review

2.1 Social distancing and innovation adoption

One of the concerns that were raised in advance of adopting and enhancing social distancing was that the restriction of physical contact weakens the economic activities for both supply and demand side of economy. Although the stringency of government measure may differ across countries, policy associated with COVID-19 turned out to reduce 10 percent in economic activity across Europe and Asia (Demirguc-Kunt, Lokshin, and Torre 2020). In times of crisis, innovation activities can be threatened due to socioeconomic changes, thus deteriorating economic performance.

However, the influence of social distancing is not only restricted to economic aspects, but also individual social activities. Social distancing, forcing individuals to isolate from others, creates higher uncertainty and causes negative impacts on one's mental health (Schwartz 2004). Yet, creative activity has turned out to have the potential to protect the resilience overall household in times of prolonged isolation (Verger et al. 2021). This indicates that there is a high possibility of people seeking innovation regardless of economic conditions to secure themselves. From previous studies, it has been found that individualism and innovation are positively related to each other (Efrat 2014; Kapoor et al. 2021), and societies with higher individualism and indulgence are more related to innovation (Cox and Khan 2017). Referring to this fact, this study assumes that the enhancement of social distancing policies positively contributes to the innovation adoption.

2.2 Social distancing and privacy concerns

As social- distancing policies have led to the spread of new information and communications technologies (ICT) that enable remote interactions, the possibility of their use or misuse also increases, for example, for surveillance and enforcement purposes. How people respond to new forms of data collection and the possibility of having their privacy violated and demand for policy responses depends on the context in which the potential intrusion happens and is perceived (Wright et al. 2009). The COVID-19 pandemic offers a novel case to study how people react to social- distancing policies that may be seen to broadly infringe on privacy.

Many of these new technologies, including mobile phones, vehicles, and wearables, enable the collection of private health and location data of citizens as a result of social- distancing policies enacted by the government (Doyle and Conboy 2020; Zhang et al. 2021). Big Data aggregates these new data with existing data, such as credit card transactions, which expands the ability to follow other people's activities to a previously unseen degree. The potential for surveillance combined with misuse of technology increases as these technologies spread and collect more data (De, Pandey and Pal 2020). Once data are collected, the vulnerability to privacy extends throughout the different stages of collecting, transmitting, processing, storing, analyzing, and securing the data (Joinson et al. 2010; Bélanger and Crossler 2011; Zhang et al. 2021).

While the technologies can be designed to various specifications that can include increased data security, it requires interaction between the technology providers and policy makers to ensure that the data are handled in such a way to protect user privacy and to prevent other abuses (Doyle and Conboy 2020; Maliphol and Hamilton 2022). These activities can involve the restriction of collecting of, the anonymization of, and/or the deletion of private data and its secondary use, sometimes after a (specified) period of time (Grandison and Sloman 2000; Bélanger and Crossler 2011; Fahey and Hino 2020).

There are several factors that affect individuals' perception of how policies affect their privacy concerns such as what data are collected—particularly personal health information (Angst and Agarwal 2009; Fahey and Hino 2020), how the data are used after collecting (Bélanger and Crossler 2011; Gu et al. 2017; Fahey and Hino 2020), the justification for collecting the data (Gu et al. 2017), and users' characteristics (Im et al. 2014; Park and Oh 2018). While public opinions with respect to government interventions are similar, additional concerns arise when citizens lack trust in the government policies related to personal information and freedoms (Carter and Bélanger 2005). The privacy concerns of individuals are also related to the transparency of how government actors will use and allow the use of the private information that is collected (Porumbescu 2017).

Surveillance technologies that gather personal data, however, is often unnoticed and persistent. Whether policymakers should focus on whether to promote data collection or protect privacy rights of individuals is challenging in light of the need to respond to shocks like the pandemic (Fahey and Hino 2020). Thus, how individuals' might respond to privacy concerns regarding data collection during the COVID-19 pandemic presents a novel case in which the justification of social distancing policies may be strong and depend on the lasting impacts of the pandemic. We examine whether individuals that live in regions that have adopted heightened social-distancing policies have different preferences than those in regions that have not.

2.3 Privacy concerns and innovation adoption

Individuals need to trust the technologies that they adopt, which affects the demand for newly innovated products and services (Nooteboom 2013). Privacy concerns can affect innovation adoption when citizens and users become wary about trusting government agencies and private companies that offer new technology products and services. Thus, privacy concerns create a tension between public health and innovation. The sudden, rapid adoption of digital technologies as a result of the pandemic poses a challenge to the current state of the literature of how privacy concerns effect innovation (Kateb et al. 2022).

First, individuals' behavior is affected by personal characteristics and perceived risks to privacy (Kang and Jung 2021). The decision to adopt new technologies or demand for new innovations depends on whether they trust if the use will lead to disclosure of a person's private information (Joinson et al. 2010; Kang and Jung 2021) and active/passive surveillance (Perez and Zeadally 2018). These types of behaviors are found across several types of technology including the Internet (Metzger 2004; Joinson et al. 2010), e-commerce (Liu et al. 2005; Joinson et al. 2010), social media (Rauniar et al. 2014), wearables (Perez and Zeadally 2018; Kang and Jung 2021), and e-government services (Porumbescu 2017; Khan et al. 2021). The concerns regarding privacy increase when considering health-related data including those related to COVID-19 (Nabity-grover et al. 2020).

Second, privacy concerns must not override the perceived benefits for innovations to be adopted in the market. While there are many factors of whether or not innovations diffuse, trust in the technology and government is an important factor (Rauniar et al. 2014). Trust in government-related policies leads to increased innovation and acceptance factors e-services (Carter and Bélanger 2005).

When users decide to buy a technology, to download an app, or to use an online service, they usually have a choice whether or not to proceed considering the data collection/sharing required, making privacy an important factor (Joinson et al. 2010). Many COVID-19 related public health policies required users to provide personal information, including health and location information to participate in previously mundane activities such as eating at a restaurant or entering a building. Other enacted policies allowed the use or access to data collected for other reasons such as handling financial transactions.

There are several privacy-related policies that affect individuals' willingness to adopt new technologies. For instance, users are more likely to trust and adopt new technologies when they are empowered to make decisions whether or not to (Sharma, Dyer and Bashir 2021). The framing of policy issues related to privacy, for example, the justification for data collection for public health purposes, can affect user adoption of new technologies (Angst and Agarwal 2009). Wearables, specifically, present a "privacy paradox" given its constant collection of personal data (Kang and Jung 2021; Jeon and Lee 2022). Since social- distancing policies allowed public agencies and private companies to make these decisions on behalf of all citizens and customers, it is unclear whether the individuals would be less likely to adopt technologies, that is, wearables, which would decrease their privacy and increase the risks related to personal information. Thus, we posit that people's perception of social- distancing policies can also have an effect on their use and adoption of new technologies such as wearables.

Table 1. Eight items to measure privacy concern.

No.	Items
1	I am worried that strangers may view my online activities and obtain personal information about me.
2	I am worried that information about me remains on devices I used in the past (computer, mobile phone), etc.
3	I am worried that information about me that I do not remember will remain online without being deleted.
4	I am worried that too much personal information is requested when signing up for an online site.
5	I am worried that my online ID will be stolen.
6	In general, I am worried about my privacy when using the Internet.
7	People who do not reveal who they are online are suspicious.
8	I am worried that my personal information, such as my photo and name, will be stolen online.

3. Methods

3.1 Data

The KMP survey is collected by the KISDI (a government agency) over a long period of time, providing high-quality, reliable panel data for households and individuals. For example, in the personal questionnaire of the KMP, there are eight items about privacy concerns along with the basic information of the interviewee, and these items have been continuously investigated since 2015. All questions were carefully selected to be highly relevant to the overall aim of the study, which is to gauge people's concerns about online privacy. As for the calculation of values, the responses were averaged across all items to generate an overall score of the privacy concerns each year. Table 1 shows the survey questions relevant to privacy concerns. It is therefore possible to trace how privacy concerns changed as a result of the evolving policies in response to the COVID-19 crisis. Through this, the KMP survey enables the design of measurement methodology reflecting the new broadcasting and communication environment and the construction of longitudinal panel data, providing micro-level data in the media sector to support evidenced-based policy-making. In this study, a panel data set including the four years (2018–2021) of the KMP is used. The samples of 2018 and 2019, 2020, and 2021 are used for the pre-COVID-19 period, with a weak COVID-19 social- distancing measure and a strong COVID-19 social- distancing measure, respectively.

3.2 Estimation strategy

For a causal analysis of the impact of social distancing on innovation adoption and individual privacy concerns, this study introduced a regression model using regional social- distancing policy changes as instrumental variables (IVs). The 2020 survey of the KMP was conducted in June, at a relatively early stage in the spread of COVID-19. The period before June

Figure 1. Trend of new COVID-19 confirmed cases in Korea (February 2020–August 2021).

2020 was under the influence of COVID-19, but social distancing was not applied in all regions. Referring to the trend of new confirmed cases in Fig. 1, the number of new confirmed cases was almost zero during the survey investigation period in June 2020 (red solid line), and the strengthened social-distancing policy was not introduced. However, the government started strengthening social distancing policies during the second wave of the spread (since November 2020), and the strengthened social distancing was implemented especially in Seoul and the metropolitan area.

After the survey investigation in June 2020, in November of that year, the government felt a sense of crisis from the second spread of COVID-19 and introduced a new five-step social- distancing policy as shown in Table 2. As the number of new confirmed cases increased mainly in the Seoul and Gyeonggi regions, social distancing step 1.5 was implemented in Seoul and the metropolitan area from 19 November to 23 November 2020. From 24 November to 7 December 2020, the second stage of social distancing was implemented in Seoul and the metropolitan area. However, the outbreak was growing; from 8 December to 14 February 2021, the next year, the level of social distancing requirements was upgraded to 2.5 for the capital area; and the nonmetropolitan area was elevated to level 2. As such, between the 2020 survey and the 2021 survey, there was a difference in policies to strengthen social distancing between the metropolitan area and nonmetropolitan areas, and this study attempted to infer a causal relationship between strengthening social distancing and privacy concerns by using these regional differences.

The strengthened social distancing region (SSDR) variable is defined by using the information on the residential area of the KMP. The social distance treatment variable was set to 1 if the residential area is in Seoul or Gyeonggi-do, and the rest were set to 0. The treatment of strengthening the social distancing variable, we use as IV, was created by multiplying the SSDR variable by the dummy variable (y2021) in 2021, when social distancing was strengthened due to the second spread of COVID-19. In this analysis, IV methodology was employed to encapsulate the DID framework. The first differential is temporal variation, while the second differential is denoted by SSDR. Demographic factors such as gender, age, and education level were used as control variables, and media utilization variables such as wage level, dummies of telecommunication companies, and use of unlimited data plans were also considered. After refining the data merging data from four years and removing outliers, the final study sample included a total of 33,429 observations. The descriptive statistics of the data sample is presented in Table 3.

3.3 Research design

To estimate the effect of the strengthened social distancing policy on people's adoption of innovative products, we conduct multivariate regression analysis. We use ordinary least-squares (OLS) regressions for one binary-dependent variable, whether users adopted any wearable device, and for one continuous-dependent variable, the degree of concerns for individual privacy. Equation (1) shows the estimation model when the dependent variable is innovation adoption, and Equation (2) is the model when the dependent variable is the privacy concern. For all regressions, we pool individual users' observations over 4 years and cluster standard errors within an individual. In the equation, i and t refer to each user and each year, respectively.

$$INNO\_Adopt_{i,t} = \beta_0 + \beta_1 IV_{i,t} + \beta_2 SSDR_{i,t} + \beta_3 X_{i,t} + \beta_4 \, Year\, FEs_t + \beta_4 \, Individual\, FEs_i + \varepsilon_{i,t} \quad (1)$$

Table 2. The five-step social distance plan in South Korea.

Class	Phase 1	Phase 1.5	Phase 2	Phase 2.5	Phase 3
	Quarantine in life	Local epidemic phase		National epidemic phase	
	Distancing in life	Start of local epidemic	Rapid spread of local epidemics	A nationwide spread	A nationwide pandemic
Priority management facility	Limited number of users	Reinforcing restrictions on the number of users	Five types of entertainment facilities are prohibited Other facilities are closed before 9:00 p.m.	Prohibition of gathering at the direct sales promotion hall and karaoke room	Prohibition of gatherings other than essential facilities
National and public facilities	Normal operation		Mandatory wearing mask	Limited number of users	Suspension
School class	Density 2/3 rule	Conforms to density 2/3	Density 1/3 rule	Conforms to density 1/3	Remote class
Meeting/event	For events with more than 500 people, consultation with local governments	Some events such as festivals are prohibited with more than 100 people	Prohibition of more than 100 people	Prohibition of more than 50 people	Prohibition of more than 10 people

Table 3. Destle ($N = 33{,}429$).

Variables	Mean	SD	Min	Max
Privacy concern	0.711	0.195	0.200	1.000
Wearable device adoption (INNOV_Adopt)**	0.076	0.266	0.000	1.000
SSDR	0.389	0.488	0.000	1.000
Instrumental variable	0.106	0.307	0.000	1.000
Male	0.478	0.500	0.000	1.000
Age group				
10s	0.127	0.333	0.000	1.000
20s	0.141	0.348	0.000	1.000
30s	0.107	0.309	0.000	1.000
40s	0.215	0.411	0.000	1.000
50s	0.223	0.416	0.000	1.000
60+	0.187	0.390	0.000	1.000
Educational attainment				
Middle school	0.167	0.373	0.000	1.000
High school	0.464	0.499	0.000	1.000
College or above	0.370	0.483	0.000	1.000
Monthly income				
No income	0.368	0.482	0.000	1.000
2,000 or below	0.130	0.336	0.000	1.000
2,000–3,500	0.391	0.488	0.000	1.000
3,500–5,500	0.093	0.291	0.000	1.000
5,500 or above	0.018	0.132	0.000	1.000
Year				
2018	0.218	0.413	0.000	1.000
2019	0.262	0.440	0.000	1.000
2020	0.257	0.437	0.000	1.000
2021	0.263	0.440	0.000	1.000
Unlimited data plan	0.316	0.465	0.000	1.000
Mobile telecom				
SKT	0.483	0.500	0.000	1.000
KT	0.270	0.444	0.000	1.000
LG U+	0.236	0.425	0.000	1.000
MVNO	0.011	0.429	0.000	1.000

**In the KMP data sample, wearable devices include smart watch, smart band, smart shoes, smart glasses, smart clothes, and wireless earphone.

$$Privacy\,Concern_{i,t} = \beta_0 + \beta_1 IV_{i,t} + \beta_2 SSDR_{i,t} + \beta_3 X_{i,t} + \beta_4\,Year\,FEs_t + \beta_4\,Individual\,FEs_i + \varepsilon_{i,t} \quad (2)$$

The key independent variable is $IV_{i,t}$, which equals to 1 if a user is subject to the strengthened social distancing policy in year t and to 0 otherwise. The slope coefficient, β_1, captures the effect of the strong social distancing measure for meeting four or more people. A vector **X** represents covariates we include in all models to reduce omitted variable bias. We also control *SSDR* since the timeline of the policy change depended on the specific regions. We control for additional media-related characteristics, such as whether a user belongs to an unlimited data plan and with which telecom companies they registered. We include respondents' demographic characteristics, including their gender, age, and educational attainment in each year.

Year FEs, a vector consisting of dummy variables for each year is included to consider year-specific trends in the dependent variables. We also try models with and without individual fixed-effects (FE), denoted by *Individual FEs*, control for unobservable characteristics that are constant within individuals over time, such as innate ability or personality traits, which could otherwise lead to biased estimates in panel data models.

To address the third research question whether lowered (or raised) privacy concerns cause an increase of the possibility of adopting an innovative product or not, we conduct regressions using two approaches. First, we estimate an FE model, shown in Equation (3), where i represents each user and t represents each year. We regress the dependent variable, $INNO\_Adopt_{i,t}$, on the endogenous individual privacy concern.

The second model, which we call the two-stage least-squares (2SLS) model, involves a binary IV that indicates whether a user is subject to the strengthened social distancing policy in a given year. IV regression is used when the independent variable in a regression model is endogenously determined, meaning that it is correlated with the error term. Here, that is the privacy concern, so we use IV to correct for the endogeneity. As shown in Equation (4), the privacy concern variable is the predicted privacy concern from the first-stage regression, and $\beta 1$ estimates the impact of a one-degree increase in a user's privacy concerns on the dependent variable. The covariates remain the same across all of the models:

$$INNO\_Adopt_{i,t} = \beta_0 + \beta_1 Privacy\,Concern_{i,t} + \beta_2 SSDR_{i,t} + \beta_3 X_{i,t} + \beta_4\, Year\,FEs_t + \beta_4\, Individual\,FEs_i + \varepsilon_{i,t} \quad (3)$$

$$INNO\_Adopt_{i,t} = \beta_0 + \beta_1 \widehat{Privacy\,Concern}_{i,t} + \beta_2 SSDR_{i,t} + \beta_3 X_{i,t} + \beta_4\, Year\,FEs_t + \beta_4\, Individual\,FEs_i + \varepsilon_{i,t} \quad (4)$$

4. Empirical findings

Table 4 presents the results of three regression models (Pooled OLS, with FE, with random-effects [RE]) estimating the relationship between the dependent variable, Wearable Device Adoption, and independent variables. In each model, the independent variable of interest is the interaction term between the SSDR and year 2021, IV (SSDR × y2021), which aims to capture the impact of social distancing policies on wearable device adoption.

Figure 2 shows the variance in privacy concerns between the SSDR and non-SSDR groups, as well as how these concerns shifted when social distancing measures were put into effect within each category. The non-SSDR group generally exhibits lower levels of privacy concerns compared to the SSDR group. Within the non-SSDR group, there was a minor decline in privacy concerns before and after introducing strengthened social distancing policies. Conversely, within the SSDR group where social distancing measures were indeed enhanced, there was a more noticeable reduction in privacy worries compared to the non-SSDR group.

Table 4. The effects of social distancing on wearable device adoption.

Variables	(1) Pooled OLS	(2) With FE	(3) With RE
IV (SSDR × y2021)	0.034***	0.032***	0.033***
	(0.006)	(0.005)	(0.005)
Strengthend social_distancing region (SSDR)	0.023***	−0.094**	0.023***
	(0.004)	(0.042)	(0.004)
Year (ref: 2018)			
2019	0.023***	0.018***	0.021***
	(0.002)	(0.004)	(0.003)
2020	0.080***	0.073***	0.078***
	(0.003)	(0.004)	(0.003)
2021	0.117***	0.114***	0.117***
	(0.004)	(0.004)	(0.004)
Control vars.			
Gender	Yes	No	Yes
Age	Yes	Yes	Yes
Educational attainment	Yes	Yes	Yes
Income level	Yes	Yes	Yes
Unlimited data plan	Yes	Yes	Yes
Constant	0.015	−0.066**	−0.010
	(0.022)	(0.029)	(0.016)
Observations	33,429	33,429	33,429
R^2	0.085	0.088	
Number of PID		11,061	11,061

Note: Robust standard errors in parentheses.
$^{***}P < 0.001$ and $^{**}P < 0.01$. Tables with all coefficients are included in the Appendix.

In the Pooled OLS model, the coefficient of the IV (SSDR × y2021) is significant (0.034, $P < 0.01$), indicating that the strengthened social distancing leads to a 0.034 increase in the wearable device adoption rate. The coefficient of SSDR is also significant (0.023, $P < 0.01$), implying that people living in the specific regions where the distancing policy was stronger than other regions tends to adopt wearable device more than those who live other regions.

In the model with FE, the coefficient of the IV is similar to the Pooled OLS model (0.032, $P < 0.01$), while the coefficient of SSDR is negative (–0.094, $P < 0.05$). This suggests that the impact of SSDR on wearable device adoption is different across the individuals. In the model with RE, the coefficients of the IV and SSDR are the same as the Pooled OLS model (0.033 and 0.023, respectively, both with $P < 0.01$), implying that the individual-specific effects are captured by the error term and do not impact the relationship between the IV and wearable device adoption. The results from the Hausman test indicated that the FE model was relatively more efficient for our data set compared to the RE model. Other variables, such as year (2019, 2020, and 2021) and control variables (gender, age, educational attainment, income level, telecom company, and unlimited data plan), are included in the models. The results show that the coefficients of the year variables are significant and positive, indicating that the wearable device adoption rate increased over time.

Table 5 presents the results of three regression models (Pooled OLS, with FE, and with RE) that estimate the relationship between the dependent variable, individual privacy concern, and independent variables. Looking at the results,

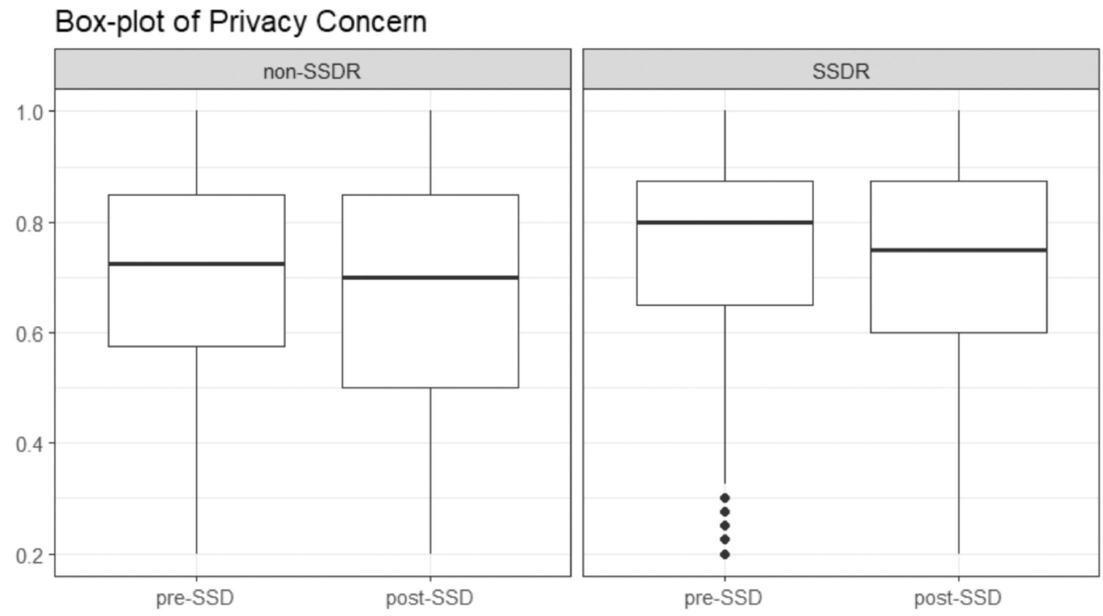

Figure 2. Boxplot graphs of privacy concern between groups.

in all models, the cross term of the social distancing reinforcement region variable used as a double-difference variable and the 2021 dummy variable was significant in a negative direction ($P < 0.001$), and the policy effect coefficient was also almost the same in all models. It is said that the strengthening of social distancing has resulted in lowering individual privacy concerns. This has accelerated digital transformation, such as increased adoption of remote work by companies due to the strengthening of distance. In addition, the areas where social distancing was strengthened were Seoul and Gyeonggi, where the secondary spread of COVID-19 was more severe, and social fear was higher than other areas.

The social distancing area variable was significantly positive in the Pooled OLS model and the RE model, but not in the FE model. This seems to be insignificant from the fixed effects because in the context of panel data analysis, the FE model suggests that the migratory patterns between metropolitan and nonmetropolitan areas exhibited minimal variation over a 4-year period for the individuals surveyed. However, in other models, it was significantly positive, indicating that the privacy concerns of individuals living in the metropolitan area were relatively higher than those in the nonmetropolitan area, regardless of the spread of COVID-19. When examining the dummy variables by year, privacy concerns are higher in 2019 and 2020 compared with the base year 2018, and overall privacy concerns decreased in 2021.

The results from the Hausman test indicated that the FE model was relatively more efficient for our data set compared to the RE model. Therefore, we only applied the FE model to the 2SLS models. Table 6 presents the regression results of the adoption of wearable devices. The key independent variable is an individual privacy concern. It includes two types of regression models: Pooled OLS and 2SLS, and those models were estimated with and without fixed effects. The results indicate that individual privacy concerns has a significant positive effect on wearable device adoption in the Pooled OLS model without fixed effects but shows the opposite significant effect in the 2SLS models with or without fixed effects. The coefficients of privacy concern are different between the Pooled OLS and 2SLS models because the 2SLS method accounts for endogeneity. This suggests that individual's privacy concerns might be endogenous. We mitigate this endogeneity by using the 2SLS method. This clearly shows that the lowered (or raised) individual privacy concerns cause an increase (or decrease) in the rate of adopting wearable devices.

Table 5. Effects of social distancing on individual privacy concerns.

Variables	(1) Pooled OLS	(2) With FE	(3) With RE
IV (SSDR × y2021)	−0.029***	−0.027***	−0.028***
	(0.004)	(0.004)	(0.004)
(SSDR)	(0.003)	(0.032)	(0.003)
Year (ref: 2018)			
2019	0.009***	0.010***	0.010***
	(0.002)	(0.003)	(0.002)
2020	0.022***	0.027***	0.024***
	(0.003)	(0.003)	(0.003)
2021	−0.010***	−0.005	−0.009***
	(0.003)	(0.003)	(0.003)
Control vars.			
Gender	Yes	No	Yes
Age	Yes	Yes	Yes
Educational attainment	Yes	Yes	Yes
Income level	Yes	Yes	Yes
Unlimited data plan	Yes	Yes	Yes
Constant	0.685***	0.669***	0.664***
	(0.013)	(0.022)	(0.012)
Observations	33,429	33,429	33,429
R^2	0.082	0.019	
Number of PID		11,061	11,061

Note: Robust standard errors in parentheses.
$^{***}P < 0.001$.

Table 6. Effects of individual privacy concerns on wearable device adoption.

	Pooled OLS		2SLS	
Variables	W/o FE	With FE	W/o FE	With FE
Privacy concern	0.050***	0.005	−1.174***	−1.202***
	(0.008)	(0.009)	(0.285)	(0.271)
SSDR	0.029***	−0.080*	0.093***	−0.062
	(0.004)	(0.042)	(0.017)	(0.057)
Year (ref: 2018)				
2019	0.023***	0.018***	0.035***	0.031***
	(0.002)	(0.004)	(0.005)	(0.006)
2020	0.078***	0.073***	0.106***	0.106***
	(0.003)	(0.004)	(0.008)	(0.009)
2021	0.131***	0.127***	0.106***	0.108***
	(0.004)	(0.004)	(0.007)	(0.006)
Control vars.				
Gender	Yes	No	Yes	No
Age	Yes	Yes	Yes	Yes
Educational attainment	Yes	Yes	Yes	Yes
Income level	Yes	Yes	Yes	Yes
Unlimited data plan	Yes	Yes	Yes	Yes
Observations	33,429	33,429	33,429	
R^2	0.082	0.019		
Number of PID		11,061	11,061	

Note: Robust standard errors in parentheses.
***$P < 0.001$ and *$P < 0.05$.

5. Discussion and conclusion

This study presented the results of three models that examine the relationship between innovation adoption, individual privacy concern, and the social distancing policy. We use an IV, the interaction term between the SSDR and the year 2021, which aims to capture the impact of social distancing policies on innovation adoption and individual privacy concern. Then, 2SLS is applied to test the causal effect of the privacy concerns on innovation adoption.

The results of the first model show that strengthened social distancing leads to an increase in wearable device adoption. The FE model shows that the impact of social distancing on wearable device adoption varies across individuals. On the contrary, the RE model implies that the individual-specific effects are captured by the error term and do not impact the relationship between social distancing and wearable device adoption. The results of the second model show that the strengthening of social distancing has resulted in a decrease in individual privacy concerns. In the third model, the coefficients of privacy concern are different between the Pooled OLS and 2SLS models, suggesting that individual privacy concerns might be endogenous. The 2SLS models indicate that a decrease (or increase) in individual privacy concerns leads to an increase (or decrease) in wearable device adoption.

Social distancing has a negative impact on the global economy as well as individual social interactions, affecting economic activities. The economy has suffered due to the restrictions imposed by COVID-19, which also threatens innovation activities. However, social distancing can lead to a higher possibility of people seeking innovations to secure themselves, as creative activity has the potential to increase resilience in times of prolonged isolation. Previous studies have found a positive relationship between individualism, indulgence, and innovation, leading to the assumption that the enhancement of social distancing positively contributes to the adoption of innovation. The results of this study are in line with previous studies. It found that the strengthened social distancing leads to an increase in wearable device adoption.

The pandemic has resulted in the spread of new ICT that enable remote interactions like remote learning and telecommuting activities; however, this also raises the possibility of their use or misuse of private information for surveillance and enforcement purposes. The privacy concerns of individuals are affected by several factors, including what data are collected, how they are used, the justification for collection, and the users' characteristics. The privacy concerns of individuals are also related to the transparency of government actors' use of private information. The research question we raised was about whether individuals that live in regions that have adopted heightened social distancing policies are likely to lower their privacy concern. The result shows that the strengthening of social distancing decreases individual privacy concerns.

The adoption of new technologies and innovations is influenced by individuals' privacy concerns and trust in the technology and government. Personal characteristics and perceived risks to privacy affect individuals' behavior and decision to adopt new technologies. Trust in the technology and government is an important factor for the diffusion of innovations, and trust in government-related policies leads to increased innovation and acceptance of e-services. Privacy concerns are also affected by privacy-related policies, such as the ability for users to make decisions about data collection and the justification for data collection. The pandemic presents a novel case or natural experiment to study the relationship between privacy concerns and innovation adoption, particularly regarding wearables during a crisis. As social distancing policies allowed public agencies and private companies to make decisions related to privacy on behalf of all citizens and customers, which may decrease their privacy and increase risks related to personal information. Our result suggests that the lowered privacy concerns due to the strengthened social distancing raised innovation adoption such as wearable devices.

Owing to the spread of COVID-19, social distancing has been strengthened, which has accelerated digital transformation. This provided safety and convenience to many people but resulted in lowering concerns about invasion of privacy and raising the rate of adopting a new technology. These choices may be acceptable during a global pandemic, and the measures taken by Korean government remain a model of successful response to a pandemic despite higher information disclosure and regulations than other countries. However, if the public has lowered privacy concerns, it does not necessarily provide license for other actors to intrude upon private data. Thus, the government may need to step in to protect and safeguard individuals' private information and collected data. Although this study has identified the relationship between the strengthening of social distancing, individual privacy concerns, and innovation adoption, additional research is necessary to understand the mechanisms and different vulnerabilities to innovation as a result of unforeseen threats to the system. In future studies, discussions should continue on what kind of psychological factors lowered privacy concerns (raised the likelihood of adopting new technologies) and what measures could be taken to restore it.

Based on our discussion, several key policy recommendations emerge. Traditionally, both business and government have roles in shaping policies related to technology and privacy. However, in the context of the pandemic and heightened social distancing measures, the government seems to have taken the lead in regulating technology use, especially in South Korea, where its interventions have been hailed as a model for success response to a pandemic.

Given our finding that strengthened social distancing measures have led to lowered privacy concerns, the government needs to exercise caution. Lowered public concern about privacy should not serve as an endorsement for increased data collection or surveillance. Hence, the government should aim to increase transparency and provide clear justifications for any data collection activities, while also offering individuals more control over their data. Furthermore, public education campaigns around data privacy could be beneficial to ensure that individuals are aware of the risks and can make informed decisions.

Regarding wearable technologies, specific policies should be designed to protect individuals' data. As our study suggests that lowered privacy concerns may drive the adoption of wearables, there should be clear guidelines around the type of data that can be collected, how it will be used, and how long it will be retained. These measures could serve as a safeguard against potential misuse of data in the future.

The Korean model of managing privacy concerns and technology adoption during a pandemic could serve as both a positive and cautionary example for other societies. On one hand, the effectiveness of its policies in terms of public health outcomes is undeniable. On the other hand, the lowered privacy concerns and accelerated technology adoption raise important ethical and societal questions.

In summary, this case provides valuable insights into how social distancing measures and governmental policies can influence individual privacy concerns and the adoption of new technologies. Further research is needed to delve into the psychological factors affecting these decisions and to explore ways to balance public health needs with individual rights to privacy.

Finally, this study has following limitations. First, its context is heavily influenced by South Korean cultural factors such as rapid technology adoption and low privacy concerns, which may limit generalizability. Second, the data used are secondary and were not collected with this specific research focus, lacking qualitative questions and therefore depth of analysis. Finally, the survey questions did not specifically address privacy concerns related to wearables, limiting the scope of applicability. These aspects should be considered when interpreting the findings.

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