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Economic Impact of Targeted Government Responses to COVID-19: Evidence from the First Large-scale Cluster in Seoul

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ABSTRACT

Economic Impact of Targeted Government Responses to COVID-19: Evidence from the First Large-scale Cluster in Seoul*

We estimate the economic impact of South Korea's targeted responses to the first large-scale COVID-19 cluster in Seoul. We find that foot traffic and retail sales decreased only within a 300 meter radius of the cluster and recovered to its pre-outbreak level after four weeks. The reductions appear to be driven by temporary business closures rather than the risk avoidance behavior of the citizens. Our results imply that less intense, but more targeted COVID-19 interventions, such as pin-pointed, temporary closures of businesses, can be a low-cost alternative after lifting strict social distancing measures.

JEL Classification: E2, H12, I12, I18

Keywords: COVID-19, pandemic, information disclosure, risk avoidance, foot traffic, retail sales, cell phone signal data, card transaction data

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1. Introduction

The majority of governments have relied on massive non-pharmaceutical interventions (NPI) for containing the spread of the novel coronavirus disease (COVID-19), such as business and school closures, stay-at-home orders, bans on social gatherings, and restrictions on local and international travels (Hale et al., 2020). However, despite the clear health benefits, strict social distancing policies can lead to prolonged economic recessions. Several studies estimate the high economic costs of intense NPIs, such as shelter-in-place orders, or economy-wide lockdowns (Alexander and Kager, 2020; Anderson et al., 2020; Baker et al., 2020; Carvalho et al., 2020; Chen, Qian, and Wen, 2020; Coibion, Gorodnichenko, and Weber, 2020; Kim, Koh, and Zhang, 2020).

Recent simulation-based studies, investigating trade-offs between health benefits and economic costs by the form and intensity of NPIs, predict that the pandemic can be controlled without complete lockdowns (Acemoglu et al., 2020; Argente, Hsieh, and Lee, 2020; Aum, Lee, and Shin, 2020; Chen and Qiu, 2020; Chudik, Pesaran and Rebucci, 2020; Fajgelbaum et al., 2020). Alternative types of lower-intensity NPIs, such as a small-scale lockdown of an individual COVID-19 cluster can be an efficient approach for controlling disease spread without significant economic costs because they are likely to cause smaller disruptions to the economy. In fact, many countries have been transitioning to mild social distancing measures to minimize adverse economic costs after the intense lockdown. However, there is limited empirical evidence on the economic impact of less intense but more targeted NPIs.

We fill this gap in the literature through a case study investigating the effects of South Korea's targeted responses to the first large-scale COVID-19 cluster in Seoul. This outbreak of a local cluster, which originated from a large call center in Guro, one of the busiest urban areas in Seoul, infected 166 individuals, and could potentially have contributed to an explosion of local transmission (Park et al., 2020).¹ We argue that this cluster outbreak provides a unique context for studying the effect of less intense but more targeted NPIs. First, the Korean government's response to this cluster was a standard strategy in the fight against COVID-19, which can be adopted by other governments that has lifted or about to lift strict social distancing measures.² The day after

¹ Figure 1 shows the call center is located near two subway stations (Guro and Sindorim) and surrounded by high-rise apartment buildings. A large department store and Walmart-like hypermarket chains are also located within a 500–900 meter (.31–.56 mile) radius from the cluster.

² Appendix B provides details of the Korean government's responses to COVID-19.

the first case in the cluster, the Korea Centers for Disease Control and Prevention (KCDC) along with local governments organized a joint response team and enforced two-week closures of businesses operating in the building where the call center was located. Additionally, the joint response team implemented rapid and meticulous contact tracing, extensive testing, and encouraged voluntary risk avoidance behavior by the citizens via public disclosure of the detailed location information of the COVID-19 positive patients along with timelines. The situation was completely contained after 25 days (i.e., no additional cases linked to the cluster).

For the empirical analysis, we use foot traffic and retail sales transaction data measured at a high-frequency granular level and apply a difference-in-differences (DID) method for comparing the changes in foot traffic and retail sales within the immediate proximity of the cluster and its surrounding areas before and after the public announcement about the cluster. We note sharp declines in foot traffic and retail sales within a 300 meter (0.19 mile) radius of the cluster during the first two weeks after the outbreak. However, there is no evidence that foot traffic and retail sales decreased beyond a 300 meter radius. The reductions in foot traffic and retail sales within the 300 meter radius started to rebound after two weeks and recovered to its pre-outbreak level after a month. Older individuals are at a significantly greater risk of developing severe illness if they are exposed to the novel coronavirus (Lian et al., 2020; Shahid et al., 2020). Thus, they may have had a stronger incentive to avoid the risk of infection and decreasing foot traffic and spending. However, our heterogeneity analysis reveals that reductions in foot traffic and sales were higher among younger individuals. Given that individuals immediately linked to the call center cluster were on average 38 years of age (Park et al., 2020), the baseline economic impact is likely to be driven by young workers whose workplace was temporarily closed after the outbreak in the cluster.

The findings suggest that the economic cost of the Korean government's targeted responses to the first large-scale COVID-19 cluster in Seoul is local and temporary. We argue that the results can provide valuable insights into a more efficient means of tackling the COVID-19 situation while protecting the economy. Several countries are lifting strict social distancing measures even as the virus is still raging to alleviate the adverse economic costs. In the U.S., Bartik et al. (2020) document that small business owners' expected length of COVID-19 leads to a lower likelihood of operating their businesses and argue for significant economic benefits of short-term NPIs such as localized temporary lockdowns. Our results indicate that the actual economic costs, measured by foot traffic and retail sales, of such a short-term containment policy could be low.

This study contributes to the literature by providing new evidence on the economic costs of targeted NPIs to a COVID-19 cluster. The previous studies quantifying the impact of a localized shock on the local economy document that the public disclosure of information about a sex criminal's move-in temporarily reduces sales prices of nearby homes after the move-in in the U.S. and South Korea (Linden and Rockoff, 2008; Pope, 2008; Kim and Lee, 2018). As more countries are lifting massive lockdowns and are likely to implement more targeted and temporary NPIs, it is of great interest to policymakers and researchers to understand the effects of the targeted NPIs on the local economy. Although an increasing number of studies have investigated the spending response of consumers to COVID-19, they have examined the economic costs through counterfactual simulations using augmented SIR epidemiology models (Acemoglu et al., 2020; Argente, Hsieh, and Lee, 2020; Fajgelbaum et al., 2020). To the best of our knowledge, this is one of the first studies that provide reduced-form evidence of the spatial distribution and persistence of the economic cost of micro-targeted NPIs.

The remainder of this study is structured as follows. Section 2 details the background to the COVID-19 situation in South Korea, and the COVID-19 cluster that originated from a large call center in Seoul. Sections 3 and 4 describe the data and empirical strategy, respectively. Section 5 discusses the results, and conclusions are presented in Section 6.

2. COVID-19 Situation in South Korea and the Guro Call Center Cluster

The first case of COVID-19 in South Korea was reported on January 20, 2020. During the early stages of the outbreak, the number of confirmed cases increased sharply, with the majority of new infections in the south-eastern region of South Korea (Daegu and Gyeongsangbuk-do province) due to mass gatherings of the Shincheonji Church of Jesus with more than 310,000 members (KCDC, 2020). South Korea has a total population of 51.8 million, and as of August 4, it has 14,389 cases and 301 deaths attributed to COVID-19.

The first case from the Guro call center cluster was confirmed on March 8, 2020. Figure A1 reports a sharp increase in the number of confirmed cases linked to this cluster for the first two days following the first case. The KCDC and local governments formed a joint response team and launched epidemiologic investigations immediately after discovering multiple cases. On March 9, 2020, after confirming more than 20 cases, the 19-story building housing the call center was ordered to close for two weeks. On March 10, the Mayor of Seoul declared the Guro call center case as the first large-scale cluster in the city. Since this was the first large-scale cluster, the media

covered the details of the situation in depth. As a result, the general public learned about the call center cluster almost immediately. Following the public announcement of the cluster, the number of news articles and keyword searches about the call center case recorded an immediate increase on Google and the most popular web search engine (NAVER) in South Korea, as shown in Figure A2.

The government tested 99.8% of individuals who were working or living in the building or visited it two weeks before March 8 (Park et al., 2020). Confirmed positive patients were isolated, while those testing negative were mandated to stay self-quarantined at home for 14 days. The joint response team also investigated, tested, and monitored household contacts of all confirmed positive patients for 14 days after discovering the cluster, regardless of symptoms. During March 13–16, 2020, the government used the mobile phone signal data of people and sent a total of 16,628 text messages to people who were found to have spent more than 5 minutes in the vicinity of the building. The messages instructed recipients to avoid contact with people and visit the nearest COVID-19 screening station for a test. The Guro call center cluster was contained completely after 25 days as there were no more positive patients linked to this cluster.

3. Data

We use two data sources that include census block-level information on foot traffic and retail sales in Seoul.³ First, we use hourly estimates of foot traffic (i.e., individuals physically present at the time) based on mobile phone signals. KT, the second-largest mobile telecom carrier in South Korea with a market share of 26%, provides these estimates based on their proprietary cell phone signal data using the following procedures: 1) KT calculates the amount of foot traffic by collecting mobile signals for each signal tower at a specific time; 2) It adjusts this number using its market share, mobile usage ratio, and the on/off ratio of mobile signals in each block. 3) KT further adjusts the block-specific foot traffic using census block characteristics because some census blocks have multiple signal towers.⁴

Second, we use estimates of daily retail sales based on data from card transactions. Shinhan Card, the largest credit card company in South Korea with a market share of 22%, provides these computed estimates based on their proprietary card transaction data. Shinhan Card uses transaction records from the payment terminal of each store and estimates the total sales of each block using

³ A census block is the minimal geographical unit classified by the statistical office of South Korea. The size of a census block is less than 0.1 km² (about 0.04 square mile) on average. There are 19,153 blocks in Seoul.

⁴ For the details, visit <http://data.seoul.go.kr/dataVisual/seoul/seoulLivingPopulation.do>.

additional information such as the market share of the card company and the card usage patterns based on sector, region, time, and demographic subgroups.

For the empirical analysis, we construct the block and week-level panel data covering 123 blocks in the vicinity of the COVID-19 cluster, and 11 weeks between February 3 and April 19, 2020.⁵ Table 1 shows the descriptive statistics of foot traffic and retail sales. Column (1) indicates that the average hourly foot traffic per block is approximately 500, implying that on average, 500 individuals are present per block within a 900 meter radius in a given hour.⁶ The average hourly foot traffic within a 100 meter radius of the cluster is about 760 individuals, higher than other blocks at longer distances from the cluster. This is because the call center building is located in a highly concentrated business area. The average hourly foot traffic level within a 100–500 meter radius is about 330–360 individuals, which is less than the 500–900 meter radius, having approximately 590 individuals, because hypermarkets and a large-scale department store are located within a 500–900 meter radius of the cluster. Column (2) reveals that the average daily sales amount per block is about 21 million Korean won (US\$17,456).⁷ Contrary to the fact that the average foot traffic is largest within a 100 meter radius, the average sales amount within a 100 meter radius is the smallest. The majority of retail sales took place in blocks at a distance of 500–900 meters from the cluster due to the presence of hypermarkets and a large department store.

4. Empirical Strategy

To identify the spatial distribution of the economic cost of the first COVID-19 cluster in Seoul and its persistency, we compare changes in foot traffic and retail sales in the immediate and surrounding areas before and after the public announcement of the cluster. Figure A3 shows trends of logarithm values for foot traffic and retail sales during weekdays in panels A and B, respectively. The trends indicate that, following the announcement of the cluster, the foot traffic and retail sales reduced sharply within a 300 meter radius. The declines within a 100 meter radius were greater than the 100–300 meter radius. However, it began to rebound two weeks after the cluster outbreak. Furthermore, little changes were observed in foot traffic and sales within a 300–900 meter radius of the cluster. We employ the following DID regression model to estimate the changes in foot traffic and retail sales:

⁵ The results, available upon request, are similar but noisier when using block- and day-level panel data.

⁶ The average hourly foot traffic increases to 1,219 if we restrict the sample to the data collected during working hours (i.e., between 9am and 6pm).

⁷ 1 US\$ is equivalent to 1,203 Korean Won as of July 20, 2020.

$$y_{i,d,t} = \beta_0 + \sum_{d \neq 5} \sum_{t \neq 0} \beta_{d,t} \cdot \text{Dist}_d \cdot \text{Week}_t + \lambda_i + \mu_t + \epsilon_{i,d,t}$$

where $y_{i,d,t}$ indicates logarithm values of foot traffic and sales at block i , in distance d , and week t .⁸ Dist_d ($d=1, \dots, 5$) is a dummy variable indicating whether block i is located within a certain radius from the call center, where d is assigned as 1 to 5 for blocks if linear distance from the call center to the blocks is within 100m, 100–300m, 300–500m, 500–700m, and 700–900m, respectively. Based on the raw data patterns shown in Figure A3, we use blocks in the farthest distance ($d=5$) as the control group, where the linear distance from the call center is 700–900 meters. As the reference week, we use the week from March 2–8 ($t=0$), a week before the cluster case. λ_i represents block fixed effects, controlling for time-invariant heterogeneity in foot traffic and sales within each block. μ_t are week-fixed effects, controlling for common time trends of dependent variables across all blocks. We do not include other control variables because we consider block fixed effects in the regression equation. Since we investigate short-term changes in the dependent variables over the two months, it is not feasible to include time-varying characteristics at the block level.

The parameter of interests are $\beta_{d,t}$ s where $d=1, \dots, 4$ and $t=-4, \dots, -1, 1, \dots, 6$. The estimated parameter values represent differences in $\log(\text{foot traffic})$ and $\log(\text{sales})$ in blocks in distance d relative to those in the control group distance ($d=5$) in week t , compared to the difference between the two distance groups in the reference week. For statistical inference, we calculated standard errors clustered at the block level to account for the serial correlations in foot traffic and retail sales.

5. Results

5.1. Effects on Foot Traffic

Figure 2 reports DID estimates of the impact of the first large-scale COVID-19 cluster on foot traffic in Seoul.⁹ Panels A and B separately present the findings based on weekdays and weekends to distinguish the role of the business closure order in the cluster building and risk avoidance behavior by the citizens. Foot traffic during weekends is more likely to reflect voluntary decisions because most employees would not need to commute to their workplaces.

⁸ We assign the following values to the week variable: -4 to February 3–9, -3 to February 10–16, -2 to February 17–23, -1 to February 24–March 1, 0 to March 2–8, 1 to March 9–15, 2 to March 16–22, 3 to March 23–29, 4 to March 30–April 5, 5 to April 6–12, and 6 to April 13–19.

⁹ Table A1 reports the corresponding regression results for $\log(\text{foot traffic})$ and $\log(\text{sales})$ during weekdays.

Panel A reveals limited heterogeneity in trends based on the distance from the cluster before the outbreak, thus providing evidence of a pre-parallel trend assumption that the change in foot traffic over time is similar across distance groups. Further, we observe a sharp decline of 14% and 18% in foot traffic within a 100-meter (.06 mile) radius of the cluster during the first and the second week after the outbreak, respectively, which is statistically significant at the 1% level. The foot traffic response within a 100–300 meter radius from the cluster records a similar pattern with smaller magnitudes, while the estimates during the first two weeks are statistically significant at the 1 percent level. However, there is no evidence of a decrease in foot traffic beyond a 300 meter radius after the outbreak of the call center cluster. The estimates are smaller in magnitude and statistically insignificant. The reduced foot traffic within a 300 meter radius starts rebounding after two weeks, consistent with the fact that businesses in the call center building are permitted to operate after two weeks. There is also a possibility of people becoming less cautious about visiting places near the call center cluster after two weeks because the vast majority of the cases linked to the call center cluster were confirmed within a couple of days after the public disclosure of the cluster, and only a few more cases were confirmed after the first week. The reduced foot traffic fully recovers to its pre-outbreak level after four weeks of the outbreak. Our back-of-the-envelope calculation suggests that, over four weeks after the call center cluster outbreak, the number of individuals visiting the area during weekdays reduced by 47.6% and 17.7% within a 100-meter and 100–300 meter radius, respectively, compared to the average foot traffic during the week just before it. The reduced foot traffic attributed to the outbreak of the Guro call center cluster over the four weeks within a 300 meter radius is equivalent to about 0.6% of the average hourly foot traffic of the entire Guro district during the week right before the cluster outbreak.

Panel B demonstrates the impact on the foot traffic during weekends, indicating little evidence of a decline in foot traffic in the vicinity of the call center building after the cluster outbreak. This result suggests that the risk avoidance behavior of the citizens did not play a significant role in reducing foot traffic in response to the cluster outbreak. It is also noteworthy that there is a strong pre-trend within a 100 meter radius well before the cluster outbreak. This decrease is possibly attributed to the risk avoidance behavior of individuals because the number of aggregate confirmed cases in South Korea recorded a sharp increase from February 18, 2020, two weeks before the call center cluster outbreak. There are large event venues exclusively used for weddings and a full-fledged hotel also containing large wedding halls in a 100 meter radius of the call center building. Since wedding ceremonies usually take place on weekends and involve a large number of guests from various locations, people might have avoided visiting places near the call center building even before the cluster was created.

We conduct the heterogeneity analysis by age to further examine potential mechanisms which would cause a decrease in foot traffic in the cluster during weekdays. Since the coronavirus presents a more severe health risk to older individuals, existing studies have shown that older people have a stronger incentive to avoid the risk of infection (Argente, Hsieh, and Lee, 2020; Brotherhood et al., 2020). However, the individuals linked to this building were ordered to self-quarantine, and their average age was 38 years (Park et al., 2020). We hypothesize that, if the risk avoidance behavior (the business closure order) is the leading factor, then the impact on foot traffic would be greater among older individuals. Panel A of Figure A4 shows a greater foot traffic impact among younger individuals in their 20s and 30s compared to older individuals. This suggests that the influence on foot traffic during the weekdays is likely due to the business closures. To further investigate the hypothesis that the reduction in foot traffic is due to business closure, we also exploited the fact that 72% of individuals connected to the call center building were females. Panel B of Figure A4 indicates that the decline in foot traffic is greater among females, which is consistent with our interpretation.

5.2. Effects on Sales

Figure 3 presents DID estimates for the total retail sales. The overall trends of sales during weekdays are similar to foot traffic, as shown in Panel A. The total sales decreased by about 140% within a 100 meter radius at its peak, which is statistically significant at the 1 percent level. Further, it starts rebounding after two weeks, reaching the pre-outbreak level after four weeks. The sales response within a 100–300 meter radius exhibits a similar pattern, but with smaller magnitudes. The estimate is statistically significant at the 1 percent level at its peak. Our back-of-the-envelope calculation indicates that during the four weeks after the outbreak of the cluster, sales within a 100 meter and 100–300 meter radius of the cluster reduced by 354% and 258% in total, respectively, compared to the average sales during the week right before the cluster outbreak. The reduction in sales due to the outbreak of the Guro call center cluster over the four weeks within a 300 meter radius is equivalent to 1.85% of average daily sales of the entire Guro district during the week just before the cluster outbreak.

Panel B shows limited evidence of systematic changes in sales during weekends. In combination with the findings of Panel B in Figure 2, this result implies that the cluster did not lead to significant economic costs during weekends because citizens did not display a definite risk avoidance behavior. However, we acknowledge that the pattern of sales within a 100 meter radius of the cluster is noisy, but appears to decrease following the outbreak of the cluster. We suspect

that the noisy pattern is mostly attributed to the change in sales linked to wedding ceremonies. Since a wedding ceremony in South Korea typically involves huge expenditure, a massive wedding ceremony can affect the sales patterns within the limited geographical boundary (i.e., only one block within a 100 meter radius) significantly.

The heterogenous sales impact by sector is further investigated in Figure 4 to examine whether sectors with more discretionary consumer spending face a larger reduction in sales. Considering that the baseline impact on sales is observed only within a 300 meter radius of the cluster, we modify our baseline DID model to estimate changes in retail sales between blocks within a 300 meter and 300–900 meter radius of the cluster before and after the outbreak in each sector. Each bar represents the DID estimates on the total sales during weekdays within a 300 meter radius during the first two weeks after the outbreak, compared to a 300–900 meter radius. This indicates that the sale reduction is driven by relatively discretionary spending items. For example, a larger decline in sales are observed in the apparel and accessories sector (-279%) and the sports/entertainment sector (-202%) compared with the restaurant or healthcare sectors.¹⁰

We further conduct the heterogeneity analysis by age and gender to examine potential mechanisms. Figure A5 shows that the estimated impact on sales is generally greater among younger individuals and females, which is consistent with the findings from Figure A4. The results imply that the reductions in sales are primarily driven by the closures of businesses located in the cluster building rather than risk avoidance behavior.¹¹

6. Conclusion

We estimate the economic impact of the Korean government's targeted responses to the first large-scale COVID-19 cluster in Seoul. We demonstrate that the economic costs are highly local and temporary. The decline in foot traffic and retail sales were only observed within a 300-meter (0.19 mile) radius from the cluster and recorded a full recovery after four weeks. Our heterogeneity analysis indicates that the reductions in foot traffic and retail sales are primarily caused by temporary business closures rather than the risk avoidance behavior of the citizens.

¹⁰ Figure A6 shows the results of the same analysis using weekend data. Apparel and accessories (-150%), sports/entertainment (-77%), event/home service (-165%), and car sales/car service (-125%) show a significant decrease.

¹¹ Hypermarkets and a large-scale department store are located within a 500–900 meter radius from the cluster. Risk-averse individuals may shun these places to avoid crowds after the call center cluster outbreak. We use a modified DID model to estimate the effects of the cluster on sales in these places compared to change in sales in other blocks within the same distance group. There is limited evidence of the outbreak at the call center cluster causing a reduction in sales at hypermarkets and the department store, suggesting that citizens' risk avoidance behavior may not manifest in significant economic costs.

Our findings imply that the economic costs of tailored responses can be localized and short-term. Since several countries are lifting strict social distance measures while the virus is still actively spreading, our findings provide valuable insight for other countries regarding better management of the COVID-19 situation while protecting the economy.

We acknowledge the limitations of this study. First, the external validity of the findings of this study should be taken cautiously as this is a case study estimating the localized economic costs of a single event. For example, Seoul is one of the most successful metropolitan cities containing COVID-19 and reported a very low caseload per capita (160 cases per million). Thus, the targeted approach may not work if local transmission being widespread and uncontrollable. Second, workers from the building housing the call center remained in their homes throughout the two-week business closure, which may have boosted retail sales in their neighborhoods (e.g., food delivery). This possibility implies that our estimates for economic costs may be overestimated. Unfortunately, the data constraint limits tracking individuals' consumption spending. However, we argue that this potential bias would not pose a significant problem with our key implication because, if this is the case, the actual economic costs would be even smaller than our estimates.

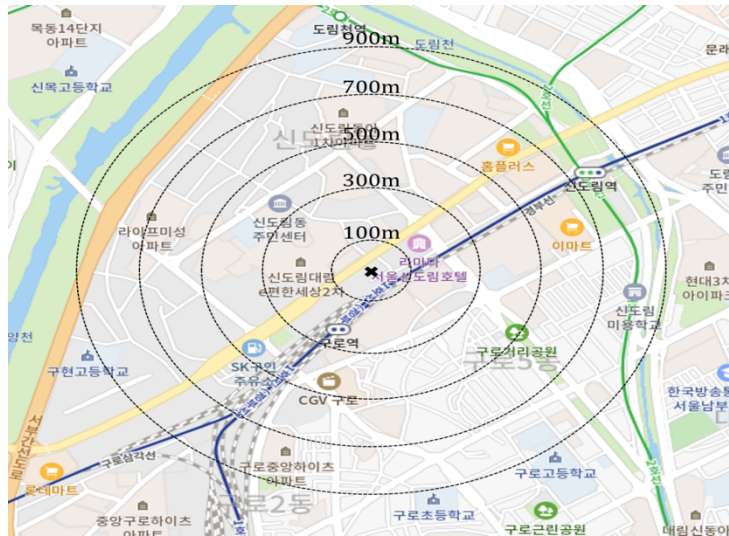
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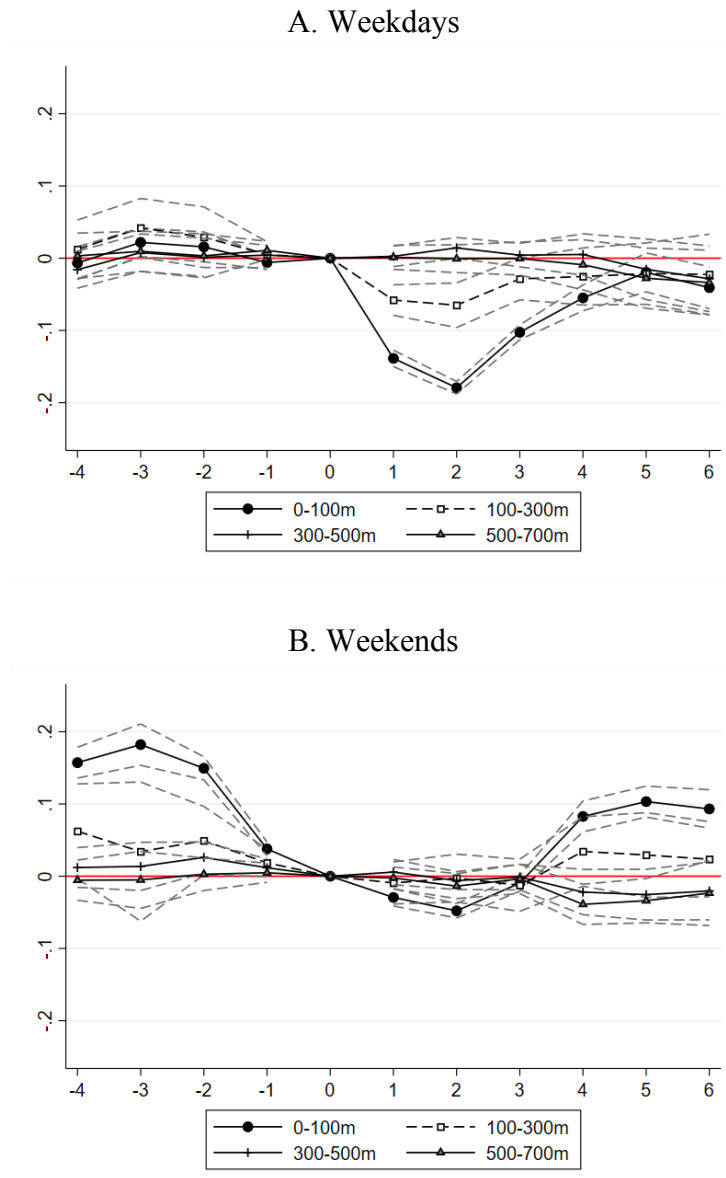
Figures and Tables

Figure 1. Map of the Guro Call Center Cluster



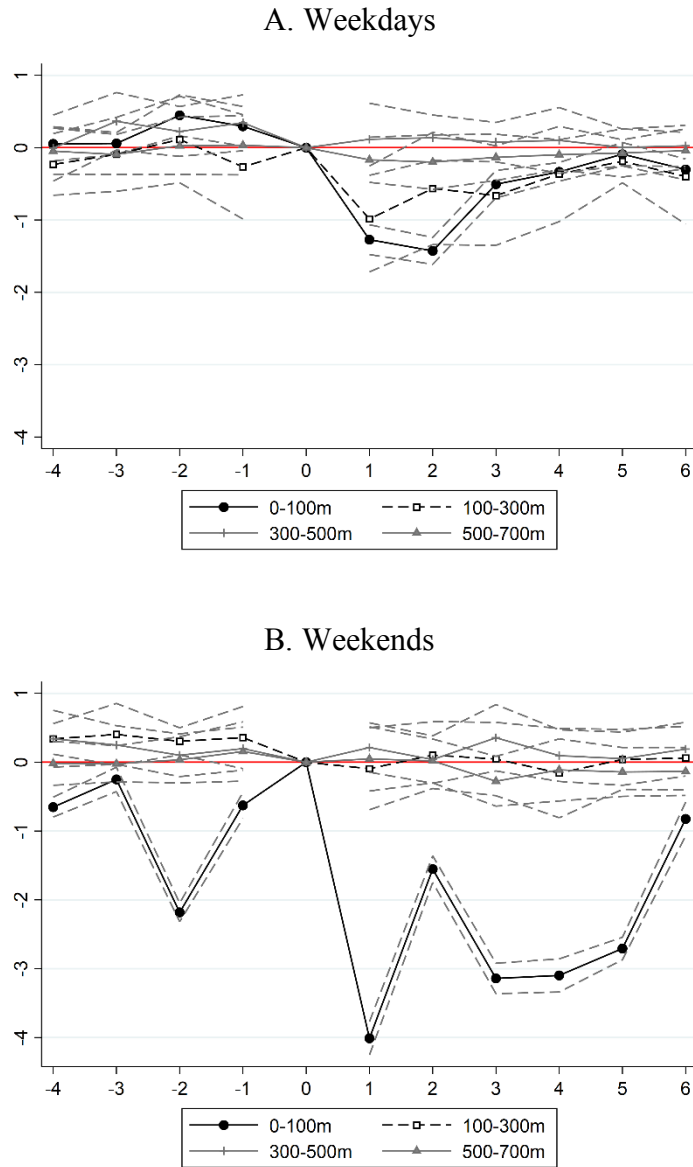
Source: Naver Maps (2020)

Figure 2. Foot Traffic Response to the Guro Call Center Cluster



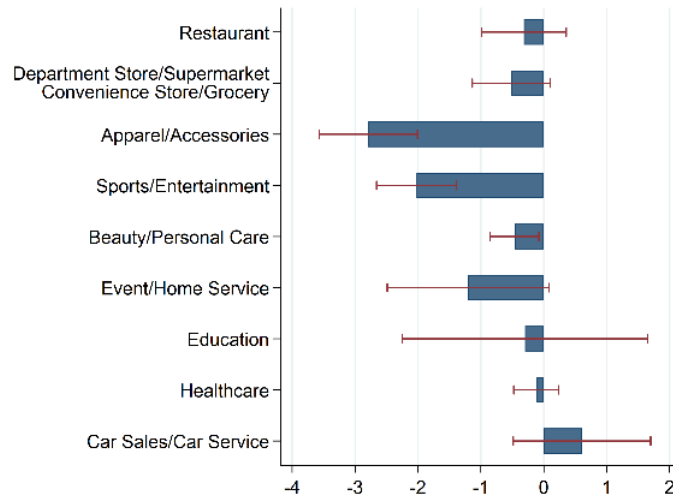
Notes: The dependent variables is the average hourly total foot traffic per week in logarithm. For panels A and B, we use foot traffic data during weekdays and weekends, separately. Lines with symbols indicate DID estimates for each distance group. We calculate standard errors clustered at the block-level and corrected for heteroscedasticity. Light gray dash lines represent 95% confidence intervals.

Figure 3. Retail Sales Response to the Guro Call Center Cluster



Notes: The dependent variable is the average daily sales amount in logarithm. In panels A and B, we use sales data during weekdays and weekends, separately. Lines with symbols indicate DID estimates for each distance group. We calculate standard errors clustered at the block-level and corrected for heteroskedasticity. Light gray dash lines represent 95% confidence intervals.

Figure 4. Sales Response to the Guro Call Center Cluster by Sector



Notes: The dependent variable is the average daily sales amount during weekdays in logarithm. We compare changes in outcomes of interests between blocks within a 300 meter radius and 300–900 meter radius of the cluster. Each bar represents the DID estimates in the first two weeks after the outbreak. We calculate standard errors clustered at the block-level and corrected for heteroskedasticity. Caps indicate 95% confidence intervals.

Table 1. Summary Statistics

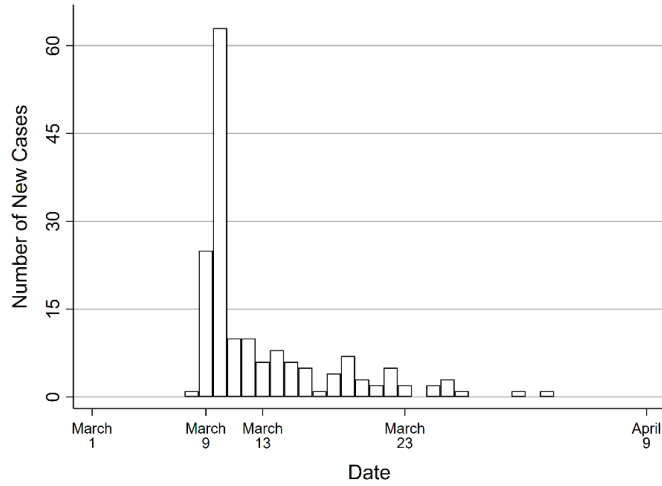
| | Average Hourly Foot Traffic per Block | Average Daily Sales per Block |
|------------|---------------------------------------|-------------------------------|
| | Mean (SD) | Mean (SD) |
| Total | 505 (633) | 20.84 (51.07) |
| By Radius: | | |
| 0-100m | 757 (21) | 3.76 (2.50) |
| 100-300m | 330 (361) | 15.14 (24.99) |
| 300-500m | 364 (190) | 7.14 (9.37) |
| 500-700m | 596 (745) | 28.69 (58.32) |
| 700-900m | 586 (774) | 23.76 (59.76) |

Notes: The statistics are calculated using the data from weekdays during February 2020, the month before the cluster outbreak. Retail sales are measured by a million Korean won.

Appendices

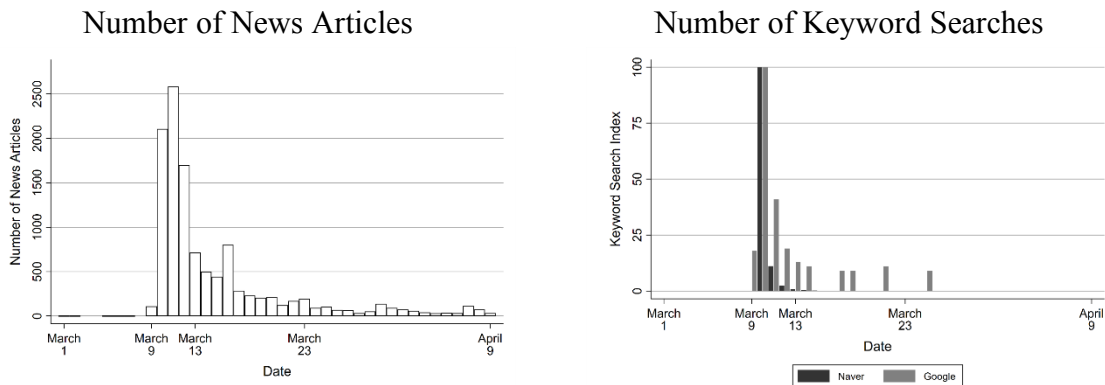
A. Appendix Figures and Tables

Figure A1. Trend of Confirmed Cases of the Guro Call Center Case



Source: Korea Centers for Disease Control and Prevention (KCDC), Press Release, March 1 – April 10, 2020; Seoul Metropolitan Government, Press Release, March 1 – April 10, 2020.

Figure A2. Number of News Articles and Keyword Searches Containing “Guro Call Center”

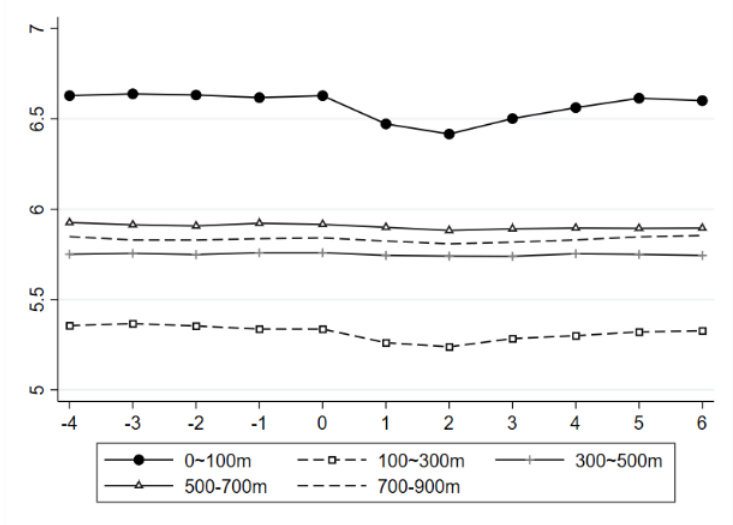


Notes: Keyword Search Index represents the degree of search interest of the keyword “Guro Call Center” on web search engines in South Korea from March 1, 2020 to April 9, 2020. A value of 100 indicates the peak popularity for the term, a value of 50 means that the term is half as popular, and a score of 0 indicates insufficient search data for this term.

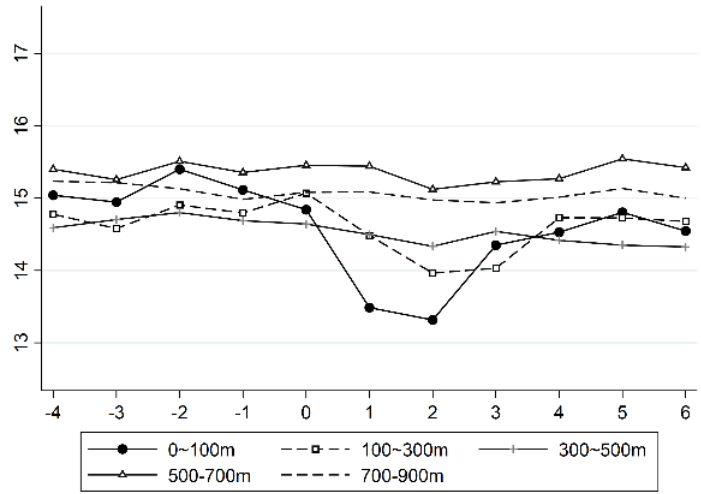
Sources: Google Trends, <https://trends.google.com>, Naver Datalab, <https://datalab.naver.com>, Naver News, <https://news.naver.com>

Figure A3. Trends of Foot Traffic and Sales by Distance to the Guro Call Center

A. Log(Foot Traffic)



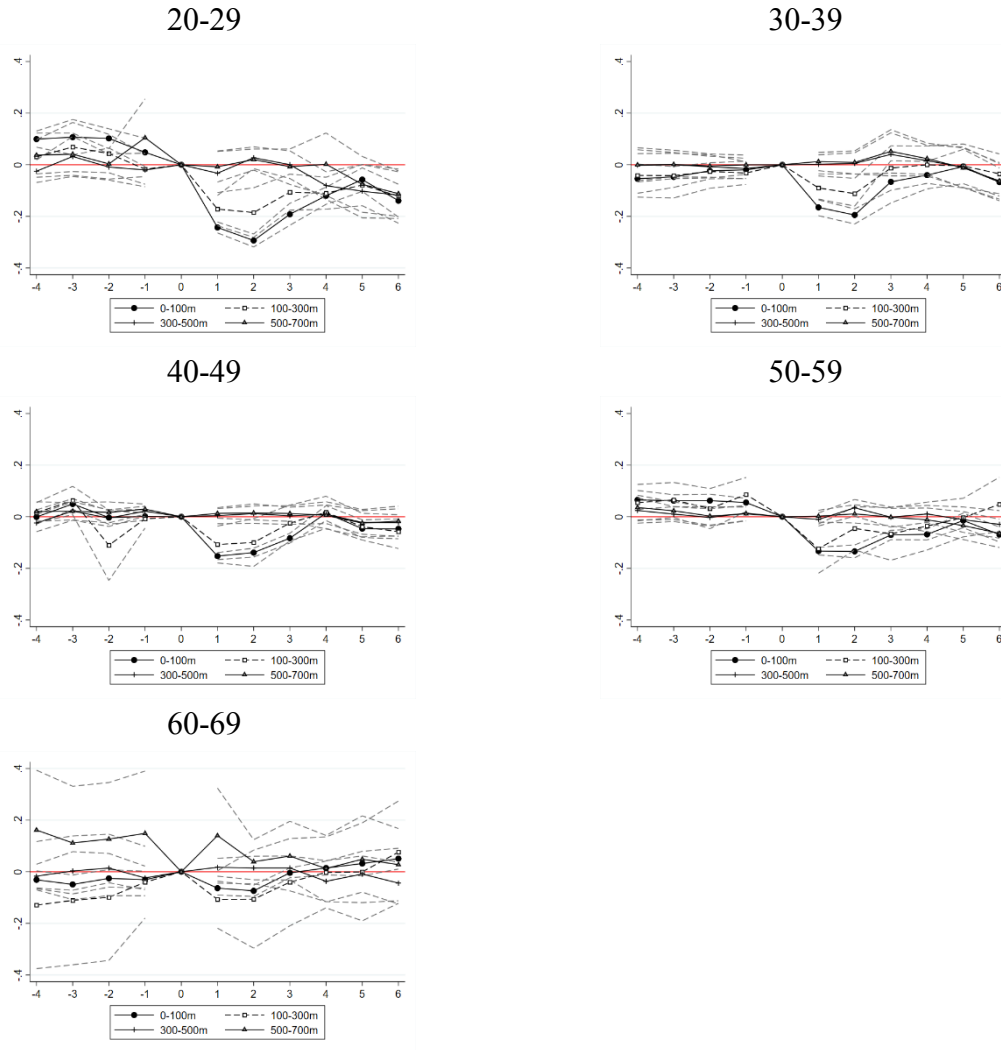
B. Log(sales)



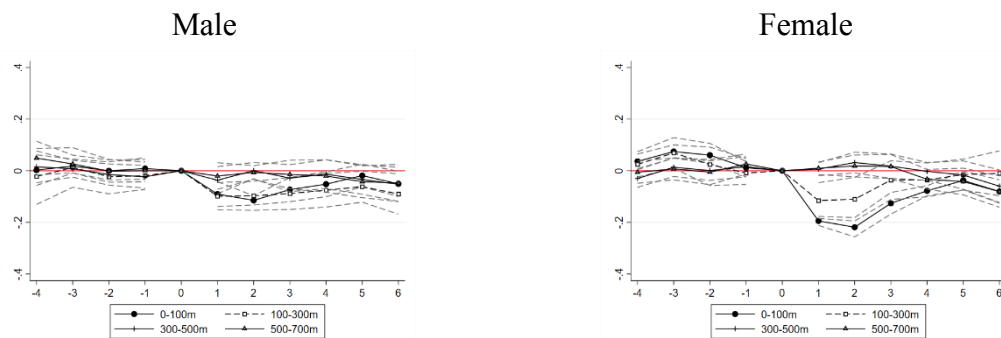
Note: The dependent variables are the average hourly total foot traffic and the average daily sales amount during weekdays in logarithm, respectively.

Figure A4. Foot Traffic Response to the Guro Call Center Cluster by Age and Gender

A. By Age Group



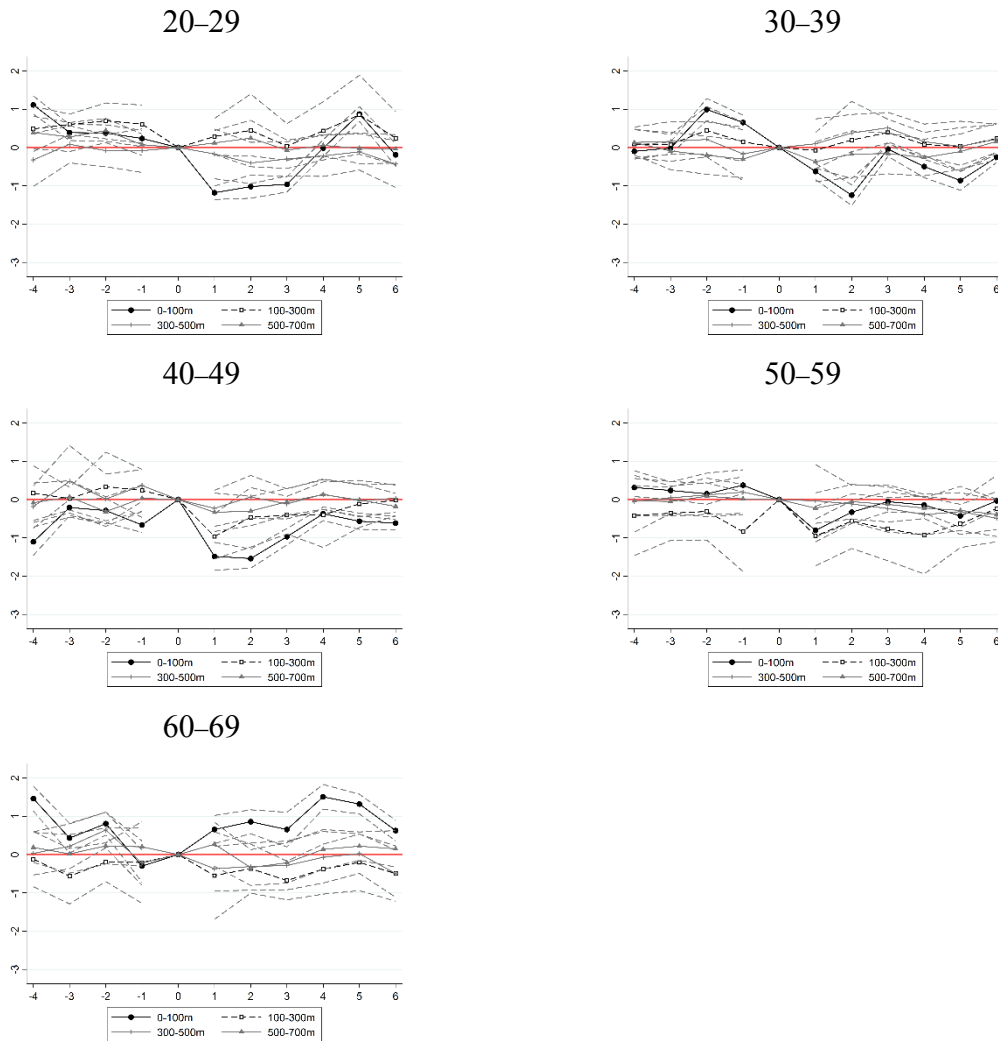
B. By Gender



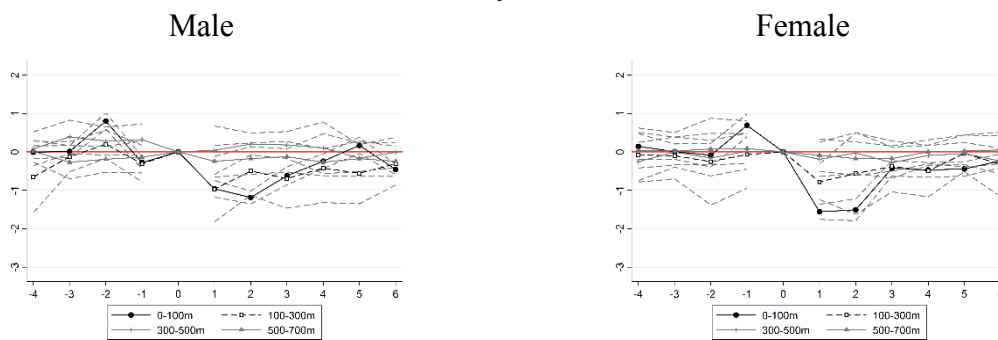
Notes: The dependent variable is the average hourly total foot traffic during weekdays in logarithm. In panels A and B, we use foot traffic data for each age and gender group during weekdays. Lines with symbols indicate DID estimates for each distance group. We calculate standard errors clustered at the block-level and corrected for heteroskedasticity. Light gray dash lines represent 95% confidence intervals.

Figure A5. Sales Response to the Guro Call Center Cluster by Age and Gender

A. By Age Group

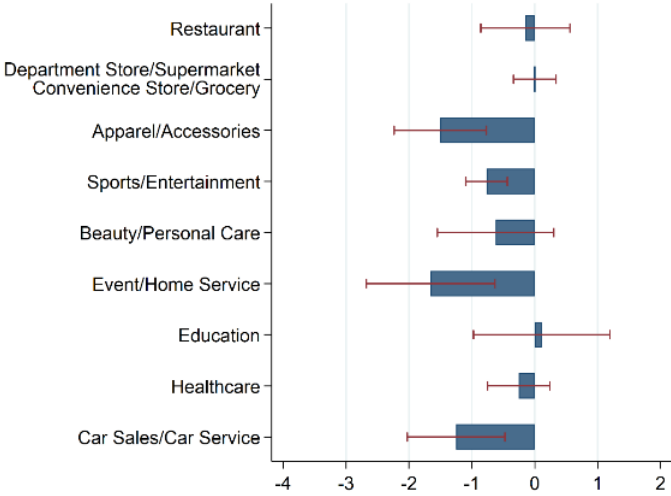


B. By Gender



Notes: The dependent variable is the average daily sales amount during weekdays in logarithm. Lines with symbols indicate DID estimates for each distance group. We calculate standard errors clustered at the block-level and corrected for heteroskedasticity. Light gray dash lines represent 95% confidence intervals.

Figure A6. Weekend Sales Response to the Guro Call Center Cluster by Sector



Notes: The dependent variable is the average daily sales amount during weekends in logarithm. We compare changes in outcomes of interests between blocks within a 300-meter and a 300–900 meter radius of the cluster. Each bar represents the DID estimates in the first two weeks following the outbreak. We calculate standard errors clustered at the block-level and corrected for heteroskedasticity. Caps indicate 95% confidence intervals.

Table A1. The Impact of Targeted COVID-19 Policy on Foot Traffic and Retail Sales

| | Log(Foot Traffic) (1) | Log(Sales) (2) |
|-----------------|--------------------------|-------------------|
| Radius 0–100m | | |
| × Week -4 | -0.007 (0.012) | 0.053 (0.121) |
| × Week -3 | 0.022** (0.010) | 0.059 (0.077) |
| × Week -2 | 0.016 (0.011) | 0.447*** (0.145) |
| × Week -1 | -0.006 (0.005) | 0.295** (0.140) |
| × Week 1 | -0.139*** (0.006) | -1.272*** (0.105) |
| × Week 2 | -0.179*** (0.004) | -1.427*** (0.095) |
| × Week 3 | -0.103*** (0.005) | -0.505*** (0.097) |
| × Week 4 | -0.055*** (0.009) | -0.334*** (0.066) |
| × Week 5 | -0.020 (0.014) | -0.090 (0.082) |
| × Week 6 | -0.041*** (0.015) | -0.302*** (0.074) |
| Radius 100–300m | | |
| × Week -4 | 0.012 (0.021) | -0.232 (0.217) |
| × Week -3 | 0.042** (0.021) | -0.092 (0.261) |
| × Week -2 | 0.029 (0.021) | 0.113 (0.305) |
| × Week -1 | 0.005 (0.009) | -0.266 (0.368) |
| × Week 1 | -0.058*** (0.011) | -0.986*** (0.373) |
| × Week 2 | -0.065*** (0.016) | -0.564 (0.396) |
| × Week 3 | -0.029* (0.015) | -0.663* (0.351) |
| × Week 4 | -0.025 (0.020) | -0.364 (0.336) |
| × Week 5 | -0.021 (0.022) | -0.188 (0.152) |
| × Week 6 | -0.022 (0.028) | -0.399 (0.336) |
| Radius 300–500m | | |
| × Week -4 | -0.016 (0.013) | -0.006 (0.233) |
| × Week -3 | 0.008 (0.013) | 0.365* (0.203) |
| × Week -2 | 0.001 (0.014) | 0.224 (0.176) |
| × Week -1 | 0.004 (0.007) | 0.344* (0.197) |
| × Week 1 | 0.003 (0.007) | 0.116 (0.254) |
| × Week 2 | 0.014* (0.007) | 0.138 (0.160) |
| × Week 3 | 0.004 (0.008) | 0.076 (0.139) |
| × Week 4 | 0.005 (0.015) | 0.101 (0.232) |
| × Week 5 | -0.015 (0.021) | 0.003 (0.129) |
| × Week 6 | -0.028 (0.023) | 0.025 (0.146) |
| Radius 500–700m | | |
| × Week -4 | 0.003 (0.016) | -0.048 (0.163) |
| × Week -3 | 0.010 (0.014) | -0.094 (0.141) |
| × Week -2 | 0.003 (0.016) | 0.026 (0.202) |
| × Week -1 | 0.011* (0.006) | 0.033 (0.209) |
| × Week 1 | 0.001 (0.009) | -0.168 (0.159) |
| × Week 2 | -0.001 (0.010) | -0.199 (0.192) |
| × Week 3 | 0.000 (0.012) | -0.134 (0.163) |
| × Week 4 | -0.009 (0.018) | -0.098 (0.106) |
| × Week 5 | -0.028 (0.021) | -0.073 (0.170) |
| × Week 6 | -0.034 (0.023) | -0.040 (0.128) |
| Observations | 1353 | 802 |
| R-squared | 0.998 | 0.954 |

Notes: The dependent variables are the average hourly total foot traffic per week and the average daily sales amount in logarithm during weekdays, respectively. Block fixed effect is controlled for in both specifications. We calculate standard errors clustered at the block-level and corrected for heteroskedasticity. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

B. Korean Government's Responses to COVID-19

The Korean government has responded to the COVID-19 situation by meticulous contact tracing and extensive testing. Basic information such as location history of confirmed cases is obtained via an interview by the local health authority where the case has been confirmed. In a scenario where this information is considered insufficient, additional data (mobile phone location, CCTV footages, card transaction records, etc.) are collected and cross-checked with the information acquired from the initial interview.

Information about the places visited by a COVID-19 positive patient during the entire period from two days before showing symptoms through the beginning of the quarantine period is publicly disclosed on the official websites of administrative districts visited by the patient so that people can avoid high-risk areas. Furthermore, for each new confirmed case, a text message is sent to district residents notifying them about the availability of contact tracing information of each new confirmed case on the official district website. In the case of the formation of a new cluster instead of a few isolated cases, a joint response team consisting of epidemiological inspectors and other government employees from the KCDC and local governments are quickly mobilized. They conduct thorough epidemiological investigations, and the findings are broadcasted through official daily briefings. The local governments enforced an executive order to temporarily shut down businesses to prevent additional infections only in highly limited circumstances.

Furthermore, the government significantly expanded access to diagnostic tests for detecting COVID-19 cases via walk-through and drive-through screening stations. Since the outbreak of COVID-19, the daily testing capacity has increased almost seven-fold in two months, from 3,000 (58 per million) in February 2020 to approximately 20,000 (386 per million) in April 2020. To contain the COVID-19 situation in the quickest possible manner, the Korean government has covered the complete costs of medical treatments for each confirmed patient, as well as the total expenses of diagnostic tests for suspected cases. A suspected case is defined as a person experiencing fever (37.5°C or higher) or respiratory symptoms (coughs, shortness of breath, etc.) within 14 days of contact with a COVID-19 patient during the symptom-exhibiting period of the patient.