Geographic spread of COVID-19 and local economies: Heterogeneous effects by establishment size and industry

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Abstract
Using province-level establishments and employment data from the Korean Employment Insurance Database, this paper investigates how the regional spread of COVID-19 affects local businesses and unemployment by establishment size and industry. We find that the number of small establishments declines substantially after the COVID-19 pandemic through a decrease in new establishment creation and a surge in establishment closures. By contrast, large establishments are not affected significantly. Examining the numbers of unemployment benefits (UB) applicants, an indicator of unemployment, we find that the higher the rate of COVID-19 confirmed cases in a province, the higher the number of UB applicants, regardless of their previous workplace size. Our analysis of employment insurance subscribers further confirms that the regional spread of COVID-19 leads to a significant reduction in employment and job mobility in small establishments. Regarding industry heterogeneity in the COVID-19 effects, we find that local COVID-19 outbreaks affect local industries more through the reduction in establishment creation and new employment than through an increase in establishment closures. Industries that require face-to-face operations, such as lodging & restaurant, experience a substantial adverse impact in the early phase, and the impact also tends to last longer as COVID-19 situations prolong.

KEYWORDS
COVID-19, employment insurance, establishment closure, unemployment benefits
The COVID-19 pandemic has caused a public health crisis and economic shocks worldwide. A significant drop in consumer spending due to health concerns in the domestic market has occurred (Chetty et al., 2020). While companies seek to reduce investment or employment to cope with this decline in demand (Campello et al., 2020), a considerable number of firms have decided to close their businesses (Bartik et al., 2020). Among all firms, small- and medium-sized establishments may be more likely to close their businesses or reduce employment because they have relatively less liquidity and are unable to adapt to the economic crisis caused by the COVID-19 pandemic. In addition, COVID-19 may strongly impact industries that require face-to-face operations because people tend to reduce their activities in response to local COVID-19 outbreaks. With this regard, we examine the effect of the regional spread of COVID-19 on establishment behaviors in terms of business entry/exit and unemployment and provides empirical evidence of how the COVID-19 effects on the local economy vary by establishment size and industry.

To investigate how local economies respond to the economic crisis, emerged by COVID-19, we exploit a regional variation in COVID-19 confirmed cases in South Korea. The first COVID-19 local outbreak in South Korea occurred in Daegu, a metropolitan city near Gyeongbuk province, in mid-February 2020. The number of confirmed COVID-19 cases has dramatically increased in Daegu, mainly due to a religious gathering by a sect called Shinchonji (Aum et al., 2021). Around the same time, other provinces and metropolitan cities in Korea had much smaller or even zero confirmed cases. The first local outbreak in Daegu has stabilized in late April. The numbers of confirmed cases in other provinces have fluctuated along with relatively small regional outbreaks, leading to a geographic variation in COVID-19 cases. Regardless of the spatial variation, the Korean government did not impose localized treatments against COVID-19. The degree of social gathering restrictions has also been maintained uniformly nationwide until the end of June 2020. Therefore, the geographic variation in the COVID-19 confirmed cases across provinces in this early phase of COVID-19 allows us to identify the effect of the regional COVID-19 infection rate on the local economy. The effect of COVID-19 that we estimate is therefore local and differs from the potential effect of the COVID-19 pandemic underlying the entire national economy.

Using the province-level monthly longitudinal Employment Insurance Database (EID) in South Korea from January 2017 to June 2020, combined with the provincial COVID-19 statistics, we find that the number of COVID-19 confirmed cases has a significant adverse effect on the number of establishments. Moreover, the effects are large and significant for small-sized establishments with fewer than 10 workers. We further show that the negative effect on the number of establishments is attributed to both a decline in establishment creation and an increase in establishment closures. By contrast, the COVID-19 effect on the number of large establishments with more than 300 employees is insignificant.

Next, we utilize the data on unemployment benefits (UB) applications and employment insurance (EI) subscribers each month. In Korea, workers hired by a company with one or more workers obtain a subscription to EI. When workers with an EI subscription lose their job involuntarily, they are eligible to receive UB. Hence, changes in the numbers of EI subscribers and UB applicants closely account for local labor market conditions. We find that COVID-19 has caused a substantial increase in UB applicants in establishments with fewer than 300 workers. The magnitude of the effect is the greatest in establishments with fewer than 10 employees. A one-unit increase in the number of confirmed cases per 1000 population raises the number of applicants in establishments with fewer than 10 employees by 7.3%, implying that the local infection rate strongly impacts unemployment in small businesses. The number of EI subscribers has also decreased in small establishments with fewer than 50 employees after regional spreads of COVID-19.

Interestingly, not only the number of new subscribers but also the number of people who lose EI have significantly decreased after COVID-19 in small-sized establishments. To understand what drives the reduction in the number of people who lose EI, we conduct an analysis by reason for insurance loss. We find that the loss of EI due to voluntary turnover has decreased, while the insurance loss after downsizing due to management reasons or recession has increased. The results show that the regional COVID-19 spreads deteriorate job mobility in small establishments.
To comprehensively understand the impact of COVID-19 on the local economy, we investigate to what extent the COVID-19 effects are heterogeneous by industry. We find that the regional spread of COVID-19 affects both establishment and employment outcomes negatively in industries that require face-to-face operations or where work from home is relatively difficult, such as lodging & restaurant and leisure (Adams-Prassl et al., 2020; Barrero et al., 2020; Papanikolaou & Schmidt, 2020). By contrast, only employment outcomes are affected in the information and communications technology (ICT) service industry. Another interesting finding is that COVID-19 influences more industries by reducing establishment creation, new employment, and job mobility than increasing establishment closures during the early phase of COVID-19 in Korea. We extend the EID data to March 2021 and compare the early-phase results with those from the extended period. The result suggests that the impact of COVID-19 in many industries became insignificant as the COVID-19 period has prolonged. However, in the lodging & restaurant industry that requires face-to-face operations most intensely, the adverse effect of COVID-19 is still substantial and statistically significant. Our results are robust to different choices of COVID-19 measures and sample periods, as well as potential spillover effects.

Our findings provide significant economic implications for the local economy. In Korea, workers in small- and medium-sized establishments, which make up a large portion of the national economy (Sung & Kim, 2020), are known to have lower wages than those in large companies and hence economically more vulnerable (e.g., Schmidt & Zimmermann, 1991). Thus, our findings on the significant COVID effects on establishment employment outcomes in small- and medium-sized establishments after the regional spread of COVID-19 imply that the COVID-19 induced economic crisis is likely to deteriorate the inequality among workers in the local labor market. Moreover, the large and prolonged COVID-19 effects on industries requiring face-to-face operations suggest that the government subsidy may have to be concentrated more on such industries. Besides, our result on the local economy’s significant responses to the regional COVID-19 shock indicates that the prompt implementation of public health policies targeted to highly infected areas may help local establishments manage their business environments more effectively against COVID-19.

Because the COVID-19 pandemic has occurred in unforeseen circumstances, many researchers have made an urgent investigation into what economic problems the COVID-19 has triggered at the global and national levels. In particular, a few papers study the effect of COVID-19 on businesses (Bartik et al., 2020; Buchheim et al., 2020; Fairlie, 2020, and many others) and the labor market (Barrero et al., 2020; Cajner et al., 2020, among others). Our paper contributes to this strand of literature by adding empirical evidence of strong COVID-19 effects on various establishment and employment outcomes. A set of previous research finds that areas with higher COVID-19 infection rates experience more significant spending declines (Chetty et al., 2020) and hiring cuts (Campello et al., 2020). We contribute to the literature by analyzing the relationship between regional COVID-19 infection rates and business dynamics, focusing on heterogeneous effects by establishment size and industry.

Regarding the economic impact of COVID-19 in Korea, Aum et al. (2021) and Lee and Yang (2020) study how COVID-19 affects unemployment and labor market conditions with the difference-in-differences or synthetic control methods, which requires a clear distinction between treated and nontreated areas. By contrast, our paper differs from those previous works as we exploit the entire provincial variation in COVID-19 infection rates to investigate the local effects of COVID-19 on both establishments and unemployment by establishment size.

This paper is also related to a strand of literature that studies firm responses, unemployment, and efficient economic policies during economic crises (e.g., Almunia et al., 2010; Holl, 2018). In particular, Garrett (2007) and Barro et al. (2020) study the impact of the 1918 Great Influenza on businesses and their employment decisions. Cobion et al. (2018) demonstrate that firms under more competition have better information and form a more accurate expectation about future economic conditions. Hassan et al. (2020) documented that firms with previous experience of the economic uncertainty induced by earlier significant epidemic diseases, such as Severe Acute Respiratory Syndrome (SARS), are less likely affected by the new COVID-19 shock. We contribute to the literature by providing empirical evidence of the COVID-19 effect on a comprehensive list of outcome variables, including the establishment creation and closure, unemployment in small establishments that are the most severely affected by the regional spread of COVID-19.
2 | COVID-19 IN KOREA

2.1 | Early phase of COVID-19

In South Korea, the first COVID-19 confirmed case occurred on January 20, 2020. Since then, the diffusion of COVID-19 had remained relatively low until mid-February, that is, only 31 cumulative confirmed cases until February 18. However, the situation changed sharply after the outbreak of large-scale group infection among followers of a sect, Shinchonji, in Daegu on February 20, 2020. Figure 1a shows that the number of confirmed cases has surged in Daegu metropolitan city until March 2020, and COVID-19 has spread to surrounding areas. For example, the number of confirmed cases in Gyeongbuk province adjacent to Daegu also increased around this time.

The numbers of confirmed cases in Daegu and Gyeongbuk increased steadily until early April. Although not as much as Daegu and Gyeongbuk, the number of confirmed cases in other provinces, particularly Seoul and Gyeonggi, also increased significantly during the same period, as shown in Figure 1b. February–April 2020 is defined as the first wave of the COVID-19 pandemic in Korea (Seong et al., 2021). During the first wave, the key treatment strategy of the Korean government to control COVID-19 was a so-called “tracing” strategy. The tracing strategy utilizes the advanced information technology in Korea to trace individuals suspected to be infected or individuals who might have been in contact with an infected patient (Park et al., 2020). In the early stage of COVID-19, the government successfully manage the number of COVID-19 cases by using this strategy rather than imposing a strong physical distancing policy in highly infected areas.\(^1\)

The number of new confirmed cases remained low nationally from early April to mid-May. However, the number of cases has gradually increased again in areas with high population density, such as Seoul, in May and June due to several low-scale local outbreaks (Figure 1c,d). Regardless of the spatial variation, the Korean government had not imposed treatments against COVID-19, targeted to high-infection areas until the end of June. The degree of social gathering restrictions, or social distancing, had also been maintained uniformly nationwide as level 1, until the end of June 2020. Note that the Korean government revised its social distancing policy as a three-tier system on May 6, 2020. The level-1 social distancing enables most activities, but limits only the number of people that can be gathered. For example, only 50% of the audience can enter professional sports events.

We refer to the period of January–June 2020 as the early phase of COVID-19 in Korea (Liu et al., 2021), and the COVID-19 situation in the early phase is unique for two reasons: First, as we have explained before, the key strategy to deal with the COVID-19 outbreak in the country is not a complete lockdown of infected areas as in the United States, Europe, and Australia, but the tracing strategy. Second, there was no variation in the degree of social distancing across regions, and thus, individuals and businesses can decide their activity level on their own. In this sense, Korean regional economic activities and COVID-19 intensities in the early phase of COVID-19 are suitable for analyzing the impact of COVID-19 on the local economy, and we will focus on the early phase in our main analysis.

2.2 | Extended period with localized social distancing

On June 28, 2020, the Korean government revised the social distancing scheme and started allowing for different levels of social distancing across provinces from July 1, 2020. Moreover, the government encourages local municipalities to actively decide their own social distancing levels from July 17, 2020. After that, the number of new COVID-19 cases remains low, and the pandemic seems to be under control until the end of July. However, due to the increased amount of social activities in summer, the number of daily COVID-19 confirmed cases skyrocketed to approximately 300 cases on August 15, 2020. The Korean government raised the social distancing level to level 2 in

\(^1\)The Korean government has started its first social distancing policy on March 22, 2020, which imposes some restrictions on social/economic activities that require physical contact, such as religious services, sports activities, and so on, uniformly in the entire country.
Seoul and Gyeonggi on August 16 and Incheon on August 18, employing the localized social distancing policy. The number of cases decreased gradually and reached less than 100 on September 19, 2020, after a few more changes in the social distancing level across provinces. This period (August and September 2020) is renowned as the second

FIGURE 1 COVID-19 by province during the early phase in South Korea. Notes: COVID-19 data from the Asia Regional Information Center. (a) March 2020, (b) April 2020, (c) May 2020, and (d) June 2020

Seoul and Gyeonggi on August 16 and Incheon on August 18, employing the localized social distancing policy. The number of cases decreased gradually and reached less than 100 on September 19, 2020, after a few more changes in the social distancing level across provinces. This period (August and September 2020) is renowned as the second

2The level-2 social distancing further limits the number of people that can be gathered. For example, only 10% of the audience can enter professional sports events, and restaurant operations were allowed only for delivery during nighttime.
wave of COVID-19 in Korea (Obnial et al., 2021), and Figure 2a shows that the high infection rate in Seoul and surrounding areas during the second wave.

Around this second wave, the Korean government implemented many economic stimulus plans, particularly for small businesses and industries that COVID-19 hit the hardest, such as restaurants and other retail shops. For example, so-called “dining-out” coupons were distributed in August 2020 to increase consumption expenditure and relieve the difficulties in restaurants. However, the dining-out coupon policy was deferred until the second wave is over.

About a month after the second wave, the number of daily confirmed cases in Korea reached 100 again on November 4, 2020, which is a signal to the kickoff of the third wave. On November 7, 2020, the Korean government revised the social distancing scheme to the new five-tier system from its previous three-tier system (Seong et al., 2021) and encouraged provincial responses to COVID-19 even more strongly.3 Despite several changes in social distancing levels across areas in November and early December, the COVID-19 cases reached the highest in most areas in the winter holiday season, as shown in Figure 2b, and remained around 1000 cases every day for more than 2 months. In early February 2021, the daily confirmed cases gradually decreased, and the COVID-19 vaccination started on February 26, 2021.

During the second and third waves, the localized social distancing policy has been started, and the government actively implemented policies to stimulate the economy in areas where COVID-19 hit harder. Moreover, workers and establishments find ways to cope with the COVID-19 era, and industry restructuring and resource redistribution have been undertaken. For these reasons, the link between the regional intensity of COVID-19 and local economic activities may have been attenuated.

3Seong et al. (2021) described the differences between the three- and five-tier social distancing systems.
3 | DATA

3.1 | Employment Insurance Database

To analyze the impacts of COVID-19 on businesses and unemployment, we use the EID in South Korea. South Korea is well known for a large proportion of small- and medium-sized businesses and establishments in the national economy (Nugent & Yhee, 2002). The ratio of self-employment to total employment in South Korea was 26.8% as of 2014, far higher than the average rate (15.4%) of OECD member countries (Sung & Kim, 2020). The economic structure with a high proportion of small- and medium-sized enterprises implies the national economic importance of small establishments' success and survival.

The EID is administrative data that contain information on all individuals and establishments that subscribe to EI. While the data set has advantages of administrative data, establishments that EI does not cover are not included in the data. In principle, however, EI provides subscriptions to all workers in establishments that employ one or more workers, and thus, it covers most of the private companies and their employees. Specifically, the proportion of wage earners who subscribe to EI to total wage earners is 66.1% in August 2018. Public servants, teachers, and post office employees are not eligible to subscribe to EI because of the low risk of unemployment. Also, the following types of workers are not eligible for EI subscription: workers in establishments with less than five employees in agriculture, forestry, and fishery industries; workers over 65 years old; part-time workers whose hours of work are less than 15 h/week excluding those who have worked for 3 months or more; workers engaged in a particular type of works, such as insurance agents, caddies, and artists. These ineligible workers account for 15.7% of the entire wage earners, and an additional 18.2% is in the blind spot. That is, they are eligible for EI but do not have EI. The proportion of EI subscribers to the entire workforce, including self-employed, is 49.2%, according to the Korean Economically Active Population Survey in 2018 (Chang & Park, 2019).

The raw microdata of the EID is not publicly available. Instead, the Korea Employment Information Service releases statistics on establishments and workers from the raw data every month. For information related to establishments, the total number of establishments, the numbers of new and closed establishments each month at the national and provincial levels are available. In terms of employment outcomes, the numbers of insured workers and new subscribers, the number of people who lose their insured status, and the number of applications for UB, among a few other outcomes, are available. The EID classifies these statistics by establishment size and industry, and we use them as dependent variables. We provide detailed explanations about all the dependent variables in Table 1.

3.2 | COVID-19 data

To investigate the impact of COVID-19 on establishment and employment outcomes, we use the number of confirmed cases per 1000 population in each province to measure the regional intensity of COVID-19. The Asia Regional Information Center provides the daily number of cumulative confirmed cases in each province, equivalent to the government-released statistics, and we calculate the monthly average of the cumulative confirmed cases in a province. We collect monthly population data of each province from the Korean Resident Registration Population Statistics. We construct the monthly average of cumulative confirmed cases per 1000 population in each province using those two

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4 According to the 2016 National Establishment Survey in Korea, 94% of small- and medium-sized establishments is single-unit establishments, and only a few large enterprises consist of multiple establishments. For this reason, we can consider establishments in our data as stand-alone enterprises (Ayyagari et al., 2014).

5 The top tier of administrative divisions in South Korea is province-level areas, including nine provinces, six metropolitan cities, one special city (Seoul), and one special self-governing city (Sejong). Henceforth, we denote this top tier of administrative divisions as "provinces."
Henceforth, the term “cumulative COVID-19 confirmed cases per 1000 population” is interchangeably referred to as cumulative confirmed cases, cumulative COVID-19 cases, or cumulative cases when there is no confusion.

We use the cumulative cases rather than the new cases for the following reasons. First, economic activities in an area, particularly establishment creation and closures, are highly affected by a few-months-lasting situations of COVID-19 in the area. Second, since the reporting process for business activities, such as entry and exit, takes some time (usually about a month), the number of confirmed cases in the previous month or months before is also likely to affect business activities. For these reasons, we use the cumulative confirmed cases as the primary measure of COVID-19 prevailing in each area. Kim et al. (2020) and Fairlie and Fossen (2021) also use the cumulative confirmed cases to investigate the effects of COVID-19 on business outcomes. To check the robustness of our results to this choice of COVID-19 measure, we have replaced the cumulative COVID-19 cases with COVID-19 cases for 1, 2, or 3 months in Section 7.1. For the further analysis for the extended period in Section 7.2, we use the cumulative COVID-19 cases for the latest 6 months, equivalent to the cumulative COVID-19 cases in the main analysis.

The COVID-19 statistics we use for our analysis are highly reliable for the following reasons. First, the Korea Disease Control and Prevention Agency (KDCA) only acknowledges the COVID-19 real-time reverse transcription-polymerase chain reaction (RT-PCR) test, which is the most reliable diagnostic method for COVID-19 (Corman et al., 2020) with highly accurate test results (usually more than 95% of accuracy). Second, the KDCA officially releases the COVID-19 statistics every morning, such as the number of confirmed cases that occurred during the day before the presentation. As the number of confirmed cases

| TABLE 1 Variable list and explanation |
|----------------------------------------|
| Variables                              | Explanation                                                                 |
| Number of establishments               | The number of all establishments that are in operation in a month. An establishment is either a stand-alone enterprise or subunit constituting an enterprise independently engaged in a main economic activity within a certain physical place. According to the 2016 National Establishment Survey, approximately 94% of establishments in South Korea is single-unit establishments that do not have a headquarter, a plant, a branch (store), or a sales office in other locations |
| Number of new establishments            | The number of establishments that are created in a month                     |
| Number of establishment closures       | The number of establishments that are permanently closed in a month           |
| Number of UB applicants                | Workers who work for establishments eligible for EI membership can apply for UB if they lose their jobs. The number of UB applicants is the number of people who are unemployed from establishments that are eligible for EI membership |
| Number of EI subscribers               | Because all workers in establishments with one or more employees are obligated to subscribe to EI, except for a few exceptions, the number of EI subscribers is another good indicator of the employment situation. A worker obtains a subscription to EI after an establishment hires the worker |
| Number of new EI subscribers            | The number of new EI subscribers is the number of workers who started working in an establishment where EI subscription is eligible |
| The number of people who lost the EI subscription | The subscription to EI is lost if a worker no longer works in the establishment. Even if the worker’s employment contract is terminated due to voluntary turnover, the EID system counts it as a loss of EI in the establishment. Hence, this measure includes both voluntary and nonvoluntary resignation |

Abbreviations: EI, employment insurance; EID, Employment Insurance Database; UB, unemployment benefits.
announced by the government is known to the public on the air, economic agents' behavior is greatly affected by this number (Kim et al., 2020). Lastly, there may be a potential discrepancy between the released statistic on COVID-19 confirmed cases and the number of people who actually were infected but not tested (and hence not counted in the government-released statistic). However, this discrepancy is tiny and can be negligible. The South Korean government has surveyed the COVID-19 antibody retention rate as a part of the Korea National Health & Nutrition Examination Survey 2020, during April–December 2020. The result shows that less than 0.14% of people hold the antibody to COVID-19 (Kamruzzaman et al., 2020).

3.3 | Final data and summary statistics

Our final data set consists of 867 observations over 17 provinces in 51 months from January 2017 to March 2021. We use data up to June 2020 for our main analysis to investigate the effect of regional COVID-19 intensity on the local economy in the early phase of COVID-19. For each province each month, we have outcomes variables at six different levels of establishment size in terms of the number of employees (all, 1–9, 10–49, 50–99, 100–299, and 300 or more). We also observe outcome variables by industry. According to the Korean Standard Industry Classification, industries are classified into 21 sectors in the raw EID data. Among the 21 sectors, we exclude seven industries where the number of establishment creation or closures is relatively small, such as mining and agriculture, forestry, and fishery. Table 2 shows summary statistics for the variables and their time trend before and after the COVID-19 pandemic. Table 3 shows the proportion of establishments and EI subscribers by establishment size or by industry.

In the first half of 2017 (2017H1), the average number of establishments over 17 provinces and 6 months is approximately 126,000, and the number of UB applicants is approximately 5100 people. These numbers have increased for the 3 years, showing 134,400 establishments and 7700 applicants on average in 2020H1. The geographical variation in the number of establishments and EI subscribers is considerable across provinces. For example, a province with the largest number of establishments (with fewer than 10 workers) has more than 0.5 million establishments, but a province with the smallest number of establishments has only approximately 10,000 establishments. Similarly, the average EI subscribers over 17 provinces in 2017H1 are approximately 748,800, varying geographically from 47,500 to 4,132,000. This spatial heterogeneity is mainly because of agglomeration economies (Hong et al., 2015) and the national population distribution that is more concentrated on the capital city Seoul and its surrounding areas. We observe that the average population in 17 provinces is approximately 3 million people, and it remains almost the same throughout the sample period.

Table 3 presents the proportion of establishments and EI subscribers by establishment size or by industry, based on statistics in June 2020. Approximately 88% of establishments has fewer than 10 workers, whereas EI subscribers in these small establishments account for only 26.3% of total EI subscribers. In terms of industrial proportions, the wholesale & retail industry has the largest share of establishments, and the manufacturing industry has the largest EI subscribers. The construction industry has the largest proportion of establishment creation and closures due to the unique feature of construction industry in Korea: Many project-based establishments are formed, and after each project, such establishments close periodically. Establishments with fewer than 10 workers account for more than 96% of the total new or closed establishments. By contrast, establishments with 300 or more workers are less likely created and closed than their proportion in the total number of establishments. This discrepancy illustrates that the startup and termination of small businesses are more frequent than those of large enterprises (Regnier, 1993).

From Table 3, we can also compare EI subscribers' proportion with the proportion of UB applicants by size and industry. Note that the EI subscribers and UB applicants are related to employment and unemployment, respectively. Establishments with fewer than 10 workers account for 37.8% of monthly UB applicants in June 2020, but only 25% of EI subscribers. By contrast, establishments with 300 or more workers account for 19% of UB applicants and 28.4% of EI subscribers in the same month. These statistics indicate that layoff occurred disproportionately by establishment size in June 2020.
## Table 2 Summary statistics and time trend of key variables over time

|                | 2017H1 Mean (SD) | 2017H1 Min (Province) | 2017H1 Max (Province) | 2018H1 Mean (SD) | 2018H1 Min (Province) | 2018H1 Max (Province) | 2019H1 Mean (SD) | 2019H1 Min (Province) | 2019H1 Max (Province) | 2020H1 Mean (SD) | 2020H1 Min (Province) | 2020H1 Max (Province) |
|----------------|------------------|-----------------------|-----------------------|------------------|-----------------------|-----------------------|------------------|-----------------------|-----------------------|------------------|-----------------------|-----------------------|
| **A. Establishment outcomes (000s)** |                  |                       |                       |                  |                       |                       |                  |                       |                       |                  |                       |                       |
| Number of establishments | 126.0 (140.1) | 9.2 (Sejong) | 527.9 (Gyeonggi) | 127.7 (141.1) | 9.6 (Sejong) | 546.2 (Gyeonggi) | 131.1 (148.4) | 10.4 (Sejong) | 577.0 (Gyeonggi) | 134.4 (151.7) | 11.0 (Sejong) | 592.3 (Gyeonggi) |
| New establishments | 5.7 (4.8) | 0.51 (Sejong) | 23.3 (Gyeonggi) | 5.9 (5.1) | 0.42 (Sejong) | 25.4 (Gyeonggi) | 6.8 (6.0) | 0.62 (Sejong) | 31.0 (Gyeonggi) | 7.6 (7.1) | 0.58 (Sejong) | 40.7 (Gyeonggi) |
| Establishment closures | 5.9 (5.4) | 0.45 (Sejong) | 27.0 (Gyeonggi) | 5.8 (5.7) | 0.12 (Sejong) | 32.4 (Gyeonggi) | 7.5 (6.4) | 0.36 (Jeju) | 33.7 (Gyeonggi) | 8.3 (7.6) | 0.28 (Jeju) | 38.2 (Gyeonggi) |
| **B. Labor market outcomes (000s)** |                  |                       |                       |                  |                       |                       |                  |                       |                       |                  |                       |                       |
| UB applicants | 5.1 (5.6) | 0.22 (Sejong) | 26.3 (Gyeonggi) | 5.8 (6.6) | 0.36 (Sejong) | 34.3 (Gyeonggi) | 6.2 (7.2) | 0.32 (Sejong) | 40.2 (Gyeonggi) | 7.7 (8.7) | 0.49 (Sejong) | 42.5 (Gyeonggi) |
| EI subscribers | 748.8 (1031) | 47.5 (Sejong) | 4132 (Seoul) | 766.8 (1057) | 51.6 (Sejong) | 4224 (Seoul) | 797.3 (1092) | 57.6 (Seoul) | 4335 (Seoul) | 812.4 (1106) | 61.5 (Sejong) | 4348 (Seoul) |
| EI new subscribers | 36.1 (49.3) | 2.5 (Sejong) | 228.4 (Seoul) | 37.9 (52.1) | 2.7 (Sejong) | 227.4 (Seoul) | 38.9 (51.4) | 2.8 (Seoul) | 236.8 (Seoul) | 36.0 (46.6) | 2.9 (Sejong) | 209.2 (Seoul) |
| People who lost EI subscription | 33.5 (45.8) | 1.9 (Sejong) | 227.6 (Seoul) | 35.3 (50.1) | 2.1 (Sejong) | 278.5 (Seoul) | 35.6 (49.1) | 2.3 (Seoul) | 279.7 (Seoul) | 35.2 (47.9) | 2.0 (Sejong) | 254.7 (Seoul) |
| **C. Explanatory variable (000s)** |                  |                       |                       |                  |                       |                       |                  |                       |                       |                  |                       |                       |
| Population | 3042 (3199) | 244.9 (Sejong) | 12,775 (Gyeonggi) | 3046 (3218) | 283.2 (Sejong) | 12,975 (Gyeonggi) | 3049 (3244) | 316.8 (Sejong) | 13,159 (Gyeonggi) | 3050 (3272) | 342.3 (Sejong) | 13,338 (Gyeonggi) |
| Observations | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 |

Notes: All summary statistics are calculated over provinces and over time during each half year. The abbreviation "H1" represents the first half of the year. For example, 2017H1 means the first half of 2017. Standard deviations (SDs) are in brackets below means, and provinces that have minimum (maximum) values are in brackets below the corresponding minimum (maximum). All statistics are shown in thousands.

Abbreviations: EI, employment insurance; UB, unemployment benefits.
| Establishment and employment proportions by establishment size and industry in June 2020 |
|---------------------------------------------------------------|
| **Number of establishments (%)** | **New establishments (%)** | **Establishment closures (%)** | **UB applicants (%)** | **EI subscribers (%)** | **EI new subscribers (%)** | **People who lost EI subscription (%)** |
|----------------------------------|----------------------------|-------------------------------|----------------------|------------------------|----------------------------|---------------------------------------|
| **A. By establishment size**     |                            |                               |                      |                        |                            |                                       |
| 0–9 workers                      | 88.0                       | 96.5                          | 96.5                 | 37.8                   | 26.3                       | 40.2                                  | 36.1                                  |
| 10–49 workers                    | 10.1                       | 3.2                           | 3.2                  | 25.2                   | 24.2                       | 25.8                                  | 25.9                                  |
| 50–99 workers                    | 1.0                        | 0.2                           | 0.2                  | 8.3                    | 8.8                        | 7.9                                   | 8.4                                   |
| 100–299 workers                  | 0.6                        | 0.1                           | 0.1                  | 9.7                    | 12.2                       | 9.0                                   | 9.6                                   |
| 300 or more workers              | 0.2                        | 0.0                           | 0.0                  | 19.0                   | 28.4                       | 17.1                                  | 20.0                                  |
| **B. By industry sectors**       |                            |                               |                      |                        |                            |                                       |
| Manufacturing                    | 15.0                       | 1.7                           | 0.9                  | 22.3                   | 26.5                       | 15.4                                  | 19.5                                  |
| Construction                     | 18.4                       | 84.9                          | 91.8                 | 13.7                   | 5.4                        | 6.3                                   | 6.7                                   |
| Wholesale & retail               | 21.2                       | 4.0                           | 2.0                  | 13.2                   | 12.0                       | 13.5                                  | 14.4                                  |
| Transportation & warehousing     | 2.3                        | 0.4                           | 0.2                  | 4.0                    | 4.8                        | 3.7                                   | 3.9                                   |
| Lodging & restaurant             | 13.4                       | 4.0                           | 2.5                  | 8.4                    | 5.0                        | 11.3                                  | 10.9                                  |
| Leisure                          | 1.5                        | 0.4                           | 0.2                  | 1.2                    | 1.1                        | 1.3                                   | 1.3                                   |
| Repair & other personal services | 2.4                        | 0.5                           | 0.2                  | 3.2                    | 4.9                        | 3.9                                   | 3.9                                   |
| ICT service                      | 5.1                        | 0.7                           | 0.3                  | 4.4                    | 6.3                        | 5.3                                   | 5.2                                   |
| Science & technology service     | 2.8                        | 0.7                           | 0.4                  | 10.9                   | 8.3                        | 10.5                                  | 11.2                                  |
| Business facility management     | 0.6                        | 0.1                           | 0.0                  | 1.5                    | 3.7                        | 1.0                                   | 1.1                                   |
| Banking & insurance              | 4.4                        | 0.7                           | 0.3                  | 3.1                    | 2.8                        | 2.9                                   | 3.0                                   |
| Industry             | Number of establishments (%) | New establishments (%) | Establishment closures (%) | UB applicants (%) | EI subscribers (%) | EI new subscribers (%) | People who lost EI subscription (%) |
|----------------------|------------------------------|------------------------|---------------------------|-------------------|-------------------|------------------------|-------------------------------------|
| Real estate          | 3.0                          | 0.6                    | 0.3                       | 2.4               | 3.7               | 4.6                    | 2.4                                |
| Education            | 6.6                          | 0.6                    | 0.5                       | 9.5               | 13.0              | 17.4                   | 14.2                               |
| Health & social work | 3.4                          | 0.7                    | 0.3                       | 2.2               | 2.5               | 2.7                    | 2.5                                |

Note: We show the proportion of each industry over the sum of each variable in the 14 industry sectors.

Abbreviations: EI, employment insurance; ICT, information and communications technology; UB, unemployment benefits.
The time trend in Table 2 also shows that despite the COVID-19 pandemic, the numbers of establishments, new establishments, and EI subscribers increased, compared with those in the pre-COVID-19 period. However, new EI subscribers decreased during the COVID-19 period, and there is a surge in the number of UB applicants in 2020H1. Hence, these statistics do not clearly depict the impact of COVID-19 on establishments, and we will implement a more systemic empirical analysis to identify the COVID-19 effect in Section 4.

Table 4 shows how cumulative COVID-19 confirmed cases change over time. In March and June 2020, the average cumulative COVID-19 confirmed cases per 1000 population in a province was around 0.20–0.23, with a standard deviation of approximately 0.6 each month. The maximum number of cumulative confirmed cases per 1000 population in June 2020 was 2.637 in Daegu, and the minimum was 0.011 in Jeonnam. In the extended period, the average 6-month cumulative cases dropped to 0.16 with a standard deviation of 0.485 in September 2020 due to the small number of confirmed cases from April to July 2020, despite the second wave in August and September 2020. However, during the third wave, which started in November 2020, the average cumulative cases increased substantially in December 2020.

In addition, we show additional statistics about gender and education differences in employment by establishment size, using the 2019 Economically Active Population Survey in Korea. The proportion of male employment in establishments with 300 or more workers is relatively high, while women work more in establishments with fewer than 10 workers, as shown in Figure 3a. Regarding the education level, Figure 3b demonstrates that high school graduates and college graduates are disproportionately employed by establishment size in Korea.

**Table 4** Summary statistics: COVID-19 regional trend in Korea

| Variable | Early phase |       |       |       |
|----------|-------------|-------|-------|-------|
|          | Mar 2020    | Jun 2020 | Overall |
| Cumulative COVID-19 confirmed cases per 1000 population in 6 months |
| Mean     | 0.206       | 0.237  | 0.160  |
| (SD)     | (0.615)     | (0.628) | (0.514) |
| Maximum  | 2.554       | 2.637  | 2.637  |
| (Province) | (Daegu)    | (Daegu) | (Daegu) |
| Minimum  | 0.005       | 0.011  | 0.000  |
| (Province) | (Jeonnam)  | (Jeonnam) | (Jeonnam) |
|          | Extended period | Sep 2020 | Dec 2020 | Overall |
| Cumulative COVID-19 confirmed cases per 1000 population in 6 months |
| Mean     | 0.160       | 0.621  | 0.503  |
| (SD)     | (0.118)     | (0.360) | (0.517) |
| Maximum  | 0.485       | 1.793  | 2.688  |
| (Province) | (Seoul)    | (Seoul) | (Seoul) |
| Minimum  | 0.313       | 0.275  | 0.017  |
| (Province) | (Gyeongnam)| (Sejong) | (Jeonnam) |

Notes: Summary statistics for cumulative COVID-19 confirmed cases per 1000 population for the latest 6 months are shown. Standard deviations (SDs) are in parentheses below means, and provinces that have minimum (maximum) values are in brackets below the corresponding minimum (maximum).
We estimate the effects of the COVID-19 pandemic on establishments and their employment by establishment size and industry in the early phase of COVID-19 up to June 2020, using the following model:

$$\log Y_{it} = \beta_1 \text{COVID}_{it} + \beta_2 \log pop_{it} + \gamma_i + \delta_t + f_i(t) + \epsilon_{it},$$

(1)

**FIGURE 3** Gender and skill differences in employment by establishment size. Notes: Data from 2019 Economically Active Population Survey. Six different levels of establishment size in terms of the number of employees (all, 1–9, 10–49, 50–99, 100–299, and 300 or more) are shown in the x-axis. (a) Gender differences in employment by establishment size and (b) skill differences in employment by establishment size

4 | EMPIRICAL STRATEGY

We estimate the effects of the COVID-19 pandemic on establishments and their employment by establishment size and industry in the early phase of COVID-19 up to June 2020, using the following model:
where $Y_{it}$ represents establishment and employment outcomes in province $i$ at time $t$, such as the number of establishments, the number of new establishments, the number of establishment closures, the number of applicants for UB, the number of EI subscribers, the number of new EI subscribers, and the number of people who lose the EI subscription. Note that we take the logarithm of all the outcome variables. The key explanatory variable $\text{COVID}_{it}$ is the number of cumulative COVID-19 confirmed cases per 1000 population in province $i$ at time $t$. The variable $\text{pop}_{it}$ represents the population in province $i$ at time $t$. We control for province fixed effects $\gamma_i$ and time fixed effects $\delta_t$ by including year and calendar month fixed effects, respectively. Specifically, we estimate Equation (1) by panel fixed effects estimation with 3-year dummies corresponding to 2018, 2019, and 2020, and 11 calendar month dummies, from February to December (January 2017 as a baseline), capturing seasonality in the outcome variables, which is common across provinces. In addition, we include $f_i(t)$ that represents province-specific time trends in the outcome variables. We specify $f_i(t)$ as both linear and quadratic functions of $t$, allowing that each outcome variable in each province has its own province-specific linear or quadratic time trend. The last variable, $\varepsilon_{it}$ represents an idiosyncratic error term.

For each dependent variable, we first estimate model (1) by establishment size. That is, we estimate the equation for each outcome variable, aggregated over all the establishments in each province, and then five more times for different levels of aggregation by establishment size (1–9, 10–49, 50–99, 100–299, and 300 or more employees). Next, we estimate the same equation by industry to investigate heterogeneous COVID-19 effects.

The main parameter of interest in the model is $\beta_1$. Given the log-level specification, if there is a one-unit increase in the number of confirmed cases per 1000 people, there will be a $100\beta_1\%$ change in the outcome variables. Alternatively, if there is a one-standard-deviation increase, say $\sigma$, in the confirmed cases, there will be a $100\sigma\beta_1$ change in the outcome variable. After controlling for the fixed effects and province-specific time trends, we estimate the parameter $\beta_1$ by comparing changes in the deviation of each outcome variable from its provincial time trend according to changes in the number of COVID-19 cases across different provinces after adjusting year and month effects that are common for all provinces.

Intuitively, the fact that we consider the deviation of an outcome variable from its provincial time trend and time fixed effects excludes the nationwide COVID-19 impact on establishments from our estimated effect. The nationwide impact could be originated from various channels, such as a global recession and reduced social activities all over the country. Thus, our empirical strategy identifies the effect of the regional intensity of COVID-19 on local establishments and (un)employment, separately from the overall COVID-19 effect that all provinces share as a base effect of the COVID-19 global pandemic. The main mechanism by which the regional spread of COVID-19 affects local establishments and employment is that people in highly infected areas further reduce socioeconomic activities, causing damage to the local economy. Identifying the local COVID-19 effect is important because most countries introduce public health interventions targeted to highly infected areas (Chudik et al., 2020).

5 | RESULTS ON HETEROGENEOUS COVID-19 EFFECTS BY SIZE

In this section, we first present our empirical results on the impact of the regional COVID-19 infection rate on establishment outcomes during the early phase of COVID-19, using data from January 2017 to June 2020. Then, we show our results on employment outcomes in Section 6. For each type of outcome, for example, establishments or employment, we discuss establishment-size heterogeneity in COVID-19 effects first and then industry heterogeneity.

5.1 | Establishment results by size

Table 5 reports estimation results for the establishment outcomes. In this table, we run two empirical specifications for each dependent variable. We first control for only provincial linear time trends (columns 1, 3, and 5), and then
control for both linear and quadratic time trends (columns 2, 4, and 6). We find that our key findings are mostly similar across two specifications, and thus, we will only report results from the model with the linear trend from the following table.

First, we find that the number of establishments in a province decreases by 0.5%–1.5% as the number of confirmed cases per 1000 people increases by one. Alternatively, a one-standard-deviation increase in the cumulative cases, which is around 0.6, leads to a 0.3%–0.9% increase in the number of establishments. Recall that the most highly infected province, Daegu, has approximately 2.6 cumulative cases per 1000 population in June 2020 (Table 4). Thus, the number of establishments declines up to 3.9% if a province has the same extent of the local outbreak as Daegu.

Panels B–F of Table 8 strongly indicate that the overall decline in the number of establishments by COVID-19 is from establishments with fewer than 10 workers. A one-unit increase in the number of cumulative confirmed cases in a given province leads to a decline in the number of establishments with fewer than 10 workers by 0.6%–1.8%. By contrast, the number of establishments of larger size in a province is not significantly affected by the regional intensity of COVID-19 in the province. This finding is in line with previous findings in the literature that small businesses' performance is worse than larger firms during a recession or economic crisis (Peric & Vitezic, 2016).

Next, we try to decompose the decrease in the number of small establishments by the regional spread of COVID-19 into two potential channels: a decrease in the creation of new establishments and an increase in the closure of existing establishments. This scrutinized analysis is essential in understanding how the COVID-19 pandemic affects businesses and deriving policy implications. Columns (3) and (4) of Table 5 show that the number of new establishments in a province decreases by 4.9%–6.2% with a one-unit increase in the number of cumulative cases. It is important to emphasize that regardless of establishment size, the creation of new establishments decreases significantly when a province has a larger number of cumulative COVID-19 cases. We also find that the regional spread of COVID-19 gives rise to a surge in establishment closures. Columns (5) and (6) of Table 5 show a consistent positive relationship between the number of COVID-19 confirmed cases and the number of establishment closures for small establishments.

Table 5 clearly shows that regions with more cumulative COVID-19 cases have a more considerable reduction in the number of new small business startups and a significant increase in the closures of small establishments. Bartik et al. (2020) and Humphries et al. (2020) find descriptive evidence from their surveys that small business owners expect the COVID-19 crisis to last two or more years, resulting in business closures in the United States. Our empirical findings on the decrease in new startups and the increase in business closures could also reflect that Korean small business entrepreneurs may form a similar expectation about the COVID-19 pandemic.

5.2 | Employment results by size

Section 5.1 shows evidence that small establishments were hit harder by the regional spread of COVID-19 at the extensive margin, resulting in more establishment closures or fewer establishment creations. However, establishments in the local economy can also respond to COVID-19 at the intensive margin by adjusting employment size. Table 6 shows the effects of COVID-19 confirmed cases on employment outcomes, such as the numbers of applicants for UB, the number of EI subscribers, by establishment size.

In panel A of Table 6, column (1) shows that the number of UB applicants in a province increases by 3.4%, with a one-unit increase in the number of cumulative confirmed cases. Recall that when a worker who works at a firm where EI subscription is eligible loses their job, the worker can apply for UB. Thus, the number of applicants for UB

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6Eligibility conditions for UB in South Korea are as follows: (1) enrolled in EI for more than 180 days over the past 18 months before the turnover date, (2) cannot get a job despite willingness and ability to work, (3) make active efforts for reemployment, and (4) lose a job involuntarily.
is closely related to the number of unemployed. The employment termination due to the COVID-19 regional spread occurs most in small establishments with fewer than 10 employees. The regional spread of COVID-19 also leads to significant job losses in most of the establishments of different sizes except for establishments with more than 300 employees. By contrast, job losses in establishments with more than 300 employees declined after the COVID-19 regional spread. Our result is consistent with findings in the recent literature on the negative impact of COVID-19 on the labor market (e.g., Cajner et al., 2020), and we expand such findings to the local labor market.

We analyze the impact of the regional intensity of COVID-19 on the numbers of EI subscribers, new subscribers, and people who lost their EI in columns (2)–(4). Because all workers in establishments with one or more employees are obligated to subscribe to EI, except for a few exceptions, the number of EI subscribers is another good indicator of the employment situation. A worker obtains a subscription to EI after an establishment hires the worker. In column (2), we find that EI subscribers in establishments with less than 50 workers decrease significantly as the cumulative cases increase in a province. Similar results hold for the number of new EI subscribers. Combining with the results from the establishment analysis, we can infer that COVID-19 affects the local labor market

| Panel A. Establishment size: All | | | | | | |
| COVID-19 confirmed cases | -0.005** | -0.015** | -0.049*** | -0.062*** | 0.060** | 0.066** |
| | (0.002) | (0.006) | (0.014) | (0.018) | (0.024) | (0.028) |

| Panel B. Establishment size: 1–9 workers | | | | | | |
| COVID-19 confirmed cases | -0.006** | -0.018** | -0.048*** | -0.061*** | 0.057** | 0.067** |
| | (0.002) | (0.006) | (0.014) | (0.019) | (0.026) | (0.030) |

| Panel C. Establishment size: 10–49 workers | | | | | | |
| COVID-19 confirmed cases | -0.001 | 0.004 | -0.072*** | -0.103*** | 0.086*** | 0.038 |
| | (0.002) | (0.003) | (0.009) | (0.015) | (0.013) | (0.022) |

| Panel D. Establishment size: 50–99 workers | | | | | | |
| COVID-19 confirmed cases | -0.004 | -0.002 | -0.081** | -0.083* | 0.185*** | 0.027 |
| | (0.003) | (0.004) | (0.032) | (0.041) | (0.028) | (0.038) |

| Panel E. Establishment size: 100–299 workers | | | | | | |
| COVID-19 confirmed cases | 0.005 | -0.010*** | -0.275*** | -0.356*** | 0.163*** | 0.076** |
| | (0.003) | (0.002) | (0.027) | (0.025) | (0.027) | (0.034) |

| Panel F. Establishment size: 300 or more workers | | | | | | |
| COVID-19 confirmed cases | 0.008 | -0.011 | -0.068 | -0.016 | 0.026 | -0.084* |
| | (0.005) | (0.011) | (0.046) | (0.058) | (0.030) | (0.042) |

| Province-level linear trend | Y | Y | Y | Y | Y | Y |
| Province-level quadratic trend | N | Y | N | Y | N | Y |
| Observations | 714 | 714 | 714 | 714 | 714 | 714 |

***p < 0.01; **p < 0.05; *p < 0.1.
negatively in small- and medium-sized establishments through the reduction of new establishments, the increase in establishment closures, and layoffs in continuing establishments. In column (4), we present estimation results for the number of people who lose EI. The subscription to EI is lost if a worker no longer works in the establishment. Even if the worker’s employment contract is terminated due to voluntary turnover, the EID system counts it as a loss of EI in the establishment. The number of people who lose their EI decreases in establishments with fewer than 100 employees as the number of cumulative COVID-19 cases increases. This result may seem contradictory to our findings in column (1) that the regional intensity of COVID-19 increases the number of applicants for UB in small establishments. However, the

TABLE 6  Heterogeneous effects of COVID-19 on the local labor market by establishment size

| Panel A. Establishment size: All | Number of UB applicants | Number of EI subscribers | Number of new EI subscribers | Number of people who lost the EI subscription |
|----------------------------------|--------------------------|--------------------------|------------------------------|---------------------------------------------|
| COVID-19 confirmed cases         | 0.034***                 | -0.005***                | -0.007                       | -0.025**                                    |
|                                  | (0.012)                  | (0.001)                  | (0.007)                      | (0.011)                                      |

| Panel B. Establishment size: 1–9 workers | Number of UB applicants | Number of EI subscribers | Number of new EI subscribers | Number of people who lost the EI subscription |
|-----------------------------------------|--------------------------|--------------------------|------------------------------|---------------------------------------------|
| COVID-19 confirmed cases                | 0.073***                 | -0.011***                | -0.073***                    | -0.026***                                   |
|                                          | (0.013)                  | (0.002)                  | (0.004)                      | (0.005)                                      |

| Panel C. Establishment size: 10–49 workers | Number of UB applicants | Number of EI subscribers | Number of new EI subscribers | Number of people who lost the EI subscription |
|-------------------------------------------|--------------------------|--------------------------|------------------------------|---------------------------------------------|
| COVID-19 confirmed cases                | 0.044**                  | -0.006***                | -0.038***                    | -0.050***                                   |
|                                          | (0.016)                  | (0.002)                  | (0.012)                      | (0.010)                                      |

| Panel D. Establishment size: 50–99 workers | Number of UB applicants | Number of EI subscribers | Number of new EI subscribers | Number of people who lost the EI subscription |
|-------------------------------------------|--------------------------|--------------------------|------------------------------|---------------------------------------------|
| COVID-19 confirmed cases                | 0.053***                 | 0.000                    | -0.017                       | -0.062***                                   |
|                                          | (0.017)                  | (0.005)                  | (0.013)                      | (0.017)                                      |

| Panel E. Establishment size: 100–299 workers | Number of UB applicants | Number of EI subscribers | Number of new EI subscribers | Number of people who lost the EI subscription |
|------------------------------------------------|--------------------------|--------------------------|------------------------------|---------------------------------------------|
| COVID-19 confirmed cases                | 0.061**                  | -0.004                   | 0.133***                     | 0.029                                       |
|                                          | (0.024)                  | (0.005)                  | (0.016)                      | (0.023)                                      |

| Panel F. Establishment size: 300 or more workers | Number of UB applicants | Number of EI subscribers | Number of new EI subscribers | Number of people who lost the EI subscription |
|------------------------------------------------|--------------------------|--------------------------|------------------------------|---------------------------------------------|
| COVID-19 confirmed cases                | -0.090***                | 0.006***                 | 0.090***                     | 0.015                                       |
|                                          | (0.028)                  | (0.002)                  | (0.021)                      | (0.027)                                      |

Observations: 714 714 714 714

Notes: We take the logarithm of all the outcome variables. All models commonly control for the logarithm of the population in each province, province fixed effects, year fixed effects, month fixed effects, and province-level linear time trend. Each column in each panel corresponds to a result from a single regression specification. For example, column (1) in panel A shows the COVID-19 coefficient estimate from the regression of the log number of applicants for UB in establishments of any size on the COVID-19 confirmed cases and controls. Standard errors are clustered at the province level. Abbreviations: EI, employment insurance; UB, unemployment benefits.

***p < 0.01; **p < 0.05; *p < 0.1.
number of people who lose their EI may decrease after COVID-19 because of a decline in job mobility in relatively small establishments.

To further investigate why the number of people who lose their insurance subscriptions decreases, we use the data on reasons for losing EI. When a worker quits a job in an establishment, the employer has to report a reason for the worker's loss of EI. Utilizing the information in the EID, we analyze the COVID-19 effect on the number of losses of EI by each of the following reasons: (1) voluntary resignation due to a personal circumstance (voluntary resignation I); (2) voluntary resignation due to relocation of a workplace, changes in working conditions, or overdue wages (voluntary resignation II); (3) downsizing due to management needs or recession; and (4) business closure, construction completion, or contract expiration. We estimate the effect of the number of COVID-19 confirmed cases per 1000 on the log of the number of insurance losers, categorized by the above four reasons.

Column (1) of Table 7 shows that the number of insurance losses by voluntary resignation due to a personal circumstance decreases by 6.0% as the number of cumulative cases increases by one unit. The establishment-size analysis further indicates that the EI losses attributed to voluntary resignation I significantly decrease in all establishments with fewer than 300 employees. Similarly, in column (2), we find that the number of employment losses by voluntary resignation due to nonpersonal reasons also decreases by 8.3%. The reduction is large and statistically significant in establishments with 1–9 and 50–99 employees. By contrast, column (3) in Table 7 shows that the number of people who lose insurance by downsizing increases in establishments with fewer than 300 employees. Likewise, column (4) finds that the number of people who lose insurance because of business closures, construction completion, or contract expiration increases overall. The increase mainly occurred at establishments with fewer than 10 employees and those with 100 or more employees. Table 7 reveals that the decrease in the number of people who lose EI after the regional spread of COVID-19 in Table 6 is mainly the consequence of reduced voluntary turnover. Thus, we interpret the decrease in the loss of EI as a marked decrease in job mobility, possibly due to decreased job openings on the demand side (Forsythe et al., 2020) and reduced job search on the supply side (Hensvik et al., 2021).

6 | RESULTS ON HETEROGENEOUS COVID-19 EFFECTS BY INDUSTRY

6.1 | Establishment results by industry

In Section 5, we find that the local outbreaks of COVID-19 affect small and large establishments disproportionately. In addition, as the regional intensity of COVID-19 increases, people voluntarily reduce activities, and the government imposes social distancing policies to prevent infection. Such behavioral changes may have different implications in different industries. To see this, we estimate Equation (1) for each outcome variable by industry.

In column (1) of Table 8, we find that COVID-19 influences negatively and significantly eight industries: manufacturing, construction, wholesale & retail, transportation & warehousing, lodging & restaurant, leisure, education, and health & social work. In these sectors, establishments decrease by 0.3%–1.3% after a one-unit increase in the cumulative COVID-19 cases within an area. The negative effect is particularly strong in industries that require face-to-face operations to run their businesses, such as lodging & restaurant and leisure.

Next, we try to decompose the negative effect of COVID-19 on establishments into changes in establishment creations or closures in columns (2) and (3). We find that the effect is mainly driven by the decrease in new establishments, particularly in manufacturing, wholesale & retail, lodging & restaurant, and education industries. By contrast, a rise in establishment closures is the main reason in the health & social work industry. In the construction industry, COVID-19 affects both establishment creation and closure.

Interestingly, we find mixed results in the COVID-19 effects on establishment closures. While the number of closed establishments rises after COVID-19 local outbreaks in some sectors, such as construction, and repair
& personal services, COVID-19 reduces establishment closures in several other industries, for example, manufacturing, science & technology services, and education. This result may indicate that industries respond to COVID-19 with different business strategies because of their differences in fixed-cost investments, expectations on how long the COVID-19 pandemic lasts, and operational strategies (e.g., work from home and online sales). For example, establishments in the manufacturing industry do not want to close within a few months after the COVID-19 pandemic because of their high level of fixed-cost investments. Finally, COVID-19 reduces new

| Panel A. Establishment size: All |  |  |  |  |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
| COVID-19 confirmed cases        | Voluntary resignation I | Voluntary resignation II | Downsizing | Business closures |
|                                 | –0.060***        | –0.083***        | 0.069***       | 0.068***        |
|                                 | (0.013)          | (0.026)          | (0.014)        | (0.012)         |

| Panel B. Establishment size: 1–9 workers |  |  |  |  |
|-----------------------------------------|-----------------|-----------------|-----------------|-----------------|
| COVID-19 confirmed cases                | Voluntary resignation I | Voluntary resignation II | Downsizing | Business closures |
|                                         | –0.069***        | –0.161***        | 0.073***       | 0.047***        |
|                                         | (0.011)          | (0.029)          | (0.013)        | (0.016)         |

| Panel C. Establishment size: 10–49 workers |  |  |  |  |
|--------------------------------------------|-----------------|-----------------|-----------------|-----------------|
| COVID-19 confirmed cases                   | Voluntary resignation I | Voluntary resignation II | Downsizing | Business closures |
|                                            | –0.067***        | 0.004           | 0.055***       | –0.007          |
|                                            | (0.014)          | (0.033)         | (0.014)        | (0.013)         |

| Panel D. Establishment size: 50–99 workers |  |  |  |  |
|-------------------------------------------|-----------------|-----------------|-----------------|-----------------|
| COVID-19 confirmed cases                  | Voluntary resignation I | Voluntary resignation II | Downsizing | Business closures |
|                                          | –0.055***        | –0.378***        | 0.067          | –0.086***       |
|                                          | (0.016)          | (0.068)         | (0.038)        | (0.030)         |

| Panel E. Establishment size: 100–299 workers |  |  |  |  |
|---------------------------------------------|-----------------|-----------------|-----------------|-----------------|
| COVID-19 confirmed cases                    | Voluntary resignation I | Voluntary resignation II | Downsizing | Business closures |
|                                             | –0.051**         | 0.144*           | 0.153***      | 0.191***        |
|                                             | (0.022)          | (0.081)        | (0.034)        | (0.042)         |

| Panel F. Establishment size: 300 or more workers |  |  |  |  |
|--------------------------------------------------|-----------------|-----------------|-----------------|-----------------|
| COVID-19 confirmed cases                         | Voluntary resignation I | Voluntary resignation II | Downsizing | Business closures |
|                                                | 0.015            | 0.013           | –0.087         | 0.074**         |
|                                                | (0.013)          | (0.095)         | (0.083)        | (0.031)         |

| Observations | 714 | 714 | 714 | 714 |

Notes: Each category of reasons includes the following. Voluntary resignation I: voluntary resignation due to a personal circumstance; Voluntary resignation II: voluntary resignation due to relocation of a workplace, changes in working conditions, or overdue wages; Downsizing: downsizing due to management needs or recession; Business closures: business closure, construction completion, or contract expiration. All models commonly control for the logarithm of the population in each province, province fixed effects, year fixed effects, month fixed effects, and province-specific linear time trends. Each column in each panel corresponds to a result from a single regression specification. For example, column (1) in panel A shows the COVID-19 coefficient estimate from the regression of the log number of people who lose employment insurance because of voluntary resignation on the COVID-19 confirmed cases and controls. Standard errors are in the parentheses, clustered at the province level. Abbreviation: EI, employment insurance.

***p < 0.01; **p < 0.05; *p < 0.1.
| Industry 1. Manufacturing | COVID-19 confirmed cases | \(-0.003***\) | \(-0.045***\) | \(-0.071***\) |
|--------------------------|--------------------------|----------------|----------------|----------------|
|                          |                          | \(0.001\)      | \(0.013\)      | \(0.023\)      |

| Industry 2. Construction | COVID-19 confirmed cases | \(-0.019^*\) | \(-0.041^{**}\) | \(0.097^{**}\) |
|--------------------------|--------------------------|----------------|----------------|----------------|
|                          |                          | \(0.009\)      | \(0.016\)      | \(0.026\)      |

| Industry 3. Wholesale & retail | COVID-19 confirmed cases | \(-0.003^*\) | \(-0.061^{***}\) | \(0.000\) |
|--------------------------------|--------------------------|----------------|----------------|----------------|
|                                |                          | \(0.002\)      | \(0.016\)      | \(0.020\)      |

| Industry 4. Transportation & warehousing | COVID-19 confirmed cases | \(-0.006^{***}\) | \(-0.023\) | \(0.019\) |
|------------------------------------------|--------------------------|----------------|----------------|----------------|
|                                          |                          | \(0.001\)      | \(0.021\)      | \(0.051\)      |

| Industry 5. Lodging & restaurant | COVID-19 confirmed cases | \(-0.013^{***}\) | \(-0.128^{***}\) | \(-0.029\) |
|----------------------------------|--------------------------|----------------|----------------|----------------|
|                                  |                          | \(0.002\)      | \(0.019\)      | \(0.018\)      |

| Industry 6. Leisure | COVID-19 confirmed cases | \(-0.013^{***}\) | \(-0.028\) | \(0.036\) |
|---------------------|--------------------------|----------------|----------------|----------------|
|                     |                          | \(0.003\)      | \(0.020\)      | \(0.026\)      |

| Industry 7. Repair & other personal services | COVID-19 confirmed cases | \(-0.003\) | \(-0.009\) | \(0.092^{***}\) |
|-----------------------------------------------|--------------------------|----------------|----------------|----------------|
|                                               |                          | \(0.002\)      | \(0.033\)      | \(0.028\)      |

| Industry 8. ICT service | COVID-19 confirmed cases | \(0.001\) | \(0.003\) | \(0.023\) |
|-------------------------|--------------------------|----------------|----------------|----------------|
|                         |                          | \(0.001\)      | \(0.010\)      | \(0.028\)      |

| Industry 9. Science & technology service | COVID-19 confirmed cases | \(-0.000\) | \(0.001\) | \(-0.068^{***}\) |
|-----------------------------------------|--------------------------|----------------|----------------|----------------|
|                                         |                          | \(0.002\)      | \(0.015\)      | \(0.023\)      |

| Industry 10. Business facility management | COVID-19 confirmed cases | \(-0.001\) | \(-0.260^{***}\) | \(-0.037\) |
|------------------------------------------|--------------------------|----------------|----------------|----------------|
|                                          |                          | \(0.002\)      | \(0.044\)      | \(0.033\)      |

| Industry 11. Banking & insurance | COVID-19 confirmed cases | \(0.002\) | \(-0.074^{***}\) | \(0.068^{**}\) |
|---------------------------------|--------------------------|----------------|----------------|----------------|
|                                 |                          | \(0.002\)      | \(0.014\)      | \(0.023\)      |
establishments in the business facility management and real estate industries, but not the number of establishments. While the result may seem contradictory, it is possible if the proportion of new establishments over the existing ones is small.

6.2 | Employment results by industry

Next, we examine the differential effects of the regional intensity of COVID-19 on employment outcomes by industry. From column (1) of Table 9, we find that COVID-19 strongly impacts the number of UB applicants in the manufacturing, construction, lodging & restaurant, repair & other personal services, real estate, education, and health & social work industries. In Section 6.1, we have seen that at least one establishment outcome in these industries is also strongly affected. The effect on the number of UB applicants is the most substantial in the lodging & restaurant industry, where work at home is known to be most difficult (Adams-Prassl et al., 2020).

In columns (2) and (3), the numbers of subscribers and new subscribers in many industry sectors are declined after local COVID-19 outbreaks. Particularly, 9 out of the 14 industries experience a substantial decrease in new employment. Specifically, there is an approximately 10% decreases in the number of new subscribers in the lodging & restaurant, leisure, transportation & warehousing, and education industries after a one-unit increase in cumulative COVID-19 cases in a province. Again, these industries require face-to-face contact to run their businesses.7

In the education industry, face-to-face contact is essential for teaching younger students.
TABLE 9  Heterogeneous effects of COVID-19 on the local labor market by industry

| Industry                          | COVID-19 confirmed cases | (1) | (2) | (3) | (4) |
|-----------------------------------|--------------------------|-----|-----|-----|-----|
| **Dependent variable: The natural logarithm of** |                           | (1) | (2) | (3) | (4) |
| **Number of UB applicants**       |                          |     |     |     |     |
| **Number of EI subscribers**      |                          |     |     |     |     |
| **Number of new EI subscribers**  |                          |     |     |     |     |
| **Number of people who lost the EI subscription** |                      |     |     |     |     |
| **Industry 1. Manufacturing**     |                          |     |     |     |     |
| COVID-19 confirmed cases          | 0.031*                   | -0.001 |     | -0.098*** | -0.039** |
|                                   | (0.016)                  | (0.002) | (0.020) | (0.018) |     |
| **Industry 2. Construction**      |                          |     |     |     |     |
| COVID-19 confirmed cases          | 0.047**                  | -0.003* | -0.007 | 0.000 |
|                                   | (0.018)                  | (0.001) | (0.006) | (0.004) |     |
| **Industry 3. Wholesale & retail**|                          |     |     |     |     |
| COVID-19 confirmed cases          | 0.020                    | -0.000 | -0.054*** | -0.037*** |
|                                   | (0.013)                  | (0.002) | (0.005) | (0.008) |     |
| **Industry 4. Transportation & warehousing** |            |     |     |     |     |
| COVID-19 confirmed cases          | -0.005                   | 0.005* | -0.122*** | -0.086*** |
|                                   | (0.017)                  | (0.002) | (0.012) | (0.011) |     |
| **Industry 5. Lodging & restaurant** |                          |     |     |     |     |
| COVID-19 confirmed cases          | 0.143***                 | -0.017*** | -0.099*** | -0.044*** |
|                                   | (0.021)                  | (0.003) | (0.017) | (0.011) |     |
| **Industry 6. Leisure**           |                          |     |     |     |     |
| COVID-19 confirmed cases          | 0.006                    | -0.026*** | -0.114*** | -0.038** |
|                                   | (0.026)                  | (0.007) | (0.024) | (0.017) |     |
| **Industry 7. Repair & other personal services** | |     |     |     |     |
| COVID-19 confirmed cases          | 0.058***                 | 0.003 | -0.062*** | -0.029 |
|                                   | (0.013)                  | (0.005) | (0.016) | (0.026) |     |
| **Industry 8. ICT service**       |                          |     |     |     |     |
| COVID-19 confirmed cases          | 0.002                    | -0.011*** | -0.058*** | -0.070*** |
|                                   | (0.016)                  | (0.002) | (0.012) | (0.013) |     |
| **Industry 9. Science & technology service** |            |     |     |     |     |
| COVID-19 confirmed cases          | 0.010                    | 0.010 | 0.016 | -0.056*** |
|                                   | (0.030)                  | (0.020) | (0.015) | (0.013) |     |
| **Industry 10. Business facility management** |            |     |     |     |     |
| COVID-19 confirmed cases          | -0.009                   | -0.006*** | -0.005 | -0.072** |
|                                   | (0.012)                  | (0.001) | (0.035) | (0.027) |     |
Adams-Prassl et al. (2020) and Papanikolaou and Schmidt (2020) also find that COVID-19 has strong adverse effects on employment in these industries. While the magnitude is relatively small, regional COVID-19 outbreaks also negatively affect other industries, such as ICT services. In column (4), we find the negative coefficient of COVID-19 on the number of people who lose EI subscriptions for all industries except construction, and the negative estimates are significant in 10 industries. This result suggests that job mobility has worsened in most industries after the local outbreaks of COVID-19.

Overall, our results indicate that the regional spread of COVID-19 deteriorates the local economy by reducing workplace creation, new employment, and job mobility rather than raising establishment closures. Also, there is industry heterogeneity in which economic outcomes are affected by local COVID-19 outbreaks. For example, COVID-19 negatively affects both establishment and employment outcomes in industries that require face-to-face operations or where work from home is relatively difficult, such as lodging & restaurant. By contrast, only employment outcomes are affected in the ICT service industry. Our results are in line with inequality or heterogeneity in the effects of COVID-19 across industries or occupations in other countries (e.g., Adams-Prassl et al., 2020; Barrero et al., 2020; Papanikolaou & Schmidt, 2020). In addition, our results suggest that industries affected at the workplace level are different from those affected at the employment level.

**TABLE 9** (Continued)

| Dependent variable: The natural logarithm of | (1) | (2) | (3) | (4) |
| Number of UB applicants | Number of EI subscribers | Number of new EI subscribers | Number of people who lost the EI subscription |
| Industry 11. Banking & insurance | 0.011 | 0.001 | −0.029** | −0.020 |
| COVID-19 confirmed cases | (0.014) | (0.002) | (0.010) | (0.013) |
| Industry 12. Real estate | 0.090*** | 0.005 | 0.076*** | −0.015 |
| COVID-19 confirmed cases | (0.021) | (0.009) | (0.016) | (0.019) |
| Industry 13. Education | 0.052*** | 0.002* | −0.095*** | −0.082*** |
| COVID-19 confirmed cases | (0.008) | (0.001) | (0.018) | (0.024) |
| Industry 14. Health & social work | 0.041* | 0.006 | 0.054** | −0.096*** |
| COVID-19 confirmed cases | (0.021) | (0.004) | (0.024) | (0.012) |

Notes: We take the logarithm of all the outcome variables. All models commonly control for the logarithm of the population in each province, province fixed effects, year fixed effects, month fixed effects, and province-level linear time trend. Each column in each panel corresponds to a result from a single regression specification. For example, column (1) in panel A shows the COVID-19 coefficient estimate from the regression of the log number of applicants for UB in the manufacturing industry on the COVID-19 confirmed cases and controls. Standard errors are in the parentheses, clustered at the province level.

Abbreviations: EI, employment insurance; ICT, information and communications technology; UB, unemployment benefits.

***p < 0.01; **p < 0.05; *p < 0.1.

Adams-Prassl et al. (2020) and Papanikolaou and Schmidt (2020) also find that COVID-19 has strong adverse effects on employment in these industries. While the magnitude is relatively small, regional COVID-19 outbreaks also negatively affect other industries, such as ICT services. In column (4), we find the negative coefficient of COVID-19 on the number of people who lose EI subscriptions for all industries except construction, and the negative estimates are significant in 10 industries. This result suggests that job mobility has worsened in most industries after the local outbreaks of COVID-19.

Overall, our results indicate that the regional spread of COVID-19 deteriorates the local economy by reducing workplace creation, new employment, and job mobility rather than raising establishment closures. Also, there is industry heterogeneity in which economic outcomes are affected by local COVID-19 outbreaks. For example, COVID-19 negatively affects both establishment and employment outcomes in industries that require face-to-face operations or where work from home is relatively difficult, such as lodging & restaurant. By contrast, only employment outcomes are affected in the ICT service industry. Our results are in line with inequality or heterogeneity in the effects of COVID-19 across industries or occupations in other countries (e.g., Adams-Prassl et al., 2020; Barrero et al., 2020; Papanikolaou & Schmidt, 2020). In addition, our results suggest that industries affected at the workplace level are different from those affected at the employment level.
7 | ROBUSTNESS CHECKS AND FURTHER ANALYSIS

7.1 | Robustness checks

We test whether the estimated results are robust to a few potential identification threats. First, we check the robustness of our results to the choice of COVID-19 measures. Note that in our analysis, we employ the number of cumulative confirmed cases per 1000 population. To check the robustness, we estimate Equation (1), using three alternative COVID-19 measures: (1) cumulative COVID-19 cases per 1000 population for the latest 3 months (including the current month $t$), (2) cumulative COVID-19 cases per 1000 population for the latest 2 months, and (3) new COVID-19 confirmed cases in a (current) month. The results in columns (1)–(3) of Table 10 show the negative effects of COVID-19 on establishments in almost the same industries as in our main results in Table 8, implying that our key findings are robust to the choice of COVID-19 measures.

Next, we consider the asymmetry in the sample period between before and after COVID-19. In our main analysis, we use 6-month data after the first case of COVID-19 in Korea, which happened on January 20, 2020, while we include pre-COVID-19 data for years 2017, 2018, and 2019 to control for the time trend in outcome variables. With this empirical design, monthly data from January to June appear one more time in the sample from January 2017 to June 2020. There may be a potential bias by having such an asymmetric sample. Hence, we run estimate Equation (1) with two alternative samples, one from July 2017 to June 2020 and the other from July 2018 to June 2020. Columns (4) and (5) of Table 10 show that the results remain mostly unchanged and that our findings are robust to the choice of sampling periods.

Third, we divide the number of establishments in each province by the province’s population each month. In column (6) of Table 10, we find that the results are almost identical to the original results, and hence, normalizing the outcome variable does not change our key findings.

Finally, we include the average cumulative COVID-19 cases in nearby provinces as an additional explanatory variable to control for potential spillover effects. Recall that we implement our analysis at the province level and that provinces are the largest regional units in Korea. Although several provincial boundaries are made up of sparsely populated areas, there are some overlapping economic boundaries between provinces, particularly for Seoul (the capital city) and its surrounding provinces (Gyeonggi and Incheon). The last column of Table 10 shows the results with this additional variable of COVID-19 cases in nearby provinces. The degree of industrial heterogeneity in the effect of COVID-19 on the number of establishments within each province remains unchanged, and therefore, we conclude that our findings are robust to potential spillover effects across provinces.

7.2 | COVID-19 in the extended period

In Sections 5 and 6, we analyze how workplaces and workers were affected by the local spread of COVID-19 during the early phase of COVID-19 in Korea, which is the period of January 2020–June 2020. As described in Section 2, we focus on the early phase of COVID-19 for the following reasons. First and most importantly, the Korean government did not employ different social and physical distancing policies by provinces until the end of June 2020. The localized social distancing policy affects both COVID-19 cases and the local economy, making it harder for researchers to identify the impact of regional intensity of COVID-19 using data in an extended period. Second, as the COVID-19 situation is prolonged, central and local governments at various levels provide a wide range of policies to stimulate the local economy. It is common that the harder the COVID-19 hit a region, the stronger policies the government implements. Thus, the negative effect of COVID-19 in an area with a high infection rate may be attenuated to some degree by various policies.


| Industry 1. Manufacturing                      | (1)   | (2)   | (3)   | (4)   | (5)   | (6)   | (7)   |
|-----------------------------------------------|-------|-------|-------|-------|-------|-------|-------|
| COVID-19 confirmed cases                      | -0.004*** | -0.004*** | -0.004** | -0.006*** | -0.006*** | -0.003*** | -0.005*** |
|                                               | (0.001) | (0.001) | (0.002) | (0.001) | (0.001) | (0.023) | (0.001) |

| Industry 2. Construction                      | (1)   | (2)   | (3)   | (4)   | (5)   | (6)   | (7)   |
|-----------------------------------------------|-------|-------|-------|-------|-------|-------|-------|
| COVID-19 confirmed cases                      | -0.004 | 0.006 | 0.035 | -0.011 | 0.016 | -0.019* | -0.034*** |
|                                               | (0.017) | (0.022) | (0.031) | (0.011) | (0.013) | (0.023) | (0.007) |

| Industry 3. Wholesale & retail                | (1)   | (2)   | (3)   | (4)   | (5)   | (6)   | (7)   |
|-----------------------------------------------|-------|-------|-------|-------|-------|-------|-------|
| COVID-19 confirmed cases                      | -0.004* | -0.003 | -0.004 | -0.009*** | -0.011*** | -0.003* | -0.003** |
|                                               | (0.002) | (0.002) | (0.003) | (0.001) | (0.001) | (0.023) | (0.002) |

| Industry 4. Transportation & warehousing      | (1)   | (2)   | (3)   | (4)   | (5)   | (6)   | (7)   |
|-----------------------------------------------|-------|-------|-------|-------|-------|-------|-------|
| COVID-19 confirmed cases                      | -0.008*** | -0.009*** | -0.012*** | -0.011*** | -0.012*** | -0.006*** | -0.007*** |
|                                               | (0.001) | (0.001) | (0.002) | (0.001) | (0.001) | (0.023) | (0.002) |

| Industry 5. Lodging & restaurant              | (1)   | (2)   | (3)   | (4)   | (5)   | (6)   | (7)   |
|-----------------------------------------------|-------|-------|-------|-------|-------|-------|-------|
| COVID-19 confirmed cases                      | -0.014*** | -0.013*** | -0.017*** | -0.021*** | -0.025*** | -0.013*** | -0.013*** |
|                                               | (0.003) | (0.003) | (0.004) | (0.002) | (0.001) | (0.023) | (0.003) |

| Industry 6. Leisure                           | (1)   | (2)   | (3)   | (4)   | (5)   | (6)   | (7)   |
|-----------------------------------------------|-------|-------|-------|-------|-------|-------|-------|
| COVID-19 confirmed cases                      | -0.013*** | -0.012*** | -0.015*** | -0.017*** | -0.016*** | -0.013*** | -0.009** |
|                                               | (0.004) | (0.004) | (0.005) | (0.003) | (0.001) | (0.023) | (0.003) |
| Industry                        | COVID-19 confirmed cases | (1)   | (2)   | (3)   | (4)   | (5)   | (6)   | (7)   |
|--------------------------------|--------------------------|-------|-------|-------|-------|-------|-------|-------|
| **Industry 7. Repair & other personal services** |                          |       |       |       |       |       |       |       |
| COVID-19 confirmed cases       | -0.003                   | -0.002| -0.001| -0.008***| -0.012***| -0.003| -0.004**|       |
|                                | (0.003)                  | (0.003)| (0.004)| (0.002)  | (0.001) | (0.023)| (0.002)|       |
| **Industry 8. ICT service**    |                          |       |       |       |       |       |       |       |
| COVID-19 confirmed cases       | 0.001                    | 0.001 | 0.000 | -0.001 | -0.002***| 0.001 | 0.002  |       |
|                                | (0.001)                  | (0.001)| (0.002)| (0.001)  | (0.001) | (0.023)| (0.001)|       |
| **Industry 9. Science & technology service** |                          |       |       |       |       |       |       |       |
| COVID-19 confirmed cases       | -0.000                   | -0.000| -0.000| -0.003* | -0.002  | -0.000| -0.000 |       |
|                                | (0.002)                  | (0.002)| (0.003)| (0.002)  | (0.002) | (0.023)| (0.002)|       |
| **Industry 10. Business facility management** |                         |       |       |       |       |       |       |       |
| COVID-19 confirmed cases       | 0.001                    | 0.003 | 0.007**| -0.004* | -0.008***| -0.001| 0.001  |       |
|                                | (0.002)                  | (0.002)| (0.003)| (0.002)  | (0.001) | (0.023)| (0.002)|       |
| **Industry 11. Banking & insurance** |                        |       |       |       |       |       |       |       |
| COVID-19 confirmed cases       | 0.003                    | 0.003 | 0.005 | -0.005**| -0.006***| 0.002 | 0.003  |       |
|                                | (0.002)                  | (0.002)| (0.003)| (0.002)  | (0.002) | (0.023)| (0.001)|       |
| **Industry 12. Real estate**  |                          |       |       |       |       |       |       |       |
| COVID-19 confirmed cases       | 0.007**                  | 0.006**| 0.007**| -0.003***| -0.011***| 0.007***| 0.007***|       |
|                                | (0.002)                  | (0.002)| (0.003)| (0.001)  | (0.000) | (0.023)| (0.002)|       |
### TABLE 10 (Continued)

| Dependent variable: The natural logarithm of the number of establishments | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| | COVID cases 3 months | COVID cases 2 months | COVID cases 1 month | Sample from July 2017 | Sample from July 2018 | Number of est. per population | Control for COVID cases in adjacent provinces |
| Industry 13. Education | | | | | | | |
| COVID-19 confirmed cases | -0.004*** | -0.004*** | -0.004*** | -0.005*** | -0.004*** | -0.004*** | -0.003*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.000) | (0.023) | (0.001) |
| Industry 14. Health & social work | | | | | | | |
| COVID-19 confirmed cases | -0.006** | -0.005** | -0.006** | -0.009*** | -0.008*** | -0.005** | -0.004* |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.001) | (0.023) | (0.002) |
| Observations | 714 | 714 | 714 | 612 | 408 | 714 | 714 |

Notes: All models commonly control for the logarithm of the population in each province, province fixed effects, year fixed effects, month fixed effects, and province-level linear time trend. The model in the last column additionally controls for the average cumulative COVID cases in adjacent provinces. For each industry, we run a separate regression equation and report the estimated coefficient of the COVID-19 confirmed cases. For example, Industry 1 in column (1) shows the COVID-19 coefficient estimate from the regression of the log number of establishments in the manufacturing industry on the COVID-19 confirmed cases for 3 months ($t$, $t−1$, and $t−2$) and controls. Standard errors are in the parentheses, clustered at the province level.

Abbreviation: ICT, information and communications technology.

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$. 


Nevertheless, it is worth considering how COVID-19 effects have evolved from the early phase of the pandemic to the extended period because establishments and workers may find a way to better adjust the COVID-19-impacted business environments. In addition, as more provinces experienced COVID-19 spread in the extended period (Figure 2), we may obtain estimates from a more considerable variation in the COVID-19 statistics. To see this, we extend the sample period by 9 months up to March 2021 and estimate Equation (1) for establishment and employment outcomes by industry.\(^8\) In this additional analysis, we use the number of cumulative COVID-19 confirmed cases per 1000 population for the latest 6 months as a COVID-19 measure to be equivalent

\(^8\)We focus on industry heterogeneity because the key findings from industry and establishment-size analyses in the extended period are similar. The results from the establishment-size analysis for the extended period are available upon request from the authors.
to our main analysis. Note that we include the observations in the early phase because our findings do not change if we exclude the early phase from the extended sample.

Figure 4a compares the effects of COVID-19 on the number of establishments by industry in the extended period with those in the early phase. The circle points represent the coefficient estimates of the COVID-19 effect for each industry in the early phase, and the corresponding solid line means the 95% confidence interval, based on Table 8. Likewise, the triangle-shaped points indicate the coefficient estimates in the extended period, and the dotted line represents the 95% confidence interval. As we have seen in Section 6.1, during the early phase, COVID-19 has negative and significant effects on the number of establishments in many industries, such as manufacturing, construction, wholesale & retail, transportation & warehousing, lodging & restaurant, leisure, education, and health & social work. By contrast, the COVID-19 effects are not significant in most industries except for lodging & restaurant, and health & social work industries in the extended period.

In Figure 4b, we compare the effects of COVID-19 on the number of UB applicants, which is closely related to unemployment. As we have shown in Section 6.2 and Table 9, manufacturing, construction, lodging & restaurant, repair & other personal services, real estate, education, and health & social work sectors exhibit a surge in the number of UB applicants after an increase in the regional intensity of COVID-19 during the early phase. However, in the extended period, we find that the COVID-19 impact remains significant only in the lodging & restaurant industry.

These results indicate that the impact of COVID-19 on many industries became insignificant as the COVID-19 period has extended. However, in some industries, particularly lodging & restaurant, which require face-to-face operations most intensely, the effect of COVID-19 still exists and is statistically significant. The 95% confidence intervals in the extended period in almost all industries become much wider than those in the early phase. The wider confidence intervals and corresponding larger standard errors may imply that the effects of COVID-19 on establishments and labor market outcomes vary more substantially across regions in the extended period, potentially because of the localized social distancing policy and economic stimulus plans.

8 | DISCUSSION AND CONCLUSION

On the basis of unique province-level establishments and employment data from the Korean Employment Insurance Database, we address how establishments and employment outcomes respond to the regional spread of COVID-19, focusing on both establishment-size and industry heterogeneity. We find that the number of small-sized establishments has decreased since the COVID-19 pandemic due to a decline in establishment entry and a surge in establishment closures. By contrast, the number of large establishments remains unaffected. In the local labor market, we find that a high COVID-19 intensity in a province raises unemployment and reduces new employment and job mobility, mainly in small- and medium-sized establishments. We also find that local COVID-19 outbreaks adversely affect establishment and employment outcomes in industries requiring face-to-face operations. The negative effects of COVID-19 tend to exist in industries more through reducing establishment creation, new employment, and job mobility than increasing establishment closures.

The deterioration of management and the decline in employment in small establishments have important implications for inequality. It is well documented that firm size and wage are positively associated (Oi & Idson, 1999; Schmidt & Zimmermann, 1991; Troske, 1999). As described in Section 3.3, the proportions of female workers and low-educated workers are significantly higher in small establishments. Thus, our finding on the decline in employment opportunities in small establishments implies that the economic conditions of female and low-educated workers may have been more deteriorated by the regional spread of COVID-19. As there is also a positive

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8 Given that we run the log-level regression model, we multiply 100 to each estimate and confidence interval to show the effects by percentage.

9 The complete estimation results for the extended period are available in Tables A1 and A2 in the appendix.
relationship between entrepreneurs’ income and the size of their businesses, measured by the number of employees in Korea (Keum & Yi, 2011), we expect employers of small-sized establishments to suffer a great deal from the pandemic and the inequality among employers could enlarge. It seems necessary to quickly implement policies that focus more on small establishments and demographic groups that have been greatly affected by the COVID-19 pandemic.

Additionally, we find that the local infection rate of COVID-19 has a substantial impact on unemployment and small establishments. The adverse effects of the regional COVID-19 spread are likely to go through the channel of demand reduction due to a decline in the frequency of physical interactions (Chetty et al., 2020; Kim & Kim, 2021). This result raises interesting future research about the short-term and long-term economic impacts of non-pharmaceutical public health interventions targeted to highly infected areas, such as lockdowns and school closures. Such interventions are likely to decrease physical interactions and yield a negative effect on local economies in the short term. However, those interventions may help reduce virus transmission (Flaxman et al., 2020) and eventually improve local businesses and labor market conditions in the long term. We leave the comparison of the short-term and long-term policy consequences for further research.

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**APPENDIX A**

See Tables A1 and A2.

**TABLE A1** The effects of COVID-19 on local establishments by industry for the extended period up to Mar 2021

| Industry 1. Manufacturing | Dependent variable: The natural logarithm of Number of establishments | New establishments | Establishment closures |
|---------------------------|---------------------------------------------------------------|-------------------|------------------------|
| COVID-19 confirmed cases  | (1) −0.028                                                     | (2) −0.025        | (3) 0.076              |
|                           | (0.017)                                                       | (0.026)           | (0.072)                |

| Industry 2. Construction  |
|---------------------------|
| COVID-19 confirmed cases  | 0.019                                                        | 0.029             | 0.139**               |
|                           | (0.030)                                                       | (0.051)           | (0.051)               |

| Industry 3. Wholesale & retail |
|-------------------------------|
| COVID-19 confirmed cases      | −0.019                                                       | −0.013            | 0.112                 |
|                               | (0.013)                                                       | (0.031)           | (0.073)               |

| Industry 4. Transportation & warehousing |
|-------------------------------------------|
| COVID-19 confirmed cases                  | −0.008                                                       | 0.025             | 0.125*                |
|                                           | (0.013)                                                       | (0.058)           | (0.067)               |

| Industry 5. Lodging & restaurant         |
|------------------------------------------|
| COVID-19 confirmed cases                 | −0.042**                                                     | −0.101***         | 0.099                 |
|                                           | (0.020)                                                       | (0.018)           | (0.078)               |

| Industry 6. Leisure                      |
|------------------------------------------|
| COVID-19 confirmed cases                 | −0.033*                                                      | −0.058            | 0.151*                |
|                                           | (0.018)                                                       | (0.043)           | (0.080)               |

| Industry 7. Repair & other personal services |
|-----------------------------------------------|
| COVID-19 confirmed cases                      | −0.022                                                       | −0.035            | 0.131                 |
|                                              | (0.013)                                                       | (0.035)           | (0.086)               |
TABLE A1  (Continued)

| Industry 8. ICT service | Dependent variable: The natural logarithm of |
|-------------------------|-----------------------------------------------|
|                         | Number of establishments | New establishments | Establishment closures |
| COVID-19 confirmed cases| -0.004                        | 0.008              | 0.072                   |
|                         | (0.005)                     | (0.021)            | (0.083)                 |

| Industry 9. Science & technology service |
|------------------------------------------|
| COVID-19 confirmed cases                 |
| -0.010                                   |
| (0.014)                                  |
| New establishments                       |
| 0.029                                    |
| (0.033)                                  |
| Establishment closures                   |
| 0.072                                    |
| (0.107)                                  |

| Industry 10. Business facility management |
|-------------------------------------------|
| COVID-19 confirmed cases                  |
| 0.023                                     |
| (0.019)                                  |
| New establishments                       |
| -0.038                                   |
| (0.056)                                  |
| Establishment closures                   |
| 0.053                                    |
| (0.053)                                  |

| Industry 11. Banking & insurance          |
|-------------------------------------------|
| COVID-19 confirmed cases                  |
| -0.008                                    |
| (0.016)                                  |
| New establishments                       |
| 0.033                                    |
| (0.052)                                  |
| Establishment closures                   |
| 0.165**                                  |
| (0.076)                                  |

| Industry 12. Real estate                  |
|-------------------------------------------|
| COVID-19 confirmed cases                  |
| 0.016**                                  |
| (0.007)                                  |
| New establishments                       |
| -0.051*                                  |
| (0.029)                                  |
| Establishment closures                   |
| 0.144                                    |
| (0.097)                                  |

| Industry 13. Education                    |
|-------------------------------------------|
| COVID-19 confirmed cases                  |
| -0.001                                    |
| (0.003)                                  |
| New establishments                       |
| -0.094***                                |
| (0.032)                                  |
| Establishment closures                   |
| 0.010                                    |
| (0.036)                                  |

| Industry 14. Health & social work         |
|-------------------------------------------|
| COVID-19 confirmed cases                  |
| -0.011**                                  |
| (0.004)                                  |
| New establishments                       |
| 0.009                                    |
| (0.024)                                  |
| Establishment closures                   |
| 0.140*                                   |
| (0.076)                                  |

| Observations | 867 | 867 | 867 |

Notes: All models commonly control for the logarithm of the population in each province, province fixed effects, year fixed effects, month fixed effects, and province-level linear time trend. Each column in each panel corresponds to a result from a single regression specification. Standard errors are in the parentheses, clustered at the province level.

Abbreviation: ICT, information and communications technology.

***p < 0.01; **p < 0.05; *p < 0.1.
Table A2: The effects of COVID-19 on the local labor market by industry for the extended period up to Mar 2021

| Industry | Dependent variable: The natural logarithm of | (1) | (2) | (3) | (4) |
|----------|---------------------------------------------|-----|-----|-----|-----|
|          | Number of UB applicants | Number of EI subscribers | Number of new EI subscribers | Number of people who lost the EI subscription |
| 1. Manufacturing | COVID-19 confirmed cases | -0.034 | 0.001 | -0.017 | -0.004 |
|          | (0.065) | (0.001) | (0.061) | (0.021) |
| 2. Construction | COVID-19 confirmed cases | -0.020 | 0.002 | 0.006 | -0.009 |
|          | (0.059) | (0.003) | (0.017) | (0.011) |
| 3. Wholesale & retail | COVID-19 confirmed cases | -0.015 | -0.001 | -0.014 | -0.027*** |
|          | (0.021) | (0.002) | (0.023) | (0.007) |
| 4. Transportation & warehousing | COVID-19 confirmed cases | -0.009 | -0.008 | -0.016 | -0.039** |
|          | (0.015) | (0.008) | (0.018) | (0.016) |
| 5. Lodging & restaurant | COVID-19 confirmed cases | 0.063** | -0.017 | -0.057*** | -0.035* |
|          | (0.029) | (0.011) | (0.017) | (0.018) |
| 6. Leisure | COVID-19 confirmed cases | -0.021 | -0.021** | -0.076*** | -0.021 |
|          | (0.039) | (0.008) | (0.026) | (0.027) |
| 7. Repair & other personal services | COVID-19 confirmed cases | 0.011 | 0.000 | 0.010 | 0.005 |
|          | (0.076) | (0.006) | (0.081) | (0.016) |
| 8. ICT service | COVID-19 confirmed cases | -0.028 | 0.005 | 0.002 | 0.010 |
|          | (0.042) | (0.008) | (0.052) | (0.046) |
| 9. Science & technology service | COVID-19 confirmed cases | -0.031 | 0.017 | -0.013 | -0.013 |
|          | (0.031) | (0.021) | (0.017) | (0.031) |
| 10. Business facility management | COVID-19 confirmed cases | -0.017 | -0.004 | -0.047 | -0.024 |
|          | (0.032) | (0.002) | (0.028) | (0.049) |
| Industry 11. Banking & insurance | | | |
| COVID-19 confirmed cases | -0.002 | -0.007 | -0.009 | -0.007 |
| | (0.013) | (0.006) | (0.034) | (0.023) |

| Industry 12. Real estate | | | |
| COVID-19 confirmed cases | -0.020 | -0.003 | 0.077*** | 0.032 |
| | (0.036) | (0.006) | (0.023) | (0.019) |

| Industry 13. Education | | | |
| COVID-19 confirmed cases | 0.015 | 0.002 | -0.059*** | -0.032** |
| | (0.039) | (0.001) | (0.015) | (0.011) |

| Industry 14. Health & social work | | | |
| COVID-19 confirmed cases | 0.005 | -0.004 | 0.022 | -0.016 |
| | (0.026) | (0.006) | (0.015) | (0.037) |

| Observations | 867 | 867 | 867 | 867 |

Notes: All models commonly control for the logarithm of the population in each province, province fixed effects, year fixed effects, calendar-month fixed effects, and province-level linear time trend. Each column in each panel corresponds to a result from a single regression specification. For example, column (1) in panel A shows the COVID-19 coefficient estimate from the regression of the log number of applicants for UB in the manufacturing industry on the COVID-19 confirmed cases and controls. Standard errors are in the parentheses, clustered at the province level.

Abbreviations: EI, employment insurance; ICT, information and communications technology; UB, unemployment benefits. ***p < 0.01; **p < 0.05; *p < 0.1.